Sleep-walker.

seem concentrated in the object with which it is occupied, and have at that time no perception of any thing but what relates to that object.

"These two causes united seem to them sufficient for explaining one of the most singular facts that occurred to their observation, to wit, how the young Devaud can write, although he has his eyes shut, and an obstacle before them. His paper is imprinted on his imagination, and every letter which he means to write is also painted there, at the place in which it ought to stand on the paper, and without being confounded with the other letters; now it is clear that his hand, which is obedient to the will of his imagination, will trace them on the real paper, in the same order in which they are represented on that which is pictured in his head. It is thus that he is able to write several letters, several sentences, and entire pieces of writing; and what seems to confirm the idea, that the young Devaud writes according to the paper painted on his imagination is, that a certain sleep-walker, who is described in the French *Encyclopédie* (article *Somnambulism*), having written something on a paper, another piece of paper of the same size was substituted in its stead, which he took for his own, and made upon this blank paper the corrections he meant to have made on the other which had been taken away, precisely in the places where they would have been.

"It appears from the recital of another fact, that Devaud, intending to write at the top of the first leaf of a white paper book, *Vevey, le*— stopped a moment as if to recollect the day of the month, left a blank space, and then proceeded to *Decembre* 1787; after which he asked for an almanac: a little book, such as is given to children for a new year's gift, was offered to him; he took it, opened it, brought it near his eyes, then threw it down on the table. An almanac which he knew was then presented to him; this was in German, and of a form similar to the almanac of Vevey: he took it, and then said, 'What is this they have given me; here, there is your German almanac.' At last they gave him the almanac of Berne; he took this likewise, and went to examine it at the bottom of an alcove that was perfectly dark. He was heard turning over the leaves, and saying 24, then a moment afterwards 34. Returning to his place, with the almanac open at the month of December, he laid it on the table and wrote in the space which he had left blank the 24th. This scene happened on the 23d; but as he imagined it to be the 24th, he did not mistake. The following is the explication given of this fact by the authors of the report.

"The dates 23d, 24th, and 25th, of the month of December, had long occupied the mind of the young Devaud. The 23d and 25th were holidays, which he expected with the impatience natural to persons of his age, for the arrival of those moments when their little daily labours are to be suspended. The 25th especially was the object of his hopes; there was to be an illumination in the church, which had been described to him in a manner that quite transported him. The 24th was a day of labour, which came very disagreeably between the two happy days. It may easily be conceived, how an imagination so irritable as that of the young Devaud would be struck with those pleasing epochs. Accordingly, from the beginning of the month he had been perpetually turning over the almanac of Vevey. He calculated the days and the hours that were to elapse before the arrival of his wished-for holidays; he showed to his friends and acquaintance the dates of those days which he expected with so much impatience; every time he took up the almanac, it was only to consult the month of December. We now see why that date presented itself to his mind. He was performing a task, because he imagined the day to be the Monday which had so long engrossed him. It is not surprising, that it should have occurred to his imagination, and that on opening the almanac in the dark he might have thought he saw this date which he was seeking, and that his imagination might have represented it to him in as lively a manner as if he had actually seen it. Neither is it surprising that he should have opened the almanac at the month of December; the custom of perusing this month must have made him find it in the dark by a mere mechanical operation. Man never seems to be a machine so much as in the state of somnambulism; it is then that habit comes to supply those of the senses that cannot be serviceable, and that it makes the person act with as much precision as if all his senses were in the utmost activity. These circumstances destroy the idea of there being any thing miraculous in the behaviour of young Devaud with respect to the date and the month that he was in quest of; and the reader, who has entered into our explanations, will not be surprised at his knowing the German almanac; the touch alone was sufficient to point it out to him; and the proof of this is the shortness of the time that it remained in his hands.

"An experiment was made by changing the place of the ink-standish during the time that Devaud was writing. He had a light beside him, and had certified himself of the place where his ink-holder was standing by means of sight. From that time he continued to take ink with precision, without being obliged to open his eyes again: but the ink-standish being removed, he returned as usual to the place where he thought it was: It must be observed, that the motion of his hand was rapid till it reached the height of the standish, and then he moved it slowly, till the pen gently touched the table as he was seeking for the ink: he then perceived that a trick had been put on him, and complained of it; he went in search of his ink-standish and put it in its place. This experiment was several times repeated, and always attended with the same circumstances. Does not what we have here stated prove, that the standish, the paper, the table, &c. are painted on his imagination in as lively a manner as if he really saw them, as he sought the real standish in the place where his imagination told him it ought to have been? Does it not prove that the same lively imagination is the cause of the most singular actions of this sleep-walker? And lastly, does it not prove, that a mere glance of his eye is sufficient to make his impressions as lively as durable?

"The committee, upon the whole, recommend to such as wish to repeat the same experiments, 1. To make their observations on different sleep-walkers. 2. To examine often whether they can read books that are unknown to them in perfect darkness. 3. To observe whether they can tell the hours on a watch in the dark. 4. To remove when they write the ink-standish from its place, to see whether they will return to the same place in in order to take ink. 5. And, laftly, to take notice whether they walk with the fame confidence in a dark and unknown place, as in one with which they are acquainted.

"They likewife recommend to fuch as would confirm or invalidate the above obfervations, to make all their experiments in the dark; becaufe it has been hitherto fuppofed that the eyes of fleep-walkers are of no ufe to them."

SLEEPERS, in *Natural Hiftory*, a name given to thofe animals which fleep all winter; fuch as bears, marmots, dormice, bats, hedgehogs, fwallows, &c. Thefe do not feed in winter, have no fenfible evacuations, breathe little or none at all, and moft of the vifcera ceafe from their functions. Some of thefe animals feem to be dead, and others return to a ftate like that of the fœtus before birth: in this ftate they continue, till by an increafe of heat the animal is reftored to its former functions.

SLEEPERS, in a fhip, timbers lying before and aft in the bottom of the fhip, as the rungheads do: the lowermoft of them is bolted to the rungheads, and the uppermoft to the futtocks and rungs.

SLEIDAN, JOHN, an excellent German hiftorian, born of obfcure parents, in 1506, at Sleidan, a fmall town on the confines of the duchy of Juliers. After ftudying fome time in his own country, together with his townfman the learned John Sturmius, he went to France, and in 1525 entered into the fervice of the cardinal and archbifhop John du Bellay. He retired to Strafburg in 1542, where he acquired the efteem and friendfhip of the moft confiderable perfons, particularly of James Sturmius; by whofe advice and affiftance he was enabled to write the hiftory of his own time. He was employed in fome public negociations; but the death of his wife, in 1555, plunged him into fo deep a melancholy, that he loft his memory entirely, and died the year following. In 1555 came out, in folio, *De ftatu Religionis et Reipublicæ fub Carolo Quinto*, &c. in 15 books; from the year 1517, when Luther began to preach, to the year of its publication; which hiftory was prefently tranflated into moft of the languages of Europe. Befides this great work, he wrote, *De quatuor fummis Imperiis, libri tres*; with fome other hiftorical and political pieces.

SLEIGHT *of* HAND. See LEGERDEMAIN.

SLESWICK, an ancient and confiderable town of Denmark, the metropolis of a duchy of the fame name, in the province of Gottorp, the fee of a bifhop, which was fecularized in the year 1586. The old palace of Gottorp is clofe to it, which was formerly the ducal refidence, but afterwards inhabited by the governor. This town at one period was much more extenfive than it is now, having fuffered greatly by the German wars. It is feated on the gulf of Sley, where there is a commodious harbour, 60 miles north-weft of Lubeck, and 125 fouth-weft of Copenhagen. The people boaft that the German language is here fpoken with as much accuracy as at Vienna, of which, however, a good German fcholar can alone be judge. Slefwick has but little trade, as none but fmall boats can have accefs to it, the paffage of the Sley having been long fince chocked up with fand and mud; before which period it was both flourifhing and populous. It is now chiefly inhabited by the officers of the caftle, and the poorer claffes, or the attendants on the court and on them. The prefent population is faid not to exceed 5000. E. Long. 10. 0. N. Lat. 54. 40.

SLESWICK, the duchy of, or *South Jutland*, is about 100 miles in length and 60 in breadth. It is bounded on the north by North Jutland, on the eaft by the Baltic fea, on the fouth by Holftein, and on the weft by the ocean. It contains 14 cities, 17 towns, 13 caftles, 278 parifhes, 1480 villages, 162 farms, 116 water-mills, and 106 gentlemen's feats. It is a pleafant, fertile, populous country, and a fovereign duchy. Formerly the king of Denmark had half of it, and the other belonged to the houfe of Holftein-Gottorp; but the former having conquered this duchy, had the poffeffion of it confirmed to him by the treaty of the north in 1720. In 1731, a prince of Bareith-Culmbach was made governor of this duchy, who refides at Gottorp.

SLEUT-HOUNDE, the ancient Scots name of the blood-hound. The word is from the Saxon *flot*, "the impreffion that a deer leaves of its foot in the mire," and *hound*, "a dog"; fo they derive their name from following the track. See the article *BLOOD-Hound*.

SLICH, in *Metallurgy*, the ore of any metal, particularly of gold, when it has been pounded, and prepared for farther working.

The manner of preparing the flich at Chremnitz in Hungary is this; they lay a foundation of wood three yards deep, upon this they place the ore, and over this there are 24 beams, armed at their bottoms with iron; thefe, by a continual motion, beat and grind the ore, till it is reduced to powder: during this operation, the ore is covered with water. There are four wheels ufed to move thefe beams, each wheel moving fix; and the water, as it runs off, carrying fome of the metalline particles with it, is received into feveral bafons, one placed behind another; and finally, after having paffed through them all, and depofited, fome fediment in each, it is let off into a very large pit, almoft half an acre in extent; in which it is fuffered to ftand fo long, as to depofit all its fediment, of whatever kind, and after this it is let out. This work is carried on day and night, and the ore taken away and replaced by more as often as occafion requires. That ore which lies next the beams, by which it was pounded, is always the cleaneft or richeft.

When the flich is wafhed as much as they can, a hundred weight of it ufually contains about an ounce, or perhaps but half an ounce of metal, which is not all gold; for there is always a mixture of gold and filver, but the gold is in the largeft quantity, and ufually is two-thirds of the mixture: they then put the flich into a furnace with fome limeftone, and flacken, or the fcoria of former meltings, and run them together. The firft melting produces a fubftance called *lech*; this lech they burn with charcoal, to make it lighter, to open its body, and render it porous, after which it is called *roft*; to this roft they add fand in fuch quantity as they find neceffary, and then melt it over again.

At Chremnitz many other ways are practifed of reducing gold out of its ore, but particularly one, in which they employ no lead during the whole operation; whereas, in general, lead is always neceffary, after the before-mentioned proceffes. See *ORES, Reduction of*.

SLIDING RULE, a mathematical inftrument, ferving to work queftions in gauging, meafuring, &c. without

out the ufe of compaffes; merely by the fliding of the parts of the inftrument one by another, the lines and divifions whereof give the anfwer by infpection.

This inftrument is varioufly contrived, and applied by various authors, particularly Everard, Coggefhall, Gunter, Hunt, and Partridge; but the moft common and ufeful are thofe of Everard and Coggefhall.

SLIGO, a county in the province of Connaught, Ireland, 25 miles in length, and as much in breadth; bounded on the eaft by that of Leitrim, on the weft by the county of Mayo, on the north and north-weft by the weftern ocean, and on the fouth and fouth-weft by Rofcommon and Mayo. It contains 5970 houfes, 41 parifhes, 6 baronies, 1 borough, and fends 4 members to parliament, two for the county, and two for the borough of the fame name, which is the only market-town in the county, and is feated on a bay of the fame name, 30 miles weft of Killalla, and 110 north-eaft of Dublin. W. Long. 8. 26. N. Lat. 54. 13.

SLING, an inftrument ferving for cafting ftones with great violence. The inhabitants of the Balearic iflands were famous in antiquity for the dexterous management of the fling; it is faid they ufed three kinds of flings, fome longer, others fhorter, which they ufed according as their enemies were either nearer or more remote. It is added, that the firft ferved them for a head-band, the fecond for a girdle, and that the third they conftantly carried in their hand.

SLINGING is ufed varioufly at fea; but chiefly for hoifting up cafks or other heavy things with flings, *i. e.* contrivances of ropes fpliced into themfelves at either end, with one eye big enough to receive the cafk or whatever is to be flung. There are other flings, which are made longer, and with a fmall eye at each end; one of which is put over the breech of a piece of ordnance, and the other eye comes over the end of an iron crow, which is put into the mouth of the piece, to weigh and hoife the gun as they pleafe. There are alfo flings by which the yards are bound faft to the crofs-tree aloft, and to the head of the maft, with a ftrong rope or chain, that if the tie fhould happen to break, or to be fhot to pieces in fight, the yard, neverthelefs, may not fall upon the hatches.

SLINGING a Man overboard, in order to ftop a leak in a fhip, is done thus: the man is truffed up about the middle in a piece of canvas, and a rope to keep him from finking, with his arms at liberty, a mallet in one hand and a plug, wrapped in oakum and well tarred in a tarpawling clout, in the other, which he is to beat with all difpatch into the hole or leak.

SLOANE, Sir Hans, Baronet, eminently diftinguifhed as a phyfician and a naturalift, was of Scotch extraction, his father Alexander Sloane being at the head of that colony of Scots which King James I. fettled in the north of Ireland, where our author was born, at Killieagh, on the 19th of April 1660. At a very early period, he difplayed a ftrong inclination for natural hiftory; and this propenfity being encouraged by a fuitable education, he employed thofe hours which young people generally lofe by purfuing low and trifling amufements, in the ftudy of nature, and contemplating her works. When about fixteen, he was attacked by a fpitting of blood, which threatened to be attended with confiderable danger, and which interrupted the regular courfe of his application for three years; he had, however, already learned enough of phyfic to know that a malady of this kind was not to be removed fuddenly, and he prudently abftained from wine and other liquors that were likely to increafe it.

By ftrictly obferving this fevere regimen, which in fome meafure he continued ever after, he was enabled to prolong his life beyond the ordinary bounds; being an example of the truth of his own favourite maxim, that fobriety, temperance, and moderation, are the beft and moft powerful prefervatives that nature has granted to mankind.

As foon as he recovered from this infirmity, he refolved to perfect himfelf in the different branches of phyfic, which was the profeffion he had made choice of; and with this view he repaired to London, where he hoped to receive that affiftance which he could not find in his own country.

On his arrival in the metropolis, he entered himfelf as a pupil to the great Stafforth, an excellent chemift, bred under the illuftrious Stahl; and by his inftructions he gained a perfect knowledge of the compofition and preparation of the different kinds of medicines then in ufe. At the fame time, he ftudied botany at the celebrated garden at Chelfea, affiduoufly attended the public lectures of anatomy and phyfic, and in fhort neglected nothing that he thought likely to prove ferviceable to him in his future practice. His principal merit, however, was his knowledge of natural hiftory; and it was this part of his character which introduced him early to the acquaintance of Mr Boyle and Mr Ray, two of the moft eminent naturalifts of that age. His intimacy with thefe diftinguifhed characters continued as long as they lived; and as he was careful to communicate to them every object of curiofity that attracted his attention, the obfervations which he occafionally made often excited their admiration and obtained their applaufe.

After ftudying four years at London with unremitting feverity, Mr Sloane determined to vifit foreign countries for farther improvement. In this view he fet out for France in the company of two other ftudents, and having croffed to Dieppe, proceeded to Paris. In the way thither they were elegantly entertained by the famous M. Lemery the elder; and in return Mr Sloane prefented that eminent chemift with a fpecimen of four different kinds of phofphorus, of which, upon the credit of other writers, M. Lemery had treated in his book of chemiftry, though he had never feen any of them.

At Paris Mr Sloane lived as he had done in London. He attended the hofpitals, heard the lectures of Tournefort, De Verney, and other eminent mafters; vifited all the literati, who received him with particular marks of efteem, and employed himfelf wholly in ftudy.

From Paris Mr Sloane went to Montpelier; and, being furnifhed with letters of recommendation from M. Tournefort to M. Chirac, then chancellor of that univerfity, he found eafy accefs, through his means, to all the learned men of the province, particularly to M. Magnol, whom he always accompanied in his botanical excurfions in the environs of that city, where he beheld with pleafure and admiration the fpontaneous productions of nature, and learned under his inftructions to clafs them in a proper manner.

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Having here found an ample field for contemplation, which was entirely suited to his taste, he took leave of his two companions, whom a curiosity of a different kind led into Italy.

After spending a whole year in collecting plants, he travelled through Languedoc with the same design; and passing through Thoulouse and Bourdeaux, returned to Paris, where he made a short stay. About the end of the year 1684 he set out for England, with an intention of settling there as a physician. On his arrival in London, he made it his first business to visit his two illustrious friends Mr Ray and Mr Boyle, in order to communicate to them the discoveries he had made in his travels. The latter he found at home, but the former had retired to Essex; to which place Mr Sloane transmitted a great variety of plants and seeds, which Mr Ray has described in his History of Plants, and for which he makes a proper acknowledgement.

About the year 1706 our author became acquainted with the celebrated Sydenham; who soon contracted so warm an affection for him that he took him into his house, and recommended him in the strongest manner to his patients. He had not been long in London before he was proposed by Dr Martin Lister as a candidate to be admitted a member of the Royal Society, on the 26th of November 1684; and being approved, he was elected on the 21st of January following.

In 1685 he communicated some curiosities to the Society; and in July the same year he was a candidate for the office of their assistant secretary, but without success, as he was obliged to give way to the superior interest of his competitor Dr Halley. On the 12th of April 1687, he was chosen a fellow of the college of physicians in London; and the same year his friend and fellow traveller Dr Tancred Robinson, having mentioned to the Society the plant called the *star of the earth*, as a remedy newly discovered for the bite of a mad dog, Dr Sloane acquainted them that this virtue of the plant was to be found in a book called *De Grey's Farriery*; and that he knew a man who had cured with it twenty couple of dogs. This observation he made on the 13th of July, and on the 12th of September following he embarked at Portsmouth for Jamaica with the duke of Albemarle, who had been appointed governor of that island. The doctor attended his grace in quality of physician, and arrived at Jamaica on the 19th of December following.

Here a new field was opened for fresh discoveries in natural productions; but the world would have been deprived of the fruits of them, had not our author, by incredible application, converted, as we may say, his minutes into hours. The duke of Albemarle died soon after he landed, and the duchess determined to return to England whenever an answer should be received to the letter she had sent to court on that melancholy occasion. As Dr Sloane could not think of leaving her grace in her distress, whilst the rest of her retinue were preparing for their departure he improved it in making collections of natural curiosities; so that though his whole stay at Jamaica was not above fifteen months, he brought together such a prodigious number of plants, that on his return to England Mr Ray was astonished that one man could procure in one island, and in so short a space, so vast a variety.

On his arrival in London he applied himself to the practice of his profession; and soon became so eminent, that he was chosen physician to Christ's Hospital on the 17th October 1694: and this office he held till the year 1730, when, on account of his great age and infirmities, he found it necessary to resign. It is somewhat singular, and redounds much to the Doctor's honour, that though he received the emoluments of his office punctually, because he would not lay down a precedent which might hurt his successors, yet he constantly applied the money to the relief of those who were the greatest objects of compassion in the hospital, that it might never be said he enriched himself by giving health to the poor. He had been elected secretary to the Royal Society on the 30th of November 1693; and upon this occasion he revived the publication of the Philosophical Transactions, which had been omitted for some time. He continued to be the editor of this work till the year 1712; and the volumes which appeared during that period are monuments of his industry and ingenuity, many of the pieces contained in them being written by himself.

In the mean time he published *Catalogus Plantarum quæ in Insula Jamaica sponte proveniunt*, &c.; *seu Prodromi Historiæ Naturalis pars prima*; which he dedicated to the Royal Society and College of Physicians. About the same time he formed the plan of a dispensary, where the poor might be furnished at prime cost with such medicines as their several maladies might require; which he afterwards carried into execution, with the assistance of the president and other members of the college of physicians.

Our author's thirst for natural knowledge seems to have been born with him, so that his cabinet of curiosities may be said to have commenced with his being. He was continually enriching and enlarging it; and the fame which, in the course of a few years, it had acquired, brought every thing that was curious in art or nature to be first offered to him for purchase. These acquisitions, however, increased it but very slowly in comparison of the augmentation it received in 1701 by the death of William Courten, Esq. a gentleman who had employed all his time, and the greater part of his fortune, in collecting rarities, and who bequeathed the whole to Dr Sloane, on condition of his paying certain debts and legacies with which he had charged it. These terms our author accepted, and he executed the will of the donor with the most scrupulous exactness; on which account some people have said, that he purchased Mr Courten's curiosities at a dear rate.

In 1707 the first volume of Dr Sloane's Natural History of Jamaica appeared in folio, though the publication of the second was delayed till 1725. By this very useful as well as magnificent work, the materia medica was enriched with a great number of excellent drugs not before known. In 1708 the Doctor was elected a foreign member of the Royal Academy of Sciences at Paris, in the room of Mr Tschirnaus; an honour so much the greater, as we were then at war with France, and the queen's express consent was necessary before he could accept it. In proportion as his credit rose among the learned, his practice increased among the people of rank: Queen Anne herself frequently consulted him, and in her last illness was blooded by him.

On the advancement of George I. to the throne, that prince, on the 3d of April 1716, created the Doctor a baronet, an hereditary title of honour to which

no

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no English physician had before attained; and at the same time made him physician general to the army, in which station he continued till 1727, when he was appointed physician in ordinary to George II. He attended the royal family till his death; and was particularly favoured by Queen Caroline, who placed the greatest confidence in his prescriptions. In the mean time he had been unanimously chosen one of the elects of the college of physicians June 1. 1716, and he was elected president of the same body on September 30. 1719, an office which he held for sixteen years. During that period he not only gave the highest proofs of his zeal and assiduity in the discharge of his duty, but in 1721 made a present to that society of 100l.; and so far remitted a very considerable debt, which the corporation owed him, as to accept it in such small sums as were least inconvenient to the state of their affairs. Sir Hans was no less liberal to other learned bodies. He had no sooner purchased the manor of Chelsea, than he gave the company of apothecaries the entire freehold of their botanical garden there, upon condition only that they should present yearly to the Royal Society fifty new plants, till the number should amount to 2000 (A). He gave besides several other considerable donations for the improvement of this garden; the situation of which, on the banks of the Thames, and in the neighbourhood of the capital, was such as to render it useful in two respects: First, by producing the most rare medicinal plants; and, secondly, by serving as an excellent school for young botanists; an advantage which he himself had derived from it in the early part of his life.

The death of Sir Isaac Newton, which happened in 1727, made way for the advancement of Sir Hans to the presidency of the Royal Society. He had been vice-president, and frequently sat in the chair for that great man; and by his long connection with this learned body he had contracted so strong an affection for it, that he made them a present of an hundred guineas, caused a curious bust of King Charles II. its founder, to be erected in the great hall where it met, and, as is said, was very instrumental in procuring Sir Godfrey Copley's benefaction of a medal of the value of five guineas, to be annually given as an honorary mark of distinction to the person who communicates the best experiments to the Society.

On his being raised to the chair, Sir Hans laid aside all thoughts of further promotion, and applied himself wholly to the faithful discharge of the duties of the offices which he enjoyed. In this laudable occupation he employed his time from 1727 to 1740, when, at the age of fourscore, he formed a resolution of quitting the service of the public, and of living for himself. With this view he resigned the presidency of the Royal Society much against the inclination of that respectable body, who chose Martin Folkes, Esq. to succeed him, and in a public assembly thanked him for the great and eminent services he had rendered them. In the month of January 1741, he began to remove his library, and his cabinet of rarities, from his house in Bloomsbury to that at Chelsea; and on the 12th of March following, having settled all his affairs, he retired thither himself, to enjoy in peaceful tranquillity the remains of a well-spent life. He did not, however, bury himself in that solitude which excludes men from society. He received at Chelsea, as he had done in London, the visits of people of distinction, of all learned foreigners, and of the royal family, who sometimes did him the honour to wait on him; but, what was still more to his praise, he never refused admittance or advice to rich or poor who came to consult him concerning their health. Not contented with this contracted method of doing good, he now, during his retreat, presented to the public such useful remedies as success had warranted, during the course of a long continued practice. Among these is the efficacious receipt for distempers in the eyes, and his remedy for the bite of a mad dog.

During the whole course of his life, Sir Hans had lived with so much temperance, as had preserved him from feeling the infirmities of old age; but in his 90th year he began to complain of pains, and to be sensible of an universal decay. He was often heard to say, that the approach of death brought no terrors along with it; that he had long expected the stroke; and that he was prepared to receive it whenever the great Author of his being should think fit. After a short illness of three days, he died on the 11th of January 1752, and was interred on the 18th at Chelsea, in the same vault with his lady, the solemnity being attended with the greatest concourse of people, of all ranks and conditions, that had ever been seen before on the like occasion.

Sir Hans being extremely solicitous lest his cabinet of curiosities, which he had taken so much pains to collect, should be again dissipated at his death, and being at the same time unwilling that so large a portion of his fortune should be lost to his children, he bequeathed it to the public, on condition that 20,000l. should be made good by parliament to his family. This sum, though large in appearance, was scarcely more than the intrinsic value of the gold and silver medals, the ores and precious stones that were found in it; for in his last will he declares, that the first cost of the whole amounted at least to 50,000l. Besides his library, consisting

(A) This garden was first established by the company in 1673; and having after that period been stocked by them with a great variety of plants, for the improvement of botany, Sir Hans, in order to encourage so serviceable an undertaking, granted to the company the inheritance of it, being part of his estate and manor of Chelsea, on condition that it should be for ever preserved as a physic garden. As a proof of its being so maintained, he obliged the company, in consideration of the said grant, to present yearly to the Royal Society, in one of their weekly meetings, fifty specimens of plants that had grown in the garden the preceding year, and which were all to be specifically distinct from each other, until the number of two thousand should be completed. This number was completed in the year 1761. In 1733 the company erected a marble statue of Sir Hans, executed by Rysbrac, which is placed upon a pedestal in the centre of the garden, with a Latin inscription, expressing his donation, and the design and advantages of it.

fifting of more than 50,000 volumes, 347 of which were illuftrated with cuts finely engraven and coloured from nature, there were 3560 manufcripts, and an infinite number of rare and curious works of every kind. The parliament accepted the legacy, and fulfilled the conditions.

SLOANEA, a genus of plants belonging to the clafs of polyandria, and order of monogynia; and in the natural fyftem ranging under the 50th order, *Amentaceæ*. See BOTANY *Index*.

SLOE. See PRUNUS, BOTANY *Index*.

SLOOP, a fmall veffel furnifhed with one maft, the mainfail of which is attached to a gaff above, or to the maft on its foremoft edge, and to a long boom below, by which it is occafionally fhifted to either quarter. See SHIP.

SLOOP of War, a name given to the fmalleft veffels of war except cutters. They are either rigged as fhips or fnows.

SLOT, in the fportfman's language, a term ufed to exprefs the mark of the foot of a ftag or other animal proper for the chace in the clay or earth, by which they are able to guefs when the animal paffed, and which way he went. The flot, or treading of the ftag, is very nicely ftudied on this occafion; if the flot be large, deep printed in the ground, and with an open cleft, and, added to thefe marks, there is a large fpace between mark and mark, it is certain that the ftag is an old one. If there be obferved the flots or treadings of two, the one long and the other round, and both of one fize, the long flot is always that of the larger animal. There is alfo another way of knowing the old ones from the young ones by the treading; which is, that the hinder feet of the old ones never reach to their fore feet, whereas thofe of the young ones do.

SLOTH. See BRADYPUS, MAMMALIA *Index*.

SLOUGH, a deep muddy place. The caft fkin of a fnake, the damp of a coal pit, and the fcar of a wound, are alfo called by the fame appellation. The flough of a wild boar is the bed, foil, or mire, wherein he wallows, or in which he lies in the day-time.

SLUCZK, a large and populous town in Poland, in Lithuania, and capital of a duchy of the fame name; famous for three battles gained here by Conftantine duke of Oftrog over the Tartars, in the reign of Sigifmund I. It is feated on the river Sluczk, 72 miles fouth-eaft of Minfki, and 70 fouth of Novogrodeck. E. Long. 27. 44. N. Lat. 53. 2.

SLUG. See LIMAX, HELMINTHOLOGY *Index*.

SLUICE, a frame of timber, ftone, or other matter, ferving to retain and raife the water of a river, &c. and on occafion to let it pafs.

Such is the fluice of a mill, which ftops and collects the water of a rivulet, &c. to let it fall at length in the greater plenty upon the mill-wheel; fuch alfo are thofe ufed as vents or drains to difcharge water off land. And fuch are the fluices of Flanders, &c. which ferve to prevent the waters of the fea from overflowing the lower lands.

Sometimes there is a kind of canal inclofed between two gates or fluices, in artificial navigations, to fave the water, and render the paffage of boats equally eafy and fafe, upwards and downwards; as in the fluices of Briare in France, which are a kind of maffive walls built parallel to each other, at the diftance of 20 or 24 feet, clofed with ftrong gates at each end, between which is a kind of canal or chamber, confiderably longer than broad; wherein a veffel being inclofed, the water is let out at the firft gate, by which the veffel is raifed 15 or 16 feet, and paffed out of this canal into another much higher. By fuch means a boat is conveyed out of the Loire into the Seine, though the ground between them rife above 150 feet higher than either of thofe rivers*.

Sluices are made different ways, according to the ufe for which they are intended: when they ferve for navigation, they are fhut with two gates, prefenting an angle towards the ftream; when they are made near the fea, two pair of gates are made, the one to keep the water out and the other in, as occafion requires: in this cafe, the gates towards the fea prefent an angle that way, and the others the contrary way; and the fpace inclofed by thofe gates is called the *chamber*. When fluices are made in the ditches of a fortrefs, to keep up the water in fome parts, inftead of gates, fhutters are made fo as to flide up and down in grooves; and when they are made to raife an inundation, they are then fhut by means of fquare timbers let down in cullifes, fo as to lie clofe and firm.

* See Canal.

The word *fluice* is formed of the French *efclufe*, which Menage derives from the Latin *exclufa*, found in the Salic law in the fame fenfe. But this is to be reftrained to the fluices of mills, &c. for as to thofe ferving to raife veffels, they were wholly unknown to the ancients.

SLUR, in *Mufic*, a mark like the arch of a circle, drawn from one note to another, comprehending two or more notes in the fame or different degrees. If the notes are in different degrees, it fignifies that they are all to be fung to one fyllable; for wind inftruments, that they are to be made in one continued breath; and for ftringed inftruments that are ftruck with a bow, as a violin, &c. that they are made with one ftroke. If the notes are in the fame degree, it fignifies that it is all one note, to be made as long as the whole notes fo connected; and this happens moft frequently betwixt the laft note of one line and the firft of the next; which is particularly called *fyncopation*.

SLUYS, a town of Dutch Flanders, oppofite the ifland of Cadfand, with a good harbour, 10 miles north of Bruges, containing 14,000 inhabitants. E. Long. 3. 25. N. Lat. 51. 19.

SMACK, a fmall veffel, commonly rigged as a floop or hoy, ufed in the coafting or fifhing trade, or as a tender in the king's fervice.

SMALAND, or EAST GOTHLAND, a province of Sweden, which makes part of Gothland; and is bounded on the north by Oftrogothia or Eaft Gothland, on the eaft by the Baltic fea, on the fouth by Schonen and Bleckingia, and on the weft by Weftrogothia or Weft Gothland. It is about 112 miles in length, and 62 in breadth. Calmar is the capital town.

SMALKALD, a town of Germany, in Franconia, and in the county of Henneberg: famous for the confederacy entered into by the German Proteftants againft the emperor, commonly called the *league of Smalkald*. The defign of it was to defend their religion and liberties. It is feated on ehe river Werra, 25 miles fouth-weft of Erford, and 50 north-weft of Bamberg. E. Long. 10. 53. N. Lat. 50. 49. It is fubject to the prince of Heffe Caffel.

SMALLAGE. See APIUM, BOTANY *Index*.

Smalt || Smeaton.

SMALT, a kind of glafs of a dark blue colour, which when levigated appears of a moft beautiful colour; and if it could be made fufficiently fine, would be an excellent fuccedaneum for ultramarine, as not only refifting all kinds of weather, but even the moft violent fires. It is prepared by melting one part of calcined cobalt with two of flint powder, and one of potafh. At the bottoms of the crucibles in which the fmalt is manufactured we generally find a regulus of a whitifh colour inclined to red, and extremely brittle. This is melted afrefh, and when cold feparates into two parts; that at the bottom is the cobaltic regulus, which is employed to make more of the fmalt; the other is bifmuth.

SMARAGDITE, a fpecies of mineral belonging to the magnefian genus. See MINERALOGY, p. 197.

SMARAGDUS, an old name for the emerald. See EMERALD, MINERALOGY, p. 159.

SMEATON, JOHN, an eminent civil engineer, was born the 28th of May 1724, O. S. at Aufthorpe, near Leeds, in a houfe built by his grandfather, and where his family have refided ever fince.

The ftrength of his underftanding and the originality of his genius appeared at an early age; his playthings were not the playthings of children, but the tools which men employ; and he appeared to have greater entertainment in feeing the men in the neighbourhood work, and afking them queftions, than in any thing elfe. One day he was feen (to the diftrefs of his family) on the top of his father's barn, fixing up fomething like a windmill; another time, he attended fome men fixing a pump at a neighbouring village, and obferving them cut off a piece of bored pipe, he was fo lucky as to procure it, and he actually made with it a working pump that raifed water. Thefe anecdotes refer to circumftances that happened while he was in petticoats, and moft likely before he attained his fixth year.

About his 14th and 15th year, he made for himfelf an engine for turning, and made feveral prefents to his friends of boxes in ivory or wood very neatly turned. He forged his iron and fteel, and melted his metal; he had tools of every fort for working in wood, ivory, and metals. He made a lathe, by which he cut a perpetual fcrew in brafs, a thing little known at that day, which was the invention of Mr Henry Hindley of York; with whom Mr Smeaton foon became acquainted, and they fpent many a night at Mr Hindley's houfe till day-light, converfing on thofe fubjects.

Thus had Mr Smeaton, by the ftrength of his genius and indefatigable induftry, acquired, at the age of 18, an extenfive fet of tools, and the art of working in moft of the mechanical trades, without the affiftance of any mafter. A part of every day was generally occupied in forming fome ingenious piece of mechanifm.

Mr Smeaton's father was an attorney, and defirous of bringing him up to the fame profeffion; Mr Smeaton therefore came up to London in 1742, and attended the courts in Weftminfter hall; but finding (as his common expreffion was) that the law did not fuit the bent of his genius, he wrote a ftrong memorial to his father on that fubject; whofe good fenfe from that moment left Mr Smeaton to purfue the bent of his genius in his own way.

In 1751 he began a courfe of experiments to try a machine of his invention to meafure a fhip's way at fea, and alfo made two voyages in company with Dr Knight to try it, and a compafs of his own invention and making, which was made magnetical by Dr Knight's artificial magnets: the fecond voyage was made in the Fortune floop of war, commanded at that time by Captain Alexander Campbell. Smeaton.

In 1753 he was elected member of the Royal Society; the number of papers publifhed in their Tranfactions will fhow the univerfality of his genius and knowledge. In 1759 he was honoured by an unanimous vote with their gold medal for his paper intitled "An Experimental Inquiry concerning the Natural Powers of Water and Wind to turn Mills, and other Machines depending on a Circular Motion."

This paper, he fays, was the refult of experiments made on working models in the years 1752 and 1753, but not communicated to the Society till 1759; before which time he had an opportunity of putting the effect of thefe experiments into real practice, in a variety of cafes, and for various purpofes, fo as to affure the Society he had found them to anfwer.

In December 1755, the Eddyftone lighthoufe was burnt down: Mr Wefton, the chief proprietor, and the others, being defirous of rebuilding it in the moft fubftantial manner, inquired of the earl of Macclesfield (then prefident of the Royal Society) whom he thought the moft proper to rebuild it; his Lordfhip recommended Mr Smeaton.

Mr Smeaton undertook the work, and completed it in the fummer of 1759. Of this Mr Smeaton gives an ample defcription in the volume he publifhed in 1791: that edition has been fold fome time ago, and a fecond is now in the prefs, under the revifal of his much efteemed friend Mr Aubert, F. R. S. and governor of the London affurance corporation.

Though Mr Smeaton completed the building of the Eddyftone lighthoufe in 1759 (a work that does him fo much credit) yet it appears he did not foon get into full bufinefs as a civil engineer; but in 1764, while in Yorkfhire, he offered himfelf a candidate for one of the receivers of the Derwentwater eftate, and on the 31ft of December in that year, he was appointed at a full board of Greenwich hofpital, in a manner highly flattering to himfelf; when two other perfons ftrongly recommended and powerfully fupported were candidates for the employment. In this appointment he was very happy, by the affiftance and abilities of his partner Mr Walton one of the receivers, who taking upon himfelf the management and accounts, left Mr Smeaton leifure and opportunity to exert his abilities on public works, as well as to make many improvements in the mills and in the eftates of Greenwich hofpital. By the year 1775 he had fo much bufinefs as a civil engineer, that he wifhed to refign this appointment; and would have done it then, had not his friend the late Mr Stuart the hofpital furveyor, and Mr Ibbetfon their fecretary, prevailed upon him to continue in the office about two years longer.

Mr Smeaton having now got into full bufinefs as a civil engineer, performed many works of general utility. He made the river Calder navigable; a work that required great fkill and judgement, owing to the very impetuous floods in that river: He planned and attended

tended the execution of the great canal in Scotland for conveying the trade of the country either to the Atlantic or German ocean; and having brought it to the place originally intended, he declined a handſome yearly ſalary, in order that he might attend to the multiplicity of his other buſineſs.

On the opening of the great arch at London bridge, the excavation around and under the ſterlings was ſo conſiderable, that the bridge was thought to be in great danger of falling. He was then in Yorkſhire, and was ſent for by expreſs, and arrived with the utmoſt diſpatch: "I think (ſays Mr Holmes, the author of his life) it was on a Saturday morning, when the apprehenſion of the bridge was ſo general that few would paſs over or under it. He applied himſelf immediately to examine it, and to ſound about the ſterlings as minutely as he could; and the committee being called together, adopted his advice, which was to repurchaſe the ſtones that had been taken from the middle pier, then lying in Moorfields. and to throw them into the river to guard the ſterlings." Nothing ſhows the apprehenſions concerning the falling of the bridge more than the alacrity with which this advice was purſued; the ſtones were repurchaſed that day, horſes, carts, and barges were got ready, and they began the work on Sunday morning. Thus Mr Smeaton, in all human probability, ſaved London bridge from falling, and ſecured it till more effectual methods could be taken.

The vaſt variety of mills which Mr Smeaton conſtructed, ſo greatly to the ſatisfaction and advantage of the owners, will ſhow the great uſe which he made of his experiments in 1752 and 1753; for he never truſted to theory in any caſe where he could have an opportunity to inveſtigate it by experiment. He built a ſteam engine at Auſthorpe, and made experiments thereon, purpoſely to aſcertain the power of Newcomen's ſteam-engine, which he improved and brought to a greater degree of perfection, both in its conſtruction and powers, than it was before.

Mr Smeaton during many years of his life was a frequent attendant on parliament, his opinion being continually called for; and here his ſtrength of judgement and perſpicuity of expreſſion had its full diſplay: it was his conſtant cuſtom, when applied to, to plan or ſupport any meaſure, to make himſelf fully acquainted with it, to ſee its merits before he would engage in it: by this caution, added to the clearneſs of his deſcription and the integrity of his heart, he ſeldom failed to obtain for the bill which he ſupported an act of parliament. No one was heard with more attention, nor had any one ever more confidence placed in his teſtimony. In the courts of law he had ſeveral compliments paid him from the bench by Lord Mansfield and others, for the new light which he threw on difficult ſubjects.

About the year 1785 Mr Smeaton's health began to decline; and he then took the reſolution to endeavour to avoid all the buſineſs he could, ſo that he might have leiſure to publiſh an account of his inventions and works, which was certainly the firſt wiſh of his heart; for he has often been heard to ſay, that "he thought he could not render ſo much ſervice to his country as by doing that." He got only his account of the Eddyſtone lighthouſe completed, and ſome preparations to his intended Treatiſe on Mills; for he could not reſiſt the ſolicitations of his friends in various works: and Mr Aubert, whom he greatly loved and reſpected, being choſen chairman of Ramſgate harbour, prevailed upon him to accept the place of engineer to that harbour; and to their joint efforts the public is chiefly indebted for the improvements that have been made there within theſe few years, which fully appears in a report that Mr Smeaton gave in to the board of truſtees in 1791, which they immediately publiſhed.

Mr Smeaton being at Auſthorpe, walking in his garden on the 16th of September 1792, was ſtruck with the palſy, and died the 28th of October. "In his illneſs (ſays Mr Holmes) I had ſeveral letters from him, ſigned with his name, but written and ſigned by another's pen; the diction of them ſhowed that the ſtrength his mind had not left him. In one written the 26th of September, after minutely deſcribing his health and feelings, he ſays, "in conſequence of the foregoing, I conclude myſelf nine-tenths dead; and the greateſt favour the Almighty can do me (as I think), will be to complete the other part; but as it is likely to be a lingering illneſs, it is only in His power to ſay when that is likely to happen."

Mr Smeaton had a warmth of expreſſion that might appear to thoſe who did not know him well to border on harſhneſs; but thoſe more intimately acquainted with him, knew it aroſe from the intenſe application of his mind, which was always in the purſuit of truth, or engaged in inveſtigating difficult ſubjects. He would ſometimes break out haſtily, when any thing was ſaid that did not tally with his ideas; and he would not give up any thing he argued for, till his mind was convinced by ſound reaſoning.

In all the ſocial duties of life he was exemplary; he was a moſt affectionate huſband, a good father, a warm, zealous, and ſincere friend, always ready to aſſiſt thoſe he reſpected, and often before it was pointed out to him in what way he could ſerve them. He was a lover and encourager of merit whatever he found it; and many men are in a great meaſure indebted to his aſſiſtance and advice for their preſent ſituation. As a companion, he was always entertaining and inſtructive; and none could ſpend any time in his company without improvement.

SMELL; this word has in moſt languages two meanings, ſignifying either that ſenſation of mind of which we are conſcious, in conſequence of certain impreſſions made on the noſtrils, and conveyed to the brain by the olfactory nerves; or that unknown virtue, or quality in bodies, which is the cauſe of our ſenſations of ſmell.

SMELLING is the act by which we perceive ſmells, or become ſenſible of the preſence of odorous bodies. The ſenſations of ſmell are excited by certain effluvia, which, in the open air, are always iſſuing from the ſurfaces of moſt bodies, and ſtriking on the extremities of the olfactory nerves, give them a peculiar ſort of impreſſion, which is communicated to the brain. The particles which iſſue thus from bodies are extremely volatile, and produce ſenſation by a degree of contact, which, though inſenſible, is ſtill more efficient than if it were more groſs and palpable. It is by a ſimilar ſpecies of inſenſible contact that the eyes and ears are affected by external objects; whilſt, in the excitation of the ſenſations of touch and of taſte, an actual and ſenſible contact of the object with the organ is neceſſary.

Smelling.

ſary. The organs of ſmelling are the noſtrils and olfactory nerves; the minute ramifications of the latter being diſtributed throughout the whole concavity of the former. For a deſcription of theſe, ſee ANATOMY.

The effluvia from odorous bodies are conſtantly floating about in the atmoſphere, and muſt of courſe be drawn into the noſtrils along with the air in inſpiration; "ſo that there is," as Dr Reid obſerves, "a manifeſt appearance of deſign in placing the organ of ſmell in the inſide of that canal, through which the air is continually paſſing in inſpiration and expiration." It has been affirmed by Boerhaave, that the matter in animals, vegetables, foſſils, &c. which chiefly affects the ſenſe of ſmelling, is that attenuated ſubſtance, inherent in their oily parts, called *ſpirits;* becauſe, when this is taken away from the moſt fragrant bodies, what remains has ſcarcely any ſmell at all; but this, he ſays, if poured on the moſt inodorous bodies, gives them a fragrancy *. We cannot, however, enter at preſent upon this inquiry.

* See alſo *Drummond's Academical Queſtions*, vol. i. book 1. ch 9.

The ſenſe of ſmell has a cloſe alliance with that of taſte; and it ſeems probable from the proximity in the ſituation of their organs in all animals, that both are principally intended to guide them in the choice of their food; ſo that from this cloſe connection, they are better enabled to chooſe what is good for them, and to reject what would be injurious. This is the opinion of Dr Reid, as it was, in a very early period of the hiſtory of philoſophy, that of Socrates and of Cicero (A). Dr Reid alſo remarks, that the ſenſe of ſmell probably ſerves the ſame purpoſe in the natural ſtate of man; but it is not always a ſure guide for this purpoſe. The organs of ſmell differ, like thoſe of the other ſenſes, according to the deſtination of the animals to which they belong; and we know, that this ſenſe is in man much leſs acute, than it is in many other animals. We ſee, that in the choice of their food, they are guided by the ſenſes of ſmell and of taſte, except when man has brought them into a ſort of unnatural ſtate by domeſtication. And this circumſtance renders it probable, that both theſe ſenſes were intended to ſerve the ſame purpoſe in the natural ſtate of our ſpecies, although leſs calculated for this end than they are in the brutes, on account of the great ſuperiority of their ſmelling organs. Beſides, ſince it is probable that man, in the natural ſtate, acts more by inſtinct than when civilized in ſociety, ſo alſo it is reaſonable to think, that he may poſſeſs ſome of the ſenſes, (this of ſmell for inſtance), in greater acuteneſs than we do. This indeed, we are aſſured to be a fact; for we are told, in the *Hiſtoire des Antilles*, that there are negroes who, by the ſmell alone, can diſtinguiſh the footſteps of a Frenchman from thoſe of a negro.

The ſenſe of ſmell is much more obtuſe in man than in ſome of the lower animals. Dogs we know poſſeſs a power of ſmelling, of which we can ſcarcely form a conception, and which, it is happy for us we do not poſſeſs (B); and birds of prey are ſaid to poſſeſs this ſenſe in ſtill greater acuteneſs. But although this be more perfect, ſtill the ſenſe of ſmelling in man, who has other means of judging of his food, &c. is ſuch as to fit him for deriving enjoyment from a diverſity of ſcents, particularly thoſe of flowers and perfumes, to which dogs and other animals ſeem perfectly inſenſible. It has been ſaid, we are aware, that ſome animals, the elephant for inſtance, are capable of this enjoyment (C); but of this fact we cannot help being very doubtful.

There is a very great ſympathy between the organs of ſmell and of taſte; for any defect or diſeaſe of one is generally attended with ſome correſponding defect or diſeaſe of the other. There is alſo a greater ſimilarity between the ſenſations of both theſe, than between thoſe of any other two ſenſes: and hence it is, that we can ſometimes tell the taſte of an object from its ſmell, and *vice verſa*. Hence alſo the reaſon why we apply the ſame epithets to the names of both theſe claſſes of ſenſations; as a ſweet ſmell or taſte, &c.

It deſerves alſo to be remarked, that both theſe ſenſes ſeem ſubſervient to the preſervation of the animal exiſtence, rather than to any other purpoſe. They accordingly conſtitute an object of the natural hiſtory of man, rather than of intellectual or of moral philoſophy. The other three ſenſes, on the contrary, ſeem rather intended for (as they certainly are eſſential to) our intellectual improvement, and become, of courſe, a proper object of inveſtigation in the ſciences of moral philoſophy, or metaphyſics.

The advantages derived by man and the other animals from the ſenſe of ſmelling are not confined to the aſſiſtance which it affords them in the choice of their food. Moſt bodies in nature, when expoſed to the open air, are conſtantly ſending forth emanations or effluvia of ſuch extreme minuteneſs as to be perfectly inviſible. Theſe diffuſe themſelves through the air, and however noxious or ſalutary, would not be perceived without the ſenſe of ſmelling, which if not vitiated by unnatural habits, is not only a faithful monitor when danger is at hand, but conveys to us likewiſe the moſt exquiſite pleaſures

(A) "Ut guſtus (ſays a learned phyſiologiſt) cibi itineri, ſic olfactus oſtio viarum, quas aër ſubire debet, cuſtos præponitur, moniturus ne quid noxii, via quæ ſemper patet, in corpus admittatur. Porro, ut guſtus, ſic quoque olfactus ad ſalutarem cibum invitat, à noxio aut corrupto, putrido imprimis vel rancido, deterret."

"When thou ſeeſt the mouth, through which animals take in whatever they deſire, always placed near the noſe and eyes, thinkeſt thou not, ſays Socrates to Ariſtodemus, that this is the work of a providence." Xenophon's Memorables, book i. chap. 4.

(B) "The exceſſive eagerneſs which dogs expreſs on ſmelling their game, ſeems to be but little connected with the appetite for food, and wholly independent of any preconceived ideas of the objects of their purſuit being fit for it. Hence ſeveral kinds of them will not eat the game which they purſue with ſuch wild impetuoſity; and of which the ſcent ſeems to animate them to a degree of ecſtaſy far beyond what the deſire of food can produce." Knight on Taſte.

(C) There is an animal to which, naturaliſts ſay, perfume is ſo agreeable and ſo neceſſary, that nature has provided it with a little bag ſtored with an exquiſite odour. "On pretend, (ſays Buffon,) que la mangouſte ouvre cette poche, pour ſe refraichir lorſqu' elle a trop chaud."

pleasures. The fragrance of a rose, and of many other flowers, is not only pleasant, but gives a refreshing and delightful stimulus to the whole system, whilst the odours proceeding from hemlock, or any noxious vegetable, or other substance, are highly offensive to our nostrils. Hence we are naturally led to seek the one class of sensations, and to avoid the other.

In some species of animals the sense of smell seems to be connected with certain mental sympathies, as those of hearing and sight are in all that possess them in any high degree: for not only their sexual desires appear to be excited by means of it, but other instinctive passions, which, according to the usual system of nature, should be still more remote from its influence. Dogs, although wholly unacquainted with lions, will shudder at their roar; and an elephant that has never seen a tiger, will in the same manner show the strongest symptoms of horror and affright at the smell of it. "The late Lord Clive (says an ingenious writer), exhibited a combat between two of these animals at Calcutta; but the scent of the tiger had such an effect upon the elephant, that nothing could either force or allure him to go along the road, where the cage in which the tiger was inclosed, had passed, until a gallon of arack was given him. Upon this, his horror suddenly turning into fury, he broke down the paling to get at his enemy, and killed him without difficulty."

If riding along a road, near which a dead horse, or part of its carcass, happens to be lying, we know, that our horse, although he sees it not, cannot be made to pass the place but with difficulty. Where blood has been shed, particularly that of their own species, oxen will assemble, and upon smelling it, roar and bellow, and show the most manifest signs of horror and distress. And yet these symptoms could not arise from any associated notions of danger or death, since they appear in such as never had any opportunities of acquiring them. They must therefore be instinctive, like other instinctive antipathies and propensities. But although in their mutual intercourse, animals make much use of the sense of smell, still it does not seem to be further concerned in exciting their sexual desires, than in indicating their object.

Some of those splenetic philosophers, who are ready upon all occasions to quarrel with the constitution of nature, have taken the liberty of condemning their Maker, because it has pleased his unfathomable wisdom to bestow in some instances upon the brutes senses and instincts more perfect than he has given to man, without reflecting that he has given to man an ample equivalent; for it may be asked with the poet,

"Is not his reason all these powers in one?
"Is Heaven unkind to man and man alone?
"Shall he alone, whom rational we call,
"Be pleased with nothing if not blessed with all."

With respect to that unknown peculiarity of bodies, which is the cause of our sensations of smell, the opinions of philosophers have been very various. Until of late, the doctrine of Descartes and Locke on this subject was pretty generally received; but, since the publication of Doctor Reid's works, his opinion, which we deem the most correct and satisfactory, has become very popular. We will endeavour to abridge his account of this matter. For this purpose, let us suppose a person, who has grown up without the sense of smell, to be immediately endowed with the use of this organ, and placed near some flowers of an exquisite savour. When he examines what he feels in such a situation, he can find no resemblance between this new sensation and any thing with which he is already acquainted. He finds himself unable to explain its nature, and cannot ascribe to it figure, extension, or any known property of matter. It is a simple affection, or feeling, of mind, and, considered abstractedly, can have no necessary connection with the nerves, the nostrils, or effluvia, or with any thing material whatever. By the nature of his constitution he is, however, led to refer this peculiar sensation to the nostrils, as its organ; and when, from experience, and by means of touch, he learns that external objects have the power of exciting this sensation, he concludes, that there must exist in bodies some unknown cause by which it is excited. In the first part of this process he considers the feeling, or sensation, abstractedly. As such it exists in the mind only; and cannot exist there but when the mind is conscious of it. His consciousness soon enables him to distinguish different sorts of smells, all of them very distinct from one another; but, conformably to the nature of all sensation, extremely simple. He concludes, that each of these must have a distinct cause; and finding, by experience, that this cause is an unknown something in bodies, he concludes, that it must be a property of matter, and, for want of another, gives it the name of smell. When he removes an odorous body from the organ, the sensation vanishes: when the body is again applied, the sensation is excited: and hence it is, that he is led naturally to connect the sensation with this unknown peculiarity of bodies by which it is produced. But since we see, that the sensation is, in a great degree, related to other objects besides its unknown cause, to the mind in which it exists, for instance, and to the organ which is its instrument, it may be asked why it becomes associated in the mind with its cause only? The reason seems pretty obvious. No single sensation or class of sensations, is more connected with the mind, than any others of which it is susceptible. Nor is the connection subsisting between the organ and any of the sensations peculiar to it greater than that which subsists between it and every other sensation of which it is the inlet. Hence the connection between the smell of an orange and the mind, or between it and the nostrils, is very general, and cannot, in the former instance, distinguish it from any other sensation of whatever kind, nor, in the latter from any other particular smell. But the connexion between this sensation and the orange is peculiar and permanent; and we accordingly find them always associated in the mind, just as we associate the notion of fire with the sensation of burning. The relation which a sensation of smell, or any sensation, bears to the mind, to an organ, or to the memory and conception of itself, is common to all sensations. The relation which any sensation bears to its own cause, suppose of the sensation of smell to a particular virtue or quality of bodies, is common to it with every other sensation, when considered with respect to its peculiar cause. And finally, a sensation of any kind bears the same sort of relation to the memory and conception of itself, that any other feeling or operation of mind bears to the conception and memory of that particular feeling or operation.

Whatever then be the nature of the minute particles of

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of bodies by which our ſenſations of ſmell are excited, we cannot help conſidering their unknown cauſe as a virtue or quality of matter. Like all other modifications of material ſubſtance, it muſt be confeſſed, that this can have no reſemblance to the ſenſations of mind. But we are not, therefore, to conclude with the followers of Des Cartes and Locke, that this ſecondary quality is a mere ſenſation; eſpecially as we can readily conceive it exiſting where it is not ſmelled, or even after ſuppoſing the annihilation of every ſentient being throughout the univerſe. The exiſtence of the ſenſation we know to be momentary and fugitive; but in the exiſtence of its cauſe we can, without difficulty, or inconſiſtency, conceive a permanency independent of mind and of its ſenſations.

The doctrine we have been illuſtrating has of late been called in queſtion by a ſceptical writer, who, it appears to us, has upon this occaſion been entirely deficient in his accuſtomed acuteneſs. Dr Reid's account of this affair ſeems ſo full, ſo clear and convincing, that we are at a loſs to conceive how his meaning can be miſunderſtood; and yet the arguments and objections of the writer to whom we allude, derive all their plauſibility from a miſinterpretation of Dr Reid's meaning, and from a deviation from the eſtabliſhed uſe of language. "An eminent metaphyſician * (ſays this author) has declared that he has not the leaſt difficulty in conceiving the air perfumed with aromatic odours in the deſerts of Arabia; and he has decided, that the man who maintains ſmells to exiſt only in the mind, muſt be mad, or muſt abuſe language and diſgrace philoſophy. There are ſome authors, neverthelеſs, who differ widely on this ſubject from the learned metaphyſician. Is it poſſible for a ſenſation to exiſt where there is no ſentient? The authors to whom I allude think it impoſſible." And ſo, we may tell this learned author, does Dr Reid, if he will take his word for it. Of the ſenſation of ſmell he remarks: "It is indeed impoſſible, that it can be in any body: it is a ſenſation; and a ſenſation can be in a ſentient thing only †." Again, "I can think of the ſmell of a roſe when I do not ſmell it; and it is poſſible that when I think of it there is no roſe any where exiſting; but, when I ſmell it, I am neceſſarily determined to believe that the ſenſation really exiſts. This is common to all ſenſations, that, *as they cannot exiſt but in being perceived*, ſo they cannot be perceived but they muſt exiſt ‡." But, continues this acute metaphyſician, "a ſmell is nothing elſe than a ſenſation. It is a feeling, which may be agreeable or diſagreeable; which may, as ſome think, be excited by various combinations of elements; but which, ſince it is a feeling, cannot be thoſe elements which are ſaid to cauſe it, and cannot exiſt where there is no creature to perceive it. What is to be underſtood, in philoſophical ſtrictneſs, by the perfumes of the deſert? We can excuſe the poet when he makes the ocean ſmile *, the winds dance †, and the flowers reſpire ‡; or even were he to perfume the deſert. But the philoſopher is no ſuch magician, and had better not wander through the regions of fancy in ſearch of ſenſations where there is no ſentient." And is it then true that the word ſmell means only a ſenſation? A ſenſation is no more than an effect; it is a tranſient modification of the mind, which the mind itſelf can never produce. It muſt then have ſome cauſe which is external to the mind. Now, it is to this cauſe, and not to the ſenſation, that the name *ſmell* is moſt frequently applied in all languages; and it is this cauſe which Dr Reid ſuppoſes capable of exiſting in the deſerts of Arabia, where there is no ſentient being to perceive it. But let us hear himſelf: "We have conſidered ſmell as ſignifying a ſenſation, feeling, or impreſſion upon the mind; and in this ſenſe it can only be in a mind or ſentient being: but it is evident that mankind give the name of *ſmell* much more frequently to ſomething which they conceive to be external, and to be a quality of body; they underſtand by it ſomething which does not at all infer a mind, and have not the leaſt difficulty in conceiving the air perfumed with aromatic odours in the deſerts of Arabia, or in ſome uninhabited iſland where the human foot never trod *." "The faculty of ſmelling is ſomething very different from the actual ſenſation of ſmelling; for the faculty may remain when we have no ſenſation. And the mind is no leſs different from the faculty, for it continues the ſame individual being when that faculty is loſt. What is ſmell in the roſe? It is a quality or virtue of the roſe, or of ſomething proceeding from it, which we perceive by the ſenſe of ſmelling; and this is all we know of the matter. But what is ſmelling? It is an act of the mind, but is never imagined to be a quality of the mind. Again, the ſenſation of ſmelling is conceived to infer neceſſarily a mind or ſentient being; but ſmell in the roſe infers no ſuch thing. We ſay, this body ſmells ſweet and that ſtinks; but we do not ſay, this mind ſmells ſweet and that ſtinks; therefore, ſmell in the roſe, and the ſenſation which it cauſes, are not conceived, even by the vulgar, to be things of the ſame kind, although they have the ſame name †."

There are ſome other remarks on Dr Reid's opinion in the work upon which we have been commenting, which we ſhall paſs by; we may, however, notice the author's concluding argument: after mentioning ſome examples, he obſerves, "Now in theſe inſtances we ſee men and animals that muſt have perception of ſmell, if I may be permitted to ſay ſo, altogether different from each other. Is not ſmell ſenſation when the ſpaniel finds ſport in the field for his maſter; when the ſhark purſues through the ocean its expected victim; and when the camel conducts the thirſty wanderer to a fountain of freſh water acroſs the burning ſands of the Arabian deſert? If no animal had the ſenſation of ſmell, there would be no odour; for *aroma* and oils may be thought to be material compoſitions, but are neither agreeable nor diſagreeable feelings." If men and animals differ in their perceptions of ſmell, (and no doubt, difference of organization will cauſe them to do ſo) the concluſion ſhould not be, we think, that ſmell is merely ſenſation, but that there is actually ſomething external which is the cauſe of their ſenſations, and about which they differ. A roſe put to the noſtrils of a man and then to thoſe of a dog, may excite very different ſenſations; but we cannot think that the peculiarity of the roſe, which excites thoſe different ſenſations, varies by thus changing the poſition of the roſe. If at table one perſon miſtakes mutton for beef, and another thinks that it is veniſon, the concluſion may be, that it is neither veniſon nor beef; but no man in his ſenſes can conclude that there is no meat at the table. But, "is not ſmell ſenſation when the ſpaniel finds ſport for his maſter in the field?" There is ſenſation no doubt; but we may be permitted to aſk, what would become of the ſpaniel's ſenſation of ſmell and of his maſter's ſport, were there no game in the

* Dr Reid.

† Reid's Inquiry, ch. ii. ſect. 2.

‡ Ibid ch. ii. ſect. 3.

* Milton.
† Cowley.
‡ Thomſon.

* Inquiry, &c. ch. ii. ſect. 8.

† Ibid. ſect. ix.

the field? What of the shark's sensation of smell and pursuit, were there no victim in the ocean? and what of the camel and the thirsty wanderer, were there no fountain of fresh water in the Arabian deserts? "The *smell of a rose* signifies two things, says Dr Reid; *First*, A sensation which can have no existence but when it is perceived, and can only be in a sentient being or mind. *Secondly*, It signifies some power, quality, or virtue in the rose, or in effluvia proceeding from it, which hath a permanent existence independent of the mind; and which, by the constitution of nature, produces the sensation in us. By the original constitution of our nature we are both led to believe that there is a permanent cause of the sensation, and prompted to seek after it; and experience determines us to place it in the rose. The names of all smells, tastes, sounds, as well as heat and cold, have a like ambiguity in all languages; but it deserves our attention, that these names are but rarely, in common language, used to signify the sensations; for the most part, they signify the external qualities which are indicated by the sensations *." We have been induced thus to discuss this topic at some length, because we regretted to see Dr Reid's opinion and reasoning misrepresented; and we shall now conclude, not as this modern Berkleian does, "that, if no animal had the sensation of smell, there would be no odour;" but, that if there were no odour or external cause of smell, no animal would have this sensation.

* *Inquiry*, chap. ii. sect. 9.

The sense of smell becomes sometimes too acute, either in consequence of some defect or disease of the organ, or from too great a sensibility of the whole nervous system, such as we sometimes observe in fevers, in phrenitis, and in hysterical diseases. It is however more frequently blunted in consequence of affections of the brain and nerves, arising from blows on the head, or from internal causes; or this may happen on account of too great a dryness of the organ, owing to a suppression of the accustomed humours, or to their being conveyed off by some other channel: or it may arise from too great a quantity of tears and of mucus choaking up the nostrils. We have instances of both in cases of common cold, in which, at the beginning of the disease, the nostrils are dry, but as it advances, begin to discharge a great deal of humour, or become obstructed by a thick mucus. Whatever hinders the free entrance of the air into the nostrils or its passage through them, must also injure the sense of smell. It is also sometimes so depraved as to perceive smells when there is no odorous body present, or to perceive smells different from those that are really present. Some of the particles of the odorous effluvia, after having remained for some time in the caverns of the nostrils, issuing forth again and affecting the organ, will sometimes cause this species of false perception, even in the most healthy persons.

The sense of smelling may be diminished or destroyed by diseases; as by the moisture, dryness, inflammation, or suppuration of the olfactory membrane, the compression of the nerves which supply it, or some fault in the brain itself at their origin. A defect, or too great a degree of solidity of the small spongy bones of the upper jaw, the caverns of the forehead, &c. may likewise impair this sense; and it may be also injured by a collection of fetid matter in these caverns, which is continually exhaling from them, and also by immoderate use of snuff. When the nose abounds with moisture, after gentle evacuations, such things as tend to take off irritation and coagulate the thin sharp serum may be applied; as the oil of anise mixed with fine flour, camphor dissolved in oil of almonds, &c. the vapours of amber, frankincense, gum-mastic, and benjamin, may likewise be received into the nose and mouth. For moistening the mucus when it is too dry, some recommend snuff made of the leaves of marjoram, mixed with oil of amber, marjoram, and aniseed; or a sternutatory of calcined white vitriol, twelve grains of which may be mixed with two ounces of marjoram water and filtrated. The steam of vinegar upon hot iron, and received up the nostrils, is also of use for softening the mucus, removing obstructions, &c. If there be an ulcer in the nose, it ought to be dressed with some emollient ointment, to which, if the pain be very great, a little laudanum may be added. If it be a venereal ulcer, 12 grains of corrosive sublimate may be dissolved in a pint and a half of brandy, a table spoonful of which may be taken twice a day. The ulcer ought likewise to be washed with it, and the fumes of cinnabar may be received up the nostrils.

If there be reason to suspect that the nerves which supply the organs of smelling are inert, or want stimulating, volatile salts, or strong snuffs, and other things which occasion sneezing, may be applied to the nose; the forehead may likewise be anointed with balsam of Peru, to which may be added a little oil of amber.

SMELT. See SALMO, ICHTHYOLOGY *Index*.

SMELTING, in *Metallurgy*, the fusion or melting of the ores of metals, in order to separate the metalline part from the earthy, stony, and other parts. See *ORES, Reduction of*.

SMEW. See MERGUS, ORNITHOLOGY *Index*.

SMILAX, ROUGH BINDWEED, a genus of plants belonging to the class of *diœcia* and order of *hexandria*; and in the natural system ranging under the 11th order, *Sarmentaceæ*. See BOTANY, and MATERIA MEDICA *Index*.

SMITH, SIR THOMAS, was born at Walden in Essex in 1512. At 14 he was sent to Queen's college Cambridge, where he distinguished himself so much, that he was made Henry VIII.'s scholar together with John Cheke. He was chosen a fellow of his college in 1531, and appointed two years after to read the public Greek lecture. The common mode of reading Greek at that time was very faulty; the same sound being given to the letters and diphthongs, ι, η, υ, ει, οι, υι. Mr Smith and Mr Cheke had been for some time sensible that this pronunciation was wrong: and after a good deal of consultation and research, they agreed to introduce that mode of reading which prevails at present. Mr Smith was lecturing on *Aristotle de Republica* in Greek. At first he dropped a word or two at intervals in the new pronunciation, and sometimes he would stop as if he had committed a mistake and correct himself. No notice was taken of this for two or three days; but as he repeated more frequently, his audience began to wonder at the unusual sounds, and at last some of his friends mentioned to him what they had remarked. He owned that something was in agitation, but that it was not yet sufficiently digested to be made public. They entreated him earnestly to discover his project: he did so; and in a short time great numbers resorted to him for information. The new pronunciation was

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was adopted with enthuſiaſm, and ſoon became univerſal at Cambridge. It was afterwards oppoſed by Biſhop Gardiner the chancellor; but its ſuperiority to the old mode was ſo viſible, that in a few years it ſpread over all England.

In 1539 he travelled into foreign countries, and ſtudied for ſome time in the univerſities of France and Italy. On his return he was made regius profeſſor of civil law at Cambridge. About this time he publiſhed a treatiſe on the mode of pronouncing Engliſh. He was uſeful likewiſe in promoting the reformation. Having gone into the family of the duke of Somerſet, the protector during the minority of Edward VI. he was employed by that nobleman in public affairs; and in 1548 was made ſecretary of ſtate, and received the honour of knighthood. While that nobleman continued in office, he was ſent ambaſſador, firſt to Bruſſels and afterwards to France.

Upon Mary's acceſſion he loſt all his places, but was fortunate enough to preſerve the friendſhip of Gardiner and Bonner. He was exempted from perſecution, and was allowed, probably by their influence, a penſion of 100 l. During Elizabeth's reign he was employed in public affairs, and was ſent three times by that princeſs as her ambaſſador to France. He died in 1577. His abilities were excellent, and his attainments uncommonly great: He was a philoſopher, a phyſician, a chemiſt, mathematician, linguiſt, hiſtorian, and architect. He wrote, 1. A treatiſe called the *Engliſh Commonwealth.* 2. A letter *De Recta et Emendata Linguæ Græcæ Pronunciatione.* 3. *De Moribus Turcarum.* 4. *De Druidum Moribus.*

Smith, *Edmund*, an Engliſh poet, the only ſon of Mr Neale an eminent merchant, by a daughter of Baron Lechmere, was born in 1668. By his father's death he was left young to the care of Mr Smith, who had married his father's ſiſter, and who treated him with ſo much tenderneſs, that at the death of his generous guardian he aſſumed his name. His writings are not many, and thoſe are ſcattered about in miſcellanies and collections: his celebrated tragedy of Phædra and Hippolitus was acted in 1707; and being introduced at a time when the Italian opera ſo much engroſſed the polite world, gave Mr Addiſon, who wrote the prologue, an opportunity to rally the vitiated taſte of the public. However, notwithſtanding the eſteem it has always been held in, it is perhaps rather to be conſidered as a fine poem than as a good play. This tragedy, with a Poem to the memory of Mr John Philips, three or four Odes, with a Latin oration ſpoken at Oxford *in laudem Thomæ Bodleii*, were publiſhed as his works by his friend Mr Oldiſworth. Mr Smith died in 1710, ſunk into indolence and intemperance by poverty and diſappointments; the hard fate of many a man of genius.

Smith, *John*, an excellent mezzotinter, flouriſhed about 1700; but neither the time of his birth nor death is accurately known. He united ſoftneſs with ſtrength, and finiſhed with freedom. He ſerved his time with one Tillet a painter in Moorfields; and as ſoon as he became his own maſter, learned from Becket the ſecret of mezzotinto, and being farther inſtructed by Van der Vaart, was taken to work in Sir Godfrey Kneller's houſe; and as he was to be the publiſher of that maſter's works, doubtleſs received conſiderable hints from him, which he amply repaid. "To poſterity perhaps his prints (ſays Mr Walpole) will carry an idea of ſomething burleſque; perukes of an enormous length flowing over ſuits of armour, compoſe wonderful habits. It is equally ſtrange that faſhion could introduce the one, and eſtabliſh the practice of repreſenting the other when it was out of faſhion. Smith excelled in exhibiting both, as he found them in the portraits of Kneller, who was leſs happy in what he ſubſtituted to armour. In the Kit-cat club he has poured full bottoms chiefly over night gowns. If thoſe ſtreams of hair were *incommode* in a battle, I know nothing (he adds) they were adapted to that can be done in a night-gown. Smith compoſed two large volumes, with proofs of his own plates, for which he aſked 50l. His fineſt works are Duke Schomberg on horſeback; that duke's ſon and ſucceſſor Maynhard: the earls of Pembroke, Dorſet, and Albemarle; three plates with two figures in each, of young perſons or children, in which he ſhone; William Cowper; Gibbons and his wife; Queen Anne; the duke of Glouceſter, a whole length, with a flower-pot; a very curious one of Queen Mary, in a high head, fan, and gloves; the earl of Godolphin; the ducheſs of Ormond, a whole length, with a black; Sir George Rooke, &c. There is a print by him of James II. with an anchor, but no inſcription; which not being finiſhed when the king went away, is ſo ſcarce that it is ſometimes ſold for above a guinea. Smith alſo performed many hiſtoric pieces; as the loves of the gods, from Titian, at Blenheim, in ten plates; Venus ſtanding in a ſhell, from a picture by Corregio, and many more, of which perhaps the moſt delicate is the holy family with angels, after Carlo Maratti."

Walpole's Catalogue of Engravers.

Smith, *Dr Adam*, the celebrated author of the Inquiry into the Nature and Cauſes of the Wealth of Nations, was the only ſon of Adam Smith comptroller of the cuſtoms at Kirkaldy, and of Margaret Douglas daughter of Mr Douglas of Strathenry. He was born at Kirkaldy on the 5th June 1723, a few months after the death of his father. His conſtitution during his infancy was infirm and ſickly, and required all the care of his ſurviving parent. When only three years old he was carried by his mother to Strathenry on a viſit to his uncle Mr Douglas; and happening one day to be amuſing himſelf alone at the door of the houſe, he was ſtolen by a party of thoſe vagrants who in Scotland are called *tinkers*. Luckily he was miſſed immediately, and the vagrants purſued and overtaken in Leſlie wood; and thus Dr Smith was preſerved to extend the bounds of ſcience, and reform the commercial policy of Europe.

Philoſophical Tranſactions of the Royal Society of Edinburgh, vol. iii.

He received the rudiments of his education in the ſchool of Kirkaldy under David Miller, a teacher of conſiderable eminence, and whoſe name deſerves to be recorded on account of the great number of eminent men which that ſeminary produced while under his direction. Dr Smith, even while at ſchool, attracted notice by his paſſionate attachment to books, and by the extraordinary powers of his memory; while his friendly and generous diſpoſition gained and ſecured the affection of his ſchoolfellows. Even then he was remarkable for thoſe habits which remained with him through life, of ſpeaking to himſelf when alone and of abſence in company. He was ſent in 1737 to the univerſity of Glaſgow, where he remained till 1740, when he went

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to Baliol college Oxford, as an exhibitioner on Snell's foundation. His favourite purſuits while at the univerſity were mathematics and natural philoſophy. After his removal to England he frequently employed himſelf in tranſlating, particularly from the French, with a view to the improvement of his own ſtyle: a practice which he often recommended to all who wiſhed to cultivate the art of compoſition. It was probably then alſo that he applied himſelf with the greateſt care to the ſtudy of languages, of which, both ancient and modern, his knowledge was uncommonly extenſive and accurate.

After ſeven years reſidence at Oxford he returned to Kirkaldy, and lived two years with his mother without any fixed plan for his future life. He had been deſigned for the church of England; but diſliking the eccleſiaſtical profeſſion, he reſolved to abandon it altogether, and to limit his ambition to the proſpect of obtaining ſome of thoſe preferments to which literary attainments lead in Scotland. In 1748 he fixed his reſidence in Edinburgh, and for three years read a courſe of lectures on rhetoric and belles lettres under the patronage of Lord Kames. In 1751 he was elected profeſſor of logic in the univerſity of Glaſgow, and the year following was removed to the profeſſorſhip of moral philoſophy, vacant by the death of Mr Thomas Cragie, the immediate ſucceſſor of Dr Hutcheſon. In this ſituation he remained 13 years, a period he uſed frequently to look back to as the moſt uſeful part of his life. His lectures on moral philoſophy were divided into four parts: The firſt contained natural theology; in which he conſidered the proofs of the being and attributes of God, and thoſe truths on which religion is founded: the ſecond comprehended ethics, ſtrictly ſo called, and conſiſted chiefly of thoſe doctrines which he afterwards publiſhed in his theory of moral ſentiments: in the third part he treated more at length of that part of morality called *juſtice;* and which, being ſuſceptible of preciſe and accurate rules, is for that reaſon capable of a full and accurate explanation: in the laſt part of his lectures he examined thoſe political regulations which are founded, not upon the principle of juſtice, but of expediency; and which are calculated to increaſe the riches, the power, and the proſperity of a ſtate. Under this view he conſidered the political inſtitutions relating to commerce, to finances, to eccleſiaſtical and military governments: this contained the ſubſtance of his *Wealth of Nations.* In delivering his lectures he truſted almoſt entirely to extemporary elocution: his manner was plain and unaffected, and he never failed to intereſt his hearers. His reputation ſoon roſe very high, and many ſtudents reſorted to the univerſity merely upon his account.

When his acquaintance with Mr Hume firſt commenced is uncertain; but it had ripened into friendſhip before the year 1752.

In 1759 he publiſhed his Theory of Moral Sentiments; a work which deſervedly extended his reputation: for, though ſeveral of its concluſions be ill-founded, it muſt be allowed by all to be a ſingular effort of invention, ingenuity, and ſubtilty. Beſides, it contains a great mixture of important truth; and, though the author has ſometimes been miſled, he has had the merit of directing the attention of philoſophers to a view of human nature, which had formerly in a great meaſure eſcaped their notice. It abounds everywhere with the pureſt and moſt elevated maxims concerning the practical conduct of life; and when the ſubject of his work leads him to addreſs the imagination and the heart, the variety and felicity of his illuſtrations, the richneſs and fluency of his eloquence, and the ſkill with which he wins the attention and commands the paſſions of his readers, leave him among our Britiſh moraliſts without a rival.

Towards the end of 1763 Dr Smith received an invitation from Mr Charles Townſend to accompany the duke of Buccleugh on his travels; and the liberal terms in which this propoſal was made induced him to reſign his office at Glaſgow. He joined the duke of Buccleugh at London early in the year 1764, and ſet out with him for the continent in the month of March following. After a ſtay of about ten days at Paris, they proceeded to Thouloufe, where they fixed their reſidence for about 18 months; thence they went by a pretty extenſive route through the ſouth of France to Geneva, where they paſſed two months. About Chriſtmas 1765 they returned to Paris, and remained there till October following. The ſociety in which Dr Smith paſſed theſe ten months may be conceived in conſequence of the recommendation of Mr Hume. Turgot, Queſnai, Necker, d'Alembert, Helvetius, Marmontel, Madame Riccoboni, were among the number of his acquaintances; and ſome of them he continued ever after to reckon among the number of his friends. In October 1766 the duke of Buccleugh returned to England.

Dr Smith ſpent the next ten years of his life with his mother at Kirkaldy, occupied habitually in intenſe ſtudy, but unbending his mind at times in the company of ſome of his old ſchoolfellows, who ſtill continued to reſide near the place of their birth. In 1776 he publiſhed his *Inquiry into the Nature and Cauſes of the Wealth of Nations;* a book ſo univerſally known, that any panegyric on it would be uſeleſs. The variety, importance, and (may we not add) novelty, of the information which it contains; the ſkill and comprehenſiveneſs of mind diſplayed in the arrangement; the admirable illuſtrations with which it abounds; together with a plainneſs and perſpicuity which makes it intellible to all —render it unqueſtionably the moſt perfect work which has yet appeared on the general principles of any branch of legiſlation.

He ſpent the next two years of his life in London, where he enjoyed the ſociety of ſome of the moſt eminent men of the age: but he removed to Edinburgh in 1778, in conſequence of having been appointed, at the requeſt of the duke of Buccleugh, one of the commiſſioners of the cuſtoms in Scotland. Here he ſpent the laſt twelve years of his life in an affluence which was more than equal to all his wants. But his ſtudies ſeemed entirely ſuſpended till the infirmities of old age reminded him, when it was too late, of what he yet owed to the public and to his own fame. The principal materials of the works which he had announced had long ago been collected, and little probably was wanting but a few years of health and retirement to complete them. The death of his mother, who had accompanied him to Edinburgh in 1784, together with that of his couſin Miſs Douglas in 1788, contributed to fruſtrate theſe projects. They had been the objects of his affection for

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for more than 60 years, and in their ſociety he had enjoyed from his infancy all that he ever knew of the endearments of a family. He was now alone and helpleſs; and though he bore his loſs with equanimity, and regained apparently his former cheerfulneſs, yet his health and ſtrength gradually declined till the period of his death, which happened in July 1790. Some days before his death he ordered all his papers to be burnt except a few eſſays, which have ſince been publiſhed.

Of the originality and comprehenſiveneſs of his views; the extent, the variety, and the correctneſs of his information; the inexhauſtible fertility of his invention—he has left behind him laſting monuments. To his private worth, the moſt certain of all teſtimonies may be found in that confidence, reſpect, and attachment, which followed him through all the various relations of life. He was habitually abſent in converſation, and was apt when he ſpoke to deliver his ideas in the form of a lecture. He was rarely known to ſtart a new topic himſelf, or to appear unprepared upon thoſe topics that were introduced by others. In his external form and appearance there was nothing uncommon. When perfectly at eaſe, and when warmed with converſation, his geſtures were animated and not ungraceful; and in the ſociety of thoſe he loved, his features were often brightened by a ſmile of inexpreſſible benignity. In the company of ſtrangers, his tendency to abſence, and perhaps ſtill more his conſciouſneſs of that tendency, rendered his manners ſomewhat embarraſſed; an effect which was probably not a little heightened by thoſe ſpeculative ideas of propriety which his recluſe habits tended at once to perfect in his conception, and to diminiſh his power of realizing.

SMITHIA, a genus of plants belonging to the *diadelphia* claſs; and in the natural method ranking under the 32d order, *Papilionaceæ*. See BOTANY *Index*.

SMITHERY, a ſmith's ſhop; alſo the art of a ſmith, by which iron is wrought into any ſhape by means of fire, hammering, filing, &c.

SMITING-LINE, in a ſhip, is a ſmall rope faſtened to the mizen-yard arm, below at the deck, and is always furled up with the mizen-ſail, even to the upper end of the yard, and thence it comes down to the poop. Its uſe is to looſe the mizen-ſail without ſtriking down the yard, which is eaſily done, becauſe the mizen-ſail is furled up only with rope-yarns; and therefore when this rope is pulled hard, it breaks all the rope-yarns, and ſo the ſail falls down of itſelf. The ſailor's phraſe is, *ſmite the mizen* (whence this rope takes its name), that is, hale by this rope that the ſail may fall down.

SMOKE, a denſe elaſtic vapour, ariſing from burning bodies. As this vapour is extremely diſagreeable to the ſenſes, and often prejudicial to the health, mankind have fallen upon ſeveral contrivances to enjoy the benefit of fire, without being annoyed by ſmoke. The moſt univerſal of theſe contrivances is a tube leading from the chamber in which the fire is kindled to the top of the building, through which the ſmoke aſcends, and is diſperſed into the atmoſphere. Theſe tubes are called *chimneys*; which, when conſtructed in a proper manner, carry off the ſmoke entirely; but, when improperly conſtructed, they carry off the ſmoke imperfectly, to the great annoyance of the inhabitants. As our maſons at preſent ſeem to have a very imperfect knowledge of the manner in which chimneys ought to be built, we can hardly perform a more acceptable ſervice to the public than to point out the manner in which they ought to be conſtructed, ſo as to carry off the ſmoke entirely; as well as to explain the cauſes from which the defects ſo often complained of generally proceed, and the method of removing them.

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Tranſactions of the American Philoſophical Society.

Thoſe who would be acquainted with this ſubject, ſhould begin by conſidering on what principle ſmoke aſcends in any chimney. At firſt many are apt to think that ſmoke is in its nature, and of itſelf, ſpecifically lighter than air, and riſes in it for the ſame reaſon that cork riſes in water. Theſe ſee no cauſe why ſmoke ſhould not riſe in the chimney though the room be ever ſo cloſe. Others think there is a power in chimneys to *draw* up the ſmoke, and that there are different forms of chimneys which afford more or leſs of this power. Theſe amuſe themſelves with ſearching for the beſt form. The equal dimenſions of a funnel in its whole length is not thought artificial enough, and it is made, for fancied reaſons, ſometimes tapering and narrowing from below upwards, and ſometimes the contrary, &c. &c. A ſimple experiment or two may ſerve to give more correct ideas. Having lighted a pipe of tobacco, plunge the ſtem to the bottom of a decanter half filled with cold water; then putting a rag over the bowl, blow through it, and make the ſmoke deſcend in the ſtem of the pipe, from the end of which it will riſe in bubbles through the water; and being thus cooled, will not afterwards riſe to go out through the neck of the decanter, but remain ſpreading itſelf and reſting on the ſurface of the water. This ſhows that ſmoke is really heavier than air, and that it is carried upwards only when attached to or acted upon by air that is heated, and thereby rarefied and rendered ſpecifically lighter than the air in its neighbourhood.

Smoke being rarely ſeen but in company with heated air, and its upward motion being viſible, though that of the rarefied air that drives it is not ſo, has naturally given riſe to the error. It is now well known that air is a fluid which has weight as well as others, though about 800 times lighter than water; that heat makes the particles of air recede from each other, and take up more ſpace, ſo that the ſame weight of air heated will have more bulk than equal weights of cold air which may ſurround it, and in that caſe muſt riſe, being forced upwards by ſuch colder and heavier air, which preſſes to get under it and take its place. That air is ſo rarefied or expanded by heat, may be proved to their comprehenſion by a lank blown bladder, which laid before a fire, will ſoon ſwell, grow tight, and burſt.

Another experiment may be to take a glaſs tube about an inch in diameter, and 12 inches long, open at both ends, and fixed upright on legs ſo that it need not be handled, for the hands might warm it. At the end of a quill faſten five or ſix inches of the fineſt light filament of ſilk, ſo that it may be held either above the upper end of the tube or under the lower end, your warm hand being at a diſtance by the length of the quill. If there were any motion of air through the tube, it would manifeſt itſelf by its effect on the ſilk; but if the tube and the air in it are of the ſame temperature with the ſurrounding air, there will be no ſuch motion, whatever may be the form of the tube, whether crooked or ſtraight, narrow below and widening upwards,

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wards, or the contrary, the air in it will be quiefcent. Warm the tube, and you will find as long as it continues warm, a conftant current of air entering below and paffing up through it till difcharged at the top; becaufe the warmth of the tube being communicated to the air it contains, rarefies that air, and makes it lighter than the air without; which therefore preffes in below, forces it upwards, follows and takes its place, and is rarefied in its turn. And, without warming the tube, if you hold under it a knob of hot iron, the air thereby heated will rife and fill the tube, going out at its top; and this motion in the tube will continue as long as the knob remains hot, becaufe the air entering the tube below, is heated and rarefied by paffing near and over that knob.

That this motion is produced merely by the difference of fpecific gravity between the fluid within and that without the tube, and not by any fancied form of the tube itfelf, may appear by plunging it into water contained in a glafs jar a foot deep, through which fuch motion might be feen. The water within and without the tube being of the fame fpecific gravity, balance each other, and both remain at reft. But take out the tube, ftop its bottom with a finger, and fill it with olive oil, which is lighter than water; then ftopping the top, place it as before, its lower end under water, its top a very little above. As long as you keep the bottom ftopped the fluids remain at reft; but the moment it is unftopt, the heavier enters below, forces up the lighter, and takes its place: and the motion then ceafes, merely becaufe the new fluid cannot be fucceffively made lighter, as air may be by a warm tube.

In fact, no form of the funnel of a chimney has any fhare in its operation or effect refpecting fmoke except its height. The longer the funnel, if erect, the greater its force when filled with heated and rarefied air to draw in below and drive up the fmoke, if one may, in compliance with cuftom, ufe the expreffion *draw*, when in fact it is the fuperior weight of the furrounding atmofphere that preffed to enter the funnel below, and fo drives up before it the fmoke and warm air it meets with in its paffage.

What is it then which makes a fmoky chimney, that is, a chimney which, inftead of conveying up all the fmoke, difcharges a part of it into the room, offending the eyes and damaging the furniture?

The caufes of this effect may be reduced to *nine*, differing from each other, and therefore requiring different remedies.

1. *Smoky chimneys in a new houfe are fuch frequently from mere want of air.* The workmanfhip of the rooms being all good, and juft out of the workman's hands, the joints of the boards of the flooring, and of the pannels of wainfcotting, are all true and tight; the more fo as the walls, perhaps not yet thoroughly dry, preferve a dampnefs in the air of the room which keeps the woodwork fwelled and clofe. The doors and the fafhes too, being worked with truth, fhut with exactnefs, fo that the room is as tight as a fnuff-box, no paffage being left open for air to enter except the key-hole, and even that is fometimes covered by a little dropping fhutter. Now if fmoke cannot rife but as connected with rarefied air, and a column of fuch air, fuppofe it filling the funnel, cannot rife unlefs other air be admitted to fupply its place; and if therefore no current of air enter the opening of the chimney—there is nothing to prevent the fmoke from coming out into the room. If the motion upwards of the air in a chimney that is freely fupplied be obferved by the rifing of the fmoke or a feather in it, and it be confidered that in the time fuch feather takes in rifing from the fire to the top of the chimney, a column of air equal to the content of the funnel muft be difcharged, and an equal quantity fupplied from the room below, it will appear abfolutely impoffible that this operation fhould go on if the tight room is kept fhut; for were there any force capable of drawing conftantly fo much air out of it, it muft foon be exhaufted like the receiver of an air-pump, and no animal could live in it. Thofe therefore who ftop every crevice in a room to prevent the admiffion of frefh air, and yet would have their chimney carry up the fmoke, require inconfiftencies, and expect impoffibilities. Yet under this fituation it is not uncommon to fee the owner of a new houfe in defpair, and ready to fell it for much lefs than it coft; conceiving it uninhabitable becaufe not a chimney in any one of its rooms will carry off the fmoke unlefs a door or window be left open. Much expence has alfo been made to alter and amend new chimneys which had really no fault: in one houfe particularly which Dr Franklin knew that belonged to a nobleman in Weftminfter, that expence amounted to no lefs than 300l. after his houfe had been, as he thought, finifhed and all charges paid. And after all, feveral of the alterations were ineffectual, for want of underftanding the true principles.

Remedies. When you find on trial that opening the door or a window enables the chimney to carry up all the fmoke, you may be fure that want of air from without was the caufe of its fmoking. "I fay from *without* (adds Dr Franklin), to guard you againft a common miftake of thofe who may tell you the room is large, contains abundance of air fufficient to fupply any chimney, and therefore it cannot be that the chimney wants air. Thefe reafoners are ignorant that the largenefs of a room, if tight, is in this cafe of fmall importance, fince it cannot part with a chimneyfull of its air without occafioning fo much vacuum; which it requires a great force to effect, and could not be borne if effected."

It appearing plainly then, that fome of the outward air muft be admitted, the queftion will be, how much is abfolutely neceffary? for you would avoid admitting more, as being contrary to one of your intentions in having a fire, viz. that of warming your room. To difcover this quantity, fhut the door gradually while a middling fire is burning, till you find that before it is quite fhut the fmoke begins to come out into the room; then open it a little till you perceive the fmoke comes out no longer. There hold the door, and obferve the width of the open crevice between the edge of the door and the rabbet it fhould fhut into. Suppofe the diftance to be half an inch, and the door eight feet high; you find thence that your room requires an entrance for air equal in area to 96 half inches, or 48 fquare inches, or a paffage of 6 inches by 8. This, however, is a large fuppofition; there being few chimneys that, having a moderate opening and a tolerable height of funnel, will not be fatisfied with fuch a crevice of a quarter of an inch: Dr Franklin found a fquare of 6 by 6, or 36 fquare inches, to be pretty good medium that

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that will ferve for moft chimneys. High funnels with fmall and low openings may indeed be fupplied through a lefs fpace; becaufe, for reafons that will appear hereafter, the force of levity, if one may fo fpeak, being greater in fuch funnels, the cool air enters the room with greater velocity, and confequently more enters in the fame time. This, however, has its limits; for experience fhows, that no increafed velocity fo occafioned has made the admiffion of air through the key-hole equal in quantity to that through an open door, though through the door the current moves flowly, and through the key-hole with great rapidity.

It remains then to be confidered, how and where this neceffary quantity of air from without is to be admitted fo as to be leaft inconvenient: for if at the door, left fo much open, the air thence proceeds directly to the chimney, and in its way comes cold to your back and heels as you fit before your fire. If you keep the door fhut, and raife a little the fafh of your window, you feel the fame inconvenience. Various have been the contrivances to avoid this; fuch as bringing in frefh air through pipes in the jams of the chimney, which pointing upwards fhould blow the fmoke up the funnel; opening paffages into the funnel above, to let in air for the fame purpofe. But thefe produce an effect contrary to that intended: for as it is the conftant current of air paffing from the room through the opening of the chimney into the funnel which prevents the fmoke from coming out into the room, if you fupply the funnel by other means or in other ways with the air which it wants, and efpecially if that air be cold, you diminifh the force of that current, and the fmoke in its efforts to enter the room finds lefs refiftance.

The wanted air muft then indifpenfably be admitted into the room, to fupply what goes off through the opening of the chimney. M. Gauger, a very ingenious and intelligent French writer on the fubject, propofes with judgement to admit it above the opening of the chimney; and to prevent inconvenience from its coldnefs, he directs that it may be fo made, that it fhall pafs in its entrance through winding cavities made behind the iron back and fides of the fire-place, and under the iron hearth-plate; in which cavities it will be warmed, and even heated, fo as to contribute much, inftead of cooling, to the warming of the room. This invention is excellent in itfelf, and may be ufed with advantage in building new houfes; becaufe the chimneys may then be fo difpofed as to admit conveniently the cold air to enter fuch paffages: but in houfes built without fuch views, the chimneys are often fo fituated as not to afford that convenience without great and expenfive alterations. Eafy and cheap methods, though not quite fo perfect in themfelves, are of more general utility; and fuch are the following.

In all rooms where there is a fire, the body of air warmed and rarefied before the chimney is continually changing place, and making room for other air that is to be warmed in its turn. Part of it enters and goes up the chimney, and the reft rifes and takes place near the ceiling. If the room be lofty, that warm air remains above our heads as long as it continues warm, and we are little benefited by it, becaufe it does not defcend till it is cooler. Few can imagine the difference of climate between the upper and lower parts of fuch a room, who have not tried it by the thermometer, or by going up a ladder till their heads are near the ceiling. It is then among this warm air that the wanted quantity of outward air is beft admitted, with which being mixed, its coldnefs is abated, and its inconvenience diminifhed fo as to become fcarce obfervable. This may be eafily done by drawing down about an inch the upper fafh of a window; or, if not moveable, by cutting fuch a crevice through its frame; in both which cafes it will be well to place a thin fhelf of the length to conceal the opening, and floping upwards, to direct the entering air horizontally along and under the ceiling. In fome houfes the air may be admitted by fuch a crevice made in the wainfcot, cornice, or plaftering, near the ceiling and over the opening of the chimney. This, if practicable, is to be chofen, becaufe the entering cold air will there meet with the warmeft rifing air from before the fire, and be fooneft tempered by the mixture. The fame kind of fhelf fhould alfo be placed here. Another way, and not a very difficult one, is to take out an upper pane of glafs in one of your fafhes, fet it in a tin frame, giving it two fpringing angular fides, and then replacing it, with hinges below on which it may be turned to open more or lefs above. It will then have the appearance of an internal fky-light. By drawing this pane in, more or lefs, you may admit what air you find neceffary. Its pofition will naturally throw that air up and along the ceiling. This is what is called in France a *Was ift das?* As this is a German queftion, the invention is probably of that nation, and takes its name from the frequent afking of that queftion when it firft appeared. In England fome have of late years cut a round hole about five inches diameter in a pane of the fafh and placed againft it a circular plate of tin hung on an axis, and cut into vanes; which, being feparately bent a little obliquely, are acted upon by the entering air, fo as to force the plate continually round like the vanes of a windmill. This admits the outward air, and by the continual whirling of the vanes, does in fome degree difperfe it. The noife only is a little inconvenient.

Fig. 2.

2. A fecond caufe of the fmoking of chimneys is, *their openings in the room being too large;* that is, too wide, too high, or both. Architects in general have no other ideas of proportion in the opening of a chimney than what relate to fymmetry and beauty refpecting the dimenfions of the room; while its true proportion refpecting its function and utility depends on quite other principles; and they might as properly proportion the ftep in a ftaircafe to the height of the ftory, inftead of the natural elevation of men's legs in mounting. The proportion then to be regarded, is what relates to the height of the funnel. For as the funnels in the different ftories of a houfe are neceffarily of different heights or lengths, that from the loweft floor being the higheft or longeft, and thofe of the other floors fhorter and fhorter, till we come to thofe in the garrets, which are of courfe the fhorteft; and the force of draft being, as already faid, in proportion to the height of funnel filled with rarefied air, and a current of air from the room into the chimney, fufficient to fill the opening, being neceffary to oppofe and prevent the fmoke from coming out into the room; it follows, that the openings of the longeft funnels may be larger, and that thofe of the fhorter funnels fhould be fmaller. For if there be a large opening to a chimney that does not draw ftrongly, the funnel may

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may happen to be furnifhed with the air which it demands by a partial current entering on one fide of the opening, and leaving the other fide free of any oppofing current, may permit the fmoke to iffue there into the room. Much too of the force of draft in a funnel depends on the degree of rarefaction in the air it contains, and that depends on the nearnefs to the fire of its paffage in entering the funnel. If it can enter far from the fire on each fide, or far above the fire, in a wide or high opening, it receives little heat in paffing by the fire, and the contents of the funnel are by thofe means lefs different in levity from the furrounding atmofphere, and its force in drawing confequently weaker. Hence if too large an opening be given to chimneys in upper rooms, thofe rooms will be fmoky: On the other hand, if too fmall openings be given to chimneys in the lower rooms, the entering air operating too directly and violently on the fire, and afterwards ftrengthening the draft as it afcends the funnel, will confume the fuel too rapidly.

Remedy. As different circumftances frequently mix themfelves in thefe matters, it is difficult to give precife dimenfions for the openings of all chimneys. Our fathers made them generally much too large: we have leffened them; but they are often ftill of greater dimenfions than they fhould be, the human eye not being eafily reconciled to fudden and great changes. If you fufpect that your chimney fmokes from the too great dimenfion of its opening, contract it by placing moveable boards fo as to lower and narrow it gradually till you find the fmoke no longer iffues into the room. The proportion fo found will be that which is proper for that chimney, and you may employ the bricklayer or mafon to reduce it accordingly. However, as in building new houfes fomething muft be fometimes hazarded, Dr Franklin propofes to make the openings in the lower rooms about 30 inches fquare and 18 deep, and thofe in the upper only 18 inches fquare and not quite fo deep; the intermediate ones diminifhing in proportion as the height of the funnel is diminifhed. In the larger openings, billets of two feet long, or half the common length of cordwood, may be burnt conveniently; and for the fmaller, fuch wood may be fawed into thirds. Where coals are the fuel, the grates will be proportioned to the openings. The fame depth is nearly neceffary to all, the funnels being all made of a fize proper to admit a chimney-fweeper. If in large and elegant rooms cuftom or fancy fhould require the appearance of a larger chimney, it may be formed of expenfive marginal decorations, in marble, &c. But in time perhaps, that which is fitteft in the nature of things may come to be thought handfomeft.

3. Another caufe of fmoky chimneys is *too fhort a funnel.* This happens neceffarily in fome cafes, as where a chimney is required in a low building; for, if the funnel be raifed high above the roof, in order to ftrengthen its draft, it is then in danger of being blown down, and crufhing the roof in its fall.

Remedies. Contract the opening of the chimney, fo as to oblige all the entering air to pafs through or very near the fire; whereby it will be more heated and rarefied, the funnel itfelf be more warmed, and its contents have more of what may be called the force of levity, fo as to rife ftrongly and maintain a good draft at the opening.

Or you may in fome cafes, to advantage, build additional ftories over the low building, which will fupport a high funnel.

If the low building be ufed as a kitchen, and a contraction of the opening therefore inconvenient, a large one being neceffary, at leaft when there are great dinners, for the free management of fo many cooking utenfils; in fuch cafe the beft expedient perhaps would be to build two more funnels joining to the firft, and having three moderate openings, one to each funnel, inftead of one large one. When there is occafion to ufe but one, the other two may be kept fhut by fliding plates, hereafter to be defcribed; and two or all of them may be ufed together when wanted. This will indeed be an expence, but not an ufelefs one, fince your cooks will work with more comfort, fee better than in a fmoky kitchen what they are about, your victuals will be cleaner dreffed and not tafte of fmoke, as is often the cafe; and to render the effect more certain, a ftack of three funnels may be fafely built higher above the roof than a fingle funnel.

The cafe of too fhort a funnel is more general than would be imagined, and often found where one would not expect it. For it is not uncommon, in ill-contrived buildings, inftead of having a funnel for each room or fire-place, to bend and turn the funnel of an upper room fo as to make it enter the fide of another funnel that comes from below. By thefe means the upper room funnel is made fhort of courfe, fince its length can only be reckoned from the place where it enters the lower room funnel; and that funnel is alfo fhortened by all the diftance between the entrance of the fecond funnel and the top of the ftack: for all that part being readily fupplied with air through the fecond funnel, adds no ftrength to the draft, efpecially as that air is cold when there is no fire in the fecond chimney. The only eafy remedy here is, to keep the opening of that funnel fhut in which there is no fire.

4. Another very common caufe of the fmoking of chimneys is, *their overpowering one another.* For inftance, if there be two chimneys in one large room, and you make fires in both of them, the doors and windows clofe fhut, you will find that the greater and ftronger fire fhall overpower the weaker, from the funnel of which it will draw air down to fupply its own demand; which air defcending in the weaker funnel, will drive down its fmoke, and force it into the room. If, inftead of being in one room, the two chimneys are in two different rooms, communicating by a door, the cafe is the fame whenever that door is open. In a very tight houfe, a kitchen chimney on the loweft floor, when it had a great fire in it, has been known to overpower any other chimney in the houfe, and draw air and fmoke into its room as often as the door communicating with the ftaircafe was opened.

Remedy. Take care that every room have the means of fupplying itfelf from without with the air which its chimney may require, fo that no one of them may be obliged to borrow from another, nor under the neceffity of lending. A variety of thefe means have been already defcribed.

5. Another caufe of fmoking is, *when the tops of chimneys are commanded by higher buildings, or by a hill,* fo that the wind blowing over fuch eminences falls like water over a dam, fometimes almoft perpendicularly on the

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Fig. 3. To illuſtrate this, let A (fig. 3.) repreſent a ſmall building at the ſide of a great rock B, and the wind coming in the direction CD; when the current of air comes to the point D, being hurried forward with great velocity, it goes a little forward, but ſoon deſcends downward, and gradually is reflected more and more inward, as repreſented by the dotted lines EE, &c. ſo that, deſcending downwards upon the top of the chimney A, the ſmoke is beat back again into the apartments.

It is evident that houſes ſituated near high hills or thick woods will be in ſome meaſure expoſed to the ſame inconvenience; but it is likewiſe plain, that if a houſe be ſituated upon the ſlope of a hill (as at F, fig. 3.), it will not be in any danger of ſmoke when the wind blows towards that ſide of the hill upon which it is ſituated; for the current of air coming over the houſe-top in the direction GH, is immediately changed by the ſlope of the hill to the direction HC, which powerfully draws the ſmoke upward from the top of the chimney. But it is alſo evident, that a houſe in this ſituation will be liable to ſmoke when the wind blows from the hill; for the current of air coming downward in the direction CH, will beat downward on the chimney F, and prevent the ſmoke from aſcending with freedom. The effect will be much heightened if the doors and windows are chiefly in the lowermoſt ſide of the houſe.

Remedy. That commonly applied to this caſe is a turncap made of tin or plate iron, covering the chimney above and on three ſides, open on one ſide, turning on a ſpindle; and which being guided or governed by a vane always preſents its back to the current. This may be generally effectual, though not certain, as there may be caſes in which it will not ſucceed. Raiſing your funnels if practicable, ſo as their tops may be higher, or at leaſt equal, with the commanding eminence, is more to be depended on. But the turning cap, being eaſier and cheaper, ſhould firſt be tried. "If obliged to build in ſuch a ſituation, I would chooſe (ſays Dr Franklin) to place my doors on the ſide next the hill, and the backs of my chimneys on the fartheſt ſide; for then the column of air falling over the eminence, and of courſe preſſing on that below, and forcing it to enter the doors or *was-iſt-daſes* on that ſide, would tend to balance the preſſure down the chimneys, and leave the funnels more free in the exerciſe of their functions."

6. There is another caſe which is the reverſe of that laſt mentioned. It is where the commanding eminence is farther from the wind than the chimney commanded. To explain this a figure may be neceſſary. Suppoſe then a building whoſe ſide AB happens to be expoſed to the wind, and forms a kind of dam againſt its progreſs. Suppoſe the wind blowing in the direction FE. The air obſtructed by this dam or building AB will like water preſs and ſearch for paſſages through it; but finding none, it is beat back with violence, and ſpreads itſelf on every ſide, as is repreſented by the curved lines *e, e, e, e, e, e.* It will therefore force itſelf down the ſmall chimney C, in order to get through by ſome door or window open on the other ſide of the building. And if there be a fire in ſuch chimney, its ſmoke is of courſe beat down, and fills the room.

Remedy. There is but one remedy, which is to raiſe ſuch a funnel higher than the roof, ſupporting it if neceſſary by iron bars. For a turncap in this caſe has no effect, the dammed-up air preſſing down through it in whatever poſition the wind may have placed its opening. Smoke.

Dr Franklin mentions a city in which many houſes are rendered ſmoky by this operation. For their kitchens being built behind, and connected by a paſſage with the houſes, and the tops of the kitchen-chimneys lower than the tops of the houſes, the whole ſide of a ſtreet when the wind blows againſt its back forms ſuch a dam as above deſcribed; and the wind ſo obſtructed forces down thoſe kitchen-chimneys (eſpecially when they have but weak fires in them) to paſs through the paſſage and houſe into the ſtreet. Kitchen-chimneys ſo formed and ſituated have another inconvenience. In ſummer, if you open your upper room windows for air, a light breeze blowing over your kitchen-chimney towards the houſe, though not ſtrong enough to force down its ſmoke as aforeſaid, is ſufficient to waft it into your windows, and fill the rooms with it; which, beſides the diſagreeableneſs, damages your furniture.

7. Chimneys, otherwiſe drawing well, are ſometimes made to ſmoke by *the improper and inconvenient ſituation of a door.* When the door and chimney are on the ſame ſide of the room, if the door being in the corner is made to open againſt the wall, which is common, as being there, when open, more out of the way, it follows, that when the door is only opened in part, a current of air ruſhing in paſſes along the wall into and acroſs the opening of the chimney, and flirts ſome of the ſmoke out into the room. This happens more certainly when the door is ſhutting, for then the force of the current is augmented, and becomes very inconvenient to thoſe who, warming themſelves by the fire, happen to ſit in its way.

The *remedies* are obvious and eaſy. Either put an intervening ſcreen from the wall round great part of the fireplace; or, which is perhaps preferable, ſhift the hinges of your door, ſo as it may open the other way, and when open throw the air along the other wall.

8. A room that has no fire in its chimney is ſometimes filled with *ſmoke which is received at the top of its funnel, and deſcends into the room.* Funnels without fires have an effect according to their degree of coldneſs or warmth on the air that happens to be contained in them. The ſurrounding atmoſphere is frequently changing its temperature; but ſtacks of funnels covered from winds and ſun by the houſe that contains them, retain a more equal temperature. If, after a warm ſeaſon, the outward air ſuddenly grows cold, the empty warm funnels begin to draw ſtrongly upward; that is, they rarefy the air contained in them, which of courſe riſes, cooler air enters below to ſupply its place, is rarefied in its turn, and riſes; and this operation continues till the funnel grows cooler, or the outward air warmer, or both, when the motion ceaſes. On the other hand, if after a cold ſeaſon the outward air ſuddenly grows warm and of courſe lighter, the air contained in the cool funnels being heavier deſcends into the room; and the warmer air which enters their tops being cooled in its turn, and made heavier, continues to deſcend; and this operation goes on till the funnels are warmed by the paſſing of warm air through them, or the air itſelf grows cooler.

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cooler. When the temperature of the air and of the funnels is nearly equal, the difference of warmth in the air between day and night is sufficient to produce these currents: the air will begin to ascend the funnels as the cool of the evening comes on, and this current will continue till perhaps nine or ten o'clock the next morning, when it begins to hesitate; and as the heat of the day approaches, it sets downwards, and continues so till towards evening, when it again hesitates for some time, and then goes upwards constantly during the night, as before mentioned. Now when smoke issuing from the tops of neighbouring funnels passes over the tops of funnels which are at the time drawing downwards, as they often are in the middle part of the day, such smoke is of necessity drawn into these funnels, and descends with the air into the chamber.

The remedy is to have a sliding plate that will shut perfectly the offending funnel. Dr Franklin has thus described it: "The opening of the chimney is contracted by brick-work faced with marble slabs to about two feet between the jams, and the breast brought down to within about three feet of the hearth. An iron frame is placed just under the breast, and extending quite to the back of the chimney, so that a plate of the same metal may slide horizontally backwards and forwards in the grooves on each side of the frame. This plate is just so large as to fill the whole space, and shut the chimney entirely when thrust quite in, which is convenient when there is no fire. Draw it out, so as to leave between its further edge and the back a space of about two inches; this space is sufficient for the smoke to pass; and so large a part of the funnel being stopt by the rest of the plate, the passage of warm air out of the room, up the chimney, is obstructed and retarded; and by those means much cold air is prevented from coming in through crevices, to supply its place. This effect is made manifest three ways. 1. When the fire burns briskly in cold weather, the howling or whistling noise made by the wind, as it enters the room through the crevices, when the chimney is open as usual, ceases as soon as the plate is slid in to its proper distance. 2. Opening the door of the room about half an inch, and holding your hand against the opening, near the top of the door, you feel the cold air coming in against your hand, but weakly, if the plate be in. Let another person suddenly draw it out, so as to let the air of the room go up the chimney, with its usual freedom where chimneys are open, and you immediately feel the cold air rushing in strongly. 3. If something be set against the door, just sufficient, when the plate is in, to keep the door nearly shut, by resisting the pressure of the air that would force it open: then, when the plate is draw out, the door will be forced open by the increased pressure of the outward cold air endeavouring to get in to supply the place of the warm air that now passes out of the room to go up the chimney. In our common open chimneys, half the fuel is wasted, and its effect lost; the air it has warmed being immediately drawn off."

9. Chimneys which generally draw well, do nevertheless sometimes give smoke into the rooms, *it being driven down by strong winds passing over the tops of their funnels*, though not descending from any commanding eminence. This case is most frequent where the funnel is short and the opening turned from the wind. It is the more grievous, when it happens to be a cold wind that produces the effect, because when you most want your fire you are sometimes obliged to extinguish it. To understand this, it may be considered that the rising light air, to obtain a free issue from the funnel, must push out of its way or oblige the air that is over it to rise. In a time of calm or of little wind this is done visibly; for we see the smoke that is brought up by that air rise in a column above the chimney: but when a violent current of air, that is, a strong wind, passes over the top of a chimney, its particles have received so much force, which keeps them in a horizontal direction and follow each other so rapidly, that the rising light air has not strength sufficient to oblige them to quit that direction and move upwards to permit its issue.

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Remedies. In Venice, the custom is to open or widen the top of the flue, rounding it in the true form of a funnel. In other places the contrary is practised; the tops of the flues being narrowed inwards, so as to form a slit for the issue of the smoke, long as the breadth of the funnel, and only four inches wide. This seems to have been contrived on a supposition that the entry of the wind would thereby be obstructed and perhaps it might have been imagined, that the whole force of the rising warm air being condensed, as it were, in the narrow opening, would thereby be strengthened, so as to overcome the resistance of wind. This, however, did not always succeed; for when the wind was at north-east and blew fresh, the smoke was forced down by fits into the room where Dr Franklin commonly sat, so as to oblige him to shift the fire into another. The position of the slit of this funnel was indeed north-east and south-west. Perhaps if it had lain across the wind, the effect might have been different. But on this we can give no certainty. It seems a matter proper to be referred to experiment. Possibly a turncap might have been serviceable, but it was not tried.

With all the science, however, that a man shall suppose himself possessed of in this article, he may sometimes meet with cases that shall puzzle him. "I once lodged (says Dr Franklin) in a house at London, which in a little room had a single chimney and funnel. The opening was very small, yet it did not keep in the smoke, and all attempts to have a fire in this room were fruitless. I could not imagine the reason, till at length observing that the chamber over it, which had no fireplace in it, was always filled with smoke when a fire was kindled below, and that the smoke came through the cracks and crevices of the wainscot; I had the wainscot taken down, and discovered that the funnel which went up behind it had a crack many feet in length, and wide enough to admit my arm; a breach very dangerous with regard to fire, and occasioned probably by an apparent irregular settling of one side of the house. The air entering this breech freely, destroyed the drawing force of the funnel. The remedy would have been, filling up the breach, or rather rebuilding the funnel: but the landlord rather chose to stop up the chimney.

"Another puzzling case I met with at a friend's country house near London. His best room had a chimney in which, he told me, he never could have a fire, for all the smoke came out into the room. I flattered myself I could easily find the cause and prescribe the cure. I opened the door, and perceived it was not want of air. I made a temporary contraction of the opening of the chimney, and found that it was not its being

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being too large that caufed the fmoke to iffue. I went out and looked up at the top of the chimney: Its funnel was joined in the fame ftack with others; fome of them fhorter, that drew very well, and I faw nothing to prevent its doing the fame. In fine, after every other examination I could think of, I was obliged to own the infufficiency of my fkill. But my friend, who made no pretenfion to fuch kind of knowledge, afterwards difcovered the caufe himfelf. He got to the top of the funnel by a ladder, and looking down found it filled with twigs and ftraw cemented by earth and lined with feathers. It feems the houfe after being built, had ftood empty fome years before he occupied it; and he concluded that fome large birds had taken the advantage of its retired fituation to make their neft there. The rubbifh, confiderable in quantity, being removed, and the funnel cleared, the chimney drew well, and gave fatisfaction."

Chimneys whofe funnels go up in the north wall of a houfe, and are expofed to the north winds, are not fo apt to draw well as thofe in a fouth wall; becaufe when rendered cold by thofe winds, they draw downwards.

Chimneys inclofed in the body of a houfe are better than thofe whofe funnels are expofed in cold walls.

Chimneys in ftacks are apt to draw better than feparate funnels, becaufe the funnels that have conftant fires in them warm the others in fome degree that have none.

SMOKE-Jack. This ingenious machine is of German origin, and Meffinger, in his *Collection of Mechanical Performances*, fays it is very ancient, being reprefented in a painting at Nurenbergh, which is known to be older than the year 1350.

Plate CCCCXCVII. Fig. 5.

Its conftruction is abundantly fimple. An upright iron fpindle GA (fig. 5.), placed in the narrow part of the kitchen chimney, turns round on two points H and I. The upper one H paffes through an iron bar, which is built in acrofs the chimney; and the lower pivot I is of tempered fteel, and is conical or pointed, refting in a conical bell-metal focket fixed on another crofs bar. On the upper end of the fpindle is a circular fly G, confifting of 4, 6, 8, or more thin iron plates, fet obliquely on the fpindle like the fails of a windmill, as we fhall defcribe more particularly by and by. Near the lower end of the fpindle is a pinion A, which works in the teeth of a contrate or face wheel B, turning on a horizontal axis BC. One pivot of this axis turns in a cock fixed on the crofs bar, which fupports the lower end of the upright fpindle HI, and the other pivot turns in a cock fixed on the fide wall of the chimney; fo that this axle is parallel to the front of the chimney. On the remote end of this horizontal axle there is a fmall pulley C, having a deep angular groove. Over this pulley there paffes a chain CDE, in the lower bight of which hangs the large pulley E of the fpit. This end of the fpit turns loofely between the branches of the fork of the rack or raxe F, but without refting on it. This is on the top of a moveable ftand, which can be fhifted nearer to or farther from the fire. The other end turns in one of the notches of another rack. The number of teeth in the pinion A and wheel B, and the diameters of the pulleys C and E, are fo proportioned that the fly G makes from 12 to 20 turns for one turn of the fpit.

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The manner of operation of this ufeful machine is eafily underftood. The air which contributes to the burning of the fuel, and paffes through the midft of it, is greatly heated, and expanding prodigioufly in bulk, becomes lighter than the neighbouring air, and is therefore pufhed by it up the chimney. In like manner, all the air which comes near the fire is heated, expanded, becomes lighter, and is driven up the chimney. This is called the *draught* or *fuction*, but would with greater propriety be termed the *drift* of the chimney. As the chimney gradually contracts in its dimenfions, and as the fame quantity of heated air paffes through every fection of it, it is plain that the rapidity of its afcent muft be greateft in the narroweft place. There the fly G fhould be placed, becaufe it will there be expofed to the ftrongeft current. The air, ftriking the fly vanes obliquely, pufhes them afide, and thus turns them round with a confiderable force. If the joint of meat is exactly balanced on the fpit, it is plain that the only refiftance to the motion of the fly is what arifes from the friction of the pivots of the upright fpindle, the friction of the pinion and wheel, the friction of the pivots of the horizontal axis, the friction of the fmall end of the fpit, and the friction of the chain in the top pulleys. The whole of this is but a mere trifle. But there is frequently a confiderable inequality in the weight of the meat on different fides of the fpit: there muft therefore be a fufficient overplus of force in the impulfe of the afcending air on the vanes of the fly, to overcome this want of equilibrium occafioned by the unfkilfulnefs or negligence of the cook. There is, however, commonly enough of power when the machine is properly conftructed. The utility of this machine will, we hope, procure us the indulgence of fome of our readers, while we point out the circumftances on which its performance depends, and the maxims which fhould be followed in its conftruction.

The upward current of air is the moving power, and fhould be increafed as much as poffible, and applied in the moft advantageous manner. Every thing will increafe the current which improves the draught of the chimney, and fecures it from fmoking. A fmoky chimney muft always have a weak current. For this particular, therefore, we refer to what has been delivered in the article PNEUMATICS, N° 359; and the article SMOKE.

With refpect to the manner of applying this force, it is evident that the beft conftruction of a windmill fails will be nearly the beft conftruction for the fly. According to the ufual theory of the impulfe of fluids, the greateft effective impulfe (that is, in the direction of the fly's motion) will be produced if the plane of the vane be inclined to the axis in an angle of 54 degrees 46 minutes. But, fince we have pronounced this theory to be fo very defective, we had better take a determination founded on the experiments on the impulfe of fluids made by the academy of Paris. Thefe authorife us to fay, that 49½ or 50 degrees will be the beft angle to give the vane: but this muft be underftood only of that part of it which is clofe adjoining to the axis. The vane itfelf muft be twifted, or *weathered* as the millwrights term it, and muft be much more oblique at its outer extremity. The exact pofition cannot be determined with any precifion; becaufe this depends on the

proportion

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proportion of the velocity of the vane to that of the current of heated air. This is ſubject to no rule, being changed according to the load of the jack. We imagine that an obliquity of 65 degrees for the outer ends of the vanes will be a good poſition for the generality of caſes. Meſſinger deſcribes an ingenious contrivance for changing this angle at pleaſure, in order to vary the velocity of the motion. Each vane is made to turn round a midrib, which ſtands out like a radius from the ſpindle, and the vane is moved by a ſtiff wire attached to one of the corners adjoining to the axle. Theſe wires are attached to a ring which ſlides on the ſpindle like the ſpreader of an umbrella; and it is ſtopped on any part of the ſpindle by a pin thruſt through a hole in the ſpindle and ring. We mention this briefly, it being eaſily underſtood by any mechanic, and but of little conſequence, becauſe the machine is not ſuſceptible of much preciſion.

It is eaſy to ſee that an increaſe of the ſurface of the vanes will increaſe the power: therefore they ſhould occupy the whole ſpace of the circle, and not conſiſt of four narrow arms like the ſails of a windmill. It is better to make many narrow vanes than a few broad ones; as will appear plain to one well acquainted with the mode of impulſe of fluids acting obliquely. We recommend eight or twelve at leaſt; and each vane ſhould be ſo broad, that when the whole is held perpendicular between the eye and the light, no light ſhall come through the fly, the vanes overlapping each other *a very ſmall matter*. We alſo recommend the making them of ſtiff plate. Their weight contributes to the ſteady motion, and enables the fly, which has acquired a conſiderable velocity during a favourable poſition of things, to retain a momentum ſufficient to pull round the ſpit while the heavy ſide of the meat is riſing from its loweſt poſition. In ſuch a ſituation a light fly ſoon loſes its momentum, and the jack ſtaggers under its load.

It is plain, from what has been ſaid, that the fly ſhould occupy the whole of that ſection of the vent where it is placed. The vent muſt therefore be brought to a round form in that place, that none of the current may paſs uſeleſsly by it.

It is an important queſtion where the fly ſhould be placed. If in a wide part of the vent, it will have a great ſurface, and act by a long lever; but the current in that place is ſlow, and its impulſe weak. This is a fit ſubject of calculation. Suppoſe that we have it in our choice to place it either as it is drawn in the figure, or farther up at *g*, where its diameter muſt be one half of what it is at G. Since the ſame quantity of heated air paſſes through both ſections, and the ſection *g* has only one-fourth of the area of the ſection G, it is plain that the air muſt be moving four times faſter, and that its impulſe is 16 times greater. But the ſurface on which it is acting is the fourth part of that of the fly G; the actual impulſe therefore is only four times greater, ſuppoſing both flies to be moving with the ſame relative velocity in reſpect of the current; that is, the rim of each moving with the ſame portion of the velocity of the current. This will be the caſe when the ſmall fly turns eight times as often in a minute as the large fly: for the air is moving four times as quick at *g*, and the diameter of *g* is one-half of that of G. Therefore, when the ſmall fly is turning eight times as quick as the great one, there is a quadruple impulſe acting at half the diſtance from the axis. The momentum or energy therefore of the current is double. Therefore, ſuppoſing the pinion, wheel, and pulleys of both jacks to be the ſame, the jack with the ſmall fly, placed in the narrow part of the vent, will be 16 times more powerful.

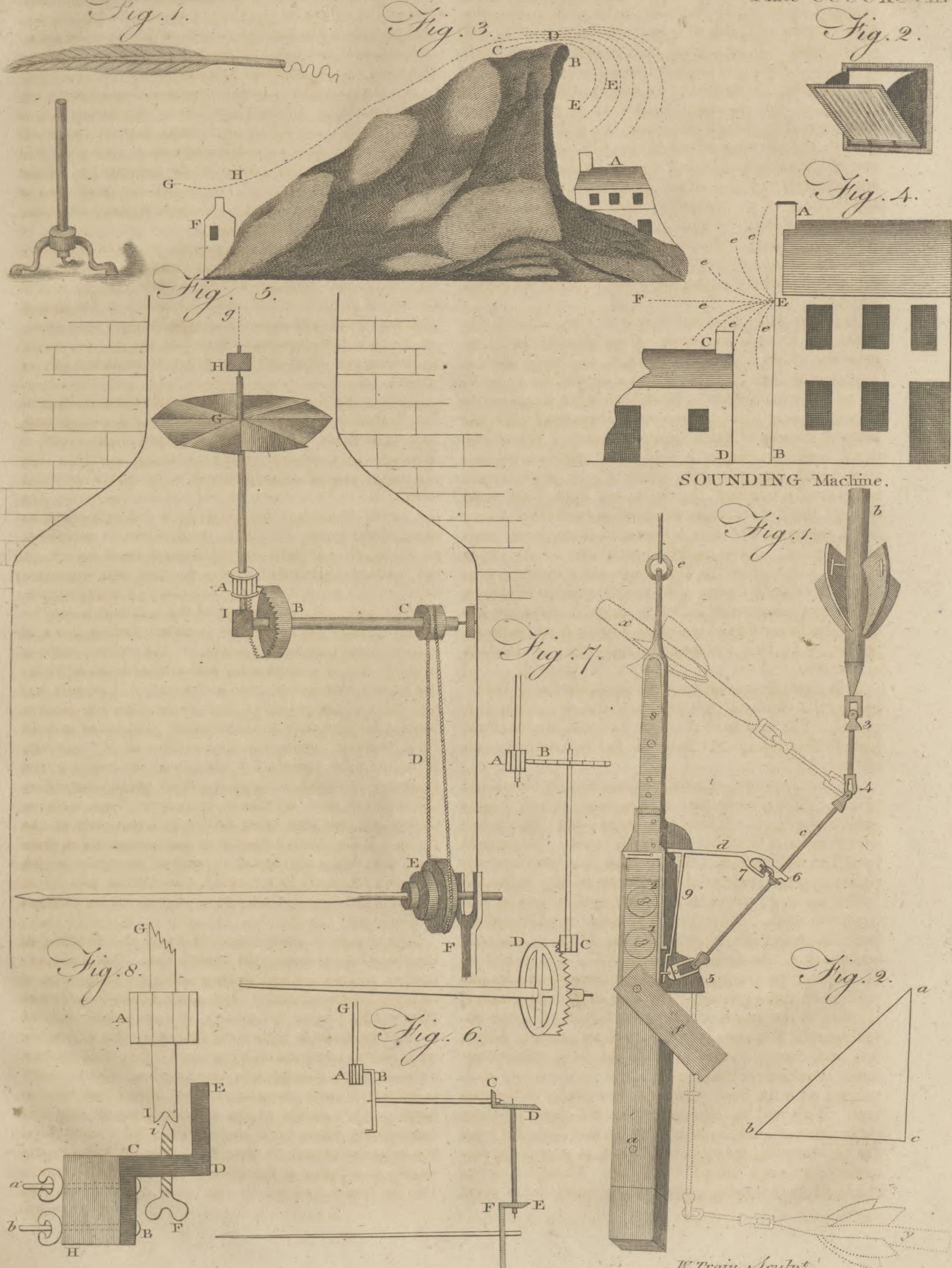
By this example, more eaſily underſtood than a general proceſs, it appears that it is of particular importance to place the fly in an elevated part of the vent, where the area may be much contracted. In order ſtill farther to increaſe the power of the machine, it would be very proper to lengthen the ſpindle ſtill more, and to put another fly on it at a conſiderable diſtance above the firſt, and a third above this, &c.

As the velocity of the current changes by every change of the fire, the motion of this jack muſt be very unſteady. To render it as adjuſtable as may be to the particular purpoſe of the cook, the pulley E has ſeveral grooves of different diameters, and the ſpit turns more or leſs ſlowly, by the ſame motion of the fly, according as it hangs in the chain by a larger or ſmaller pulley or groove.

Such is the conſtruction of the ſmoke-jack in its moſt ſimple form. Some are more artificial and complicated, having, in place of the pulleys and connecting chain, a ſpindle coming down from the horizontal axis BC. On the upper end of this ſpindle is a horizontal contrate wheel, driven by a pinion in place of the pulley C. On the lower end is a pinion, driving a contrate wheel in place of the pulley E. This conſtruction is repreſented in fig. 6. Others are conſtructed more ſimply, in Fig. 6.
the manner repreſented in fig. 7. But our firſt con- Fig. 7.
ſtruction has great advantage in point of ſimplicity, and allows a more eaſy adjuſtment of the ſpit, which may be brought nearer to the fire or removed farther from it without any trouble; whereas, in the others, with a train of wheels and pinions, this cannot be done without ſeveral changes of pins and ſcrews. The only imperfection of the pulley is, that by long uſe the grooves become ſlippery, and an ill-balanced joint is apt to hold back the ſpit, while the chain ſlides in the grooves. This may be completely prevented by making the grooves flat inſtead of angular (which greatly diminiſhes the friction), and furniſhing them with ſhort ſtuds or pins which take into every third or fourth link of the chain. If the chain be made of the ſimpleſt form, with flat links, and each link be made of an exact length (making them all on a mould), the motion will be as eaſy as with any wheelwork, and without the leaſt chance of ſlipping.

It is always of importance to avoid this ſlipping of the chain by balancing the loaded ſpit. For this purpoſe it will be extremely convenient to have what is called a *balance-ſkewer*. Let a part of the ſpit, immediately adjoining to the pulley, be made round, and let an arm be made to turn on it ſtiffly, ſo that it may be made faſt in any poſition by a ſcrew. Let a leaden ball be made to ſlide along this arm, with a ſcrew to faſten it at any diſtance from the ſpit. When the meat is ſpitted, lay it on the racks, and the heavieſt ſide will immediately place itſelf undermoſt. Now turn round the balance-ſkewer, ſo that it may point ſtraight upwards, and make it faſt in that poſition by the ſcrew. Put the leaden ball on it, and ſlide it inwards or outwards

Plate CCCCXCVII.



W. Train Sculp.t

wards till it exactly balances the heavy ſide, which will appear by the ſpit's remaining in any poſition in which it is put.

The greateſt difficulty is to keep the machine in repair. The eſſential part of it, the firſt mover, the fly, and the pinion and wheel, by which its motion is tranſmitted to the reſt of the machine, are ſituated in a place of difficult acceſs, and where they are expoſed to violent heat and to the ſmoke and ſoot. The whole weight of the fly, reſting on the lower pivot I, muſt exert a great preſſure there, and occaſion great friction, even when this pinion is reduced to the ſmalleſt ſize that is compatible with the neceſſary ſtrength. The pivot muſt be of hardened ſteel, tapered like an obtuſe cone, and muſt turn in a conical ſocket, alſo of hardened ſteel or of bell-metal; and this ſeat of preſſure and friction muſt be continually ſupplied with oil, which it conſumes very quickly. It is not ſufficient that it be from time to time ſmeared with an oiled feather; there muſt be an iron cup formed round the ſocket, and kept filled with oil. It is ſurpriſing how quickly it diſappears; it ſoon becomes clammy by evaporation, and by the ſoot which gathers about it. The continued rubbing of the pivot and ſocket wears them both very faſt; and this is increaſed by hard powders, ſuch as ſandy duſt, that are hurried up by the rapid current every time that the cook ſtirs the fire. Theſe, getting between the rubbing parts, cauſe them to grind and wear each other prodigiouſly. It is a great improvement to invert theſe rubbing parts. Let the lower end of the ſpindle be of a conſiderable thickneſs, and have a conical hollow nicely drilled in its extremity. Let a blunt-pointed conical pin riſe up in the middle of the oil cup, on which the conical hollow of the ſpindle may reſt. Here will be the ſame ſteady ſupport, and the ſame friction as in the other way; but no grinding duſt can now lodge between the pivot and its ſocket: and if this upright pin be ſcrewed up through the bottom of the cup, it may be ſcrewed farther up in proportion as it wears; and thus the upper pivot *g* will never deſert its hole, a thing which ſoon happens in the common way. We can ſay from experience, that a jack conſtructed in this way will not require the fifth part of the repairs of one done in the other way.

It is of importance that the whole be ſo put together as to be eaſily taken down, in order to ſweep the vent, or to be repaired, &c. For this purpoſe, let the croſs bar which carries the lower end of the upright ſpindle be placed a little on one ſide of the perpendicular line from the upper pivot hole. Let the cock which carries the oil-cup and the pivot of the horizontal axis BC be ſcrewed to one ſide of this croſs bar, ſo that the centre of the cup may be exactly under the upper pivot hole. By this conſtruction we have only to unſcrew this cock, and then both axles come out of their places at once, and may be replaced without any trouble. We have ſketched in fig. 8. the manner in which this may be done, where M repreſents a ſection of the lower croſs bar. BCDE is the cock, fixed to the bar by the pins which go through both, with finger nuts *a* and *b* on the oppoſite ſide. F *i* is the hard ſteel pin with the conical top *i*, on which the lower end I of the upright ſpindle AG reſts, in the manner recommended as the beſt and moſt durable. The pivot of the horizontal axis turns in a hole at E the top of the cock.

Fig. 8.

After all, we muſt acknowledge that the ſmoke-jack is inferior to the common jack that is moved by a weight. It is more expenſive at firſt, and requires more frequent repairs; its motion is not ſo much under command; it occaſions ſoot to be thrown about the fire, to the great annoyance of the cook; and it is a great encumbrance when we would clean the vent.

SMOKE-Farthings. The pentecoſtals or cuſtomary oblations offered by the diſperſed inhabitants within a dioceſe when they made their proceſſion to the mother or cathedral church, came by degrees into a ſtanding annual rent called *ſmoke-farthings.*

SMOKE-Silver. Lands were holden in ſome places by the payment of the ſum of 6d. yearly to the ſheriff, called *ſmoke-ſilver* (Par. 4. Edw. VI.). Smoke-ſilver and ſmoke-penny are to be paid to the miniſters of divers pariſhes as a *modus* in lieu of tithe-wood: and in ſome manors formerly belonging to religious houſes, there is ſtill paid, as appendant to the ſaid manors, the ancient Peter-pence, by the name of *ſmoke-money* (*Twiſd. Hiſt. Vindicat.* 77.).—The biſhop of London *anno* 1444 iſſued out his commiſſion, *Ad levandum le* ſmoke-farthings, &c.

SMOLENSKO, a large and ſtrong city of Ruſſia, and capital of a palatinate of the ſame name, with a caſtle ſeated on a mountain, and a biſhop's ſee. It is ſtrong by its ſituation, being in the middle of a wood, and ſurrounded by almoſt inacceſſible mountains. It has been taken and retaken ſeveral times by the Poles and Ruſſians; but theſe laſt have had poſſeſſion of it ever ſince the year 1687. It is ſeated on the river Nieper, near the frontiers of Lithuania, 188 miles ſouth-weſt of Moſcow. E. Long. 31. 22. N. Lat. 54. 50.

SMOLENSKO, a duchy and palatinate of Ruſſia, bounded on the north by Biela, on the eaſt by the duchy of Moſcow, on the ſouth by that of Severia and the palatinate of Meiſlaw, and on the weſt by the ſame palatinate and by that of Witepſk. It is full of foreſts and mountains: and the capital is of the ſame name.

SMOLLET, Dr Tobias, an author whoſe writings will tranſmit his name with honour to poſterity, was born in the year 1720 at a ſmall village within two miles of Cameron, on the banks of the river Leven. He appears to have received a claſſical education, and was bred to the practice of phyſic and ſurgery; and in the early part of his life ſerved as a ſurgeon's mate in the navy.

The incidents that befel him during his continuance in this capacity ſerved as a foundation for Roderic Random, one of the moſt entertaining novels in the Engliſh tongue. He was preſent at the ſiege of Carthagena; and in the before mentioned novel he has given a faithful, though not very pleaſing, account of the management of that ill-conducted expedition, which he cenſures in the warmeſt terms, and from circumſtances which fell under his own particular obſervation.

His connection with the ſea ſeems not to have been of long continuance; and it is probable that he wrote ſeveral pieces before he became known to the public by his capital productions. The firſt piece we know of with certainty is a Satire in two parts, printed firſt in the years 1746 and 1747, and reprinted in a Collection of his Plays and Poems in 1777. About this period, or ſome time before, he wrote for Mr Rich an opera intitled Alceſte, which has never been performed nor printed.

At

Smollet.

At the age of 18 he wrote a tragedy intitled The Regicide, founded on the ſtory of the aſſaſſination of James I. of Scotland. In the preface to this piece, publiſhed by ſubſcription in the year 1749, he bitterly exclaimed againſt falſe patrons, and the duplicity of theatrical managers. The warmth and impetuoſity of his temper hurried him, on this occaſion, into unjuſt reflections againſt the late George Lord Lyttleton and Mr Garrick: the character of the former he characteriſed in the novel of Peregrine Pickle, and he added a burleſque of the Monody written by that nobleman on the death of his lady. Againſt Mr Garrick he made illiberal ill-founded criticiſms; and in his novel of Roderic Random gave a very unfair repreſentation of his treatment of him reſpecting this tragedy. Of this conduct he afterwards repented, and acknowledged his errors; though in the ſubſequent editions of the novel the paſſages which were the haſty effuſions of diſappointment were not omitted.

However, in giving a ſketch of the liberal arts in his Hiſtory of England, he afterwards remarked, "the exhibitions of the ſtage were improved to the moſt exquiſite entertainment by the talents and management of Garrick, who greatly ſurpaſſed all his predeceſſors of this and perhaps every other nation, in his genius for acting, in the ſweetneſs and variety of his tones, the irreſiſtible magic of his eye, the fire and vivacity of his action, the eloquence of attitude, and the whole pathos of expreſſion.

Not ſatisfied with this public declaration, he wrote an apology to Mr Garrick in ſtill ſtronger terms. With theſe ample conceſſions, Mr Garrick was completely ſatisfied; ſo that in 1757, when Dr Smollet's comedy of the Repriſals, an afterpiece of two acts, was performed at Drury Lane theatre, the latter acknowledged himſelf highly obliged for the friendly care of Mr Garrick exerted in preparing it for the ſtage; and ſtill more for his acting the part of Luſignan in Zara for his benefit, on the ſixth inſtead of the ninth night, to which he was only intitled by the cuſtom of the theatre.

The Adventures of Roderic Random, publiſhed in 1748, 2 vols 12mo, a book which ſtill continues to have a moſt extenſive ſale, firſt eſtabliſhed the Doctor's reputation. All the firſt volume and the beginning of the ſecond appear to conſiſt of real incident and character, though certainly a good deal heightened and diſguiſed. The Judge his grandfather, Crab and Potion the two apothecaries, and 'Squire Gawky, were characters well known in that part of the kingdom where the ſcene was laid. Captains Oakhum and Whiffle, Doctors Mackſhane and Morgan, were alſo ſaid to be real perſonages; but their names we have either never learned or have now forgotten. A bookbinder and barber long eagerly contended for being ſhadowed under the name of *Strap*. The Doctor ſeems to have enjoyed a peculiar felicity in deſcribing ſea characters, particularly the officers and ſailors of the navy. His Trunnion, Hatchway, and Pipes, are highly finiſhed originals; but what exceeds them all, and perhaps equals any character that has yet been painted by the happieſt genius of ancient or modern times, is his Lieutenant Bowling. This is indeed nature itſelf; original, *unique*, and *ſui generis*.

By the publication of this work the Doctor had acquired ſo great a reputation, that henceforth a certain degree of ſucceſs was inſured to every thing known or ſuſpected to proceed from his hand. In the courſe of a few years, the Adventures of Peregrine Pickle appeared; a work of great ingenuity and contrivance in the compoſition, and in which an uncommon degree of erudition is diſplayed, particularly in the deſcription of the entertainment given by the Republican Doctor, after the manner of the ancients. Under this perſonage the late Dr Akenſide, author of The Pleaſures of Imagination, is ſuppoſed to be typified; and it would be difficult to determine whether profound learning or genuine humour predominate moſt in this epiſode. Another epiſode of The Adventures of a Lady of Quality, likewiſe inſerted in this work, contributed greatly to its ſucceſs, and is indeed admirably executed; the materials, it is ſaid, the lady herſelf (the celebrated Lady *Vane*) furniſhed.

Theſe were not the only original compoſitions of this ſtamp with which the Doctor has favoured the public. Ferdinand Count Fathom, and Sir Launcelot Greaves, are ſtill in the liſt of what may be called *reading novels*, and have gone through ſeveral editions; but there is no injuſtice in placing them in a rank far below the former. No doubt invention, character, compoſition, and contrivance, are to be found in both; but then ſituations are deſcribed which are hardly poſſible, and characters are painted which, if not altogether unexampled, are at leaſt incompatible with modern manners; and which ought not to be, as the ſcenes are laid in modern times.

The laſt work which we believe the Doctor publiſhed was of much the ſame ſpecies, but caſt into a different form—The Expedition of Humphrey Clinker. It conſiſts of a ſeries of letters, written by different perſons to their reſpective correſpondents. He has here carefully avoided the faults which may be juſtly charged to his two former productions. Here are no extravagant characters nor unnatural ſituations. On the contrary, an admirable knowledge of life and manners is diſplayed; and moſt uſeful leſſons are given applicable to intereſting but to very common ſituations.

We know not whether the remark has been made, but there is certainly a very obvious ſimilitude between the characters of the three heroes of the Doctor's chief productions. Roderic Random, Peregrine Pickle, and Matthew Bramble, are all brothers of the ſame family. The ſame ſatirical, cynical diſpoſition, the ſame generoſity and benevolence, are the diſtinguiſhing and characteriſtical features of all three; but they are far from being ſervile copies or imitations of each other. They differ as much as the Ajax, Diomed, and Achilles of Homer. This was undoubtedly a great effort of genius; and the Doctor ſeems to have deſcribed his own character at the different ſtages and ſituations of his life.

Before he took a houſe at Chelſea, he attempted to ſettle as practitioner of phyſic at Bath; and with that view wrote a treatiſe on the waters; but was unſucceſsful, chiefly becauſe he could not render himſelf agreeable to the women, whoſe favour is certainly of great conſequence to all candidates for eminence, whether in medicine or divinity. This, however, was a little extraordinary; for thoſe who remembered Dr Smollet at that time, cannot but acknowledge that he was as graceful and handſome a man as any of the age he lived in; beſides, Smollet.

besides, there was a certain dignity in his air and manner which could not but inspire respect wherever he appeared. Perhaps he was too soon discouraged; in all probability, had he persevered, a man of his great learning, profound sagacity, and intense application, besides being endued with every other external as well as internal accomplishment, must have at last succeeded, and, had he attained to common old age, been at the head of his profession.

Abandoning physic altogether as a profession, he fixed his residence at Chelsea, and turned his thoughts entirely to writing. Yet, as an author, he was not near so successful as his happy genius and acknowledged merit certainly deserved. He never acquired a patron among the great, who by his favour or beneficence relieved him from the necessity of writing for a subsistence. The truth is, Dr Smollet possessed a loftiness and elevation of sentiment and character which appear to have disqualified him for paying court to those who were capable of conferring favours. It would be wrong to call this disposition pride or haughtiness; for to his equals and inferiors he was ever polite, friendly, and generous. Booksellers may therefore be said to have been his only patrons; and from them he had constant employment in translating, compiling, and reviewing. He translated Gil Blas and Don Quixote, both so happily, that all the former translations of these excellent productions of genius have been almost superseded by his. His name likewise appears to a translation of Voltaire's Prose Works; but little of it was done by his own hand; he only revised it, and added a few notes. He was concerned in a great variety of compilations. His History of England was the principal work of that kind. It had a most extensive sale; and the Doctor is said to have received 2000l. for writing it and the continuation.

In 1755 he set on foot the Critical Review, and continued the principal manager of it till he went abroad for the first time in the year 1763. He was perhaps too acrimonious sometimes in the conduct of that work; and at the same time displayed too much sensibility when any of the unfortunate authors attempted to retaliate whose works he had perhaps justly censured.

Among other controversies in which his engagements in this publication involved him, the most material in its consequences was that occasioned by his remarks on a pamphlet published by Admiral Knowles. That gentleman, in defence of his conduct on the expedition to Rochfort, published a vindication of himself; which falling under the Doctor's examination, produced some very severe strictures both on the performance and on the character of the writer. The admiral immediately commenced a prosecution against the printer; declaring at the same time that he desired only to be informed who the writer was, that if he proved to be a gentleman he might obtain the satisfaction of one from him. In this affair the Doctor behaved both with prudence and with spirit. Desirous of compromising the dispute with the admiral in an amicable manner, he applied to his friend Mr Wilkes to interpose his good offices with his opponent. The admiral, however, was inflexible; and just as sentence was going to be pronounced against the printer, the Doctor came into court, avowed himself the author of the Strictures, and declared himself ready to give Mr Knowles any satisfaction he chose.

Smollet.

The admiral immediately commenced a fresh action against the Doctor, who was found guilty, fined 100l., and condemned to three months imprisonment in the King's Bench. It is there he is said to have written the Adventures of Sir Launcelot Greaves, in which he has described some remarkable characters, then his fellow-prisoners.

When Lord Bute was called to the chief administration of affairs, he was prevailed upon to write in defence of that nobleman's measures; which he did in a weekly paper called the *Briton*. This gave rise to the famous North Briton; wherein, according to the opinion of the public, he was rather baffled. The truth is, the Doctor did not seem to possess the talents necessary for political altercation. He wanted temper and coolness; and his friends accused his patron of having denied him the necessary information, and even neglected the fulfilling of some of his other engagements with him. Be that as it will, the Doctor is said not to have forgotten him in his subsequent performances.

Besides the Briton, Dr Smollet is supposed to have written other pieces in support of the cause he espoused. The Adventures of an Atom, in two volumes, are known to be his production.

His constitution being at last greatly impaired by a sedentary life and assiduous application to study, he went abroad for his health in June 1763, and continued in France and Italy two years. He wrote an account of his travels in a series of letters to some friends, which were afterwards published in two volumes octavo, 1766. During all that time he appears to have laboured under a constant fit of chagrin. A very slight perusal of these letters will sufficiently evince that this observation is founded in fact, and is indeed a melancholy instance of the influence of bodily distemper over the best disposition.

His relation of his travels is actually cynical; for which Sterne, in his Sentimental Journey, has animadverted on him under the character of Smelfungus. The Doctor lived to return to his native country: but his health continuing to decline, and meeting with fresh mortifications and disappointments, he went back to Italy, where he died in October 21. 1771. He was employed, during the last years of his life, in abridging the Modern Universal History, great part of which he had originally written himself, particularly the histories of France, Italy, and Germany.

He certainly met with many mortifications and disappointments; which, in a letter to Mr Garrick, he thus feelingly expresses: "I am old enough to have seen and observed, that we are all playthings of Fortune; and that it depends upon something as insignificant and precarious as the tossing up of a halfpenny, whether a man rises to affluence and honours, or continues to his dying day struggling with the difficulties and disgraces of life."

It would be needless to expatiate on the character of a man so well known as Dr Smollet, who has, besides, given so many strictures of his own character and manner of living in his writings, particularly in Humphrey Clinker; where he appears under the appellation of *Mr Serle*, and has an interview with Mr Bramble; and his manner of living is described in another letter, where young Melford is supposed to dine with him at his house in Chelsea. No doubt he made money by his connec-

Smollet, Smugglers.

tions with the bookfellers; and had he been a rigid economift, or endued with the gift of retention (an expreffion of his own), he might have lived and died very independent. However, to do juftice to his memory, his difficulties, whatever they were, proceeded not from extravagance or want of economy. He was hofpitable, but not oftentatioufly fo; and his table was plentiful, but not extravagant. No doubt he had his failings; but ftill it would be difficult to name a man who was fo refpectable for the qualities of his head, or more amiable for the virtues of his heart.

Since his death a monument has been erected to his memory near Leghorn, on which is infcribed an epitaph written in Latin by his friend Dr Armftrong, author of The Art of Preferving Health, and many other excellent pieces. An infcription written in Latin was likewife infcribed on a pillar erected to his memory on the banks of the Leven, by one of his relations.

To thefe memoirs we are extremely forry to add, that fo late as 1785 the widow of Dr Smollet was refiding in indigent circumftances at Leghorn. On this account the tragedy of Venice Preferved was acted for her benefit at Edinburgh on the 5th of March, and an excellent prologue fpoken on that occafion.

The pieces inferted in the pofthumous collection of Dr Smollet's plays and poems are, The Regicide, a tragedy: The Reprifal, a comedy; Advice and Reproof, two fatires; The Tears of Scotland; Verfes on a Young Lady; a Love Elegy, in imitation of Tibullus; two Songs; a Burlefque Ode; Odes to Mirth, to Sleep, to Leven Water, to Blue-ey'd Ann, and to Independence.

SMUGGLERS, perfons who import or export prohibited goods without paying the duties appointed by the law.

The duties of cuftoms, it is faid, were originally inftituted, in order to enable the king to afford protection to trade againft pirates: they have fince been continued as a branch of the public revenue. As duties impofed upon the importation of goods neceffarily raife their price above what they might otherwife have been fold for, a temptation is prefented to import the commodity clandeftinely and to evade the duty. Many perfons, prompted by the hopes of gain, and confidering the violation of a pofitive law of this nature as in no refpect criminal (an idea in which they have been encouraged by a great part of the community, who make no fcruple to purchafe fmuggled goods), have engaged in this illicit trade. It was impoffible that government could permit this practice, which is highly injurious to the fair trader, as the fmuggler is enabled to underfell him, while at the fame time he impairs the national revenue, and thus wholly deftroys the end for which thefe duties were appointed. Such penalties are therefore inflicted as it was thought would prevent fmuggling.

Burn's Law Dictionary, vol. ii.

Many laws have been made with this view. If any goods be fhipped or landed without warrant and prefence of an officer, the veffel fhall be forfeited, and the wharfinger fhall forfeit 100l. and the mafter or mariner of any fhip inward bound fhall forfeit the value of the goods: and any carman, porter, or other affifting, fhall be committed to gaol, till he find furety of his good behaviour, or until he fhall be difcharged by the court of exchequer (13 & 14 C. II. c. 11.) If goods be relanded after drawback, the veffel and goods fhall be forfeited; and every perfon concerned therein fhall forfeit double the value of the drawback (8 An. c. 13.) Goods taken in at fea fhall be forfeited, and alfo the veffel into which they are taken; and every perfon concerned therein fhall forfeit treble value (9 G. II. c. 35.) A veffel hovering near the coaft fhall be forfeited, if under 50 tons burden; and the goods fhall alfo be forfeited, or the value thereof (5 G. III. c. 43.) Perfons receiving or buying run goods fhall forfeit 20l. (8 G. c. 18.) A concealer of run goods fhall forfeit treble value (8 G. c. 18.) Offering run goods to fale, the fame fhall be forfeited, and the perfon to whom they are offered may feize them; and the perfon offering them to fale fhall forfeit treble value (11 G. c. 30.) A porter or other perfon carrying run goods fhall forfeit treble value (9 G. II. c. 35.) Perfons armed or difguifed carrying run goods fhall be guilty of felony, and tranfported for feven years (8 G. c. 18. 9 G. II. c. 35.)

Smugglers.

But the laft ftatute, 19 G. II. c. 34. is for this purpofe *inftar omnium;* for it makes all forcible acts of fmuggling, carried on in defiance of the laws, or even in difguife to evade them, felony without benefit of clergy: enacting, that if three or more perfons fhall affemble, with fire-arms or other offenfive weapons, to affift in the illegal exportation or importation of goods, or in refcuing the fame after feizure, or in refcuing offenders in cuftody for fuch offences: or fhall pafs with fuch goods in difguife; or fhall wound, fhoot at, or affault, any officers of the revenue when in the execution of their duty; fuch perfons fhall be felons, without the benefit of clergy.

When we confider the nature, and ftill more the hiftory of mankind, we muft allow that the enacting of fevere penal laws is not the way to prevent crimes. It were indeed much to be wifhed that there were no fuch thing as a political crime; for the generality of men, but efpecially the lower orders, not difcerning the propriety or utility of fuch laws, confider them as oppreffive and tyrannical, and never hefitate to violate them when they can do it with impunity. Inftead therefore of punifhing fmugglers, it would be much better to remove the temptation. But the high duties which have been impofed upon the importation of many different forts of foreign goods, in order to difcourage their confumption in Great Britain, have in many cafes ferved only to encourage fmuggling; and in all cafes have reduced the revenue of the cuftoms below what more moderate duties would have afforded. The faying of Dr Swift, that in the arithmetic of the cuftoms two and two, inftead of making four, make fometimes only one, holds perfectly true with regard to fuch heavy duties, which never could have been impofed, had not the mercantile fyftem taught us, in many cafes, to employ taxation as an inftrument, not of revenue, but of monopoly.

Smith's Wealth of Nations, vol. iii.

The bounties which are fometimes given upon the exportation of home produce and manufactures, and the drawbacks which are paid upon the re-exportation of the greater part of foreign goods, have given occafion to many frauds, and to a fpecies of fmuggling more deftructive of the public revenue than any other. In order to obtain the bounty or drawback, the goods, it is well known, are fometimes fhipped and fent to fea, but

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soon afterwards clandestinely relanded in some other part of the country.

Heavy duties being imposed upon almost all goods imported, our merchant importers smuggle as much, and make entry of as little as they can. Our merchant exporters, on the contrary, make entry of more than they export; sometimes out of vanity, and to pass for great dealers in goods which pay no duty; and sometimes to gain a bounty or a drawback. Our exports, in consequence of these different frauds, appear upon the customhouse books greatly to overbalance our imports; to the unspeakable comfort of those politicians who measure the national prosperity by what they call the balance of trade.

SMUT, in *Husbandry*, a disease in corn, when the grains, instead of being filled with flour, are full of a stinking black powder. See WHEAT.

SMYRNA, or ISMIR, at present the largest and richest city of Asia Minor, is situated in north latitude 38° 28′, and in E. Long. 27° 25′ from Greenwich, and about 183 miles west by south of Constantinople. The town extends along the shore about half a mile on a gentle declivity. The houses of the English, French, and Dutch consuls are handsome structures; these, with most of those occupied by the Christian merchants, are washed on one side by the sea, forming a street named *Frank-street*, from its being solely inhabited by European Christians. In the year 1763 the whole of this quarter was consumed by fire: the loss sustained by this calamity in merchandise was estimated at a million and a half of Turkish dollars, or near 200,000l. sterling. The port is one of the finest of the Levant, it being able to contain the largest fleet; and indeed there are seldom in it fewer than 100 ships of different nations.

A castle stands at its entrance, and commands all the shipping which sail in or out. There is likewise an old ruinous castle, near a mile in circumference, which stands in the upper part of the city, and, according to tradition, was built by the empress Helena: and near it is an ancient structure, said to be the remains of a palace where the Greek council was held when Smyrna was the metropolis of Asia Minor. They also show the ruins of an amphitheatre, where it is said St Polycarp, the first bishop, fought with lions.

This city is about four miles in circumference, and nearly of a triangular form; but the side next the mountain is much longer than the other sides. The houses are low, and mostly built with clay walls, on account of the earthquakes to which the country is subject; but the caravanseras and some other of the public buildings have an air of magnificence. The streets are wide, and almost a continued bazar, in which a great part of the merchandise of Europe and Asia is exposed to sale, with plenty of provisions; though these are not so cheap as in many other parts of Turkey, on account of the populousness of the place, and the great resort of foreigners. It is said to contain 15,000 Turks 10,000 Greeks, 1800 Jews, 200 Armenians, and 200 Franks: but the whole population is computed at 120,000. The Turks have 19 mosques; two churches belong to the Greeks; one to the Armenians; and the Jews have eight synagogues. The Romanists have three convents. There is also one of the fathers Della Terra Santa. Here resides an archbishop of the Greek church; a Latin bishop who has a salary from Rome, with the title of bishop of Smyrna *in partibus infidelium*; and the English and Dutch factories have each their chaplain.

The walks about the town are extremely pleasant, particularly on the west side of Frank street, where there are several little groves of orange and lemon trees, which being always clothed with leaves, blossoms, and fruit, regale several of the senses at the same time. The vines which cover the little hills about Smyrna afford both a delightful prospect and plenty of grapes, of which good wine is made. These hills are agreeably interspersed with fertile plains, little forests of olives and other fruit-trees, and many pleasure-houses, to which the Franks usually retire during the summer. In the neighbourhood of Smyrna is great plenty of game and wild-fowl, and particularly deer and wild-hogs. The sea also abounds with a variety of good fish. The European Christians are here allowed all imaginable liberties, and usually clothe themselves after the European manner.

The chief commerce of this city consists in raw silk, silk-stuffs, grograms, and cotton yarn.

However, the unhealthfulness of the situation, and more especially the frequent earthquakes, from which, it is said, they are scarcely ever free for two years together, and which have been felt 40 days successively, are an abatement of the pleasure that might otherwise be enjoyed here. A very dreadful one happened in June 1688, which overthrew a great number of the houses; and the rock opening where the castle stood, swallowed it up, and no less than 5000 persons perished on this occasion.

In the year 1758, so desolating a plague raged here, that scarcely a sufficient number of the inhabitants survived to gather in the fruits of the earth. In the year 1772, three-fourth parts of the city were consumed by fire; and six years after it was visited by the most dreadful earthquakes, which continued from the 25th of June to the 5th of July; by which successive calamities the city has been so much reduced, that its former consequence is never likely to be restored.

The ladies here wear the oriental dress, consisting of large trowsers or breeches, which reach to the ancle; long vests of rich silk or velvet, lined in winter with costly furs; and round their waist an embroidered zone with clasps of silver or gold. Their hair is plaited, and descends down the back often in great profusion. The girls have sometimes above twenty thick tresses, besides two or three encircling the head as a coronet, and set off with flowers and plumes of feathers, pearls, or other jewels. They commonly stain it of a chesnut colour, which is the most desired. Their apparel and carriage are alike antique. It is remarkable that the trowsers are mentioned in a fragment of Sappho as part of the female dress.

SMYRNIUM, ALEXANDERS; a genus of plants belonging to the class of pentandria, and to the order of digynia; and in the natural system ranging under the 45th order, *Umbellatæ*. See BOTANY *Index*.

SNAFFLE, in the manege, is a very slender bit-mouth without any branches, much used in England; the true bridles being reserved for war.

SNAIL, in *Zoology*. See HELIX, CONCHOLOGY *Index*, and LIMAX, HELMINTHOLOGY *Index*.

SNAKE, in *Zoology*. See ANGUIS and SERPENS, OPHIOLOGY *Index*.

SNAKE-Stones, *Ammonitæ*, in *Natural Hiſtory*, the name of a large genus of foſſil ſhells, very few if any of which are yet known in their recent ſtate, or living either on our own or any other ſhores; ſo that it ſeems wonderful whence ſo vaſt a number and variety of them ſhould be brought into our ſubterranean regions. They ſeem indeed diſperſed in great plenty throughout the world, but nowhere are found in greater numbers, beauty, and variety, than in our iſland.

Mr Harenberg found prodigious numbers of them on the banks of a river in Germany. He traced this river through its ſeveral windings for many miles, and among a great variety of belemnitæ, cornua ammonis, and cochlitæ, of various kinds; he found alſo great quantities of wood of recent petrifaction, which ſtill preſerved plain marks of the axe by which it had been cut from the trees then growing on the ſhore. The water of this river he found in dry ſeaſons, when its natural ſprings were not diluted with rains, to be conſiderably heavier than common water; and many experiments ſhowed him that it contained ferruginous, as well as ſtony particles, in great quantity, whence the petrifactions in it appeared the leſs wonderful, though many of them of recent date.

Of the cornua ammonis, or ſerpent-ſtones, he there obſerved more than 30 different ſpecies. They lie immerſed in a bluiſh foſſil ſtone, of a ſoft texture and fatty appearance, in prodigious numbers, and of a great variety of ſizes, from the larger known ſorts down to ſuch as could not be ſeen without very accurate inſpection or the aſſiſtance of a microſcope. Such as lie in the ſofteſt of theſe ſtones are ſoft like their matrix, and eaſily crumble to pieces; others are harder. In a piece of this ſtone, of the bigneſs of a finger, it is common to find 30 or more of theſe foſſils; and often they are ſeen only in form of white ſpecks, ſo minute that their figure cannot be diſtinguiſhed till examined by the microſcope.

They all conſiſt of ſeveral volutæ, which are different in number in the different ſpecies, and their ſtriæ alſo are extremely various; ſome very deep with very high ridges between them, others very ſlight; ſome ſtraight, others crooked; others undulated, and ſome terminating in dots, tubercles, or cavities, towards the back, and others having tubercles in two or three places. They are all compoſed of a great number of chambers or cells, in the manner of the *nautilus Græcorum*, each having a communication with the others, by means of a pipe or ſiphunculus. There is a ſmall white ſhell fiſh of Barbadoes, which ſeems truly a recent animal of this genus; and in the Eaſt Indies there is another alſo, ſmall and grayiſh; but the large and beautifully marked ones are found only foſſil.

They are compoſed of various foſſil bodies, often of quarry ſtone, ſometimes of the matter of the common pyrites, and of a great variety of other ſubſtances; and though they appear uſually mere ſtones, yet in ſome the pearly part of the original ſhell is preſerved in all its beauty. Sometimes alſo, while the outer ſubſtance is of the matter of the pyrites, or other coarſe, ſtony, or mineral matter, the inner cavity is filled with a pure white ſpar of the common plated texture. This gives a great beauty to the ſpecimen. The cornua ammonis, or ſnake-ſtones, are found in many parts of England, particularly in Yorkſhire, where they are very plentiful in the alum rocks of ſeveral ſizes.

SNAKE-Root. See POLYGALA, BOTANY *Index*.

SNAKE-Weed. See POLYGONUM, BOTANY *Index*.

SNAPEDRAGON. See ANTIRRHINUM, BOTANY *Index*.

SNEEZING, a convulſive motion of the muſcles of the breaſt, whereby the air is expelled from the noſe with much vehemence and noiſe. It is cauſed by the irritation of the upper membrane of the noſe, occaſioned by acrid ſubſtances floating in the air, or by medicines called *ſternutatory*.

This irritation is performed either externally, by ſtrong ſmells, as marjoram, roſes, &c. or by duſt floating in the air, and taken in by inſpiration; or by ſharp pungent medicines, as creſſes and other ſternutatories, which vellicate the membrane of the noſe; or internally, by the acrimony of the lympha or mucus, which naturally moiſtens that membrane. The matters caſt forth in ſneezing come primarily from the noſe and throat; the pituitary membrane continually exuding a mucus thither; and, ſecondarily, from the breaſt, the trachea, and the bronchia of the lungs.

The practice of ſaluting the perſon who ſneezed exiſted in Africa, among nations unknown to the Greeks and Romans. The accounts we have of Monomotapa inform us *, that when the prince ſneezes, all his ſubjects in the capital are advertiſed of it, that they may offer up prayers for his ſafety. The author of the conqueſt of Peru aſſures us, that the cacique of Guachoia having ſneezed in preſence of the Spaniards, the Indians of his train fell proſtrate before him, ſtretched forth their hands, and diſplayed to him the accuſtomed marks of reſpect, while they invoked the ſun to enlighten him, to defend him, and to be his conſtant guard.

Every body knows that the Romans ſaluted each other on theſe occaſions: and Pliny relates †, that Tiberius exacted theſe ſigns of homage when drawn in his chariot. Superſtition, whoſe influence can debaſe every thing, had degraded this cuſtom for ſeveral ages, by attaching favourable or unfavourable omens to ſneezing according to the hour of the day or night, according to the ſigns of the zodiac, according as a work was more or leſs advanced, or according as one had ſneezed to the right or to the left ‡. If a man ſneezed at riſing from table or from his bed, it was neceſſary for him to ſit or lie down again. You are ſtruck with aſtoniſhment, ſaid Timotheus to the Athenians, who wiſhed to return into the harbour with their fleet §, becauſe he had ſneezed; you are ſtruck with aſtoniſhment, becauſe among 10,000 there is one man whoſe brain is moiſt.

Polydore Virgil pretends, that in the time of Gregory the Great, there reigned in Italy an epidemic diſtemper, which carried off by ſneezing all thoſe who were ſeized by it; and that this pontiff ordered prayers to be made againſt it, accompanied by certain ſigns of the croſs. But beſides that, there are very few caſes in which ſneezing can be conſidered as dangerous, and that it is frequently a favourable ſymptom ||: it is evident, that we ought not to date from the ſixth century the origin of a cuſtom which loſes itſelf in the obſcurity of antiquity. Avicenna and Cardan ſay, it is a ſort of convulſion, which gives occaſion to dread an epilepſy, and that

* *Strada, Prol. Acad.*

† *Plin. Hiſt. Nat.* lib. ii. cap. 2.

‡ *Spond. Homeri Comment.*

§ *Frontin.* lib. i. cap. 11.

|| *Hippocrat. Halleri Phyſ.*

Sneezing.

that this disease is endeavoured to be warded off by prayers. Clement of Alexandria considers it as a mark of intemperance and effeminacy, which ought to be proscribed. And he inveighs bitterly against those who endeavour to procure sneezing by external aid. Montaigne, on the contrary, explains this fact in a tone rather cynical. It is singular enough, that so many ridiculous, contradictory, and superstitious opinions, have not abolished those customary civilities which are still preserved equally among high and low; and which only the Anabaptists and Quakers have rejected, because they have renounced salutations in every case.

Among the Greeks sneezing was almost always a good omen. It excited marks of tenderness, of respect, and attachment. The genius of Socrates informed him by sneezing, when it was necessary to perform any action *. The young Parthenis, hurried on by her passion, resolved to write to Sarpedon an avowal of her love †; she sneezes in the most tender and impassioned part of her letter: This is sufficient for her; this incident supplies the place of an answer, and persuades her that Sarpedon is her lover. Penelope, harassed by the vexatious courtship of her suitors, begins to curse them all, and to pour forth vows for the return of Ulysses ‡. Her son Telemachus interrupts her by a loud sneeze. She instantly exults with joy, and regards this sign as an assurance of the approaching return of her husband. Xenophon was haranguing his troops; a soldier sneezed in the moment when he was exhorting them to embrace a dangerous but necessary resolution. The whole army, moved by this presage, determine to pursue the project of their general; and Xenophon orders sacrifices to Jupiter the preserver §.

* *Plutarch de gen. Socrat.*
† *Aristenæt.*
‡ *Homeri Odyss.* lib. xvii.
§ *Xenoph. Anab.*

This religious reverence for sneezing, so ancient and so universal even in the times of Homer, always excited the curiosity of the Greek philosophers and of the rabbins. These last have spread a tradition, that, after the creation of the world, God made a general law to this purport, that every living man should sneeze but once in his life, and that at the same instant he should render up his soul into the hand of his Creator ||, without any preceding indisposition. Jacob obtained an exemption from the common law, and the favour of being informed of his last hour: He sneezed and did not die; and this sign of death was changed into a sign of life. Notice of this was sent to all the princes of the earth; and they ordained, that in future sneezing should be accompanied with forms of blessing, and vows for the persons who sneezed.

|| *Acad. des Inscrip.* vol. iv.

Aristotle remounts likewise to the sources of natural religion. He observes, that the brain is the origin of the nerves, of our sentiments, our sensations, the seat of the soul, the image of the Divinity *; that upon all these accounts, the substance of the brain has ever been held in honour; that the first men swore by their head; that they durst not touch nor eat the brains of any animal; that it was even a sacred word which they dared not to pronounce. Filled with these ideas, it is not wonderful that they extended their reverence even to sneezing. Such is the opinion of the most ancient and sagacious philosophers of Greece.

* *Aristot. in Prob.*

According to mythology, the first sign of life Prometheus's artificial man gave was by sternutation. This supposed creator is said to have stolen a portion of the solar rays; and filling with them a phial, which he had made on purpose, sealed it up hermetically. He instantly flies back to his favourite automaton, and opening the phial holds it close to the statue; the rays still retaining all their activity, insinuate themselves through the pores, and set the fictitious man a sneezing. Prometheus, transported with the success of his machine, offers up a fervent prayer, with wishes for the preservation of so singular a being. His automaton observed him, remembering his ejaculations, was very careful, on the like occasions, to offer these wishes in behalf of his descendants, who perpetuated it from father to son in all their colonies.

Sneezing || Snoring.

SNIGGLING, a method of fishing for eels, chiefly used in the day-time, when they are found to hide themselves near wears, mills, or flood-gates. It is performed thus: Take a strong line and hook, baited with a garden-worm, and observing the holes where the eels lie hid, thrust your bait into them by the help of a stick; and if there be any, you shall be sure to have a bite; and may, if your tackling hold, get the largest eels.

SNIPE, in *Ornithology*. See SCOLOPAX and SHOOTING.

SNORING, in *Medicine*, otherwise called *stertor*, is a sound like that of the cerchnon, but greater and more manifest.

Many confound those affections, and make them to differ only in place and magnitude, calling by the name of *stertor* that sound or noise which is heard or supposed to be made in the passage between the palate and the nostrils as in those who sleep; that boiling or bubbling noise, which in respiration proceeds from the larynx or head, or orifice of the aspera arteria, they call *cerchon*; but if the sound comes from the aspera arteria itself, it is called *cerchnos*, that is, as some understand it, a rattling, or as others a stridulous or wheezing roughness of the aspera arteria. In dying persons this affection is called by the Greeks ῥεγχος, *rhenchos*, which is a snoring or rattling kind of noise, proceeding as it were from a conflict between the breath and the humours in the aspera arteria.

This and such like affections are owing to a weakness of nature, as when the lungs are full of pus or humours: to which purpose we read in the Prognostics of Hippocrates, "it is a bad sign when there is no expectoration, and no discharge from the lungs, but a noise as from an ebullition is heard in the aspera arteria from a plenitude of humour." Expectoration is suppressed either by the viscidity of the humour, which requires to be discharged, and which adhering to the aspera arteria, and being there agitated by the breath, excites that bubbling noise or stertor; or by an obstruction of the bronchia; or, lastly, by a compression of the aspera arteria and throat, whence the passage is straitened, in which the humours being agitated, excite such a kind of noise as before described. Hence Galen calls those who are strait-breasted *stertorous*. That author assigns but two causes of this symptom, which are either the straitness of the passage of respiration or redundance of humours, or both together; but it is necessary to add a third, to wit, the weakness of the faculty, which is the cause of the rhenchos in dying persons, where nature is too weak to make discharges.

From what has been said we conclude, that this symptom, or this sort of fervour or ebullition in the throat, Snoring. throat, is not always mortal, but only when nature is oppressed with the redundance of humour, in such a manner, that the lungs cannot discharge themselves by spitting; or the passage appointed for the breath (being the aspera arteria) is very much obstructed, upon which account many dying persons labour under a stertor with their mouths gaping.

SNOW, a well known meteor, formed by the freezing of the vapour of water in the atmosphere. It differs from hail and hoar-frost, in being as it were crystallized, which they are not. This appears on examining a flake of snow by a magnifying glass; when the whole of it will appear to be composed of fine shining spicula diverging like rays from a centre. As the flakes fall down through the atmosphere, they are continually joined by more of these radiated spicula, and thus increase in bulk like the drops of rain or hailstones. Dr Grew, in a discourse of the nature of snow, observes, that many parts thereof are of a regular figure, for the most part stars of six points, and are as perfect and transparent ice as any we see on a pond, &c. Upon each of these points are other collateral points, set at the same angles as the main points themselves: among which there are divers other irregular, which are chiefly broken points, and fragments of the regular ones. Others also, by various winds, seem to have been thawed and frozen again into irregular clusters; so that it seems as if the whole body of snow were an infinite mass of icicles irregularly figured. That is, a cloud of vapours being gathered into drops, the said drops forthwith descend; upon which descent, meeting with a freezing air as they pass through a colder region, each drop is immediately frozen into an icicle, shooting itself forth into several points; but these still continuing their descent, and meeting with some intermitting gales of warmer air, or in their continual waftage to and fro touching upon each other, some of them are a little thawed, blunted, and again frozen into clusters, or entangled so as to fall down in what we call *flakes*.

The lightness of snow, although it is firm ice, is owing to the excess of its surface, in comparison to the matter contained under it; as gold itself may be extended in surface till it ride upon the least breath of air.

The whiteness of snow is owing to the small particles into which it is divided; for ice, when pounded, will become equally white. An artificial snow has been made by the following experiment. A tall phial of aquafortis being placed by the fire till it is warm, and filings of pure silver, a few at a time, being put into it; after a brisk ebullition, the silver will dissolve slowly. The phial being then placed in a cold window, as it cools the silver particles will shoot into crystals, several of which running together will form a flake of snow, which will descend to the bottom of the phial. While they are descending, they represent perfectly a shower of silver snow, and the flakes will lie upon one another at the bottom, like real snow upon the ground.

According to Signior Beccaria, clouds of snow differ in nothing from clouds of rain, but in the circumstance of cold that freezes them. Both the regular diffusion of the snow, and the regularity of the structure of its parts (particularly some figures of snow or hail which fall about Turin, and which he calls *rosette*), show that clouds of snow are acted upon by some uniform cause like electricity; and he endeavours to show how electricity is capable of forming these figures. He was confirmed in his conjectures by observing, that his apparatus for observing the electricity of the atmosphere never failed to be electrified by snow as well as rain. Professor Winthrop sometimes found his apparatus electrified by snow when driven about by the wind, though it had not been affected by it when the snow itself was falling. A more intense electricity, according to Beccaria, unites the particles of hail more closely than the more moderate electricity does those of snow, in the same manner as we see that the drops of rain which fall from thunder-clouds are larger than those which fall from others, though the former descend through a less space.

But we are not to consider snow merely as a curious and beautiful phenomenon. The Great Dispenser of universal bounty has so ordered it, that it is eminently subservient, as well as all the works of creation, to his benevolent designs. Were we to judge from appearances only, we might imagine, that so far from being useful to the earth, the cold humidity of snow would be detrimental to vegetation. But the experience of all ages asserts the contrary. Snow, particularly in those northern regions where the ground is covered with it for several months, fructifies the earth, by guarding the corn or other vegetables from the intenser cold of the air, and especially from the cold piercing winds. It has been a vulgar opinion, very generally received, that snow fertilizes the lands on which it falls more than rain, in consequence of the nitrous salts which it is supposed to acquire by freezing. But it appears from the experiments of Margraaf, in the year 1751, that the chemical difference between rain and snow water is exceedingly small; that the latter contains a less proportion of earth than the former; but neither of them contain either earth or any kind of salt in any quantity which can be sensibly efficacious in promoting vegetation. Allowing, therefore, that nitre is a fertilizer of lands, which many are upon good grounds disposed utterly to deny, yet so very small is the quantity of it contained in snow, that it cannot be supposed to promote the vegetation of plants upon which the snow has fallen. The peculiar agency of snow, as a fertilizer in preference to rain, may admit of a very rational explanation, without recurring to nitrous salts supposed to be contained in it. It may be rationally ascribed to its furnishing a covering to the roots of vegetables, by which they are guarded from the influence of the atmospheric cold, and the internal heat of the earth is prevented from escaping.

The internal part of the earth, by some principle which we do not understand, is heated uniformly to the 48th degree of Fahrenheit's thermometer. This degree of heat is greater than that in which the watery juices of vegetables freeze, and it is propagated from the inward parts of the earth to the surface, on which the vegetables grow. The atmosphere being variably heated by the action of the sun in different climates, and in the same climate at different seasons, communicates to the surface of the earth and to some distance below it the degree of heat or cold which prevails in itself. Different vegetables are able to preserve life under different degrees of cold, but all of them perish when the cold which reaches their roots is extreme. Providence has therefore, in the coldest climates, provided a covering of

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of ſnow for the roots of vegetables, by which they are protected from the influence of the atmoſpherical cold. The ſnow keeps in the internal heat of the earth, which ſurrounds the roots of vegetables, and defends them from the cold of the atmoſphere.

Snow or ice water is always deprived of its fixed air, which eſcapes during the proceſs of congelation. Accordingly, as ſome of the inhabitants of the Alps who uſe it for their conſtant drink have enormous wens upon their throats, it has been aſcribed to this circumſtance. If this were the cauſe of theſe wens, it would be eaſy to remove it by expoſing the ſnow-water to the air for ſome time. But ſeveral eminent phyſicians have rejected the notion that ſnow-water is the cauſe of theſe wens; for in Greenland, where ſnow-water is commonly uſed, the inhabitants are not affected with ſuch ſwellings: on the other hand, they are common in Sumatra where ſnow is never ſeen.

Snow, in ſea-affairs, is generally the largeſt of all two-maſted veſſels employed by Europeans, and the moſt convenient for navigation.

The ſails and rigging on the mainmaſt and foremaſt of a ſnow are exactly ſimilar to thoſe on the ſame maſts in a ſhip; only that there is a ſmall maſt behind the mainmaſt of the former, which carries a ſail nearly reſembling the mizen of a ſhip. The root of the maſt is fixed on a block of wood on the quarter-deck abaft the mainmaſt; and the head of it is attached to the after-top of the maintop. The ſail which is called the *try-ſail* is extended from its maſt towards the ſtern of the veſſel.

When the ſloops of war are rigged as ſnows, they are furniſhed with a horſe, which anſwers the purpoſe of the tryſail-maſt, the fore-part of the ſail being attached by rings to the ſaid horſe, in different parts of its height.

SNOW-Grotto, an excavation made by the waters on the ſide of Mount Etna, by making their way under the layers of lava, and by carrying away the bed of pozzolana below them. It occurred to the proprietor, that this place was very ſuitable for a magazine of ſnow: for in Sicily, at Naples, and particularly at Malta, they are obliged for want of ice to make uſe of ſnow for cooling their wine, ſherbet, and other liquors, and for making ſweetmeats.

This grotto was hired or bought by the knights of Malta, who having neither ice nor ſnow on the burning rock which they inhabit, have hired ſeveral caverns on Etna, into which people whom they employ collect and preſerve quantities of ſnow to be ſent to Malta when needed. The grotto has therefore been repaired within at the expence of that order; flights of ſteps are cut into it, as well as two openings from above, by which they throw in the ſnow, and through which the grotto is enlightened. Above the grotto they have alſo levelled a piece of ground of conſiderable extent: this they have incloſed with thick and lofty walls, ſo that when the winds, which at this elevation blow with great violence, carry the ſnow from the higher parts of the mountains, and depoſit it in the incloſure, it is retained and amaſſed by the walls. The people then remove it into the grotto through the two openings; and it is there laid up, and preſerved in ſuch a manner as to reſiſt the force of the ſummer heats; as the layers of lava with which the grotto is arched above prevent them from making any impreſſion.

Snow, Snowdon-Hill.

When the ſeaſon for exporting the ſnow comes on, it is put into large bags, into which it is preſſed as cloſely as poſſible; it is then carried by men out of the grotto, and laid upon mules, which convey it to the ſhore, where ſmall veſſels are waiting to carry it away.

But before thoſe lumps of ſnow are put into bags, they are wrapped in freſh leaves; ſo that while they are conveyed from the grotto to the ſhore, the leaves may prevent the rays of the ſun from making any impreſſion upon them.

The Sicilians carry on a conſiderable trade in ſnow, which affords employment to ſome thouſands of mules, horſes, and men. They have magazines of it on the ſummits of their loftieſt mountains, from which they diſtribute it through all their cities, towns, and houſes; for every perſon in the iſland makes uſe of ſnow. They conſider the practice of cooling their liquors as abſolutely neceſſary for the preſervation of health; and in a climate the heat of which is conſtantly relaxing the fibres, cooling liquors, by communicating a proper tone to the fibres of the ſtomach, muſt greatly ſtrengthen them for the performance of their functions.

In this climate a ſcarcity of ſnow is no leſs dreaded than a ſcarcity of corn, wine, or oil. We are informed by a gentleman who was at Syracuſe in the year 1777, when there was a ſcarcity of ſnow, the people of the town learned that a ſmall veſſel loaded with that article was paſſing the coaſt: without a moment's deliberation they ran in a body to the ſhore, and demanded her cargo; which when the crew refuſed to deliver up, the Syracuſans attacked and took, though with the loſs of ſeveral men.

SNOW-Drop. See CHIONANTHUS, BOTANY *Index*.

SNOWDON HILL, the name of a mountain in Caernarvon-ſhire in Wales, generally thought to be the higheſt in Britain; though ſome have been of opinion that its height is equalled, or even exceeded, by mountains in the Highlands of Scotland. The mountain is ſurrounded by many others, called in the Welſh language *Crib Coch*, *Crib y Diſtill*, *Lliwedd yr Arran*, &c.

According to Mr Pennant *, this mountainous tract yields ſcarcely any corn. Its produce is cattle and ſheep; which, during ſummer, keep very high in the mountains, followed by their owners with their families, who reſide during that ſeaſon in *havodtys*, or "ſummer dairy-houſes," as the farmers in the Swiſs Alps do in their *ſennes*. Theſe houſes conſiſt of a long low room, with a hole at one end to let out the ſmoke from the fire which is made beneath. Their furniture is very ſimple; ſtones are ſubſtituted for ſtools, and their beds are of hay, ranged along the ſides. They manufacture their own clothes, and dye them with the *lichen omphaloides* and *lichen parietinus*, moſſes collected from the rocks. During ſummer the men paſs their time in tending their herds or in making hay, &c. and the women in milking or in making butter and cheeſe. For their own uſe they milk both ewes and goats, and make cheeſe of the milk. Their diet conſiſts of milk, cheeſe, and butter; and their ordinary drink is whey; though they have, by way of reſerve, a few bottles of very ſtrong beer, which they uſe as a cordial when ſick. They are people of good underſtanding, wary, and circumſpect; tall, thin,

* *Journey to Snowdon.*

Snowdon-Hill.

thin, and of ſtrong conſtitutions. In the winter-time they deſcend into the *hen dref*, or "old dwelling," where they paſs their time in inactivity.

The view from the higheſt peak of Snowdon is very extenſive. From it Mr Pennant ſaw the county of Cheſter, the high hills of Yorkſhire, part of the north of England, Scotland, and Ireland; a plain view of the iſle of Man; and that of Angleſea appeared like a map extended under his feet, with every rivulet viſible. Our author took much pains to have this view to advantage; ſat up at a farm on the weſt till about 12, and walked up the whole way. The night was remarkably fine and ſtarry; towards morning the ſtars faded away, leaving an interval of darkneſs, which, however, was ſoon diſpelled by the dawn of day. The body of the ſun appeared moſt diſtinct, with the roundneſs of the moon, before it appeared too brilliant to be looked at. The ſea, which bounded the weſtern part of the proſpect, appeared gilt with the ſun-beams, firſt in ſlender ſtreaks, and at length glowed with redneſs. The proſpect was diſcloſed like the gradual drawing up of a curtain in a theatre; till at laſt the heat became ſufficiently ſtrong to raiſe miſts from the various lakes, which in a ſlight degree obſcured the proſpect. The ſhadow of the mountain extended many miles, and ſhowed its bicapitated form; the Wyddfa making one head, and Crib y Diſtill the other. At this time he counted between 20 and 30 lakes either in Caernarvon or in Merionethſhire. In making another viſit, the ſky was obſcured very ſoon after he got up. A vaſt miſt involved the whole circuit of the mountain, and the proſpect down was horrible. It gave an idea of numbers of abyſſes, concealed by a thick ſmoke furiouſly circulating around them. Very often a guſt of wind made an opening in the clouds, which gave a fine and diſtinct viſta of lake and valley. Sometimes they opened in one place, at others in many at once; exhibiting a moſt ſtrange and perplexing ſight of water, fields, rocks, and chaſms. They then cloſed again, and every thing was involved in darkneſs; in a few minutes they would ſeparate again, and repeat the above-mentioned ſcene with infinite variety. From this proſpect our traveller deſcended with great reluctance; but before he had reached the place where his horſes were left, he was overtaken by a thunder ſtorm. The rolling of the thunder-claps, being reiterated by the mountains, was inexpreſſibly awful; and after he had mounted, he was in great danger of being ſwept away by the torrents which poured down in conſequence of a very heavy rain.

It is very rare (Mr Pennant obſerves) that the traveller gets a proper day to aſcend this hill: it indeed often appears clear; but by the evident attraction of the clouds by this lofty mountain, it becomes ſuddenly and unexpectedly enveloped in miſt, when the clouds have juſt before appeared very high and very remote. At times he obſerved them lower to half their height; and notwithſtanding they have been diſperſed to the right and left, yet they have met from both ſides, and united to involve the ſummit in one great obſcurity.

The height of Snowdon was meaſured, in 1682, by Mr Caſwell, with inſtruments made by Flamſtead: according to his menſuration, the height is 3720 feet; but more modern computations make it only 3568, reckoning from the quay at Caernarvon to the higheſt peak. The ſtone that compoſes this mountain is exceſſively hard. Large coarſe cryſtals, and frequently cubic pyrites, are found in the fiſſures. An immenſe quantity of water ruſhes down the ſides of Snowdon and the neighbouring mountains, inſomuch that Mr Pennant ſuppoſes, if collected into one ſtream, they would exceed the waters of the Thames.

Snowdon-Hill ‖ Soap.

SNUFF, a powder chiefly made of tobacco, the uſe of which is too well known to need any deſcription here.

Tobacco is uſually the baſis of ſnuff; other matters being only added to give it a more agreeable ſcent, &c. The kinds of ſnuff, and their ſeveral names, are infinite, and new ones are daily invented; ſo that it would be difficult, not to ſay impoſſible, to give a detail of them. We ſhall only ſay, that there are three principal ſorts: the firſt granulated; the ſecond an impalpable powder; and the third the bran, or coarſe part remaining after ſifting the ſecond ſort.

"Every profeſſed, inveterate, and incurable ſnuff-taker (ſays Lord Stanhope), at a moderate computation, takes one pinch in ten minutes. Every pinch, with the agreeable ceremony of blowing and wiping the noſe and other incidental circumſtances, conſumes a minute and a half. One minute and a half out of every ten, allowing 16 hours to a ſnuff-taking day, amounts to two hours and 24 minutes out of every natural day, or one day out of every ten. One day out of every 10 amounts to 36 days and a half in a year. Hence if we ſuppoſe the practice to be perſiſted in 40 years, two entire years of the ſnuff-taker's life will be dedicated to tickling his noſe, and two more to blowing it. The expence of ſnuff, ſnuff boxes, and handkerchiefs, will be the ſubject of a ſecond eſſay; in which it will appear, that this luxury encroaches as much on the income of the ſnuff taker as it does on his time; and that by a proper application of the time and money thus loſt to the public, a fund might be conſtituted for the diſcharge of the national debt." See Nicotiana.

SNYDERS, Francis, a Flemiſh painter, born at Antwerp in 1579, and bred under his countryman Henry Van Balen. His genius firſt diſplayed itſelf in painting fruit: he afterwards attempted animals, huntings, &c. in which he exceeded all his predeceſſors. He alſo painted kitchens, &c. and gave dignity to ſubjects that ſeemed incapable of it. He was made painter to Ferdinand and Iſabella, archduke and dutcheſs, and became attached to the houſe of the cardinal infant of Spain. The king of Spain and the elector Palatine adorned their palaces with huntings by this artiſt. Rubens, Jordaens, and Snyders, uſed to co-operate in the enriching of each other's pictures according to their ſeveral talents; and thus they became more valuable than if finiſhed by either of them ſingly. Snyders died in 1657.

SOAL-fish. See Pleuronectes, Ichthyology *Index*.

SOAP, a compoſition of cauſtic, fixed alkaline ſalt, and oil, ſometimes hard and dry, ſometimes ſoft and liquid; much uſed in waſhing, whitening linens, and by dyers and fullers.—Soap may be made by ſeveral methods, which, however, all depend upon the ſame principle. The ſoap which is uſed in medicine is made without heat.

In manufactures where large quantities of it are prepared, ſoap is made with heat. A lixivium of quicklime

and

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and soda is made, but is less concentrated than that above referred to, and only so much that it can sustain a fresh egg. A part of this lixivium is to be even diluted and mixed with an equal weight of oil of olives. The mixture is to be put on a gentle fire, and agitated, that the union may be accelerated. When the mixture begins to unite well, the rest of the lixivium is to be added to it; and the whole is to be digested with a very gentle heat, till the soap be completely made. A trial is to be made of it, to examine whether the just proportion of oil and alkali has been observed. Good soap of this kind ought to be firm, and very white when cold; not subject to become moist by exposure to air, and entirely miscible with pure water, to which it communicates a milky appearance, but without any drops of oil floating on the surface. When the soap has not these qualities, the combination has not been well made, or the quantity of salt or oil is too great, which faults must be corrected.

In soft or liquid soaps, green or black soaps, cheaper oils are employed, as oil of nuts, of hemp, of fish, &c. These soaps, excepting in consistence, are not essentially different from white soap.

Fixed alkalies are much disposed to unite with oils that are not volatile, both vegetable and animal, since this union can be made even without heat. The compound resulting from this union partakes at the same time of the properties of oil and of alkali; but these properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into soap has not nearly the same acrimony as when it is pure; it is even deprived of almost all its causticity, and its other saline alkaline properties are almost entirely abolished. The same oil contained in soap is less combustible than when pure, from its union with the alkali, which is an uninflammable body. It is miscible, or even soluble, in water, to a certain degree, by means of the alkali. Soap is entirely soluble in spirit of wine; and still better in aquavitæ sharpened by a little alkaline salt, according to an observation of Mr Geoffroy.

The manufacture of soap in London first began in the year 1524; before which time this city was served with white soap from foreign countries, and with gray soap speckled with white from Bristol, which was sold for a penny a pound; and also with black soap, which sold for a halfpenny the pound.

The principal soaps of our own manufacture are the soft, the hard, and the ball soap. The soft soap is either white or green. The process of making each of these shall now be described.

Green soft soap. The chief ingredients used in making this are lees drawn from pot-ash and lime, boiled up with tallow and oil. First, the ley of a proper degree of strength (which must be estimated by the weight of the liquor), and tallow, are put into the copper together, and as soon as they boil up the oil is added; the fire is then damped or stopped up, while the ingredients remain in the copper to unite; when they are united, the copper is again made to boil, being fed or filled with lees as it boils, till there be a sufficient quantity put into it; then it is boiled off and put into casks. When this soap is first made it appears uniform; but in about a week's time the tallow separates from the oil into those white grains which we see in common soap. Soap thus made would appear yellow, but by a mixture of indigo added at the end of the boiling, it is rendered green, that being the colour which results from the mixture of yellow and blue.

White soap. Of this one sort is made after the same manner as green soft soap, oil alone excepted, which is not used in white. The other sort of white soft soap is made from the lees of ashes of lime boiled up two different times with tallow. First, a quantity of lees and tallow are put into the copper together, and kept boiling, being fed with lees as they boil, until the whole is boiled sufficiently; then the lees are separated or discharged from the tallowish part, which part is removed into a tub, and the lees are thrown away; this is called the *first half-boil:* then the copper is filled again with fresh tallow and lees, and the first half-boil is put out of the tub into the copper a second time, where it is kept boiling with fresh lees and tallow till the soap is produced. It is then put out of the copper into the same sort of casks as are used for green soft soap. The common soft soap used about London, generally of a greenish hue, with some white lumps, is prepared chiefly with tallow: a blackish sort, more common in some other places, is said to be made with whale oil.

Hard soap is made with lees from ashes and tallow, and is most commonly boiled twice: the first, called the *half-boil*, hath the same operation as the first half-boil of soft white soap. Then the copper is charged with fresh lees again, and the first half boil put into it, where it is kept boiling, and fed with lees as it boils, till it grains or is boiled enough: then the ley is discharged from it, and the soap put into a frame to cool and harden. Common salt is made use of for the purpose of graining the soap; for when the oil or tallow has been united with the ley, after a little boiling, a quantity of salt is thrown into the mass, which dissolving readily in water, but not in the oil or tallow, draws out the water in a considerable degree, so that the oil or tallow united with the salt of the ley swims on the top. When the ley is of a proper strength, less salt is necessary to raise the curd than when it is too weak. It must be observed, that there is no certain time for bringing off a boiling of any of these sorts of soap: it frequently takes up part of two days.

Ball soap, commonly used in the north, is made with lees from ashes and tallow. The lees are put into the copper, and boiled till the watery part is quite gone, and there remains nothing in the copper but a sort of saline matter (the very strength or essence of the ley); to this the tallow is put, and the copper is kept boiling and stirring for above half an hour, in which time the soap is made; and then it is put out of the copper into tubs or baskets with sheets in them, and immediately (whilst soft) made into balls. It requires near 24 hours in this process to boil away the watery part of the ley.

When oil unites with alkali in the formation of soap, it is little altered in the connection of its principles; for it may be separated from the alkali by decomposing soap with any acid, and may be obtained nearly in its original state.

Concerning the decomposition of soap by means of acids, we must observe, first, that all acids, even the weakest vegetable acids, may occasion this decomposition, because every one of them has a greater affinity than

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than oil with fixed alkali. Secondly, these acids, even when united with any basis, excepting fixed alkali, are capable of occasioning the same decomposition; whence all ammoniacal salts, all salts with bases of earth, and all those with metallic bases, are capable of decomposing soap, in the same manner as disengaged acids are; with this difference, that the oil separated from the fixed alkali, by the acid of these salts, may unite more or less intimately with the substance which was the basis of the neutral salt employed for the decomposition.

Soap may also be decomposed by distillation, as Lemery has done. When first exposed to fire, it yields a phlegm called by him a *spirit;* which nevertheless is neither acid nor alkaline, but some water which enters into the composition of soap. It becomes more and more coloured and empyreumatic as the fire is increased, which shows that it contains the most subtle part of the oil. It seems even to raise along with it, by help of the oil and action of the fire, a small part of the alkali of the soap: for as the same chemist observes, it occasions a precipitate in a solution of corrosive sublimate. After this phlegm the oil rises altered, precisely as if it had been distilled from quicklime, that is, empyreumatic, soluble in spirit of wine, at first sufficiently subtle and afterwards thicker. An alkaline residuous coal remains in the retort, consisting chiefly of the mineral alkali contained in the soap, and which may be disengaged from the coal by calcination in an open fire, and obtained in its pure state.

Alkaline soaps are very useful in many arts and trades, and also in chemistry and medicine. Their principal utility consists in a detersive quality that they receive from their alkali, which, although it is in some measure saturated with oil, is yet capable of acting upon oily matters, and of rendering them saponaceous and miscible with water. Hence soap is very useful to cleanse any substances from all fat matters with which they happen to be soiled. Soap is therefore daily used for the washing and whitening of linen, for the cleansing of woollen-cloths from oil, and for whitening silk and freeing it from the resinous varnish with which it is naturally covered. Pure alkaline lixiviums being capable of dissolving oils more effectually than soap, might be employed for the same purposes; but when this activity is not mitigated by oil, as it is in soap, they are capable of altering, and even of destroying entirely by their causticity, most substances, especially animal matters, as silk, wool, and others: whereas soap cleanses from oil almost as effectually as pure alkali, without danger of altering or destroying; which renders it very useful.

Woodville's Medical Botany, p. 390.

Soap was imperfectly known to the ancients. It is mentioned by Pliny as made of fat and ashes, and as an invention of the Gauls. Aretæus and others informs us, that the Greeks obtained their knowledge of its medical use from the Romans. Its virtues, according to Bergius, are detergent, resolvent, and aperient, and its use recommended in jaundice, gout, calculous complaints, and in obstructions of the viscera. The efficacy of soap in the first of these diseases was experienced by Sylvius, and since recommended very generally by various authors who have written on this complaint; and it has also been thought of use in supplying the place of bile in the primæ viæ. The utility of this medicine in icterical cases was inferred chiefly from its supposed power of dissolving biliary concretions; but this medicine has lost much of its reputation in jaundice, since it is now known that gall-stones have been found in many after death who had been daily taking soap for several months and even years. Of its good effects in urinary calculous affections, we have the testimony of several, especially when dissolved in lime-water, by which its efficacy is considerably increased; for it thus becomes a powerful solvent of mucus, which an ingenious modern author supposes to be the chief agent in the formation of calculi; it is, however, only in the incipient state of the disease that these remedies promise effectual benefit; though they generally abate the more violent symptoms where they cannot remove the cause. With Boerhaave soap was a general medicine: for as he attributed most complaints to viscidity of the fluids, he, and most of the Boerhaavian school, prescribed it in conjunction with different resinous and other substances, in gout, rheumatism, and various visceral complaints. Soap is also externally employed as a resolvent, and gives name to several officinal preparations.

From the properties of soap we may know that it must be a very effectual and convenient anti-acid. It absorbs acids as powerfully as pure alkalies and absorbent earths, without having the causticity of the former, and without oppressing the stomach by its weight like the latter.

Lastly, we may perceive that soap must be one of the best of all antidotes to stop quickly, and with the least inconvenience, the bad effects of acid corrosive poisons, as aquafortis, corrosive sublimate, &c.

Soap imported is subject by 10 Ann. cap. 19. to a duty of 2d. a pound (over and above former duties); and by 12 Ann. stat. 2. cap. 9. to the farther sum of 1d. a pound. And by the same acts, the duty on soap made in the kingdom is $1\frac{1}{2}$d. a pound. By 19 G. III. cap. 52. no person within the limits of the head office of excise in London shall be permitted to make any soap unless he occupy a tenement of 10l. a year, be assessed, and pay the parish rates; or elsewhere, unless he be assessed, and pay to church and poor. Places of making are to be entered on pain of 50l. and covers and locks to be provided under a forfeiture of 100l.; the furnace-door of every utensil used in the manufacture of soap shall be locked by the excise officer, as soon as the fire is damped or drawn out, and fastenings provided, under the penalty of 50l.; and opening or damaging such fastening incurs a penalty of 100l. Officers are required to enter and survey at all times, by day or night, and the penalty of obstructing is 20l.; and they may unlock and examine every copper, &c. between the hours of five in the morning and eleven in the evening, and the penalty of obstructing is 100l. Every maker of soap before he begins any making, if within the bills of mortality, shall give 12 hours, if elsewhere 24 hours, notice in writing to the officer, of the time when he intends to begin, on pain of 50l. No maker shall remove any soap unsurveyed on pain of 20l. without giving proper notice of his intention. And if any maker shall conceal any soap or materials, he shall forfeit the same, and also 500l. Every barrel of soap shall contain 256 lb. avoirdupois, half barrel 128 lb. firkin 64 lb. half-firkin 32 lb. besides the weight or tare of each cask: and all soap, excepting hard cake soap and ball soap, shall be put into such casks and no other, on pain of forfeiture, and 5l. The maker shall

weekly

Soap || Society.

weekly enter in writing at the next office the ſoap made by him in each week, with the weight and quantity at each boiling, on pain of 50l.; and within one week after entry clear off the duties, on pain of double duty. See, beſides the ſtatutes above cited, 5 Geo. III. cap. 43. 12 Geo III. cap. 46. 11 Geo. cap. 30. 1 Geo. ſtat. 2. cap. 36.

Acid SOAP. This is formed by the addition of concentrated acids to the expreſſed oils. Thus the oil is rendered partially ſoluble in water; but the union is not ſufficiently complete to anſwer any valuable purpoſe.

SOAP-Berry Tree. See SAPINDUS, BOTANY *Index*.

SOAP-Earth. See STEATITES, MINERALOGY *Index*.

SOAPWORT. See SAPONARIA, BOTANY *Index*.

SOC (Sax.), ſignifies power or liberty to miniſter juſtice or execute laws; alſo the circuit or territory wherein ſuch power is exerciſed. Whence our law-Latin word *ſocca* is uſed for a ſeigniory or lordſhip enfranchiſed by the king, with the liberty of holding or keeping a court of his *ſockmen*: And this kind of liberty continues in divers parts of England to this day, and is known by the names of *ſoke* and *ſoken*.

SOCAGE, in its moſt general and extenſive ſignification, ſeems to denote a tenure by any certain and determinate ſervice. And in this ſenſe it is by our ancient writers conſtantly put in oppoſition to chivalry or knight-ſervice, where the render was precarious and uncertain. The ſervice muſt therefore be certain, in order to denominate it ſocage; as to hold by fealty and 20s. rent; or, by homage, fealty, and 20s. rent; or, by homage and fealty without rent; or, by fealty and certain corporal ſervice, as ploughing the lord's land for three days; or, by fealty only without any other ſervice: for all theſe are tenures in ſocage.

Blackſt. Comment. vol. ii.

Socage is of two ſorts: *free*-ſocage, where the ſervices are not only certain but honourable; and *villein*-ſocage, where the ſervices, though certain, are of a baſer nature (ſee VILLENAGE). Such as hold by the former tenure are called, in Glanvil and other ſubſequent authors, by the name of *liberi ſokemanni*, or tenants in free-ſocage. The word is derived from the Saxon appellation *ſoc*, which ſignifies liberty or privilege; and, being joined to an uſual termination, is called *ſocage*, in Latin *ſocagium*; ſignifying thereby a free or privileged tenure.

It ſeems probable that the ſocage-tenures were the relics of Saxon liberty; retained by ſuch perſons as had neither forfeited them to the king, nor been obliged to exchange their tenure for the more honourable, as it was called, but at the ſame time more burthenſome, tenure of knight-ſervice. This is peculiarly remarkable in the tenure which prevails in Kent, called *gavelkind*, which is generally acknowledged to be a ſpecies of ſocage-tenure; the preſervation whereof inviolate from the innovations of the Norman conquerer is a fact univerſally known. And thoſe who thus preſerved their liberties were ſaid to hold in free and common ſocage.

As therefore the grand criterion and diſtinguiſhing mark of this ſpecies of tenure are the having its renders or ſervices aſcertained, it will include under it all other methods of holding free lands by certain and invariable rents and duties; and in particular, *Petit* SERJEANTY, *Tenure in* BURGAGE, and GAVELKIND. See theſe articles.

1 Definition.

SOCIETY, a number of rational and moral beings, united for their common preſervation and happineſs.

2 How far brutes are capable of a ſocial ſtate.

There are ſhoals of fiſhes, herds of quadrupeds, and flocks of birds. But till obſervation enable us to determine with greater certainty, how far the inferior animals are able to look through a ſeries of means to the end which theſe are calculated to produce, how far their conduct may be influenced by the hope of reward and the fear of puniſhment, and whether they are at all capable of moral diſtinctions—we cannot with propriety apply to them the term *Society*. We call crows and beavers, and ſeveral other ſpecies of animals, *gregarious*; but it is hardly good Engliſh to ſay that they are *ſocial*.

3 Mankind the only ſocial beings ſubject to our obſervation.

It is only human ſociety, then, that can become the ſubject of our preſent inveſtigation. The phenomena which it preſents are highly worthy of our notice.

4 A ſocial and a ſavage ſtate.

Such are the advantages which each individual evidently derives from living in a ſocial ſtate; and ſo helpleſs does any human being appear in a ſolitary ſtate, that we are naturally led to conclude, that if there ever was a period at which mankind were ſolitary beings, that period could not be of long duration; for their averſion to ſolitude and love of ſociety would ſoon induce them to enter into ſocial union. Such is the opinion which we are led to conceive, when we compare our own condition as members of civilized and enlightened ſociety with that of the brutes around us, or with that of ſavages in the earlier and ruder periods of ſocial life. When we hear of Indians wandering naked through the woods, deſtitute of arts, unſkilled in agriculture, ſcarce capable of moral diſtinctions, void of all religious ſentiments, or poſſeſſed with the moſt abſurd notions concerning ſuperior powers, and procuring means of ſubſiſtence in a manner equally precarious with that of the beaſts of prey—we look down with pity on their condition, or turn from it with horror. When we view the order of cultivated ſociety, and conſider our inſtitutions, arts, and manners—we rejoice over our ſuperior wiſdom and happineſs.

Man in a civilized ſtate appears a being of a ſuperior order to man in a ſavage ſtate; yet ſome philoſophers tell us, that it is only he who, having been educated in ſociety, has been taught to depend upon others, that can be helpleſs or miſerable when placed in a ſolitary ſtate. They view the ſavage who exerts himſelf with intrepidity to ſupply his wants, or bears them with fortitude, as the greateſt hero, and poſſeſſing the greateſt happineſs. And therefore if we agree with them, that the propenſities of nature may have prompted men to enter into ſocial union, though they may have hoped to enjoy ſuperior ſecurity and happineſs by engaging to protect and ſupport each other, we muſt conclude that the Author of the univerſe has deſtined man to attain greater dignity and happineſs in a ſavage and ſolitary than in a ſocial ſtate; and therefore that thoſe diſpoſitions and views which lead us to ſociety are fallacious and inimical to our real intereſt.

Whatever be the ſuppoſed advantages of a ſolitary ſtate, certain it is that mankind, at the earlieſt periods, were united in ſociety. Various theories have been formed concerning the circumſtances and principles which gave riſe to this union: but we have elſewhere ſhown, that the greater part of them are founded in error; that they ſuppoſe the original ſtate of man to have been

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been that of savages; and that such a supposition is contradicted by the most authentic records of antiquity. For though the records of the earlier ages are generally obscure, fabulous, and imperfect; yet happily there is *one* free from the imperfections of the rest, and of undoubted authenticity, to which we may safely have recourse *. This record is the Pentateuch of Moses, which presents us with a genuine account of the origin of man and of society, perfectly consonant to what we have laid down in the article referred to (see SAVAGE).

* See *Scripture*, N° 7—15.

5 First state of society according to authentic history.

According to Moses, the first society was that of a husband and wife united in the bonds of marriage: the first government that of a father and husband, the master of his family. Men lived together under the patriarchal form of government while they employed themselves chiefly in tending flocks and herds. Children in such circumstances cannot soon rise to an equality with their parents, where a man's importance depends on his property, not on his abilities. When flocks and herds are the chief articles of property, the son can only obtain these from his father; in general therefore the son must be entirely dependent on the father for the means of subsistence. If the parent during his life bestow on his children any part of his property, he may do it on such conditions as shall make their dependence upon him continue till the period of his death. When the community are by this event deprived of their head, instead of continuing in a state of union, and selecting some one from among themselves whom they may invest with the authority of a parent, they separate into so many distinct tribes, each subjected to the authority of a different lord, the master of the family, and the proprietor of all the flocks and herds belonging to it. Such was the state of the first societies which the narrative of Moses exhibits to our attention.

6 Theories of philosophers concerning the origin of society

Those philosophers who have made society, in its various stages between rudeness and refinement, the subject of their speculations, have generally considered mankind, in whatever region of the globe, and under whatever climate, as proceeding uniformly through certain regular gradations from one extreme to the other. They regard them, first, as gaining a precarious subsistence by gathering the spontaneous fruits of the earth, preying on the inhabitants of the waters, if placed on the seashore, or along the banks of large rivers; or hunting wild beasts, if in a situation where these are to be found in abundance; without foresight or industry to provide for future wants when the present call of appetite is gratified. Next, they say, man rises to the shepherd state, and next to that of husbandmen, when they turn their attention from the management of flocks to the cultivation of the ground. Next, these husbandmen improve their powers, and better their condition, by becoming artizans and merchants; and the beginning of this period is the boundary between barbarity and civilization.

These are the stages through which they who have employed themselves on the natural history of society have generally conducted mankind in their progress from rudeness to refinement: but they seem to have overlooked the manner in which mankind were at first established on this earth; for the circumstances in which the parents of the human race were originally placed; for the degree of knowledge communicated to them; and for the instruction which they must have been capable of communicating to their posterity. They rather appear to consider the inhabitants of every different region of the globe as aborigines, springing at first from the ground, or dropped on the spot which they inhabit; no less ignorant than infants of the nature and relations of the objects around them, and of the purposes which they may accomplish by the exercise of their organs and faculties.

7 are fanciful.

The absurdity of this theory has been fully demonstrated in another place: and if we agree to receive the Mosaic account of the original establishment of mankind, we shall be led to view the phenomena of social life in a light very different. We must first allow, that though many of the rudest tribes are found in the state of *hunters* or *fishers*; yet the hunting or fishing state cannot have been invariably the primary form of society. Notwithstanding the powers with which we are endowed, we are in a great measure the creatures of circumstances. Physical causes exert, though indirectly, a mighty influence in forming the character and directing the exertions of the human race. From the information of Moses we gather, that the first societies of men lived under the patriarchal form of government, and employed themselves in the cultivation of the ground and the management of flocks. And as we know that mankind, being subjected to the influence both of physical and moral causes, are no less liable to degeneracy than capable of improvement; we may easily conceive, that though descending all from the same original pair, and though enlightened with much traditionary knowledge relative to the arts of life, the order of society, moral distinctions, and religious obligations; yet as they were gradually, and by various accidents, dispersed over the earth, being removed to situations in which the arts with which they were acquainted could but little avail them, where industry was overpowered, or indolence encouraged by the severity or the profusion of nature, they might degenerate and fall into a condition almost as humble and precarious as that of the brutal tribes. Other moral causes might also concur to debase or elevate the human character in that early period. The particular character of the original settlers in any region, the manner in which they were connected with one another, and the arts which they were best qualified to exercise, with various other causes of a similar nature, would have considerable influence in determining the character of the society.

When laying aside the spirit of theory and system, we set ourselves, with due humility, to trace facts, and to listen to evidence, though our discoveries may be fewer than we should otherwise fancy them; yet the knowledge which we thus acquire will be more useful and solid, and our speculations more consistent with the spirit of true philosophy. Here, though we learn from the information of the sacred writings, that the first family of mankind was not cruelly exposed in this world, as children whom the inhumanity of their parents induces them to desert; yet we are not, in consequence of admitting this fact, laid under any necessity of denying or explaining away any of the other phenomena which occur to our observation when tracing the natural history of society. Tradition may be corrupted; arts and sciences may be lost; the sublimest religious doctrines may be debased into absurdity.

If then we are desirous of surveying society in its rudest

deſt form, we muſt look, not to the earlieſt period of its exiſtence, but to thoſe diſtricts of the globe where external circumſtances concur to drive them into a ſtate of ſtupidity and wretchedneſs. Thus in many places of the happy clime of Aſia, which a variety of ancient records concur with the ſacred writings in repreſenting as the firſt peopled quarter of the globe, we cannot trace the form of ſociety backwards beyond the ſhepherd ſtate. In that ſtate indeed the bonds which connect ſociety extend not to a wide range of individuals, and men remain for a long period in diſtinct families; but yet that ſtate is highly favourable to knowledge, to happineſs, and to virtue. Again, the torrid and the frozen regions of the earth, though probably peopled at a later period, and by tribes ſprung from the ſame ſtock with the ſhepherds of Aſia, have yet exhibited mankind in a much lower ſtate. It is in the parched deſerts of Africa and the wilds of America that human beings have been found in a condition approaching the neareſt to that of the brutes.

8 Yet in ſome particular inſtances realized.

We may therefore with ſome propriety deſert the order of time, and take a view of the different ſtages through which philoſophers have conſidered mankind as advancing, beginning with that of rudeneſs, though we have ſhown that it cannot have been the firſt in the progreſs.

9 Rudeſt ſtate or firſt ſtage of ſociety.

Where the human ſpecies are found in the loweſt and rudeſt ſtate, their rational and moral powers are very faintly diſplayed; but their external ſenſes are acute, and their bodily organs active and vigorous. Hunting and fiſhing are then their chief employments on which they depend for ſupport. During that portion of their time which is not ſpent in theſe purſuits, they are ſunk in liſtleſs indolence. Deſtitute of foreſight, they are rouſed to active exertion only by the preſſure of immediate neceſſity or the urgent calls of appetite. Accuſtomed to endure the ſeverity of the elements, and but ſcantily provided with the means of ſubſiſtence, they acquire habits of reſignation and fortitude, which are beheld with aſtoniſhment by thoſe who enjoy the plenty and indulgence of cultivated life. But in this ſtate of want and depreſſion, when the powers and poſſeſſions of every individual are ſcarcely ſufficient for his own ſupport, when even the calls of appetite are repreſſed becauſe they cannot always be gratified, and the more refined paſſions, which either originate from ſuch as are merely animal, or are intimately connected with them, have not yet been felt—in this ſtate all the milder affections are unknown; or if the breaſt is at all ſenſible to their impulſe, it is extremely feeble. Huſband and wife, parent and child, brother and brother, are united by the weakeſt ties. Want and misfortune are not pitied. Why indeed ſhould they, where they cannot be relieved? It is impoſſible to determine how far beings in this condition can be capable of moral diſtinctions. One thing certain is, that in no ſtate are the human race entirely incapable of theſe. If we liſten, however, to the relations of reſpectable travellers, we muſt admit that human beings have ſometimes been found in that abject ſtate where no proper ideas of ſubordination, government, or diſtinction of ranks, could be formed. No diſtinct notions of Deity can be here entertained. Beings in ſo humble a condition cannot look through the order of the univerſe and the harmony of nature to that Eternal Wiſdom and Goodneſs which contrived, and that Almighty Power which brought into exiſtence, the ſyſtem of things. Of arts they muſt be almoſt totally deſtitute. They may uſe ſome inſtruments for fiſhing or the chace; but theſe muſt be extremely rude and ſimple. If they be acquainted with any means to ſhelter them from the inclemency of the elements, both their houſes and clothing will be aukward and inconvenient.

10 Second ſtage in the progreſs of ſociety.

But human beings have not been often found in ſo rude a ſtate as this. Even thoſe tribes which we denominate ſavage, are for the moſt part farther removed from mere animal life. They generally appear united under ſome ſpecies of government, exerciſing the powers of reaſon, capable of morality, though that morality be not always very refined; diſplaying ſome degree of ſocial virtues, and acting under the influence of religious ſentiments. Thoſe who may be conſidered as but one degree higher in the ſcale than the ſtupid and wretched beings whoſe condition we have ſurveyed, are to be found ſtill in the hunting and fiſhing ſtate; but they are farther advanced towards ſocial life, and are become more ſenſible to the impulſe of ſocial affection. By unavoidable intercourſe in their employments, a few individual hunters or fiſhers contract a certain degree of fondneſs for each other's company, and are led to take ſome part in each other's joys and ſorrows; and when the ſocial affections thus generated (ſee PASSION) begin to exert themſelves, all the other powers of the mind are at the ſame time called forth, and the circumſtances of the little ſociety are immediately improved. We behold its members in a more comfortable condition, and find reaſon to view the human character with more complacency and reſpect. Huts are now built, more commodious clothes are faſhioned, inſtruments for the annoyance of wild beaſts and even of enemies are contrived; in ſhort, arts, and ſcience, and ſocial order, and religious ſentiment, and ceremonies, now make their appearance in the riſing ſociety, and ſerve to characterize it by the particular form which diſtinguiſhes each of them. But though ſocial order is no longer unknown nor unobſerved, yet the form of government is ſtill extremely ſimple, and its ties are but looſe and feeble. It will perhaps bear ſome reſemblance to the patriarchal; only all its members are on a more equal footing, and and at the ſame time leſs cloſely connected than in the ſhepherd ſtate, to which that form of government ſeems almoſt peculiar. The old men are treated with veneration; but the young are not entirely ſubject to them. They may liſten reſpectfully to their advice; but they do not ſubmit to their arbitrary commands. Where mankind are in the ſtate of hunters and fiſhers, where the means of ſubſiſtence are precariouſly acquired, and prudent foreſight does not prompt to accumulate much proviſion for the future, no individual can acquire comparative wealth. As ſoon as the ſon is grown up, he ceaſes to be dependent on his father, as well as on the ſociety in general. Difference of experience therefore conſtitutes the only diſtinction between the young and the old; and if the old have experience, the young have ſtrength and activity. Here, then, neither age nor property can give riſe to any ſtriking diſtinction of ranks. All who have attained to manhood, and are not diſabled by unuſual deficiency of ſtrength or agility, or by the infirmities of old age, are on an equal footing; or if any one poſſeſs a pre-eminence over the reſt, he owes it to ſuperior

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superior addreſs or fortitude. The whole tribe deliberate; the old give their advice; each individual of the aſſembly receives or rejects it at his pleaſure (for the whole body think not of exerciſing any compulſatory power over the will of individuals); and the warrior who is moſt diſtinguiſhed for ſtrength, addreſs, and valour, leads out the youth of the tribe to the chace or againſt the enemy. War, which in the former ſtage did not prevail, as they who were ſtrangers to ſocial ſentiments were, at the ſame time, ſcarce capable of being enemies, now firſt begins to depopulate the thinly inhabited regions where thoſe hunters and fiſhers purſue their prey. They are ſcattered, poſſibly in ſcanty and ſeparate tribes, over an immenſe tract of country; but they know no medium between the affection which brethren of the ſame tribe bear to each other and the hatred of enemies. Though thinly ſcattered over the earth, yet the hunting parties of different tribes will ſometimes meet as they range the foreſts; and when they meet, they will naturally view each other with a jealous eye; for the ſucceſs of the one party in the chace may cauſe the other to be unſucceſsful; and while the one ſnatches the prey, the other muſt return home to all the pangs of famine. Inveterate hoſtility will therefore long prevail among neighbouring tribes in the hunting ſtate.

If we find them not incapable of ſocial order, we may naturally expect that their conduct will be influenced by ſome ſentiments of religion. They have at this period ideas of ſuperior beings. They alſo practiſe certain ceremonies to recommend them to thoſe beings; but both their ſentiments and ceremonies are ſuperſtitious and abſurd.

We have elſewhere ſhown (ſee POLYTHEISM) how ſavage tribes have probably degenerated from the pure worſhip of the one true God to the adoration of a multitude of imaginary divinities in heaven, earth, and hell. We have traced this idolatrous worſhip from that of the heavenly bodies, through all the gradations of dæmon-worſhip, hero-worſhip, and ſtatue-worſhip, to that wonderful inſtance of abſurd ſuperſtition which induced the inhabitants of ſome countries to fall proſtrate in adoration before the vileſt reptiles. But though we are convinced that the heavenly bodies have by all idolaters been conſidered as their firſt and greateſt gods, we pretend not that the progreſs through the other ſtages of polytheiſm has been everywhere in the very ſame order. It is indeed impoſſible to exhibit under one general view an account of arts, manners, and religious ſentiments, which may apply to ſome certain period in the hiſtory of every nation. The characters and circumſtances of nations are ſcarce leſs various and anomalous than thoſe of individuals. Among many of the American tribes, among the ancient inhabitants of the foreſts of Germany, whoſe manners have been ſo accurately delineated by the maſterly pen of Tacitus, and in ſome of the iſlands ſcattered over the ſouthern ocean, religion, arts, and government, have been found in that ſtate which we have deſcribed as characteriſing the ſecond ſtage of ſocial life. But neither can we pretend that all thoſe ſimple and rude ſocieties have been deſcribed by hiſtorians and travellers as agreeing preciſely in their arts, manners, and religious ſentiments; or that the difference of circumſtances always enables us to account in a ſatisfactory manner for the diſtinction of their characters. There is a variety of facts in the hiſtory of the early periods of ſociety, which no ingenuity, no induſtry however painful, can reduce under general heads. Here, as well as when we attempt to philoſophize on the phenomena of the material world, we find reaſon to confeſs that our powers are weak, and our obſervation confined within a narrow ſphere.

11
Third ſtage in the progreſs of ſociety, in which ideas of property and inequality of ranks appear.

But we may now carry our views a little forward, and ſurvey human life as approaching ſomewhat nearer to a civilized and enlightened ſtate. As property is acquired, inequality and ſubordination of ranks neceſſarily follow: and when men are no longer equal, the many are ſoon ſubjected to the will of the few. But what gives riſe to theſe new phenomena is, that after having often ſuffered from the precariouſneſs of the hunting and fiſhing ſtate, men begin to extend their cares beyond the preſent moment, and to think of providing ſome ſupply for future wants. When they are enabled to provide ſuch a ſupply, either by purſuing the chace with new eagerneſs and perſeverance, by gathering the ſpontaneous fruits of the earth, or by breeding tame animals—theſe acquiſitions are at firſt the property of the whole ſociety, and diſtributed from a common ſtore to each individual according to his wants: But as various reaſons will ſoon concur to convince the community, that by this mode of diſtribution, induſtry and activity are treated with injuſtice, while negligence and indolence receive more than their due, each individual will in a ſhort time become his own ſteward, and a community of goods will be aboliſhed. As ſoon as diſtinct ideas of property are formed, it muſt be unequally diſtributed; and as ſoon as property is unequally diſtributed, there ariſes an inequality of ranks. Here we have the origin of the depreſſion of the female ſex in rude ages, of the tyrannical authority exerciſed by parents over their children, and perhaps of ſlavery. The women cannot diſplay the ſame perſeverance, or activity, or addreſs, as the men, in purſuing the chace. They are therefore left at home; and from that moment are no longer equals, but ſlaves and dependants, who muſt ſubſiſt by the bounty of the males, and muſt therefore ſubmit with implicit obedience to all their capricious commands. Even before the era of property, the female ſex were viewed as inferiors; but till that period they were not reduced to a ſtate of abject ſlavery.

In this period of ſociety new notions are formed of the relative duties. Men now become citizens, maſters, and ſervants; huſbands, parents, &c. It is impoſſible to enumerate all the various modes of government which take place among the tribes who have advanced to this ſtage; but one thing certain is, that the authority of the few over the many is now firſt eſtabliſhed, and that the riſe of property firſt introduces inequality of ranks. In one place, we ſhall perhaps find the community ſubjected during this period to the will of a ſingle perſon; in another, power may be lodged in the hands of a number of chiefs; and in a third, every individual may have a voice in creating public officers, and in enacting laws for the ſupport of public order. But as no code of laws is formed during this period, juſtice is not very impartially adminiſtered, nor are the rights of individuals very faithfully guarded. Many actions, which will afterwards be conſidered as heinouſly immoral, are now conſidered as praiſe-worthy or indifferent. This is the age of hero-worſhip, and of houſehold and tutelary gods; for

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for it is in this ſtage of ſociety that the invention of arts, which gave riſe to that worſhip, contributes moſt conſpicuouſly to the public good. War, too, which we conſidered as beginning firſt to ravage the earth during the former period, and which is another cauſe of the deification of dead men, will ſtill prevail in this age, and be carried on with no leſs ferocity than before, though in a more ſyſtematic form.

The prevalence of war, and the means by which ſubſiſtence is procured, cannot but have conſiderable influence on the character and ſentiments of ſocieties and individuals. The hunter and the warrior are characters in many reſpects different from the ſhepherd and the huſbandman. Such, in point of government, arts, and manners, religious and moral ſentiments, were ſeveral of the German tribes deſcribed by Tacitus; and the Britons whoſe character has been ſketched by the pen of Cæſar: ſuch, too, were the Romans in the early period of their hiſtory; ſuch too the inhabitants of Aſia Minor about the time of the ſiege of Troy, as well as the Greeks whom Homer celebrates as the deſtroyers of the Trojan ſtate: the northern tribes alſo, who poured through Aſia, Africa, and Europe, and overthrew the Roman empire, appear to have been of a nearly ſimilar character. It ſeems to be a general opinion among thoſe who have directed their attention to the hiſtory of ſociety, that, in the ſcale aſcending from the loweſt condition of human beings to the moſt civilized and enlightened ſtate of ſociety, the ſhepherd ſtate is the next in order above the hunting; and that as mankind improve in knowledge and in moral ſentiments, and as the foreſts are gradually depopulated of their inhabitants, inſtead of deſtroying the inferior animals, men become their guardians and protectors. But we cannot unreſervedly ſubſcribe to this opinion: we believe, that in the ſhepherd ſtate ſocieties have been ſometimes found ſuperior to the moſt poliſhed tribes of hunters; but upon viewing the annals of mankind in early ages, we obſerve that there is often no inconſiderable reſemblance even between hunters and ſhepherds in point of the improvement of the rational faculties and the moral ſenſe; and we are therefore led to think, that theſe two ſtates are ſometimes parallel: for inſtance, ſeveral of the American tribes, who ſtill procure their ſubſiſtence by hunting, appear to be nearly in the ſtate which we have deſcribed as the third ſtage in the progreſs of ſociety; and the ancient ſhepherds of Aſia do not appear to have been much more cultivated and refined. We even believe that men have ſometimes turned their attention from hunting to agriculture, without paſſing through any intermediate ſtate. Let us remember, that much depends upon local circumſtances, and ſomewhat undoubtedly on original inſpiration and traditionary inſtruction. In this period of ſociety the ſtate of the arts well deſerves our attention. We ſhall find, that the ſhepherds and the hunters are in that reſpect on a pretty equal footing. Whether we examine the records of ancient hiſtory, or view the iſlands ſcattered through the South ſea, or range the wilds of America, or ſurvey the ſnowy waſtes of Lapland and the frozen coaſt of Greenland—ſtill we find the uſeful arts in this period, though known and cultivated, in a very rude ſtate; and the fine arts, or ſuch as are cultivated merely to pleaſe the fancy or to gratify caprice, diſplaying an odd and fantaſtic, not a true or natural, taſte; yet this is the period in which eloquence ſhines with the trueſt luſtre: all is metaphor or glowing ſentiment. Languages are not yet copious; and therefore ſpeech is figurative, expreſſive, and forcible. The tones and geſtures of nature, not being yet laid aſide, as they generally are, from regard to decorum, in more poliſhed ages, give a degree of force and expreſſion to the harangues of the ruſtic or ſavage orator, which the moſt laborious ſtudy of the rules of rhetoric and elocution could not enable even a more poliſhed orator to diſplay.

12
Fourth ſtage; in which agriculture flouriſhes, the arts are ſubdivided, commerce and regular government are introduced.

But let us advance a little farther, and contemplate our ſpecies in a new light, where they will appear with greater dignity and amiableneſs of character. Let us view them as huſbandmen, artizans, and legiſlators. Whatever circumſtances might turn the attention of any people from hunting to agriculture, or cauſe the herdſman to yoke his oxen for the cultivation of the ground, certain it is that this change in the occupation would produce a happy change on the character and circumſtances of men; it would oblige them to exert a more regular and perſevering induſtry. The hunter is like one of thoſe birds that are deſcribed as paſſing the winter in a torpid ſtate. The ſhepherd's life is extremely indolent. Neither of theſe is very favourable to refinement. But different is the condition of the huſbandman. His labours ſucceed each other in regular rotation through the year. Each ſeaſon with him has its proper employments: he therefore muſt exert active perſevering induſtry; and in this ſtate we often find the virtues of rude and poliſhed ages united. This is the period where barbariſm ends and civilization begins. Nations have exiſted for ages in the hunting or the ſhepherd ſtate, fixed as by a kind of ſtagnation, without advancing farther. But ſcarcely any inſtances occur in the hiſtory of mankind of thoſe who once reached the ſtate of huſbandmen, remaining long in that condition without riſing to a more civilized and poliſhed ſtate. Where a people turn their attention in any conſiderable degree to the objects of agriculture, a diſtinction of occupations naturally ariſes among them. The huſbandman is ſo cloſely employed through the ſeveral ſeaſons of the year in the labours of the field, that he has no longer leiſure to exerciſe all the rude arts known among his countrymen. He has not time to faſhion the inſtruments of huſbandry, to prepare his clothes, to build his houſe, to manufacture houſehold utenſils, or to tend thoſe tame animals which he continues to rear. Thoſe different departments therefore now begin to employ different perſons; each of whom dedicates his whole time and attention to his own occupation. The manufacture of cloth is for a conſiderable time managed excluſively by the women; but ſmiths and joiners ariſe from among the men. Metals begin now to be conſidered as valuable materials. The intercourſe of mankind is now placed on a new footing. Before, every individual practiſed all the arts that were known, as far as was neceſſary for ſupplying himſelf with the conveniences of life. Now he confines himſelf to one or to a few of them; and, in order to obtain a neceſſary ſupply of the productions of thoſe arts which he does not cultivate himſelf, he gives in exchange a part of the productions of his own labours. Here we have the origin of commerce.

After continuing perhaps for ſome time in this ſtate, as arts and diſtinctions multiply in ſociety, the exchange

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change of one commodity for another is found troublesome and inconvenient. It is ingeniously contrived to adopt a medium of commerce, which being estimated not by its intrinsic value, but by a certain nominal value which it receives from the agreement of the society among whom it is used, serves to render the exchange of property, which is so necessary for the purposes of social life, easy and expeditious. Wherever metals have been known, they appear to have been adopted as the medium of commerce almost as soon as such a medium began to be used: and this is one important purpose for which they serve; but they have still more important uses. Almost all the necessary arts depend on them. Where the metals are known, agriculture practised, and the necessary arts distributed among different orders of artisans—civilization and refinement, if not obstructed by some accidental circumstances, advance with a rapid progress. With regard to the first applying of the precious metals as the medium of commerce, we may observe, that this was probably not accomplished by means of a formal contract. They might be first used as ornaments; and the love of ornament, which prevails among rude as much as among civilized nations, would render every one willing to receive them in exchange for such articles as he could spare. Such might be the change produced on society with regard to the necessary arts by the origin of agriculture. As soon as ornament and amusement are thought of, the fine arts begin to be cultivated. In their origin therefore they are not long posterior to the necessary and useful arts. They appear long before men reach the comfortable and respectable condition of husbandmen; but so rude is their character at their first origin, that our *Dilettanti* would probably view the productions of that period with unspeakable contempt and disgust. But in the period of society which we now consider, they have aspired to a higher character; yet poetry is now perhaps less generally cultivated than during the shepherd state. Agriculture, considered by itself, is not directly favourable either to refinement of manners or to the fine arts. The conversation of shepherds is generally supposed to be far more elegant than than of husbandmen; but though the direct and immediate effects of this condition of life be not favourable to the fine arts, yet indirectly it has a strong tendency to promote their improvement. Its immediate influence is extremely favourable to the necessary and useful arts; and these are no less favourable to the fine arts.

One of the noblest changes which the introduction of the arts by agriculture produces on the form and circumstances of society, is the introduction of regular government and laws. In tracing the history of ancient nations, we scarcely ever find laws introduced at an earlier period. Minos, Solon, and Lycurgus, do not appear to have formed codes of wisdom and justice for regulating the manners of their countrymen, till after the Cretans, the Athenians, and even the Lacedemonians, had made some progress in agriculture and the useful arts.

Religion, under all its various forms, has in every stage of society a mighty influence on the sentiments and conduct of men (see RELIGION); and the arts cultivated in society have on the other hand some influence on the system of religious belief. One happy effect which will result from the invention of arts, though perhaps not immediately, will be, to render the character of the deities more benevolent and amiable, and the rites of their worship more mild and humane.

The female sex in this period generally find the yoke of their slavery somewhat lightened. Men now become easier in their circumstances; the social affections assume stronger influence over the mind; plenty, and security, and ease, at once communicate both delicacy and keenness to the sensual desires. All these circumstances concur to make men relax in some degree that tyrannic sway by which they before depressed the softer sex. The foundation of that empire, where beauty triumphs over both wisdom and strength, now begins to be laid. Such are the effects which history warrants as to attribute to agriculture and the arts; and such the outlines of the character of that which we reckon the fourth stage in the progress of society from rudeness to refinement.

13
Fifth stage in the progress of society; in which literature, arts, and sciences, are much cultivated, and religion assumes a mild and engaging aspect.

Let us advance one step farther. We have not yet surveyed mankind in their most polished and cultivated state. Society is rude at the period when the arts first begin to show themselves, in comparison of that state to which it is raised by the industrious cultivation of them. The neighbouring commonwealths of Athens and Lacedemon afford us a happy opportunity of comparing this with the former stage in the progress of society. The chief effect produced by the institutions of Lycurgus seems to have been, to fix the manners of his countrymen for a considerable period in that state to which they had attained in his days. Spartan virtue has been admired and extolled in the language of enthusiasm; but in the same manner has the character and the condition of the savage inhabitants of the wilds of America, been preferred by some philosophers, to the virtues and the enjoyments of social life in the most polished and enlightened state. The Spartans in the days of Lycurgus had begun to cultivate the ground, and were not unacquainted with the useful arts. They must soon have advanced farther had not Lycurgus arisen, and by effecting the establishment of a code of laws, the tendency of which appears to have been in many particulars directly opposite to the designs of nature, retarded their progress towards complete civilization and refinement. The history of the Lacedemonians, therefore, while the laws of Lycurgus continued in force, exhibits the manners and character of a people in that which we have denominated the fourth stage in the progress of society. But if we turn our eyes to their neighbours the Athenians, we behold in their history the natural progress of opinions, arts, and manners. The useful arts are first cultivated with such steady industry, as to raise the community to opulence, and to furnish them with articles for commerce with foreign nations. The useful arts cannot be raised to this height of improvement without leading men to the pursuit of science. Commerce with foreign nations, skill in the useful arts, and a taste for science, mutually aid each other, and conspire to promote the improvement of the fine arts. Hence magnificent buildings, noble statues, paintings expressive of life, action, and passion; and poems in which imagination adds new grace and sublimity to nature, and gives the appearances of social life more irresistible power over the affections of the heart. Hence are moral distinctions more carefully studied, and the

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the rights of every individual and every order in society better understood and more accurately defined. Moral science is generally the first scientific pursuit which strongly attracts the attention of men. Lawgivers appear before geometricians and astronomers. Some particular circumstances may cause these sciences to be cultivated at a very early period. In Egypt the overflowing of the Nile caused geometry to be early cultivated. Causes no less favourable to the study of astronomy, concurred to recommend that science to the attention of the Chaldeans long before they had attained the height of refinement. But, in general, we find, that the laws of morality are understood, and the principles of morals inquired into, before men make any considerable progress in physical science, or even prosecute it with any degree of keenness. Accordingly, when we view the state of literature in this period (for it is now become an object of so much importance as to force itself on our attention), we perceive that poetry, history, and morals, are the branches chiefly cultivated. Arts are generally casual inventions, and long practised before rules and principles on which they are founded assume the form of science. But morality, if considered as an art, is that art which men have soonest and most constantly occasion to practise. Besides, we are so constituted by the wisdom of nature, that human actions, and the events which befal human beings, have more powerful influence than any other object to engage and fix our attention. Hence we are enabled to explain why morality, and those branches of literature more immediately connected with it, are almost always cultivated in preference to physical science. Though poetry, history, and morals, be pursued with no small eagerness and success in that period of society which we now consider, we need not therefore be greatly surprised that natural philosophy is neither very generally nor very successfully cultivated. Were we to consider each particular in that happy change which is now produced on the circumstances of mankind, we should be led into a too minute and perhaps unimportant detail. This is the period when human virtue and human abilities shine with most splendour. Rudeness, ferocity, and barbarism, are now banished. Luxury has made her appearance; but as yet she is the friend and the benefactress of society. Commerce has stimulated and rewarded industry, but has not yet contracted the heart and debased the character. Wealth is not yet become the sole object of pursuit. The charms of social intercourse are known and relished; but domestic duties are not yet deserted for public amusements. The female sex acquire new influence, and contribute much to refine and polish the manners of their lords. Religion now assumes a milder and more pleasing form; splendid rites, magnificent temples, pompous sacrifices, and gay festivals, give even superstition an influence favourable to the happiness of mankind. The gloomy notions and barbarous rites of former periods fall into disuse. The system of theology produced in former ages still remains: but only the mild and amiable qualities of the deities are celebrated; and none but the gay, humane, and laughing divinities, are worshipped. Philosophy also teaches men to discard such parts of their religion as are unfriendly to good morals, and have any tendency to call forth or cherish unsocial sentiments in the heart. War (for in this period of society enough of causes will arise to arm one nation against another)—war, however, no longer retains its former ferocity; nations no longer strive to extirpate one another: to procure redress for real or imaginary injuries; to humble, not to destroy, is now its object. Prisoners are no longer murdered in cold blood, subjected to horrid and excruciating tortures, or condemned to hopeless slavery. They are ransomed or exchanged; they return to their country, and again fight under its banners. In this period the arts of government are likewise better understood, and practised so as to contribute most to the interests of society. Whether monarchy, or democracy, or aristocracy, be the established form, the rights of individuals and of society are in general respected. The interests of society are so well understood, that the few, in order to preserve their influence over the many, find it necessary to act rather as the faithful servants than the imperious lords of the public. Though the liberties of a nation in this state be not accurately defined by law, nor their property guaranteed to them by any legal institutions, yet their governors dare not violate their liberties, nor deprive them wantonly of their properties. This is truly the golden age of society: every trace of barbarism is entirely effaced; and vicious luxury has not yet begun to sap the virtue and the happiness of the community. Men live not in listless indolence; but the industry in which they are engaged is not of such a nature as to overpower their strength or exhaust their spirits. The social affections have now the strongest influence on men's sentiments and conduct.

14 Degeneracy and decline of society.

But human affairs are scarcely ever stationary. The circumstances of mankind are almost always changing, either growing better or worse. Their manners are ever in the same fluctuating state. They either advance towards perfection or degenerate. Scarcely have they attained that happy period in which we have just contemplated them, when they begin to decline till they perhaps fall back into a state nearly as low as that from which we suppose them to have emerged. Instances of this unhappy degeneracy occur more than once in the history of mankind; and we may finish this short sketch of the history of society by mentioning in what manner this degeneracy takes place. Perhaps, strictly speaking, every thing but the simple necessaries of life may be denominated luxury: For a long time, however, the welfare of society is best promoted, while its members aspire after something more than the mere necessaries of life. As long as these superfluities are to be obtained only by active and honest exertion; as long as they only engage the leisure hours, without becoming the chief objects of pursuit—the employment which they give to the faculties is favourable both to the virtue and the happiness of the human race.

The period arrives, however, when luxury is no longer serviceable to the interests of nations; when she is no longer a graceful, elegant, active form, but a languid, overgrown, and bloated carcase. It is the love of luxury, which contributed so much to the civilization of society, that now brings on its decline. Arts are cultivated and improved, and commerce extended, till enormous opulence be acquired: the effect of opulence is to awaken the fancy, to conceive ideas of new and capricious wants, and to inflame the breast with new desires. Here we have the origin of that selfishness which, operating in conjunction with caprice and the violence of unbridled

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unbridled paſſions, contributes ſo much to the corruption of virtuous manners. Selfiſhneſs, caprice, indolence, effeminacy, all join to looſen the bonds of ſociety, to bring on the degeneracy both of the uſeful and the fine arts, to baniſh at once the mild and the auſtere virtues, to deſtroy civil order and ſubordination, and to introduce in their room anarchy or deſpotiſm.

Scarcely could we have found an example of the beautiful form of ſociety which we laſt attempted to deſcribe. Never, at leaſt, has any nation continued long to enjoy ſuch happy circumſtances, or to diſplay ſo amiable and reſpectable a character. But when we ſpeak of the declining ſtate of ſociety, we have no difficulty in finding inſtances to which we may refer. Hiſtory tells of the Aſſyrians, the Egyptians, and the Perſians, all of them once flouriſhing nations, but brought low by luxury and an unhappy corruption of manners. The Greeks, the Romans, and the Aſſyrians, owed their fall to the ſame cauſes; and we know not if a ſimilar fate does not now threaten many of thoſe nations who have long made a diſtinguiſhed figure in the ſyſtem of Europe. The Portugueſe, the Venetians, and the Spaniards, have already fallen; and what is the preſent ſtate of our neighbours the French? They have long been a people deſtitute of religion, corrupted in morals, unſteady in conduct, and ſlaves to pleaſure and public amuſements. Among them luxury had arrived at its higheſt pitch; and the conſequence has been, that after capriciouſly ſhaking off the yoke of deſpotiſm, they have eſtabliſhed, or rather ſet up (for eſtabliſhed it cannot be), a motley kind of government, which, in the courſe of a few years, has exhibited ſcenes of tyranny and oppreſſion, to which we doubt if the annals of the world can furniſh any parallel. Yet this is the people whoſe manners the other nations of Europe were ambitious to imitate. May thoſe nations take warning in time, and avoid the rocks upon which they have ſplit.

15 Concluding remarks.

THUS have we viewed the ſeveral ſtages in which ſociety appears in its progreſs from rudeneſs to refinement and decay. The intelligent reader will perceive, that the various and anomalous phenomena which occur in the natural hiſtory of ſociety, cannot eaſily be ſolved; becauſe the neceſſary information cannot be obtained. Others have been well accounted for by the reſearches of curious philoſophical inquirers. Local circumſtances, the influence of climate, the intercourſe of nations in different ſtates of civilization, have been taken notice of, as cauſes ſerving to accelerate or retard the progreſs of arts and manners. But our proper buſineſs here was merely to mark the gradations between barbariſm and refinement: and as the painter who is to exhibit a ſeries of portraits repreſenting the human form in infancy, puerility, youth, and manhood, will not think of delineating all that variety of figures and faces which each of thoſe periods of life affords, and will find himſelf unable to repreſent in any ſingle figure all diverſities of form and features; ſo we have not once thought of deſcribing particularly under this article, all the various national characters reducible to any one of thoſe diviſions under which we have viewed the progreſs of ſociety, nor have found it poſſible to comprehend under one conſiſtent view, all the particulars which may be gathered from the remains of antiquity, from the relations of later travellers, and the general records of hiſtory concerning the progreſſive character of mankind in various regions, and under the influence of various accidents and circumſtances. This indeed would even have been improper, as all that information appears under other articles in this Work.

Societies.

SOCIETIES, aſſociations voluntarily formed by a number of individuals for promoting knowledge, induſtry, or virtue. They may therefore be divided into three claſſes; ſocieties for promoting ſcience and literature, ſocieties for encouraging and promoting arts and manufactures, and ſocieties for diffuſing religion and morality and relieving diſtreſs. Societies belonging to the firſt claſs extend their attention to all the ſciences and literature in general, or devote it to one particular ſcience. The ſame obſervation may be applied to thoſe which are inſtituted for improving arts and manufactures. Thoſe of the third claſs are eſtabliſhed, either with a view to prevent crimes, as the Philanthropic Society; for the diffuſion of the Chriſtian religion among unenlightened nations, as the Society for the Propagation of the Goſpel in Foreign Parts; or for introducing arts and civilization, along with a knowledge of the Chriſtian religion, as the Sierra Leona company.

The honour of planning and inſtituting ſocieties for thoſe valuable purpoſes is due to modern times. A literary aſſociation is ſaid to have been formed in the reign of Charlemagne (ſee ACADEMY); but the plan ſeems to have been rude and defective. Several others were inſtituted in Italy in the 16th century; but from the accounts which we have ſeen of them, they ſeem to have been far inferior to thoſe which are moſt flouriſhing at preſent. The moſt enlarged idea of literary ſocieties ſeems to have originated with the great Lord Bacon, the father of modern philoſophy, who recommended to the reigning prince to inſtitute ſocieties of learned men, who ſhould give to the world from time to time a regular account of their reſearches and diſcoveries. It was the idea of this great philoſopher, that the learned world ſhould be united, as it were, into one immenſe republic; which, though conſiſting of many detached ſtates, ſhould hold a ſtrict union and preſerve a mutual intelligence with each other, in every thing that regards the common intereſt. The want of this union and intelligence he laments as one of the chief obſtacles to the advancement of ſcience; and, juſtly conſidering the inſtitution of public ſocieties, in the different countries of Europe, under the auſpices of the ſovereign, to be the beſt remedy for that defect, he has given, in his fanciful work, the New Atlantis, the delineation of a philoſophical ſociety on the moſt extended plan, for the improvement of all arts and ſciences; a work which, though written in the language, and tinctured with the colouring of romance, is full of the nobleſt philoſophic views. The plan of Lord Bacon, which met with little attention from the age in which he lived, was deſtined to produce its effect in a period not very diſtant. The ſcheme of a philoſophical college by Cowley is acknowledged to have had a powerful influence in procuring the eſtabliſhment of the Royal Society of London by charter from Charles II. §; and Cowley's plan is manifeſtly copied in almoſt all its parts from that in the New Atlantis. The inſtitution of the Royal Society of London was ſoon followed by the eſtabliſhment of the Royal Academy

§ *Sprat's Hiſtory of the Royal Society*, 2d edit. p. 39.

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demy of Sciences at Paris; and these two have served as models to the philosophical academies of highest reputation in the other kingdoms of Europe.

The experience of ages has shown, that improvements of a public nature are best carried on by societies of liberal and ingenious men, uniting their labours without regard to nation, sect, or party, in one grand pursuit alike interesting to all, whereby mutual prejudices are worn off, and a humane philosophical spirit is cherished. Men united together, and frequently meeting for the purpose of advancing the sciences, the arts, agriculture, manufactures, and commerce, may oftentimes suggest such hints to one another as may be improved to important ends; and such societies, by being the repositories of the observations and discoveries of the learned and ingenious, may from time to time furnish the world with useful publications which might otherwise be lost: for men of ingenuity and modesty may not choose to risk their reputation, by sending abroad unpatronized what a learned society might judge richly worth the public eye; or perhaps their circumstances being straitened, they may not be able to defray the expence of publication. Societies instituted for promoting knowledge may also be of eminent service, by exciting a spirit of emulation, and by enkindling those sparks of genius which otherwise might for ever have been concealed; and if, when possessed of funds sufficient for the purpose, they reward the exertions of the industrious and enterprising with pecuniary premiums or honorary medals, many important experiments and useful discoveries will be made, from which the public may reap the highest advantages.

Eminent instances of the beneficial effects of such institutions we have in the Royal Academy of Sciences at Paris, the Royal Society, and the Society instituted for the Encouragement of Arts, Manufactures, and Commerce, in London, and many others of a similar kind. Hereby a spirit of discovery and improvement has been excited among the ingenious in almost every nation; knowledge of various kinds, and greatly useful to mankind, has taken place of the dry and uninteresting speculations of schoolmen; and bold and erroneous hypothesis has been obliged to give way to demonstrative experiment. In short, since the establishment of these societies, solid learning and philosophy have more increased than they had done for many centuries before.

As to those societies established for promoting industry, religion and morality, and relieving distress, the design is laudable and excellent, and presents a beautiful picture of the philanthropy of modern times. We are happy to find, from the minutes of some of these societies, that their beneficial effects are already conspicuous.

We will now give some account of the most eminent societies; arranging them under the three classes into which we have divided them: I. *Religious and Humane Societies.* II. *Societies for Promoting Science and Literature.* III. *Societies for Encouraging Arts, Manufactures*, &c.

I. Religious and Humane Societies.

1. *Society for the Propagation of the Gospel in Foreign Parts*, was instituted by King William III. in 1701, in order to secure a maintenance for an orthodox clergy, and to make other provisions for propagating the gospel in the plantations, colonies, and factories beyond the seas. To that end he incorporated the archbishops, several of the bishops, and others of the nobility, gentry, and clergy, to the number of 90, into one body, which, by the name of *The Society for the Propagation of the Gospel in Foreign Parts*, was to plead and be impleaded; to have perpetual succession, with privilege to purchase 2000l. a-year inheritance, and estates for lives or years, with other goods and chattels to any value. By its charter the society is authorised to use a common seal; and to meet annually on the third Friday in February for the purpose of choosing a president, vice-president, and officers for the year ensuing; and on the third Friday in every month, or oftener if there should be occasion, to transact business, and to depute persons to take subscriptions, and collect money contributed for the purposes aforesaid; and of all moneys received and laid out, it is obliged to give account yearly to the lord-chancellor or keeper, the lord-chief-justice of the King's-bench, the lord-chief-justice of the Common-pleas, or to any two of these magistrates. Of this society there is a standing committee at St Paul's chapter-house, to prepare matters for the monthly meeting, which is held at St Martin's library.

Before the incorporation of the society for the propagation of the gospel in foreign parts, there had been formed, for the promoting of Christian knowledge both at home and in the colonies, a voluntary association of persons of rank and respectability, who in March 1699 began to hold stated meetings in London for that purpose, regulating themselves by the laws of the land and the canons of the church; and when the new society was formed, they had already transmitted to America and the West Indies 800l. worth of Bibles, Books of Common Prayer, and treatises of practical religion, besides securing a tolerable maintenance to several clergymen on that continent. This association still subsists under the denomination of *The Society for Promoting Christian Knowledge*, and has been productive of much good in the cities of London and Westminster; but upon the formation of the new society, into which all its original members were incorporated by name, the care which the voluntary association had taken of the colonies devolved of course upon the incorporated society; of which incorporation we believe the object has been sometimes mistaken, and the labours of its missionaries grossly misrepresented. It has by many been supposed that the society was incorporated for the *sole* purpose of converting the savage Americans; and it has been much blamed for sending missionaries into provinces where, in the common language of the complainers, a *gospel-ministry* was already established. But an impartial view of the rise and progress of the American provinces, now become independent states, will show the folly and injustice of those complaints.

The English colonies in North America were in the last century formed and first peopled by religious men; who, made uneasy at home by their intolerant brethren, left the *old world* to enjoy in peace that first and chief prerogative of man, *the free worship of God according to his own conscience*. At one time Puritans were driven across the Atlantic by the episcopal church; at another, Churchmen were forced away by the presbyterians, just as the revolutions of state threw the civil power into the hands of the one or the other party; and not a few members

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members of the CHURCH OF ROME were chafed to the wilds of America by the united exertions of both. It has been often obferved, that people perfecuted for their religion become for the moft part enthufiaftically attached to it; and the conduct of thofe colonifts was in perfect harmony with this obfervation. Their zeal, inflamed by their violent removal to the other hemifphere, kept religion alive and active among themfelves; but their poverty difabled them from fupplying fuel to the flame, by making provifion for a miniftry to inftruct their offspring. The confequence was, that the new Chriftian commonwealth, without the kindly affiftance of its mother-country, would have been, in the words of the Roman hiftorian, *Res unius ætatis*. Againft this danger a timely aid was to be provided by the fociety; which, as it confifted not of fanatical members, would not intruft the important bufinefs of the miffion to fanatical preachers, who, though always ready for fuch fpiritual enterprifes, are never qualified to carry them on with fuccefs.

It was therefore thought fit to affign a decent maintenance for clergymen of the church of England, who might preach the gofpel to their brethren in America: and though thofe miffionaries in general carefully avoided the conduct of thofe of Rome, whofe principal aim is to reduce all churches under fubmiffion to the papal tyranny; yet fo lately as 1765, did fome of the colonies, in which the puritanic fpirit of the laft century characterifed the church eftablifhed by law, raife a hideous outcry againft the fociety for fending a miffion into their quarters, though only for the fervice of the difperfed members of the Epifcopal church refiding among them, and for the converfion of thofe men whom their rigid fanaticifm had prejudiced againft Chriftianity itfelf.

Indeed the commodity called FREETHINKING, as Bifhop Warburton expreffes it, was at an early period imported by the opulent and fafhionable colonifts. The celebrated Berkeley, who had refided fome years in Rhode Ifland, and at his return was called upon to preach the anniverfary fermon before the fociety, informs us, that the ifland where he lived was inhabited by an Englifh colony, confifting chiefly of fectaries of many different denominations; that feveral of the better fort of the inhabitants of towns were accuftomed to affemble themfelves regularly on the Lord's day for the performance of divine worfhip; but that moft of thofe who were difperfed through the colony rivalled fome well-bred people of other countries, in a thorough indifference for all that is facred, being equally carelefs of outward worfhip and of inward principles. He adds, that the miffionaries had done, and were continuing to do, good fervice in bringing thofe planters to a ferious fenfe of religion. "I fpeak it knowingly (fays he), that the minifters of the gofpel, in thofe provinces which go by the name of New England, fent and fupported at the expence of the fociety, have, by their fobriety of manners, difcreet behaviour, and a competent degree of ufeful knowledge, fhown themfelves worthy of the choice of thofe who fent them." We have the honour to be acquainted with fome of the miffionaries fent at a later period, and have reafon to believe that, down to the era of the American revolution, they had the fame virtues, and were doing the fame good fervices, which procured to their predeceffors this honourable teftimony from one of the greateft and the beft of men. Surely fuch a miffion deferved not to be evil fpoken of by fectarifts of any denomination who believe in Chrift; efpecially as the very charter of incorporation affigns as a reafon for miffionaries being fent to the colonies, "that by reafon of their poverty thofe colonies were deftitute and unprovided of a MAINTENANCE for minifters and the public worfhip of God."

* See his *Sermon*, vol. ii. of his *Works*, 4to.

The fociety, however, was incorporated for other purpofes than this. It was obliged by its charter to attempt the converfion of the native Americans and the negro flaves; and we have reafon to believe, that, as foon as the fpiritual wants of the colonifts were decently fupplied, it was not inattentive to thefe glorious objects. Its fuccefs indeed in either purfuit has not been fo great as could be wifhed; but it would be rafh and unfair to attribute this failure to the prefident, vice-prefident, or other officers of the corporation at home. An erroneous notion, that the being baptized is inconfiftent with a ftate of flavery, rendered the felfifh colonifts for a long time averfe from the converfion of their negroes, and made them throw every obftacle in the way of all who made the attempt; while the difficulties of the Indian miffion are fuch as hardly any clergyman educated in a Proteftant country can be fuppofed able to furmount.

He who hopes fuccefsfully to preach the gofpel among a tribe of favage wanderers, muft have an ardent zeal and unwearied diligence; appetites fubdued to all the diftreffes of want; and a mind fuperior to all the terrors of mortality. Thefe qualities and habits may be acquired in the church of Rome by him who from infancy has been trained up in the feverities of fome of the monaftic orders, and afterwards fent to the college *de propaganda fide* to be inftructed in the languages, and inured to the manners and cuftoms, of the barbarous nations whofe converfion he is deftined to attempt. But in the reformed churches of Britain there are no monaftic orders, nor any college *de propaganda fide*; and yet without the regular preparation, which is to be looked for in fuch inftitutions alone, it is not in nature, whatever grace may effect, for any man cheerfully, and at the fame time foberly, to undergo all the accumulated diftreffes ever ready to overtake a faithful miffionary among favage idolaters. A fanatic zealot will indeed undertake it, though he is totally unqualified for every fober and important work; and a man of ruined fortunes may be preffed into the fervice, though the impotency of his mind has fhown him unable to bear either poverty or riches. The failure of the fociety therefore in its attempts to convert the American Indians may be attributed, we think, in the firft inftance, to the want of a college *de propaganda* for training up young men for the American miffion.

Perhaps another caufe of this failure may be found in the conduct of the miffionaries, who, it is to be prefumed, have not always employed in a proper manner even the fcanty qualifications which they actually poffeffed. The gofpel, plain and fimple as it is, and fitted in its nature for what it was ordained to effect, cannot be apprehended but by an intellect fomewhat raifed above that of a favage. Such of the miffionaries therefore as began their work with *preaching to favage and brutal men*, certainly fet out at the wrong end; for to make the gofpel underftood, and much more to propagate

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gate and establish it, those savages should have been first taught the necessary arts of civil life, which, while they improve every bodily accommodation, tend at the same time to enlarge and enlighten the understanding. For want of this previous culture, we doubt not, it hath happened that such of the savages as have been baptized into the faith have so seldom persevered themselves, or been able in any degree to propagate among their tribes the Christianity which they had been taught, and that successive missions have always found it necessary to begin anew the work of conversion.

To one or other of these causes, or to both, may justly be attributed the little progress which reformed Christianity has made among the Indians of North America; and not to any want of zeal, attention, or liberality, in the directors of the society at home. During the dependence of the United States on the mother-country, great part of the society's funds was properly expended in keeping alive a just sense of religion among the Christian colonists from Europe, who had surely the first claims upon this best of charities; but now that America has separated herself from Great Britain, and shown that she is able to maintain her independence, and to make ample provision for a regular clergy of her own, the members of the corporation must feel themselves at liberty to bestow greater attention, and to expend more money than they could formerly do, on the conversion of such Indians as have any intercourse with the settlements which we still possess. To a body so respectable, we presume not to offer advice; but we cannot help thinking, with Bishop Berkeley, that the most successful missionaries would be children of Indians, educated in a considerable number together from the age of ten or twelve in a college *de propaganda fide*, where they should be in no danger of losing their mother-tongue while they were acquiring a competent knowledge of religion, morality, history, practical mathematics, and agriculture. "If there were a yearly supply (says he) of a dozen such missionaries sent abroad into their respective countries, after they had received the degree of master of arts, and been admitted into holy orders, it is hardly to be doubted but that in a little time the world would see good and great effects of their mission."

Proposal for the better supplying of Churches in our Foreign Plantations, &c.

2. *Society in Scotland for Propagating Christian Knowledge*, was instituted in the beginning of the eighteenth century. At that period the condition of the Scotch Highlanders was truly deplorable. Shut up in desolate islands by tempestuous seas, or dispersed over a wide extent of country, intersected by high mountains, rapid rivers, and arms of the sea, without bridges or highways, by which any communication could be kept open either with remote or neighbouring districts, they lived in small detached companies in hamlets or solitary huts. Being thus secluded from intercourse with the more civilized part of the island, they could not enjoy the advantages of trade and manufactures. As their soil was barren and their climate severe, in agriculture no progress was to be expected: and as they were acquainted with no language but Gaelic, in which no books were then written, to possess knowledge was impossible. Their parishes being of great extent, often 30 or 40 miles long and of a proportionable breadth, and sometimes consisting of several islands separated by seas, which are often impassable, a considerable number of the inhabitants was entirely deprived of religious instruction or fell a prey to Popish emissaries. A single school in such extensive parishes could be of little benefit; yet many parishes were entirely destitute even of this resource; and where schools were established, the want of books prevented them from producing the useful effects otherwise to have been expected from them (A). To all this we must add, that they lived in a state of the greatest oppression: For though the Highlands formed a part of the British empire, the blessings of the British constitution had not reached them. The feudal system reigned in its utmost rigour; the chieftains exercising the most despotic sway over the inferior Highlanders, whom at their pleasure they deprived of their lives or property (B).

Thus the Highlanders were ignorant, oppressed, and uncivilized; slaves rather than subjects; and either entirely destitute of the advantages of the Christian religion, or unqualified to improve them. Hitherto they had been unhappy and useless to themselves and dangerous to the state; for they were ready at the call of their chieftains to issue from their mountains, and to turn their arms against their lawful king and his loyal subjects. This character, however, arose from their situation. It was therefore impossible for benevolent minds to contemplate this unhappy situation of their countrymen without feeling a desire to raise them to the dignity of rational beings, and to render them useful as citizens.

Accordingly, in the year 1701, some private gentlemen of the city of Edinburgh, who had formed themselves into a society for the reformation of manners, directed their attention to the Highlands of Scotland, and endeavoured to devise some plan for alleviating the distresses of the inhabitants. The remedy which promised to be most efficacious was, to establish charity schools in different places, But as the exigency was great, it was no easy matter to raise a sufficient fund for this purpose. They began therefore with what voluntary subscriptions they could procure, hoping afterwards to increase their capital by vacant stipends and public contributions. A memorial with this view was presented to the General Assembly in 1704, which received their approbation; and they accordingly passed an act, recommending a general contribution. In 1706 the General Assembly appointed some of their number to inquire more carefully into the state of the Highlands, and the year following appointed a select committee to confer with the gentlemen who had suggested the plan. The result of these conferences was the publication of proposals "for propagating Christian knowledge

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(A) Even so late as the year 1758, not fewer than 175 parishes, within the bounds of 39 presbyteries, had no parochial school. We are sorry to add, that even in the present enlightened and benevolent age the complaint is not entirely removed.

(B) The feudal system was at length abolished in the year 1748 by the jurisdiction act.

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ledge in the Highlands and Iflands of Scotland, and in foreign parts of the world." Copies of thefe propofals, with fubfcription papers, were diftributed through the kingdom; and the contributions having foon amounted to 1000l. her majefty Queen Anne encouraged this infant fociety by her royal proclamation, and at the fame time iffued letters patent under the great feal of Scotland for erecting certain of the fubfcribers into a corporation; the firft nomination of whom was lodged with the lords of council and feffion.

This corporation held its firft meeting on Thurfday 3d November 1709. It was attended by feveral of the nobility, fourteen of the lords of feffion, many gentlemen of rank, together with moft of the minifters of the city of Edinburgh and neighbourhood. A prefident, fecretary, and treafurer, with a committee of fifteen directors, were appointed for the difpatch of bufinefs. At their fecond meeting in January 1710, a fcheme of management was formed and approved; in which it was propofed, 1. To erect and maintain fchools in fuch places of Scotland, particularly in the Highlands and Iflands, as fhould be found to need them moft; in which fchools all perfons whatfoever fhould be taught by fit and well qualified fchoolmafters, appointed by the fociety, to read the Holy Scriptures and other pious books; as alfo to write, and to underftand the common rules of arithmetic, with fuch other things as fhould be thought fuitable to their circumftances. 2. That the fchoolmafters fhould be particularly careful to inftruct their fcholars in the principles of the Chriftian reformed religion; and for that end fhould be obliged to catechife them at leaft twice a week, and to pray publicly with them twice a day. 3. That not only fuch as were unable to pay fhould be taught gratis, but that thofe whofe circumftances required it, fhould have fuch farther encouragement as the fociety fhould think fit in a confiftency with their patent. 4. To name fome prudent perfons, minifters and others, to be overfeers of thofe fchools, who fhould take care that the fchoolmafters do their duty, and that the inftructions to be given from time to time by the fociety or their committee be punctually obferved; which overfeers fhould make their report to the fociety quarterly or half-yearly at fartheft. 5. To give fuitable encouragement to fuch minifters or catechifts as fhould be willing to contribute their affiftance towards the farther inftruction of the fcholars remote from church, by not only catechifing, but preaching to them; which minifters or catechifts fhould take the fame care of the other inhabitants as of the fcholars. 6. To extend their endeavours for the advancement of the Chriftian religion to heathen nations; and for that end to give encouragement to minifters to preach the gofpel among them.

Having thus formed a plan, they immediately proceeded to eftablifh fchools in the moft ufeful and economical manner; and as the capital continued to accumulate, the intereft was faithfully applied, and the utility of the inftitution was more extenfively diffufed.

Until the year 1738 the attention of the fociety had been wholly directed to the eftablifhment of fchools; but their capital being then confiderably augmented, they began to extend their views of utility much farther. The grand object of all public affociations ought certainly to be the promoting of religion and morality. It muft, however, be evident to every man of reflection, that thefe can neither be propagated nor preferved among a people without agriculture, unaccuftomed to commerce and manufactures, and confequently without labour or exertion. Languor and debility of mind muft always be the companions of idlenefs. While the Highlanders roved about with arms in their hands, the latent vigour of their minds muft often have been called forth into action; but when their arms were taken away, and themfelves confined to a domeftic life, where there was nothing to roufe their minds, they muft have funk into indolence and inactivity. All attempts therefore to inftruct them in religion and morality, without introducing among them fome of the neceffary arts of life, would probably have been unavailing. The fociety accordingly refolved to adopt what appeared to them the moft effectual methods of introducing induftry among the Highlanders. But as their patent did not extend far enough, they applied to his majefty George II. for an enlargement of their powers; and accordingly obtained a fecond patent, by which they are empowered, "befides fulfilling the purpofes of their original patent, to caufe fuch of the children as they fhall think fit to be bred to hufbandry and houfewifery, to trades and manufactures, or in fuch manual occupations as the fociety fhall think proper."

The objects of this fecond patent the fociety have not failed to purfue; and though many obftacles and difcouragements to their efforts occurred among a rude and barbarous people, yet their perfeverance, and the obvious utility of their plans, at length fo far overcame the reluctance of the inhabitants, that not fewer than 94 fchools of induftry in various parts of the Highlands and Iflands are now upon their eftablifhment, at which are educated 2360 fcholars.

The fociety, while anxioufly endeavouring to diffufe a fpirit of induftry through the Highlands, were ftill equally folicitous to promote the knowledge of the Chriftian religion. As the Englifh language had been the only channel by which knowledge was conveyed to them (a language which, being not ufed in converfation, was in all refpects foreign to them), it was judged requifite that they fhould have the Scriptures in their vernacular tongue. The fociety therefore firft appointed a tranflation of the New Teftament to be made into Gaelic: A tranflation was accordingly undertaken by the Rev. Mr Stewart minifter of Killin in Perthfhire, and printed in 1767, which is faid to be executed with much fidelity. Of this work many thoufand copies have been diftributed in the Highlands. The greater part of the Old Teftament has alfo been tranflated by the Rev. Dr Smith of Campbelton and others, but chiefly by the Rev. Dr Stewart of Lufs, by the appointment and at the expence of the fociety: and as foon as the remaining part can be got ready, the whole will be fold at fo low a price as the poor may without difficulty afford. This plan the fociety have judicioufly chofen, in order to prevent difcontent and murmuring; effects which the diffufion of the Scriptures ought never to produce; but which could not poffibly have been prevented, had the diftribution been gratuitous, and of courfe partial.

For fome years paft the funds of the fociety have rapidly

pidly accumulated, from the very liberal donations of several individuals.

Lady Glenorchy -	L. 5,000
By a person unknown -	10,000
Lord Van Vryhouven of Holland	20,000
Miss Gray of Teasses -	3,500

In consequence of these great additions to their stock, insinuations have been thrown out that the society have become so wealthy as to be at a loss for proper objects on which to bestow their increased revenue. If such an opinion be *seriously* entertained by any one, we must beg him to remember, that the society have erected and endowed not fewer than 323 schools for religion, the first principles of literature and industry, at the annual expence of 3214l. 10s. sterling; and that at these seminaries are educated from 14,000 to 15,000 children; who, but for the means of instruction thus obtained, would in all probability be bred up in ignorance and idleness: That they employ 12 missionary ministers and catechists in remote parts of the Highlands and islands, or among the ignorant Highlanders settled in the great towns of Scotland, at the annual expence of 296l.: That they bestow a bursary or pension of 15l. per annum on each of six students of divinity having the Gaelic language: That they employ two missionary ministers and one schoolmaster among the Oneida and Stockbridge Indians of North America (being the destination of certain legacies bequeathed to them for that purpose), at the annual expence of 140l. Such is their fixed scheme of annual expenditure, amounting in all to 3740l., 10s. sterling—a sum it will be acknowledged of very considerable magnitude. The whole of their incidental expences arising from the Gaelic translation of the Scriptures of the Old Testament; from annuities which they have to pay, in consequence of sums left them as residuary legatees; from land and house taxes; from enabling candidates for the office of schoolmaster to come to Edinburgh for examination; from furnishing books to poor scholars in their various schools; and from removing schoolmasters from one station to another, is generally about 875l., which added to the former sum makes the whole annual expence amount to 4615l. 10s.

If it be inquired at what expence, in the *management* of it, this extensive and complicated charity is annually conducted, we are authorised to say, that the treasurer, bookholder, and clerk, are allowed each 25l. per annum, the same salaries which were annexed to these offices from the commencement of the society. The beadle or officer is allowed 12l. per annum. No salary whatever is enjoyed by any of the other officers of the society. The secretary, comptroller, accountant, and librarian, although subjected, some of them especially, to no small expence of time and labour, have no pecuniary recompense or emolument. Theirs are labours of love, for which they seek and expect no other reward than the consciousness of endeavouring to promote the best interests of mankind. The whole amount of the expence of managing the business of the society, including the above salaries, and coals, candle, stationary ware, postages, and other incidents, exceeds not at an average 115l. per annum. From this statement it appears, that hitherto at least the directors have been at no loss for important objects within the proper sphere of their institution on which to bestow their increased funds. They have, it is true, the disposal of very considerable sums for promoting the objects of the institution; but they are so far from accumulating wealth, that every year their expenditure, notwithstanding the late increase of their capital, exceeds rather than falls short of their income. They have depended upon a kind Providence and a generous public to refund these anticipations of their revenue, and hitherto they have never been disappointed.

Thus has the Society for Propagating Christian Knowledge proceeded for almost a century. It was founded by the pious exertions of a few private individuals, whose names are unknown to the world; and its funds, by faithful and judicious management, as well as by generous contributions, have now become of such magnitude, as to excite the hope that they will be productive of the most valuable effects. The benefits arising from public societies, it is well known, depend entirely upon the management of their directors. If so, the advantages which have accrued from this society intitle it to the praise and gratitude of the nation. While eager to increase the number of schools, the society have not been inattentive to their prosperity. In the year 1771 Mr Lewis Drummond, a gentleman in whom they placed great confidence, was commissioned by them to visit their schools, and to make an exact report of their state and circumstances. Again, in the year 1790, a commission was granted to the Rev. Dr Kemp, one of the ministers of Edinburgh and secretary to the society, to visit all the schools on their establishment. This laborious and gratuitous task he accomplished in the course of four summers with much ability and care, and highly to the satisfaction of the society. At his return he communicated a variety of important information respecting the state of the Highlands and Islands, and the means necessary for their improvement in religion, literature, and industry; an abstract of which was published by the society in appendixes to the anniversary sermons preached before them in the years 1789, 90, 91, and 92 (c)

The following table will exhibit at a glance the funds, establishment, and expenditure, of the society, from a few years after its commencement to the present time. Where

(c) It is well known, that the number of Roman Catholics in the Highlands is considerable; but it must give much pleasure to the Protestant reader to be informed, that the ancient malignant spirit of Popery has in that district given place to mildness and liberality. This is chiefly owing to the gentleman who superintends the priests in that quarter, whose mind is enlightened by science and learning. So far from being hostile to the views of the society, he recommended to his clergy to promote them. They accordingly received the secretary with much politeness; exhorted the people to send their children to the Protestant schools to be instructed in literature, to be taught to read the Scriptures in their own language, and to be made acquainted with those great principles of religion in which all Christians are agreed. What a blessed reformation!

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Where the number of ſcholars is not mentioned, the defect may be ſupplied by taking an average from thoſe years where a computation has been made. Where the capital is not mentioned, it may eaſily be made out by conſidering the ſalaries as the intereſt.

A. D.	Capital.	Schools.	Scholars.
1713		12	
1715	L. 6,177	25	
1719	8,168	48	
1727	9,131	78	2757
1732	13,318	109	
1742	19,287	128	
1753	24,308	152	
1758	28,413	176	6409
1781	34,000	180	7000
	Salaries		
1793	3,080	307	12,913
1794	3,214	323	14,370

Hitherto we have taken no notice of the correſponding board which was eſtabliſhed at London ſo early as the year 1729, to receive ſubſcriptions and lay out ſums. That board indeed remained long inactive; but in 1773 its members began to co-operate more cordially with their brethren in Scotland. Since that period an annual ſermon has been preached in recommendation of the charity; and the preacher is now ſelected without any regard to the religious denomination to which he belongs; ſometimes from the church of England, ſometimes from the church of Scotland, and ſometimes from ſectaries of different perſuaſions. The meetings of the correſpondent board have been attended by many of the nobility and gentry, who have made great exertions to promote the views of the ſociety. From its preſent flouriſhing ſtate therefore, from the indefatigable exertion and laudable zeal of the managers, and from the countenance and ſupport which they have received from perſons of the firſt rank and reſpectability in the nation, the benevolent mind may look forward with much confidence and ſatisfaction to a period not very diſtant, when its beneficial effects ſhall be felt not only in the Highlands, but ſhall be communicated to the reſt of the nation. We have been thus particular in our account of the Society for Propagating Chriſtian Knowledge, becauſe we have had acceſs to the moſt authentic ſources of information, and becauſe we know it to be an inſtitution calculated to enlighten and improve a conſiderable part of the Britiſh nation.

3. *Society of the Sons of the Clergy*, was incorporated by King Charles II. in 1678, by the name of *The Governors of the Charity for Relief of the Poor Widows and Children of Clergymen.* This ſociety is under the direction and management of a preſident and vice-preſident, three treaſurers, and a court of aſſiſtants compoſed of forty members. Several hundreds of widows and children of the clergy have annually received conſiderable relief from this uſeful charity.

4. *Society for the Sons of the Clergy of the Eſtabliſhed Church of Scotland*, was inſtituted at Edinburgh in February 1790, and was conſtituted a body corporate by his majeſty's royal charter in 1792. The ſociety, after ſeveral meetings, are of opinion, that the period in which the families of clergymen feel moſt urgently the need both of friends and of pecuniary aid, is that which commences with the introduction of the ſons either to an univerſity or to buſineſs, and terminates with their eſtabliſhment in their reſpective profeſſions; that many of the miniſters of this church, living at great diſtances from the ſeats either of univerſities or of buſineſs, poſſeſs incomes which, in the preſent ſtate of the country, are inadequate to the purpoſes of procuring for their ſons either the literary or profeſſional education which might enable them to come forward with credit and ſucceſs in the world; that the ſons of clergymen, from domeſtic tuition and example, have in general very advantageous means of receiving in their early years the impreſſions of virtue and honour, together with the rudiments of liberal knowledge; and that of courſe the public intereſt may be promoted, by enabling this claſs of young men to obtain their ſhare in the reſpectable ſituations of life. The views of the ſociety have been limited to the ſons only of clergymen; as they are of opinion, that within the limits which they have fixed, the field of beneficence will be ſtill very extenſive, and the claims for aid as many and as great as their funds can be ſuppoſed able to anſwer, at leaſt for many years to come. If the ſociety ſhall ever be in a ſituation to undertake more than the aids which will be neceſſary in bringing forward the ſons of the clergy, it may then be conſidered in what manner the daughters alſo may become ſharers in its bounty.

A ſociety of the ſame nature, and having the ſame objects in view, was inſtituted at Glaſgow we think the year before; and both ſocieties, we know, have in many caſes proved highly beneficial in promoting the views for which they were inſtituted.

5. *Royal Humane Society*, was inſtituted in London in 1774, for the recovery of perſons drowned or otherwiſe ſuffocated. We have already given ſome account of ſocieties inſtituted in other countries with the ſame views, and have alſo copied the directions of this ſociety for the recovery of life, for which ſee the article DROWNING. We have therefore only to ſtate, that the plan of this ſociety is ſo averſe to any private intereſted views, that it acquits its founders of all ſordid motives. For the medical practitioners accept no pecuniary recompenſe for the time which they devote to a difficult and tedious proceſs; for the anxiety which they feel while the event is doubtful: for the mortification which they too often undergo, when death, in ſpite of all their efforts, at laſt carries off his prey; nor for the inſults to which they willingly expoſe themſelves from vulgar incredulity. Their ſole reward is in the holy joy of doing good. Of an inſtitution thus free in its origin from the ſuſpicion of ambitious views, and in its plan renouncing ſelf-intereſt in every ſhape, philanthropy muſt be the only baſis. The good intention therefore of the ſociety is proved by its conſtitution; the wiſdom and utility of the undertaking are proved by its ſucceſs: not fewer than 3000 fellow-creatures having ſince its commencement been (1794) reſtored to the community by its timely and indefatigable exertions. For it is to be obſerved, that the benefit of this ſociety is by no means confined to the two caſes of drowning and ſuſpenſion. Its timely ſuccours have rouſed the lethargy of opium taken in immoderate and repeated doſes; they have reſcued the wretched victims of intoxication; rekindled the life extinguiſhed by the ſudden ſtroke of lightning; recovered the apoplectic; reſtored life to the infant that had loſt it in the birth; they have proved efficacious

efficacious in cafes of accidental fmothering and of fuffocation by noxious damps; in inftances in which the tendernefs of the infant body or the debility of old age greatly leffened the previous probability of fuccefs: infomuch that no fpecies of death feems to be placed beyond the reach of this fociety's affiftance, where the mifchief had gone no farther than an obftruction of the movements of the animal machine without any damage of the organs themfelves. In confequence of every neceffary affiftance afforded by this fociety, fimilar inftitutions have been eftablifhed at Algiers, Lifbon, Philadelphia, Bofton, Jamaica, Dublin, Leith, Glafgow, Paifley, Aberdeen, Birmingham, Gloucefter, Shropfhire, Northamptonfhire, Lancafter, Briftol, Whitehaven, Norwich, Exeter, Kent, and Newcaftle. The fociety has publifhed an 8vo volume with plates, confifting of cafes, correfpondence, and a variety of interefting matter relating to the object of this benevolent inftitution.

6. *The Philanthropic Society*, was inftituted in September 1788. It aims at the prevention of crimes, by removing out of the way of evil counfel, and evil company, thofe children who are, in the prefent ftate of things, deftined to ruin. It propofes to educate and inftruct in fome ufeful trade or occupation the children of convicts or other infant poor who are engaged in vagrant or criminal courfes; thus to break the chain of thofe pernicious confederacies, deprive the wicked of fucceffors, the gaols of inhabitants, juftice of its victims, and by all thefe means add citizens to fociety. This inftitution is not only calculated to decreafe vice and infamy, but to increafe ufeful induftry; fo that thofe children who would otherwife fucceed to their parents hereditary crimes, and become the next race of beggars and thieves, will now be taught to fupply by honeft means their own wants and the wants of others.

To carry into effect thefe defirable purpofes, it is the firft bufinefs of the fociety to felect from prifons, and from the haunts of vice, profligacy, and beggary, fuch objects as appear moft likely to become obnoxious to the laws, or prejudicial to the community; and, in the execution of this duty, the affiftance of the magiftrates, the clergy, and all who are interefted in the promotion of good morals and good government, is moft earneftly requefted. For the employment of the children, feveral houfes are fupported, at Cambridge Heath, near Hackney, in each of which a mafter-workman is placed for the purpofe of teaching the children fome ufeful trade. The trades already eftablifhed are thofe of a printer, carpenter, fhoemaker, and taylor. The girls are at prefent educated as menial fervants.

In the year 1791 not fewer than 70 children were under the protection of this fociety, among whom were many who have been guilty of various felonies, burglaries, and other crimes. Yet, fingular as it may appear, in lefs than two years thofe very children became no lefs remarkable for induftry, activity, decency, and obedience, than they formerly were for the contrary vices. Such are the grounds on which the Philanthropic Society now claims the attention and folicits the patronage of the public. If we regard humanity and religion, this inftitution opens an afylum to the moft forlorn and abject of the human race; it befriends the moft friendlefs; it faves from the certain and fatal confequences of infamy and vicious courfes orphans and deferted children. If we regard national profperity and the public welfare, it is calculated to increafe induftry; and it directs that induftry into the moft ufeful and neceffary channels. If we regard felf-intereft, its immediate object is to protect our perfons from affault and murder, our property from depredation, and our peaceful habitations from the defperate fury of midnight incendiaries.

One guinea per annum conftitutes a member of the fociety; and 10l. at one payment a member for life. A life-fubfcription, or an annual payment of at leaft two guineas, is a neceffary qualification for being elected into the committee.

II. Societies for Promoting Science and Literature.

1. *The Royal Society of London* is an academy or body of perfons of eminent learning, inftituted by Charles II. for the promoting of natural knowledge. The origin of this fociety is traced by Dr Sprat, its earlieft hiftorian, no farther back than to "fome fpace after the end of the civil wars" in the 17th century. The fcene of the firft meetings of the learned men who laid the foundation of it, is by him fixed in the univerfity of Oxford at the lodgings of Dr Wilkins warden of Wadham college. But Dr Birch, on the authority of Dr Wallis, one of its earlieft and moft confiderable members, affigns it an earlier origin. According to him, certain worthy perfons, refiding in London about the year 1645, being "inquifitive into natural and the new and experimental philofophy, agreed to meet weekly on a certain day, to difcourfe upon fuch fubjects, and were known by the title of *The Invifible* or *Philofophical College*." In the years 1648 and 1649, the company who formed thefe meetings was divided, part retiring to Oxford and part remaining in London; but they continued the fame purfuits as when united, correfponding with each other, and giving a mutual account of their refpective difcoveries. About the year 1659 the greater part of the Oxford fociety returned to London, and again uniting with their fellow-labourers, met once, if not twice, a-week at Grefham college, during term time, till they were fcattered by the public diftractions of that year, and the place of their meeting made a quarter for foldiers. On the reftoration 1660 their meetings were revived, and attended by a greater concourfe of men eminent for their rank and learning. They were at laft taken notice of by the king, who having himfelf a confiderable tafte for phyfical fcience, was pleafed to grant them an ample charter, dated the 15th of July 1662, and afterwards a fecond dated 15th April 1763, by which they were erected into a corporation, confifting of a prefident, council, and fellows, for promoting natural knowledge; and to give their inveftigations, againft which ftrange prejudices were entertained, every poffible fupport, he fometimes honoured their meetings with his prefence.

Their manner of electing fellows is by balloting. Their council are in number 21, including the prefident, vice-prefident, treafurer, and two fecretaries; 11 of which are continued for the next year, and 10 more added to them; all chofen on St Andrew's day. Each member at his admiffion fubfcribes an engagement that he will endeavour to promote the good of the fociety; from which he may be freed at any time, by fignifying to the prefident that he defires to withdraw. The charges have been different at different times, and were at at firft irregularly paid: but they are now five guineas paid to the treafurer at admiffion, and 13s. per quarter fo long as the perfon continues a member; or, in lieu of the annual fubfcription, a compofition of 25 guineas in one payment.

Their defign is, to "make faithful records of all the works of nature or art which come within their reach; fo that the prefent as well as future ages may be enabled to put a mark on errors which have been ftrengthened by long prefcription; to reftore truths that have been neglected; to pufh thofe already known to more various ufes; to make the way more paffable to what remains unrevealed," &c. To this purpofe they have made a great number of experiments and obfervations on moft of the works of nature; and alfo numbers of fhort hiftories of nature, arts, manufactures, ufeful engines, contrivances, &c. The fervices which they have rendered to the public are very great. They have improved naval, civil, and military architecture; advanced the fecurity and perfection of navigation; improved agriculture; and put not only this kingdom, but alfo Ireland, the plantations, &c. upon planting. They have regiftered experiments, hiftories, relations, obfervations, &c. and reduced them into one common ftock; and have, from time to time, publifhed thofe which they reckoned moft ufeful, under the title of *Philofophical Tranfactions*, &c. and laid the reft up in public regifters, to be nakedly tranfmitted to pofterity, as a folid groundwork for future fyftems.

They have a library adapted to their inftitution; towards which Mr Henry Howard, afterwards duke of Norfolk, contributed the Norfolcian library, and which is, at this time, greatly increafed by a continual feries of benefactions. The mufeum or repofitory of natural and artificial rarities, given them by Daniel Colwal, Efq. and fince enriched by many others, is now removed to the Britifh mufeum, and makes a part of that great repofitory. Their motto is *Nullius in verba;* and their place of affembling is Somerfet-houfe in the Strand. Sir Godfrey Copley, baronet, left five guineas to be given annually to the perfon who fhould write the beft paper in the year, under the head of experimental philofophy. This reward, which is now changed to a gold medal, is the higheft honour the fociety can beftow. It is conferred on St Andrew's day.

2. *The Royal Society of Edinburgh*, was incorporated by royal charter on the 29th of March 1783, and has for its object the cultivation of every branch of fcience, erudition, and tafte. Its rife and progrefs towards its prefent ftate was as follows: In the year 1718 a literary fociety was eftablifhed in Edinburgh by the learned Ruddiman and others, which in 1731 was fucceeded by a fociety inftituted for the improvement of medical knowledge. In the year 1739 the celebrated Maclaurin conceived the idea of enlarging the plan of this fociety, by extending it to fubjects of philofophy and literature. The inftitution was accordingly new-modelled by a printed fet of laws and regulations, the number of members was increafed, and they were diftinguifhed from that time by the title of *The Society for Improving Arts and Sciences*, or more generally by the title of *The Philofophical Society of Edinburgh.* Its meetings, however, were foon interrupted by the diforders of the country during the rebellion in 1745; and they were not renewed till the year 1752. Soon after this period the firft volume of the Tranfactions of the Philofophical Society of Edinburgh was publifhed, under the title of *Effays and Obfervations, Phyfical and Literary*, and was followed by other volumes of acknowledged merit. About the end of the year 1782, in a meeting of the profeffors of the univerfity of Edinburgh, many of whom were likewife members of the Philofophical Society, and warmly attached to its interefts, a fcheme was propofed by the Rev. Dr Robertfon, principal of the univerfity, for the eftablifhment of a new fociety on a more extended plan, and after the model of fome of the foreign academies. It appeared an expedient meafure to folicit the royal patronage to an inftitution of this nature, which promifed to be of national importance, and to requeft an eftablifhment by charter from the crown. The plan was approved and adopted; and the Philofophical Society, joining its influence as a body in feconding the application from the univerfity, his majefty, as we have already obferved, was moft gracioufly pleafed to incorporate The Royal Society of Edinburgh by charter.

This fociety confifts of ordinary and honorary members; and the honorary places are reftricted to perfons refiding out of Great Britain and Ireland. The election of new members is appointed to be made at two ftated general meetings, which are to be held on the fourth Monday of January and the fourth Monday of June. A candidate for the place of an ordinary member muft fignify by a letter, addreffed to one of the members, his wifh to be received into the fociety. He muft then be publicly propofed at leaft a month before the day of election. If the propofal be feconded by two of the members prefent, his name is to be inferted in the lift of candidates, and hung up in the ordinary place of meeting. The election is made by ballot, and is determined in favour of a candidate, if he fhall have the votes of two-thirds of thofe prefent, in a meeting confifting of at leaft 21 members. The general bufinefs of the fociety is managed by a prefident, two vice-prefidents, with a council of 12, a general fecretary, and a treafurer. Thefe officers are chofen by ballot annually on the laft Monday of November. All public deeds, whether of a civil or of a literary nature, are tranfacted by this board, and proceed in the name of the prefident or vice-prefident.

As it was thought that the members would have a greater inducement to punctual attendance on the meetings of the fociety, if they had fome general intimation of the nature of the fubjects which were to be confidered, and made the topics of converfation, it was therefore refolved to divide the fociety into two claffes, which fhould meet and deliberate feparately. One of thefe claffes is denominated the *Phyfical Clafs*, and has for its department the fciences of mathematics, natural philofophy, chemiftry, medicine, natural hiftory, and whatever relates to the improvement of arts and manufactures. The other is denominated the *Literary Clafs*, and has for its department literature, philology, hiftory, antiquities, and fpeculative philofophy. Every member is defired at his admiffion to intimate which of thofe claffes he wifhes to be more particularly affociated with; but he is at the fame time intitled to attend the meetings of the other clafs, and to take part in all its proceedings. Each of the claffes has four prefidents and two fecretaries, who officiate by turns. The meetings of the phyſical claſs are held on the firſt Mondays of January, February, March, April, July, Auguſt, November, and December; and the meetings of the Literary claſs are held on the third Mondays of January, February, March, April, June, July, November, and December, at 7 o'clock afternoon.

At theſe meetings the written eſſays and obſervations of the members of the ſociety, or their correſpondents, are read publicly, and become the ſubjects of converſation. The ſubjects of theſe eſſays and obſervations are announced at a previous meeting, in order to engage the attendance of thoſe members who may be particularly intereſted in them. The author of each diſſertation is likewiſe deſired to furniſh the ſociety with an abſtract of it, to be read at the next enſuing meeting, when the converſation is renewed with increaſed advantage, from the knowledge previouſly acquired of the ſubject. At the ſame meetings are exhibited ſuch ſpecimens of natural or artificial curioſities, ſuch remains of antiquity, and ſuch experiments, as are thought worthy of the attention of the ſociety. All objects of natural hiſtory preſented to the ſociety, are ordered by the charter of the inſtitution to be depoſited, on receipt, in the muſeum of the univerſity of Edinburgh; and all remains of antiquity, public records, or ancient manuſcripts, in the library belonging to the faculty of advocates at Edinburgh.

The ordinary members, whoſe uſual reſidence is in the city of Edinburgh or its immediate neighbourhood, are expected to attend regularly the monthly meetings; and are required to defray, by an annual contribution, the current expences of the inſtitution. The members who reſide at ſuch a diſtance from Edinburgh, that they cannot enjoy the advantages ariſing from a regular attendance on the meetings of the ſociety, are not ſubjected to any contribution for defraying its expences, but have a right to attend thoſe meetings when occaſionally in Edinburgh, and to take part in all their proceedings.

Five volumes of the Tranſactions of the ſociety have been publiſhed, which bear ample teſtimony to the learning and acuteneſs of their various authors.

3. *Medical Society* of London, inſtituted in the year 1752, on the plan recommended by Lord Bacon (*De Augm. Scient.* lib. iv. cap. 2.), to revive the Hippocratic method of compoſing narratives of particular caſes, in which the nature of the diſeaſe, the manner of treating it, and the conſequences, are to be ſpecified; to attempt the cure of thoſe diſeaſes which, in his opinion, have been too boldly pronounced incurable; and, laſtly, to extend their inquiries after the powers of particular medicines in the cure of particular caſes; the collections of this ſociety have been already publiſhed, under the title of *Medical Obſervations and Inquiries*, in ſeveral volumes.

4. *The Medical Society* of Edinburgh was incorporated by royal charter in 1778; but there appears to have been in that city a voluntary aſſociation of the ſame name from the firſt eſtabliſhment of a regular ſchool of phyſic in the univerſity. To the voluntary ſociety the public is indebted for ſix volumes of curious and uſeful eſſays, collected principally by the late Dr Monro from June 1731 to June 1736; but in the year 1739 that ſociety was united to another, as we have already obſerved in a former article. The ordinary members of the preſent medical ſociety are elected by ballot, and three diſſentients exclude a candidate; an ordinary member may alſo be elected an honorary member, who enjoys the privileges of the others, and receives a diploma, but is freed from the obligation of attendance, delivering papers in rotation, &c. to which the ordinary members are ſubject; but in this caſe the votes muſt be unanimous. The meetings of this ſociety are held every Friday evening (formerly Saturday) in their own hall, during the winter ſeaſon, when papers on medical ſubjects are delivered by the ſeveral members in rotation; and four of theſe are annually elected to fill the chair in rotation, with the title of annual preſidents. This ſociety poſſeſſes an excellent library of books on ſubjects connected with its purſuits.

5. The *Royal Medical Society* of Paris was inſtituted in 1776. The members are divided into aſſociates ordinary, limited to 30, honorary to 12, extraordinary to 60, and foreign to 60, and correſpondents. This ſociety has publiſhed ſeveral volumes of Memoirs in 4to.

6. *Aſiatic Society*, an inſtitution planned by the late illuſtrious Sir William Jones, and actually formed at Calcutta on the 15th of January 1784, for the purpoſe of tracing the hiſtory, antiquities, arts, ſciences, and literature, of the immenſe continent of Aſia. As it was reſolved to follow as nearly as poſſible the plan of the ROYAL SOCIETY of London, of which the king is *patron*, the patronage of the Aſiatic Society was offered to the governor-general and council, as the executive power in the territories of the company. By their acceptance of this offer, Mr Haſtings, as governor-general, appeared among the patrons of the new ſociety; "but he ſeemed in his private ſtation, as the firſt liberal promoter of uſeful knowledge in Bengal, and eſpecially as the great encourager of Perſian and Shanſcrit literature, to deſerve a particular mark of diſtinction:" he was requeſted, therefore, to accept the honorary title of preſident. This was handſomely declined in a letter from Mr Haſtings, in which he requeſted "to yield his pretenſions to the gentleman whoſe genius planned the inſtitution, and was moſt capable of conducting it to the attainment of the great and ſplendid purpoſes of its formation." On the receipt of this letter, Sir William Jones was nominated preſident of the ſociety; and we cannot give the reader a view of the object of the inſtitution in clearer language than that which he employed in his firſt diſcourſe from the chair.

"It is your deſign, I conceive (ſaid the preſident), to take an ample ſpace for your learned inveſtigations, bounding them only by the geographical limits of Aſia; ſo that, conſidering Hindoſtan as a centre, and turning your eyes in idea to the north, you have on your right many important kingdoms in the eaſtern peninſula, the ancient and wonderful empire of China with all her Tartarian dependencies, and that of Japan, with the cluſter of precious iſlands, in which many ſingular curioſities have too long been concealed: before you lies that prodigious chain of mountains, which formerly perhaps were a barrier againſt the violence of the ſea, and beyond them the very intereſting country of Tibet, and the vaſt regions of Tartary, from which, as from the Trojan horſe of the poets, have iſſued ſo many conſummate warriors, whoſe domain has extended at leaſt from the banks of the Ilyſſus to the mouths of the Ganges: on your left are the beautiful and celebrated provinces of

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of Iran or Persia, the unmeasured and perhaps unmeasurable deserts of Arabia, and the once flourishing kingdom of Yemen, with the pleasant isles that the Arabs have subdued or colonized; and farther westward, the Asiatic dominions of the Turkish sultans, whose moon seems approaching rapidly to its wane. By this great circumference the field of your useful researches will be inclosed; but since Egypt had unquestionably an old connection with this country, if not with China, since the language and literature of the Abyssinians bear a manifest affinity to those of Asia, since the Arabian arms prevailed along the African coast of the Mediterranean, and even erected a powerful dynasty on the continent of Europe, you may not be displeased occasionally to follow the streams of Asiatic learning a little beyond its natural boundary; and, if it be necessary or convenient that a short name or epithet be given to our society, in order to distinguish it in the world, that of *Asiatic* appears both classical and proper, whether we consider the place or the object of the institution, and preferable to *Oriental*, which is in truth a word merely relative, and though commonly used in Europe, conveys no very distinct idea.

"If now it be asked, What are the intended objects of our inquiries within these spacious limits? we answer, MAN and NATURE; whatever is performed by the *one* or produced by the *other*. Human knowledge has been elegantly analysed according to the three great faculties of the mind, *memory*, *reason*, and *imagination*, which we constantly find employed in arranging and retaining, comparing and distinguishing, combining and diversifying, the ideas, which we receive through our senses, or acquire by reflection: hence the three main branches of learning are, *history*, *science*, and *art*; the first comprehends either an account of natural productions, or the genuine records of empires and states, the second embraces the whole circle of pure and mixed mathematics, together with ethics and law, as far as they depend on the reasoning faculty; and the third includes all the beauties of imagery and the charms of invention, displayed in modulated language, or represented by colour, figure, or sound.

"Agreeably to this analysis, you will investigate whatever is rare in the stupendous fabric of nature, will correct the geography of Asia by new observations and discoveries; will trace the annals and even traditions of those nations who from time to time have peopled or desolated it; and will bring to light their various forms of government, with their institutions civil and religious; you will examine their improvements and methods in arithmetic and geometry; in trigonometry, mensuration, mechanics, optics, astronomy, and general physics; their systems of morality, grammar, rhetoric, and dialectic; their skill in chirurgery and medicine; and their advancement, whatever it may be, in anatomy and chemistry. To this you will add researches into their agriculture, manufactures, trade; and whilst you inquire with pleasure into their music, architecture, painting, and poetry, will not neglect those inferior arts by which the comforts and even elegancies of social life are supplied or improved. You may observe, that I have omitted their languages, the diversity and difficulty of which are a sad obstacle to the progress of useful knowledge; but I have ever considered languages as the mere instruments of real learning, and think them improperly confounded with learning itself: the attainment of them is, however, indispensably necessary; and if to the Persian, Armenian, Turkish, and Arabic, could be added not only the Shanscrit, the treasures of which we may now hope to see unlocked, but even the Chinese, Tartarian, Japanese, and the various insular dialects, an immense mine would then be open, in which we might labour with equal delight and advantage."

Of this society three volumes of the Transactions have been published, which are replete with information in a high degree curious and important; and we hope that the European world shall soon be favoured with another. The much-to-be-lamented death of the accomplished president may indeed damp the spirit of investigation among the members; for to conquer difficulties so great as they must meet with, a portion seems to be necessary of that enthusiasm which accompanied all the pursuits of Sir William Jones; but his successor is a man of great worth and learning, and we trust will use his utmost endeavours to have the plan completed of which Sir William gave the outlines.

5. *The American Philosophical Society*, held at Philadelphia, was formed in January 1769 by the union of two societies which had formerly subsisted in that city. This society extends its attention to geography, mathematics, natural philosophy, and astronomy; medicine and anatomy; natural history and chemistry; trade and commerce; mechanics and architecture; husbandry and American improvements. Its officers are a patron, president, three vice-presidents, one treasurer, four secretaries, and three curators, who are annually chosen by ballot. The duty of the president, vice-presidents treasurer, and secretaries, is the same as in other societies. The business of the curators is to take the charge of all specimens of natural productions, whether of the animal, vegetable, or fossil kingdom; all models of machines and instruments; and all other matters belonging to the society which shall be intrusted to them. The ordinary meetings are held on the first and third Fridays of every month from October to May inclusive. This society was incorporated by charter 15th March 1780; and has published three volumes of its Transactions, containing many ingenious papers on general literature and the sciences, as well as respecting those subjects peculiar to America. It is a delightful prospect to the philosopher to consider, that Asia, Europe, and America, though far separated and divided into a variety of political states, are all three combined to promote the cause of knowledge and truth.

6. *A Literary and Philosophical Society* of considerable reputation has been lately established at Manchester, under the direction of two presidents, four vice-presidents, and two secretaries. The number of members is limited to 50; besides whom there are several honorary members, all of whom are elected by ballot; and the officers are chosen annually in April. Five volumes of valuable essays have been already published by this society.

A society on a similar plan has been established at Newcastle. It is composed of a number of most respectable members, and possesses a very valuable library and philosophical apparatus. Lectures on the different branches of natural philosophy have been delivered for several years at this institution.

7. *Society for Promoting the Discovery of the Interior Parts*

Parts of Africa. This ſociety or aſſociation for exploring the internal diſtricts of Africa, of which ſo little is at preſent known, was formed in London by ſome opulent individuals in 1788; who, ſtrongly impreſſed with a conviction of the practicability and utility of thus enlarging the fund of human knowledge, determined if poſſible to reſcue the age from that ſtigma which attaches to its ignorance of ſo large and ſo near a portion of the globe. The founders of this ſociety reſolved to admit no man a member for a ſhorter period than three years, during which he muſt pay annually into the public fund five guineas. After three years, any member, upon giving a year's notice, may withdraw himſelf from the aſſociation. During the firſt 12 months each of the members was allowed to recommend for the approbation of the ſociety ſuch of his friends as he might think proper to be admitted into it; but ſince that period we believe all additional members have been elected by a ballot of the aſſociation at large. A committee was choſen by ballot to manage the funds of the ſociety, to chooſe proper perſons to be ſent on the diſcovery of the interior parts of Africa, and to carry on the ſociety's correſpondence, with expreſs injunctions to diſcloſe no intelligence received from their agents but to the ſociety at large. But a fuller account of the nature of this eſtabliſhment, and the very happy efforts they have made, may be ſeen in the ſuperb edition of their proceedings printed in 1790, 4to, for their own uſe; or in the 8vo edition ſince made public. They ſoon found two gentlemen, Mr Lucas and Mr Ledyard, who were ſingularly well qualified for the important miſſion. The information they have acquired will be found in the above work; with a new map by Mr Rennel, exhibiting the geographical knowledge collected by the African aſſociation. Mr Ledyard very unfortunately died during his reſearches at Cairo.

Few of our readers are unacquainted with the travels of Mr Park under the patronage of the ſociety. For an account of which ſee AFRICA. A ſecond journey was undertaken by the ſame gentleman within theſe three years; but as he has not been heard of for a long time, the moſt ſerious apprehenſions are entertained that he and his companions have fallen victims either to the inhoſpitable climate, or to the watchful jealouſy of the Moors. Another enterpriſing traveller, Mr Horneman, was ſent out by the ſociety about 1800. He departed from Cairo with a caravan, and reached Mourzouk, a place ſituated ſouth from Tripoli; and from thence ſent a communication to his conſtituents which has ſince been publiſhed by the ſociety. This is the laſt account that was received of this traveller, from which it is feared that he has alſo periſhed.

8. *The Society of Antiquaries of London*, was founded about the year 1572 by Archbiſhop Parker, a munificent patron of learned men. For the ſpace of 20 years it aſſembled in the houſe of Sir Robert Cotton; in 1589 they reſolved to apply to Queen Elizabeth for a charter and a public building where they might hold their meetings; but it is uncertain whether any ſuch application was ever made. In the mean time, the reputation of the ſociety gradually increaſed, and at length it excited the jealouſy of James I. who was afraid leſt it ſhould preſume to canvaſs the ſecret tranſactions of his government. He accordingly diſſolved it. But in the beginning of the laſt century, the Antiquarian ſociety began to revive; and a number of gentlemen, eminent for their affection to this ſcience, had weekly meetings, in which they examined the antiquities and hiſtory of Great Britain preceding the reign of James I. but without excluding any other remarkable antiquities that might be offered to them. From this time the ſociety grew in importance; and in 1750 they unanimouſly reſolved to petition the king for a charter of incorporation. This they obtained the year following, by the influence of the celebrated earl of Hardwicke, then lord-chancellor, and Martin Folkes, Eſq; who was then their preſident. The king declared himſelf their founder and patron, and empowered them to have a body of ſtatutes, and a common ſeal, and to hold in perpetuity lands, &c. to the yearly value of 1000l.

The chief object of the inquiries and reſearches of the ſociety are Britiſh antiquities and hiſtory; not, however, wholly excluding thoſe of other countries. It muſt be acknowledged, that the ſtudy of antiquity offers to the curious and inquiſitive a large field for reſearch and amuſement. The inquirer in this branch furniſhes the hiſtorian with his beſt materials, while he diſtinguiſhes from truth the fictions of a bold invention, and aſcertains the credibility of facts; and to the philoſopher he preſents a fruitful ſource of ingenious ſpeculation, while he points out to him the way of thinking, and the manners of men, under all the varieties of aſpect in which they have appeared.

An antiquarian ought to be a man of ſolid judgement, poſſeſſed of learning and ſcience, that he may not be an enthuſiaſtic admirer of every thing that is ancient merely becauſe it is ancient; but be qualified to diſtinguiſh between thoſe reſearches which are valuable and important, and thoſe which are trifling and uſeleſs. It is from the want of theſe qualifications that ſome men have contracted ſuch a blind paſſion for every thing that is ancient, that they have expoſed themſelves to ridicule, and their ſtudy to contempt. But if a regard to utility were always to regulate the purſuits of the antiquarian, the ſhafts of ſatire would no longer be levelled at him; but he would be reſpected as the man who labours to reſtore or to preſerve ſuch ancient productions as are ſuited to illuminate religion, philoſophy, and hiſtory, or to improve the arts of life.

We by no means intend to apply theſe obſervations to any particular ſociety of antiquarians; but we throw them out, becauſe we know that an aſſiduous ſtudy of antiquity is apt, like the ardent purſuit of money, to loſe ſight of its original object, and to degenerate into a paſſion which miſtakes the mean for the end, and conſiders poſſeſſion without a regard to utility as enjoyment.

An aſſociation ſimilar to that of the Antiquarian Society of London was founded in *Edinburgh* in 1780, and received the royal charter in 1783. A volume of the tranſactions of this ſociety has been publiſhed; but with the exception of two or three memoirs, it contains little worthy of notice; and accordingly, it has never attracted the attention of the public.

Beſides theſe literary ſocieties here mentioned, there are a great number more in different parts of Europe, ſome of which are noticed under the article ACADEMY. Thoſe which are omitted are not omitted on account of any idea of their inferior importance; but either becauſe

Societies for Encouraging and Promoting Arts, Manufactures, &c.

caufe we have had no accefs to authentic information, or becaufe they refemble the focieties already defcribed fo clofely, that we could have given nothing but their names.

III. Societies for Encouraging and Promoting Arts, Manufactures, &c.

1. *London Society for the Encouragement of Arts, Manufactures, and Commerce*, was inftituted in the year 1754 by Lord Folkftone, Lord Romney, Dr Stephen Hales, and a few private gentlemen; but the merit of this inftitution chiefly belonged to Mr William Shipley, an ingenious mechanic; who, though deriving no advantages from learning, by unwearied perfonal attendance found means to engage a few perfons of rank and fortune to meet at Peele's coffeehoufe in Fleet-ftreet, and to adopt a plan for promoting arts and manufactures.

The office-bearers of this fociety are a prefident, 12 vice-prefidents, a fecretary, and regifter. Their proceedings are regulated by a body of rules and orders eftablifhed by the whole fociety, and printed for the ufe of the members. All queftions and debates are determined by the holding up of hands, or by ballot if required; and no matter can be confirmed without the affent of a majority at two meetings. They invite all the world to propofe fubjects for encouragement; and whatever is deemed deferving of attention is referred to the confideration of a committee, which, after due inquiry and deliberation, make their report to the whole fociety, where it is approved, rejected, or altered. A lift is printed and publifhed every year of the matters for which they propofe to give premiums; which premiums are either fums of money, and thofe fometimes very confiderable ones; or the fociety's medal in gold or filver, which they confider as the greateft honour they can beftow. All poffible care is taken to prevent partiality in the diftribution of their premiums, by defiring the claimants names to be concealed, and by appointing committees, (who when they find occafion call to their affiftance the moft fkilful artifts) for the ftrict examination of the real merit of all matters and things brought before them, in confequence of their premiums.

The chief objects of the attention of the Society for the Encouragement of Arts, Manufactures, and Commerce, in the application of their revenues, are ingenuity in the feveral branches of the polite and liberal arts, ufeful difcoveries and improvements in agriculture, manufactures, mechanics, and chemiftry, or the laying open of any fuch to the public; and, in general, all fuch ufeful inventions, difcoveries, or improvements (though not mentioned in the book of premiums) as may appear to have a tendency to the advantage of trade and commerce.

The following are fome of the moft important regulations of this fociety. It is required that the matters for which premiums are offered be delivered in without names, or any intimation to whom they belong; that each particular thing be marked in what manner each claimant thinks fit, fuch claimant fending with it a paper fealed up, having on the outfide a correfponding mark, and on the infide the claimant's name and addrefs; and all candidates are to take notice, that no claim for a premium will be attended to, unlefs the conditions of the advertifement are fully complied with. No papers fhall be opened but fuch as fhall gain premiums, unlefs where it appears to the fociety abfolutely neceffary for the determination of the claim: all the reft fhall be returned unopened, with the matters to which they belong, if inquired after by the marks within two years; after which time, if not demanded, they fhall be publicly burnt unopened at fome meeting of the fociety. All the premiums of this fociety are defigned for that part of Great Britain called England, the dominion of Wales, and the town of Berwick upon Tweed, unlefs exprefsly mentioned to the contrary. No perfon fhall receive any premium, bounty, or encouragement, from the fociety for any matter for which he has obtained or propofes to obtain a patent. No member of this fociety fhall be a candidate for or intitled to receive any premium, bounty, or reward whatever, except the honorary medal of the fociety.

The refpectability of the members who compofe it may be feen by perufing the lift which generally accompanies thetr tranfactions. In the laft volume (vol. xii.) it occupies no lefs than 43 pages. Some idea may be formed of the wealth of this fociety, by obferving that the lift of their premiums fills 96 pages, and amounts to 250 in number. Thefe confift of gold medals worth from 30 to 50, and in a few inftances to 100 guineas; and filver medals valued at 10 guineas.

This fociety is one of the moft important in Great Britain. Much money has been expended by it, and many are the valuable effects of which it has been productive. Among thefe we reckon not only the difcoveries which it has excited, but the inftitution of other focieties on the fame principles to which it has given birth; and we do not hefitate to conclude, that future ages will confider the founding of this fociety as one of the moft remarkable epochs in the hiftory of the arts. We contemplate with pleafure the beneficial effects which muft refult to this nation and to mankind by the diffufion of fuch inftitutions; and rejoice in the hope that the active minds of the people of Great Britain, inftead of being employed as formerly in controverfies about religion, which engender ftrife, or in difcuffions concerning the theory of politics, which lead to the adoption of fchemes inconfiftent with the nature and condition of man, will foon be more generally united into affociations for promoting ufeful knowledge and folid improvement, and for alleviating the diftreffes of their fellow creatures.

1. *Society inftituted at Bath for the Encouragement of Agriculture, Arts, Manufactures, and Commerce.* It was founded in the year 1777 by feveral gentlemen who met at the city of Bath. This fcheme met with a very favourable reception both from the wealthy and learned. The wealthy fubfcribed very liberally, and the learned communicated many important papers. On application to the London and provincial focieties inftituted for the like purpofes, they very politely offered their affiftance. Seven volumes of their tranfactions have already been publifhed, containing very valuable experiments and obfervations, particularly refpecting agriculture, which well deferve the attention of all farmers in the kingdom. We have confulted them with much fatisfaction on feveral occafions, and have frequently referred to them in the courfe of this work; and therefore, with pleafure, embrace

embrace the prefent opportunity of repeating our obligations. We owe the fame acknowledgments to the Society for the Improvement of Arts, &c. of London.

3. *Society for working Mines*, an affociation lately formed on the continent of Europe. This inftitution arofe from the accidental meeting of feveral mineralogifts at Skleno near Schemnitz in Hungary, who were collected in order to examine a new method of amalgamation. Struck with the fhackles impofed on mineralogy by monopolizers of new and ufeful proceffes, they thought no method fo effectual to break them, as forming a fociety, whofe common labours fhould be directed to fix mining on its fureft principles; and whofe memoirs, fpread all over Europe, might offer to every adventurer the refult of the refearches, of which they are the object. By thefe means they fuppofed, that there would be a mafs of information collected; the interefts of individuals would be loft in the general intereft; and the one would materially affift the other. Impofture and quackery would, by the fame means, be banifhed from a fcience, which muft be improved by philofophy and experience; and the fociety, they fuppofed, would find, in the confidence which they infpired, the reward and the encouragement of their labours. They defign, that the memoirs which they publifh fhall be fhort and clear; truth muft be their bafis, and every idle difcuffion, every foreign digreffion, muft be banifhed; politics and finance muft be avoided, though the differtations may feem to lead towards them; and they oblige themfelves to oppofe the affectation of brilliancies, and the oftentation of empty fpeculation, when compared with plain, fimple, and ufeful facts.

The object of the fociety is phyfical geography; mineralogy founded on chemiftry; the management of ore in the different operations which it undergoes; fubterraneous geometry; the hiftory of mining; founderies, and the proceffes for the extraction of metals from the ores, either by fufion or amalgamation, in every inftance applied to practice. The end of this inftitution is to collect, in the moft extenfive fenfe, every thing that can affift the operations of the miner, and to communicate it to the different members, that they may employ it for the public good, in their refpective countries. Each member muft confider himfelf as bound to fend to the fociety every thing which will contribute to the end of its inftitution; to point out, with precifion, the feveral facts and obfervations; to communicate every experiment which occurs, even the unfuccefsful ones, if the relation may feem to be advantageous to the public; to communicate to the fociety their examination of fchemes, and their opinions on queftions propofed by it; and to pay annually two ducats (about 18s. 6d.) to the direction every Eafter. The fociety, on the other hand, is bound to publifh every novelty that fhall be communicated to it; to communicate to each member, at the member's expence, the memoirs, defigns, models, productions, and every thing connected with the inftitution; to anfwer all the neceffary demands made, relating in any refpect to mining; and to give its opinion on every plan or project communicated through the medium of an honorary member.

The great centre of all intelligence is to be at Zellerfield in Hartz, Brunfwick: but the fociety is not fixed to any one fpot; for every particular ftate fome practical mineralogift is nominated as director. Among thefe are the names of Baron Born, M. Pallas, M. Charpentier, M. Prebra, and M. Henkel. Their office is to propofe the members; to take care that the views of the fociety are purfued in the different countries where they refide; to anfwer the requefts of the members of their country who are qualified to make them; in cafe of the death of a director, to choofe another; and the majority is to determine where the archives and the ftrong box is to be placed.

All the eminent mineralogifts in Europe are members of this fociety. It is erected on fo liberal and fo extenfive a plan, that we entertain the higheft hopes of its fuccefs; and have only to add, that we wifh much to fee the ftudy of feveral other fciences purfued in the fame manner.

4. *The Society for the Improvement of Naval Architecture*, was founded in 1791. The object of it is to encourage every ufeful invention and difcovery relating to naval architecture as far as fhall be in their power, both by honorary and pecuniary rewards. They have in view particularly to improve the theories of floating bodies and of the refiftance of fluids; to procure draughts and models of different veffels, together with calculations of their capacity, centre of gravity, tonnage, &c.; to make obfervations and experiments themfelves, and to point out fuch obfervations and experiments as appear beft calculated to further their defigns, and moft deferving thofe premiums which the fociety can beftow. But though the improvement of naval architecture in all its branches be certainly the principal object of this inftitution, yet the fociety do not by any means intend to confine themfelves merely to the form and ftructure of veffels. Every fubordinate and collateral purfuit will claim a fhare of the attention of the fociety in proportion to its merits; and whatever may have any tendency to render navigation more fafe, falutary, and even pleafant, will not be neglected.

This inftitution owes its exiftence to the patriotic difpofition and extraordinary attention of Mr Sewel a private citizen of London, who (though engaged in a line of bufinefs totally oppofite to all concerns of this kind) has been led, by mere accident, to take fuch ocular notice of, and make fuch obfervations on, the actual ftate of naval architecture in this country, as naturally occurred to a man of plain underftanding, zealous for the honour and intereft of his country, and willing to beftow a portion of that time for the public good, which men of a different defcription would rather have devoted to their own private advantage. His attention was the more ferioufly excited, by finding that it was the opinion of fome private fhip-builders, who, in a debate on the failure of one of our naval engagements, pronounced, that fuch "would ever be the cafe while that bufinefs (the conftruction of our fhips of war) was not ftudied as a fcience, but carried on merely by precedent; that there had not been one improvement in our navy that did not originate with the French, who had naval fchools and feminaries for the ftudy of it; and that our fhips were not a match for thofe of that nation either fingly or in a fleet, &c. &c."

In a fhort time the fociety were enabled to offer very confiderable premiums for particular improvements in the conftruction of our fhipping, &c. &c. and alfo to encourage our philofophers, mathematicians, and mechanics, to make fatisfactory experiments, tending to af-

certain

certain the laws of resistance of water to solids of different forms, in all varieties of circumstance. On this head the reward is not less than one hundred pounds or a gold medal. Other premiums of 50, 30, and 20 guineas, according to the importance or difficulty of the particular subject or point of investigation, are likewise offered, for different discoveries, inventions, or improvements. The terms of admission into the society are a subscription of two guineas annually, or twenty guineas for life.

5. *Society of Artists of Great Britain*, which consists of directors and fellows, was incorporated by charter in 1765, and empowered to purchase and hold lands, not exceeding 1000l. a-year. The directors of this society, annually elected, are to consist of 24 persons, including the president, vice-president, treasurer, and secretary; and it is required that they be either painters, sculptors, architects, or engravers by profession.

6. *British Society for Extending the Fisheries and Improving the Sea-Coasts of this Kingdom*, was instituted in 1786. The end and design of this society will best appear from their charter, of which we present an abstract.

The preamble states, "the great want of improvement in fisheries, agriculture, and manufactures, in the Highlands and Islands of North Britain; the prevalence of emigration from the want of employment in those parts; the prospect of a new nursery of seamen, by the establishment of fishing towns and villages in that quarter. The act therefore declares, that the persons therein named, and every other person or persons who shall thereafter become proprietors of the joint stock mentioned therein, shall be a distinct and separate body politic and corporate, by the name of *The British Society for Extending the Fisheries and Improving the Sea-coasts of this Kingdom*: That the said society may raise a capital joint stock not exceeding 150,000l. to be applied to purchasing or otherwise acquiring lands and tenements in perpetuity, for the building thereon, and on no other land whatever, free towns, villages, and fishing stations: That the joint stock shall be divided into shares of 50l. each: That no one person shall in his or her name possess more than ten shares, or 500l.: That the society shall not borrow any sum or sums of money whatsoever: That the sums to be advanced for this undertaking, and the profits arising therefrom, shall be divided proportionally to the sum subscribed; and that no person shall be liable for a larger sum than he or she shall have respectively subscribed: That one or two shares shall intitle to one vote and no more, in person or by proxy, at all meetings of proprietors; three or four shares to two votes; five, six, or seven shares, to three votes; eight or nine shares to four votes; and ten shares to five votes and no more: That more persons than one inclining to hold in their joint names one or more shares shall be intitled to vote, by one of such persons, according to the priority of their names, or by proxy: That bodies corporate shall vote by proxy under their seal: That all persons holding proxies shall be proprietors, and that no one person shall hold more than five votes by proxy: That the affairs of the society shall be managed by a governor, deputy governor, and 13 other directors, to be elected annually on the 25th of March, from among the proprietors of the society, holding at least one full share, by signed lists of their names to be transmitted by the proprietors to the secretary of the society: that five proprietors, not being governor, director, or other officer, shall be in like manner annually elected to audit the accounts of the society: That there shall be one general meeting of the proprietors annually on the 25th of March: That occasional general meetings shall be called on the request of nine or more proprietors: That the general meetings of the proprietors shall make all bye-laws and constitutions for the government of the society, and for the good and orderly carrying on of the business of the same: That no transfer shall be made of the stock of the society for three years from the 10th of August 1786: That the cash of the society shall be lodged in the bank of England, bank of Scotland, or the royal bank of Scotland: That no director, proprietor, agent, or officer of the society, shall retain any sum or sums of money in his hands beyond the space of 30 days, on any account whatsoever: That all payments by the society shall be made by drafts on the said banks, under the hands of the governor or deputy-governor, countersigned by the secretary or his deputy, and two or more directors: And that the books in which the accounts of the society shall be kept shall be open to all the proprietors."

The institution of this public-spirited society was in a great measure owing to the exertions of the patriotic John Knox; who, in the course of 23 years, traversed and explored the Highlands of Scotland not fewer than 16 times, and expended several thousand pounds of his own fortune in pursuing his patriotic designs.

7. *British Wool Society*. See *British* WOOL *Society*.

SOCIETY Isles, a cluster of isles, so named by Captain Cook in 1769. They are situated between the latitudes of 16. 10. and 16. 55. south, and between the longitudes of 150. 57. and 152. west. They are eight in number; namely, Otaheite, Huaheine, Ulietea, Otaha, Bolabola, Maurua, Toobouai, and Tabooyamanoo or Saunders's Island. The soil, productions, people, their language, religion, customs, and manners, are so nearly the same as at OTAHEITE, that little need be added here on that subject. Nature has been equally bountiful in uncultivated plenty, and the inhabitants are as luxurious and as indolent. A plantain branch is the emblem of peace, and exchanging names the greatest token of friendship. Their dances are more elegant, their dramatic entertainments have something of plot and consistency, and they exhibit temporary occurrences as the objects of praise or satire; so that the origin of ancient comedy may be already discerned among them. The people of Huaheine are in general stouter and fairer than those of Otaheite, and this island is remarkable for its populousness and fertility. Those of Ulietea, on the contrary, are smaller and blacker, and much less orderly. Captain Cook put on shore a Cape ewe at Bolabola, where a ram had been left by the Spaniards; and also an English boar and sow, with two goats, at Ulietea. If the valuable animals which have been transported thither from Europe should be suffered to multiply, no part of the world will equal these islands in variety and abundance of refreshments for future navigators.

SOCINIANS, in *Church-History*, a sect of Christian heretics, so called from their founder Faustus Socinus (see SOCINUS). They maintain, "That Jesus Christ was a mere man, who had no existence before he was conceived by the Virgin Mary; that the Holy Ghost is no no diſtinct perſon, but that the Father is truly and properly God. They own, that the name of God is given in the Holy Scriptures to Jeſus Chriſt; but contend, that it is only a deputed title, which, however, inveſts him with an abſolute ſovereignty over all created beings, and renders him an object of worſhip to men and angels. They deny the doctrines of ſatisfaction and imputed righteouſneſs; and ſay that Chriſt only preached the truth to mankind, ſet before them in himſelf an example of heroic virtue, and ſealed his doctrines with his blood. Original ſin and abſolute predeſtination they eſteem ſcholaſtic chimeras. They likewiſe maintain the ſleep of the ſoul, which they ſay becomes inſenſible at death, and is raiſed again with the body at the reſurrection, when the good ſhall be eſtabliſhed in the poſſeſſion of eternal felicity, while the wicked ſhall be conſigned to a fire that will not torment them eternally, but for a certain duration in proportion to their demerits."

This ſect has long been indignant at being ſtyled *Socinians*. They diſclaim every human leader; and profeſſing to be guided ſolely by the word of God and the deductions of reaſon, they call themſelves *Unitarians*, and affect to conſider all other Chriſtians, even their friends the Arians, as *Polytheiſts*. Modern Unitarianiſm, as taught by Dr Prieſtley, is, however, a very different thing from Socinianiſm, as we find it in the Racovian catechiſm and other ſtandard works of the ſect. This far-famed philoſopher has diſcovered, what eſcaped the ſagacity of all the *fratres poloni*, that Jeſus Chriſt was the ſon of Joſeph as well as Mary; that the evangeliſts miſtook the meaning of Iſaiah's prophecy, that "a virgin ſhould conceive and bear a ſon;" that the applying of this prophecy to the birth of our Saviour, led them to conclude that his conception was miraculous; and that we are not to wonder at this miſtake, as the apoſtles were not always inſpired, and were in general inconcluſive reaſoners. The modeſty of the writer in claiming the merit of ſuch diſcoveries will appear in its proper colours to all our readers: the truth of his doctrine ſhall be conſidered in another place. See THEOLOGY.

SOCINUS, LÆLIUS, the firſt author of the ſect of the Socinians, was born at Sienna in Tuſcany in 1525. Being deſigned by his father for the law, he began very early to ſearch for the foundation of that ſcience in the Word of God; and by that ſtudy diſcovered that the Romiſh religion taught many things contrary to revelation; when, being deſirous of penetrating farther into the true ſenſe of the Scriptures, he ſtudied Greek, Hebrew, and even Arabic. In 1547 he left Italy, to go and converſe with the Proteſtants; and ſpent four years in travelling through France, England, the Netherlands, Germany, and Poland, and at length ſettled at Zurich. He by this means became acquainted with the moſt learned men of his time, who teſtified by their letters the eſteem they had for him: but as he diſcovered to them his doubts, he was greatly ſuſpected of hereſy. He, however, conducted himſelf with ſuch addreſs, that he lived among the capital enemies of his opinions, without receiving the leaſt injury. He met with ſome diſciples, who heard his inſtructions with reſpect; theſe were Italians who left their native country on account of religion, and wandered about in Germany and Poland. He communicated likewiſe his ſentiments to his relations by his writings, which he cauſed to be conveyed to them at Sienna. He died at Zurich in 1562. Thoſe who were of ſentiments oppoſite to his, and were perſonally acquainted with him, confeſs that his outward behaviour was blameleſs. He wrote a Paraphraſe on the firſt chapter of St John; and other works are aſcribed to him.

SOCINUS, *Fauſtus*, nephew of the preceding, and principal founder of the Socinian ſect, was born at Sienna in 1539. The letters which his uncle Lælius wrote to his relations, and which infuſed into them many ſeeds of hereſy, made an impreſſion upon him; ſo that, knowing himſelf not innocent, he fled as well as the reſt when the inquiſition began to perſecute that family. He was at Lyons when he heard of his uncle's death, and departed immediately to take poſſeſſion of his writings. He returned to Tuſcany; and made himſelf ſo agreeable to the grand duke, that the charms which he found in that court, and the honourable poſts he filled there, hindered him for twelve years from remembering that he had been conſidered as the perſon who was to put the laſt hand to the ſyſtem of ſamoſatenian divinity, of which his uncle Lælius had made a rough draught. At laſt he went into Germany in 1574, and paid no regard to the grand duke's advices to return. He ſtaid three years at Baſil, and ſtudied divinity there, and having adopted a ſet of principles very different from the ſyſtem of Proteſtants, he reſolved to maintain and propagate them; for which purpoſe he wrote a treatiſe *De Ieſu Chriſto Servatore*. In 1579 Socinus retired into Poland, and deſired to be admitted into the communion of the Unitarians; but as he differed from them in ſome points, on which he refuſed to be ſilent, he met with a repulſe. However, he did not ceaſe to write in defence of their churches againſt thoſe who attacked them. At length his book againſt James Paleologus furniſhed his enemies with a pretence to exaſperate the king of Poland againſt him; but though the mere reading of it was ſufficient to refute his accuſers, Socinus thought proper to leave Cracow, after having reſided there four years. He then lived under the protection of ſeveral Poliſh lords, and married a lady of a good family; but her death, which happened in 1587, ſo deeply afflicted him as to injure his health; and to complete his ſorrow, he was deprived of his patrimony by the death of Francis de Medicis great duke of Florence. The conſolation he found in ſeeing his ſentiments at laſt approved by ſeveral miniſters, was greatly interrupted in 1598; for he met with a thouſand inſults at Cracow, and was with great difficulty ſaved from the hands of the rabble. His houſe was plundered, and he loſt his goods; but this loſs was not ſo uneaſy to him as that of ſome manuſcripts, which he extremely regretted. To deliver himſelf from ſuch dangers, he retired to a village about nine miles diſtant from Cracow, where he ſpent the remainder of his days at the houſe of Abraham Blonſki, a Poliſh gentleman, and died there in 1604. All Fauſtus Socinus's works are contained in the two firſt volumes of the *Bibliotheca Fratrum Polonorum*.

SOCMANS, SOKEMANS, or *Socmen (Socmanni)*, are ſuch tenants as hold their lands and tenements by ſocage tenure. See SOCAGE.

SOCOTORA, an iſland lying between Aſia and Arabia Felix; about 50 miles in length, and 22 in breadth. It is particularly noted for its fine aloes, known by the name of *Socotrine ALOES*. The religion of the natives

natives is a mixture of Mahometanism and Paganism; but they are civil to strangers who call there in their passage to the East Indies. It abounds in fruit and cattle; and they have a king of their own, who is dependent on Arabia.

SOCRATES, the greatest of the ancient philosophers, was born at Alopece, a village near Athens, in the fourth year of the 77th olympiad. His parents were of low rank; his father Sophroniscus being a statuary, and his mother Phænareta a midwife. Sophroniscus brought up his son, contrary to his inclination, in his own manual employment; in which Socrates, though his mind was continually aspiring after higher objects, was not unsuccessful, for whilst he was a young man, he is said to have formed statues of the habited Graces, which were allowed a place in the citadel of Athens. Upon the death of his father he was left in such straitened circumstances as laid him under the necessity of exercising that art to procure the means of subsistence, though he devoted, at the same time, all the leisure which he could command to the study of philosophy. His distress, however, was soon relieved by Crito, a wealthy Athenian; who, remarking his strong propensity to study, and admiring his ingenuous disposition and distinguished abilities, generously took him under his patronage, and intrusted him with the instruction of his children. The opportunities which Socrates by this means enjoyed of attending the public lectures of the most eminent philosophers, so far increased his thirst after wisdom, that he determined to relinquish his occupation, and every prospect of emolument which that might afford, in order to devote himself entirely to his favourite pursuits. Under Anaxagoras and Archelaus he prosecuted the study of nature in the usual manner of the philosophers of the age, and became well acquainted with their doctrines. Prodicus the sophist was his preceptor in eloquence, Evenus in poetry, Theodorus in geometry, and Damo in music. Aspasia, a woman no less celebrated for her intellectual than her personal accomplishments, whose house was frequented by the most celebrated characters, had also some share in the education of Socrates. Under such preceptors it cannot reasonably be doubted but that he became master of every kind of learning which the age in which he lived could afford; and being blessed with very uncommon talents by nature, he appeared in Athens, under the respectable characters of a good citizen and a true philosopher. Being called upon by his country to take arms in the long and severe struggle between Athens and Sparta, he signalized himself at the siege of Potidæa, both by his valour and by the hardiness with which he endured fatigue. During the severity of a Thracian winter, whilst others were clad in furs, he wore only his usual clothing, and walked barefoot upon the ice. In an engagement in which he saw ALCIBIADES falling down wounded, he advanced to defend him, and saved both him and his arms: and though the prize of valour was on this occasion unquestionably due to Socrates, he generously gave his vote that it might be bestowed upon Alcibiades, to encourage his rising merit. He served in other campaigns with distinguished bravery, and had the happiness on one occasion to save the life of Xenophon, by bearing him, when covered with wounds, out of the reach of the enemy.

It was not till Socrates was upwards of 60 years of age that he undertook to serve his country in any civil office, when he was chosen to represent his own district, in the senate of five hundred. In this office, though he at first exposed himself to some degree of ridicule from the want of experience in the forms of business, he soon convinced his colleagues that he was superior to them all in wisdom and integrity. Whilst they, intimidated by the clamours of the populace, passed an unjust sentence of condemnation upon the commanders, who, after the engagement at the Arginusian islands, had been prevented by a storm from paying funeral honours to the dead, Socrates stood forth singly in their defence, and to the last refused to give his suffrage against them, declaring that no force should compel him to act contrary to justice and the laws. Under the subsequent tyranny he never ceased to condemn the oppressive and cruel proceedings of the thirty tyrants; and when his boldness provoked their resentment, so that his life was in hazard, fearing neither treachery nor violence, he still continued to support with undaunted firmness the rights of his fellow citizens.

Having given these proofs of public virtue both in a military and civil capacity, he wished to do still more for his country. Observing with regret how much the opinions of the Athenian youth were misled, and their principles and taste corrupted by philosophers who spent all their time in refined speculations upon nature and the origin of things, and by sophists who taught in their schools the arts of false eloquence and deceitful reasoning; Socrates formed the wise and generous design of instituting a new and more useful method of instruction. He justly conceived the true end of philosophy to be, not to make an ostentatious display of superior learning and ability in subtle disputations or ingenious conjectures, but to free mankind from the dominion of pernicious prejudices; to correct their vices; to inspire them with the love of virtue; and thus conduct them in the path of wisdom to true felicity. He therefore assumed the character of a moral philosopher; and, looking upon the whole city of Athens as his school, and all who were disposed to lend him their attention as his pupils, he seized every occasion of communicating moral wisdom to his fellow citizens. He passed the greater part of his time in public; and the method of instruction of which he chiefly made use was, to propose a series of questions to the person with whom he conversed, in order to lead him to some unforeseen conclusion. He first gained the consent of his respondent to some obvious truths, and then obliged him to admit others from their relation or resemblance to those to which he had already assented. Without making use of any direct argument or persuasion, he chose to lead the person he meant to instruct, to deduce the truths of which he wished to convince him, as a necessary consequence from his own concessions. He commonly conducted these conferences with such address, as to conceal his design till the respondent had advanced too far to recede. On some occasions he made use of ironical language, that vain men might be caught in their own replies, and be obliged to confess their ignorance. He never assumed the air of a morose and rigid preceptor, but communicated useful instruction with all the ease and pleasantry of polite conversation. Though eminently furnished with every kind of learning, he preferred moral to speculative wisdom. Convinced that phi-

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losophy is valuable, not as it furnishes questions for the schools, but as it provides men with a law of life, he censured his predecessors for spending all their time in abstruse researches into nature, and taking no pains to render themselves useful to mankind. His favourite maxim was, Whatever is above us doth not concern us. He estimated the value of knowledge by its utility, and recommended the study of geometry, astronomy, and other sciences, only so far as they admit of a practical application to the purposes of human life. His great object in all his conferences and discourses was, to lead men into an acquaintance with themselves; to convince them of their follies and vices; to inspire them with the love of virtue; and to furnish them with useful moral instructions. Cicero might therefore very justly say of Socrates, that he was the first who called down philosophy from heaven to earth, and introduced her into the public walks and domestic retirements of men, that she might instruct them concerning life and manners.

Through his whole life this good man discovered a mind superior to the attractions of wealth and power. Contrary to the general practice of the preceptors of his time, he instructed his pupils without receiving from them any gratuity. He frequently refused rich presents, which were offered him by Alcibiades and others, though importunately urged to accept them by his wife. The chief men of Athens were his stewards: they sent him in provisions, as they apprehended he wanted them; he took what his present wants required, and returned the rest. Observing the numerous articles of luxury which were exposed to sale in Athens, he exclaimed, " How many things are there which I do not want!" With Socrates, moderation supplied the place of wealth. In his clothing and food, he consulted only the demands of nature. He commonly appeared in a neat but plain cloak, with his feet uncovered. Though his table was only supplied with simple fare, he did not scruple to invite men of superior rank to partake of his meals; and when his wife, upon some such occasion, expressed her dissatisfaction on being no better provided, he desired her to give herself no concern; for if his guests were wise men, they would be contented with whatever they found at his table; if otherwise, they were unworthy of notice. Whilst others, says he, live to eat, wise men eat to live.

Though Socrates was exceedingly unfortunate in his domestic connection, he converted this infelicity into an occasion of exercising his virtues. Xantippe, concerning whose ill humour ancient writers relate many amusing tales, was certainly a woman of a high and unmanageable spirit. But Socrates while he endeavoured to curb the violence of her temper, improved his own. When Alcibiades expressed his surprise that his friend could bear to live in the same house with so perverse and quarrelsome a companion, Socrates replied, that being daily inured to ill humour at home, he was the better prepared to encounter perverseness and injury abroad.

In the midst of domestic vexations and public disorders, Socrates retained such an unruffled serenity, that he was never seen either to leave his own house or to return home with a disturbed countenance. In acquiring this entire dominion over his passions and appetites, he had the greater merit, as it was not effected without a violent struggle against his natural propensities. Zopyrus, an eminent physiognomist, declared, that he discovered in the features of the philosopher evident traces of many vicious inclinations. The friends of Socrates who were present ridiculed the ignorance of this pretender to extraordinary sagacity. But Socrates himself ingenuously acknowledged his penetration, and confessed that he was in his natural disposition prone to vice, but that he had subdued his inclinations by the power of reason and philosophy.

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Through the whole of his life Socrates gave himself up to the guidance of unbiassed reason, which is supposed by some to be all that he meant by the genius or *dæmon* from which he professed to receive instruction. But this opinion is inconsistent with the accounts given by his followers of that dæmon, and even with the language in which he spoke of it himself. Plato sometimes calls it his *guardian*, and Apuleius his *god*; and as Xenophon attests that it was the belief of his master that the gods occasionally communicate to men the knowledge of future events, it is by means improbable that Socrates admitted, with the generality of his countrymen, the existence of those intermediate beings called *dæmons*, of one of which he might fancy himself the peculiar care.

It was one of the maxims of Socrates, " That a wise man will worship the gods according to the institutions of the state to which he belongs." Convinced of the weakness of the human understanding, and perceiving that the pride of philosophy had led his predecessors into futile speculations on the nature and origin of things, he judged it most consistent with true wisdom to speak with caution and reverence concerning the divine nature.

The wisdom and the virtues of this great man, whilst they procured him many followers, created him also many enemies. The Sophists*, whose knavery and ignorance he took every opportunity of exposing to public contempt, became inveterate in their enmity against so bold a reformer, and devised an expedient, by which they hoped to check the current of his popularity. They engaged Aristophanes, the first buffoon of the age, to write a comedy, in which Socrates should be the principal character. Aristophanes, pleased with so promising an occasion of displaying his low and malignant wit, undertook the task, and produced the comedy of *The Clouds*, still extant in his works. In this piece, Socrates is introduced hanging in a basket in the air, and thence pouring forth absurdity and profaneness. But the philosopher, showing in a crowded theatre that he was wholly unmoved by this ribaldry, the satire failed of its effect; and when Aristophanes attempted the year following to renew the piece with alterations and additions, the representation was so much discouraged, that he was obliged to discontinue it.

* See *Sophist*.

From this time Socrates continued for many years to pursue without interruption his laudable design of instructing and reforming his fellow-citizens. At length, however, when the inflexible integrity with which he had discharged the duty of a senator, and the firmness with which he had opposed every kind of political corruption and oppression, had greatly increased the number of his enemies, clandestine arts were employed to raise a general prejudice against him. The people were industriously reminded, that Critias, who had been one of the most cruel of the thirty tyrants, and Alcibiades,

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who had insulted religion, by defacing the public statues of Mercury, and performing a mock representation of the Eleusinian mysteries, had in their youth been disciples of Socrates; and the minds of the populace being thus prepared, a direct accusation was preferred against him before the supreme court of judicature. His accusers were Anytus a leather-dresser, who had long entertained a personal enmity against Socrates, for reprehending his avarice, in depriving his sons of the benefits of learning, that they might pursue the gains of trade; Melitus, a young rhetorician, who was capable of undertaking any thing for the sake of gain; and Lycon, who was glad of any opportunity of displaying his talents. The accusation, which was delivered to the senate under the name of Melitus, was this: "Melitus, son of Melitus, of the tribe of Pythos, accuseth Socrates, son of Sophroniscus, of the tribe of Alopece. Socrates violates the laws, in not acknowledging the gods which the state acknowledges, and by introducing new divinities. He also violates the laws by corrupting the youth. Be his punishment DEATH."

This charge was delivered upon oath to the senate; and Crito a friend of Socrates became surety for his appearance on the day of trial. Anytus soon afterwards sent a private message to Socrates, assuring him that if he would desist from censuring his conduct, he would withdraw his accusation. But Socrates refused to comply with so degrading a condition; and with his usual spirit replied, "Whilst I live I will never disguise the truth, nor speak otherwise than my duty requires." The interval between the accusation and the trial he spent in philosophical conversations with his friends, choosing to discourse upon any other subject rather than his own situation.

When the day of trial arrived, his accusers appeared in the senate, and attempted to support their charge in three distinct speeches, which strongly marked their respective characters. Plato, who was a young man, and a zealous follower of Socrates, then rose up to address the judges in defence of his master; but whilst he was attempting to apologise for his youth, he was abruptly commanded by the court to sit down. Socrates, however needed no advocate. Ascending the chair with all the serenity of conscious innocence, and with all the dignity of superior merit, he delivered, in a firm and manly tone, an unpremeditated defence of himself, which silenced his opponents, and ought to have convinced his judges. After tracing the progress of the conspiracy which had been raised against him to its true source, the jealousy and resentment of men whose ignorance he had exposed, and whose vices he had ridiculed and reproved, he distinctly replied to the several charges brought against him by Melitus. To prove that he had not been guilty of impiety towards the gods of his country, he appealed to his frequent practice of attending the public religious festivals. The crime of introducing new divinities, with which he was charged, chiefly as it seems on the ground of the admonitions which he professed to have received from an invisible power, he disclaimed, by pleading that it was no new thing for men to consult the gods and receive instructions from them. To refute the charge of his having been a corrupter of youth, he urged the example which he had uniformly exhibited of justice, moderation, and temperance; the moral spirit and tendency of his discourses; and the effect which had actually been produced by his doctrine upon the manners of the young. Then, disdaining to solicit the mercy of his judges, he called upon them for that justice which their office and their oath obliged them to administer; and professing his faith and confidence in God, resigned himself to their pleasure.

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The judges, whose prejudices would not suffer them to pay due attention to this apology, or to examine with impartiality the merits of the cause, immediately declared him guilty of the crimes of which he stood accused. Socrates, in this stage of the trial, had a right to enter his plea against the punishment which the accusers demanded, and instead of the sentence of death, to propose some pecuniary amercement. But he at first peremptorily refused to make any proposal of this kind, imagining that it might be construed into an acknowledgement of guilt; and asserted, that his conduct merited from the state reward rather than punishment. At length, however, he was prevailed upon by his friends to offer upon their credit a fine of thirty *minæ*. The judges, notwithstanding, still remained inexorable: they proceeded, without farther delay, to pronounce sentence upon him; and he was condemned to be put to death by the poison of hemlock.

The sentence being passed, he was sent to prison: which, says Seneca, he entered with the same resolution and firmness with which he had opposed the thirty tyrants; and took away all ignominy from the place, which could not be a prison while he was there. He lay in fetters 30 days; and was constantly visited by Crito, Plato, and other friends, with whom he passed the time in dispute after his usual manner. Anxious to save so valuable a life, they urged him to attempt his escape, or at least to permit them to convey him away; and Crito went so far, as to assure him that, by his interest with the jailor, it might be easily accomplished, and to offer him a retreat in Thessaly; but Socrates rejected the proposal, as a criminal violation of the laws; and asked them, whether there was any place out of Attica which death could not reach.

At length the day arrived when the officers to whose care he was committed delivered to Socrates early in the morning the final order for his execution, and immediately, according to the law, set him at liberty from his bonds. His friends, who came thus early to the prison that they might have an opportunity of conversing with their master through the day, found his wife sitting by him with a child in her arms. Socrates, that the tranquillity of his last moments might not be disturbed by her unavailing lamentations, requested that she might be conducted home. With the most frantic expressions of grief she left the prison. An interesting conversation then passed between Socrates and his friends, which chiefly turned upon the immortality of the soul. In the course of this conversation, he expressed his disapprobation of the practice of suicide, and assured his friends that his chief support in his present situation was an expectation, though not unmixed with doubts, of a happy existence after death. "It would be inexcusable in me (said he) to despise death, if I were not persuaded that it will conduct me into the presence of the gods, who are the most righteous governors, and into the society of just and good men: but I derive confidence from the hope that something of man remains after death,

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death, and that the condition of good men will then be much better than that of the bad." Crito afterwards asking him, in what manner he wished to be buried? Socrates replied, with a smile, "As you please, provided I do not escape out of your hands." Then, turning to the rest of his friends, he said, "Is it not strange, after all that I have said to convince you that I am going to the society of the happy, that Crito still thinks that this body, which will soon be a lifeless corpse, is Socrates? Let him dispose of my body as he pleases, but let him not at its interment mourn over it as if it were Socrates."

Towards the close of the day he retired into an adjoining apartment to bathe; his friends, in the mean time, expressing to one another their grief at the prospect of losing so excellent a father, and being left to pass the rest of their days in the solitary state of orphans. After a short interval, during which he gave some necessary instructions to his domestics, and took his last leave of his children, the attendant of the prison informed him, that the time for drinking the poison was come. The executioner, though accustomed to such scenes, shed tears as he presented the fatal cup. Socrates received it without change of countenance or the least appearance of perturbation: then offering up a prayer to the gods that they would grant him a prosperous passage into the invisible world, with perfect composure he swallowed the poisonous draught. His friends around him burst into tears. Socrates alone remained unmoved. He upbraided their pusillanimity, and entreated them to exercise a manly constancy worthy of the friends of virtue. He continued walking till the chilling operation of the hemlock obliged him to lie down upon his bed. After remaining for a short time silent, he requested Crito (probably in order to refute a calumny which might prove injurious to his friends after his decease) not to neglect the offering of a cock which he had vowed to Esculapius. Then, covering himself with his cloak, he expired. Such was the fate of the virtuous Socrates! A story, says Cicero, which I never read without tears.

The friends and disciples of this illustrious teacher of wisdom were deeply afflicted by his death, and attended his funeral with every expression of grief. Apprehensive, however, for their own safety, they soon afterwards privately withdrew from the city, and took up their residence in distant places. Several of them visited the philosopher Euclid of Megara, by whom they were kindly received. No sooner was the unjust condemnation of Socrates known through Greece, than a general indignation was kindled in the minds of good men, who universally regretted that so distinguished an advocate for virtue should have fallen a sacrifice to jealousy and envy. The Athenians themselves, so remarkable for their caprice, who never knew the value of their great men till after their death, soon became sensible of the folly as well as criminality of putting to death the man who had been the chief ornament of their city and of the age, and turned their indignation against his accusers. Melitus was condemned to death; and Anytus, to escape a similar fate, went into voluntary exile. To give a farther proof of the sincerity of their regret, the Athenians for a while interrupted public business; decreed a general mourning; recalled the exiled friends of Socrates; and erected a statue to his memory in one of the most frequented parts of the city. His death happened in the first year of the 96th olympiad, and in the 70th year of his age.

Socrates, Soda.

Socrates left behind him nothing in writing; but his illustrious pupils Xenophon and Plato have in some measure supplied this defect. The Memoirs of Socrates, written by Xenophon, afford, however, a much more accurate idea of the opinions of Socrates, and of his manner of teaching, than the Dialogues of Plato, who everywhere mixes his own conceptions and diction with the ideas and language of his master. It is related, that when Socrates heard Plato recite his Lysis, he said, "How much does this young man make me say which I never conceived!"

His distinguishing character was that of a moral philosopher; and his doctrine concerning God and religion was rather practical than speculative. But he did not neglect to build the structure of religious faith upon the firm foundation of an appeal to natural appearances: He taught, that the Supreme Being, though invisible, is clearly seen in his works: which at once demonstrate his existence and his wise and benevolent providence. He admitted, besides the one Supreme Deity, the existence of beings who possess a middle station between God and man, to whose immediate agency he ascribed the ordinary phenomena of nature, and whom he supposed to be particularly concerned in the management of human affairs. Hence he declared it to be the duty of every one, in the performance of religious rites, to follow the customs of his country. At the same time, he taught, that the merit of all religious offerings depends upon the character of the worshipper, and that the gods take pleasure in the sacrifices of none but the truly pious.

Concerning the human soul, the opinion of Socrates, according to Xenophon, was, that it is allied to the Divine Being, not by a participation of essence, but by a similarity of nature; that man excels all other animals in the faculty of reason; and that the existence of good men will be continued after death in a state in which they will receive the reward of their virtue. Although it appears that on this latter topic he was not wholly free from uncertainty, the consolation which he professed to derive from this source in the immediate prospect of death, leaves little room to doubt that he entertained a real expectation of immortality: and there is reason to believe that he was the only philosopher of ancient Greece whose principles admitted of such an expectation (see METAPHYSICS, Part III. Chap. iv.). Of his moral system, which was in a high degree pure, and founded on the surest basis, the reader will find a short view in our article MORAL PHILOSOPHY, N° 4.

SOCRATES was also the name of an ecclesiastical historian of the 5th century, born at Constantinople in the beginning of the reign of Theodosius: he professed the law and pleaded at the bar, whence he obtained the name of *Scholasticus*. He wrote an ecclesiastical history from the year 309, where Eusebius ended, down to 440; and wrote with great exactness and judgement. An edition of Eusebius and Socrates, in Greek and Latin, with notes by Reading, was published at London in 1720.

SODA, the name given by the French chemists to the mineral alkali, which is found native in many parts of the world: it is obtained also from common salt, and from

from the aſhes of the *kali*, a ſpecies of ſalſola. See CHEMISTRY *Index*, for an account of its properties and combinations: but long after that article was written, ſoda and potaſh were decompoſed by means of galvaniſm; and the alkalies, hitherto conſidered as ſimple ſubſtances, appear, from the experiments of Mr Davy, who firſt made the diſcovery, to be compounds of oxygen and a metallic baſe. Mr Davy's concluſions have been controverted by ſome of the French chemiſts; and as the ſubject may perhaps in a few months receive ſome farther elucidation, we ſhall delay our account of the whole till we come to deſcribe the apparatus by which the experiments are conducted. See *TROUGH, Galvanic*.

SODA is alſo a name for a heat in the ſtomach, or heart-burn. See MEDICINE, N° 275.

SODOM, formerly a town of Paleſtine in Aſia, famous in Scripture for the wickedneſs of its inhabitants, and their deſtruction by fire from heaven on account of that wickedneſs. The place where it ſtood is now covered by the waters of the Dead ſea, or the lake Aſphaltites. See ASPHALTITES.

SODOMY, an unnatural crime, ſo called from the city of Sodom, which was deſtroyed by fire for the ſame. The Levitical law adjudged thoſe guilty of this execrable crime to death; and the civil law aſſigns the ſame puniſhment to it. The law of England makes it felony. There is no ſtatute in Scotland againſt Sodomy; the libel of the crime is therefore founded on the divine law, and practice makes its puniſhment to be burned alive.

SODOR, a name always conjoined with Man, in mentioning the biſhop of Man's dioceſe. Concerning the origin and application of this word, very different opinions have been formed by the learned. Buchanan (lib. i. cap. 34.) ſays, that before his time the name of *Sodor* was given to a town in the iſle of Man. In Gough's edition of Camden's *Britannia* (vol. iii. p. 701.) it is ſaid, that after the iſle of Man was annexed to the crown of England, this appellation was given to a ſmall iſland within muſket-ſhot of Man, in which the cathedral ſtands, called by the Norwegians the *Holm*, and by the inhabitants the *Peel*. In ſupport of this opinion a charter is quoted A. D. 1505, in which Thomas earl of Derby and lord of Man confirms to Huan Heſketh biſhop of Sodor all the lands, &c. anciently belonging to the biſhops of Man. "Eccleſiam cathedralem ſancti Germani in *Holm Sodor vel Pele* vocatam, eccleſiam ſancti Patricii ibidem, et locum præfatum in quo eccleſiæ præfatæ ſitæ ſunt." The truth of either, or perhaps of both, theſe accounts might be allowed; but neither of them is ſufficient to account for the conſtant conjunction of Sodor and Man, in charters, regiſters, and hiſtories. If Sodor was a ſmall town or iſland belonging to Man, it cannot be conceived why it is always mentioned before it, or rather why it ſhould be mentioned at all in ſpeaking of a biſhop's dioceſe. To ſpeak of the biſhopric of Sodor and Man in this caſe would be as improper as it would be to call the biſhopric of Durham the biſhopric of Holy Iſland and Durham, or the biſhopric of Darlington and Durham; the former being a ſmall iſland and the latter a town belonging to the county and dioceſe of Durham. Neither of theſe accounts, therefore, gives a ſatisfactory account of the original conjunction of Sodor and Man.

The iſland of Iona was the place where the biſhop of the Iſles reſided, the cathedral church of which, it is ſaid, was dedicated to our Saviour, in Greek *Soter*, hence *Sotorenſes*, which might be corrupted into *Sodorenſes*, a name frequently given by Daniſh writers to the weſtern iſles of Scotland. That we may be the more diſpoſed to accede to this Grecian etymology, the advocates for this opinion tell us, that the name *Icolumkill*, which is often applied to this iſland, is alſo of Greek extraction, being derived from *Columba*, "a pigeon;" a meaning that exactly correſponds to the Celtic word *Colum* and the Hebrew word *Iona*. We muſt confeſs, however, that we have very little faith in the conjectures of etymologiſts, and think that upon no occaſion they alone can eſtabliſh any fact, though when concurring with facts they certainly tend to confirm and explain them. It is only from hiſtorical facts that we can know to what Sodor was applied.

It appears from the hiſtory of the Orkneys, compiled by an old Icelandic writer, tranſlated and enlarged by Torfæus, that the Æbudæ or Weſtern iſles of Scotland were divided into two cluſters, Nordureys and Sudereys. The Nordureys, which were ſeparated from the Sudereys by the point of Ardnamurchan, a promontory in Argyleſhire, conſiſted of Muck, Egg, Rum, Canna, Skye, Raſay, Barra, South Uiſt, North Uiſt, Benbecula, and Lewis, including Harris, with a great number of ſmall iſles. The Sudereys were, Man, Arran, Bute, Cumra, Avon, Gid, Ila, Colonſay, Jura, Scarba, Mull, Iona, Tiree, Coll, Ulva, and other ſmall iſlands. All theſe, when joined together, and ſubject to the ſame prince, made up the kingdom of Man and the Iſles. In the Norwegian language, *Suder* and *Norder* ſignify ſouthern and northern, and *ey* or *ay* an iſland. When the Æbudæ were under one monarch, the ſeat of empire was fixed in the Sudereys, and the Nordureys were governed by deputies; hence the former are much oftener mentioned in hiſtory than the latter; hence, too, the Sudereys often comprehend the Nordureys, as in our days Scotland is ſometimes comprehended under England. Sudereys, or Suder, when angliciſed, became Sodor; and all the Weſtern iſles of Scotland being included in one dioceſe under the Norwegian princes, the biſhop appointed to ſuperintend them was called the biſhop of Man and the Iſles, or the biſhop of Sodor and Man. Since Man was conquered by Edward III. it has been ſeparated from the other iſles, and its biſhops have exerciſed no juriſdiction over them. Should it now be aſked, why then is the biſhop of Man ſtill called the biſhop of Sodor and Man? we reply, that we have been able to diſcover no reaſon; but ſuppoſe the appellation to be continued in the ſame way, as the title king of France has been kept up by the kings of Great Britain, for ſeveral centuries after the Engliſh were entirely expelled from France.

SOFA, in the eaſt, a kind of alcove raiſed half a foot above the floor of a chamber or other apartment; and uſed as the place of ſtate, where viſitors of diſtinction are received. Among the Turks the whole floor of their ſtate-rooms is covered with a kind of tapeſtry, and on the window-ſide is raiſed a ſofa or ſopha, laid with a kind of mattreſs, covered with a carpet much richer than the other. On this carpet the Turks are ſeated, both men and women, like the tailors in England, croſs-legged, leaning againſt the wall, which is bolstered with velvet, satin, or other stuff suitable to the season. Here they eat their meals; only laying a skin over the carpet to serve as a tablecloth, and a round wooden board over all, covered with plates, &c.

SOFALA, or CEFALA, a kingdom of Africa, lying on the coast of Mosambique, near Zanguebar. It is bounded on the north by Monomotapa; on the east by the Mosambique sea; on the south by the kingdom of Sabia; and on the west by that of Manica. It contains mines of gold and iron, and a great number of elephants. It is governed by a king, tributary to the Portuguese, who built a fort at the principal town, which is of the same name, and of great importance for their trade to the East Indies. It is seated in a small island, near the mouth of a river. E. Long. 35. 40. S. Lat. 20. 20.

SOFFITA, or SOFFIT, in *Architecture*, any timber ceiling formed of cross beams of flying corniches, the square compartiments or pannels of which are enriched with sculpture, painting, or gilding; such are those in the palaces of Italy, and in the apartments of Luxembourg at Paris.

SOFFITA, or *Soffit*, is also used for the underside or face of an architrave; and more particularly for that of the corona or larmier, which the ancients called *lacunar*, the French *plafond*, and we usually the *drip*. It is enriched with compartments of roses; and in the Doric order has 18 drops, disposed in three ranks, six in each, placed to the right of the guttæ, at the bottom of the triglyphs.

SOFI, or SOPHI. See SOPHI.

SOFTENING, in *Painting*, the mixing and diluting of colours with the brush or pencil.

SOHO, the name of a set of works, or manufactory of a variety of hardwares, belonging to the late Mr Boulton, situated on the borders of Staffordshire, within two miles of Birmingham; now so justly celebrated as to deserve a short historical detail.

About 30 years ago the premises consisted of a small mill and a few obscure dwellings. Mr Boulton, in conjunction with Mr Fothergill, then his partner, at an expence of 9000l. erected a handsome and extensive edifice, with a view of manufacturing metallic toys. The first productions consisted of buttons, buckles, watch-chains, trinkets, and such other articles as were peculiar to Birmingham. Novelty, taste, and variety, were however always conspicuous; and plated wares, known by the name of Sheffield plate, comprising a great variety of useful and ornamental articles, became another permanent subject of manufacture.

To open channels for the consumption of these commodities, all the northern part of Europe was explored by the mercantile partner Mr Fothergill. A wide and extensive correspondence was thus established, the undertaking became well known, and the manufacturer, by becoming his own merchant, eventually enjoyed a double profit.

Impelled by an ardent attachment to the arts, and by the patriotic ambition of forming his favourite Soho into a fruitful seminary of artists, the proprietor extended his views; and men of taste and talents were now sought for, and liberally patronised. A successful imitation of the French *or moulisa* ornaments, consisting of vases, tripods, candelabra, &c. &c. extended the celebrity of the works. Services of plate and other works in silver, both massive and airy, were added, and an assay office was established in Birmingham.

Mr Watt, the ingenious improver of the steam-engine, was afterwards taken into partnership with Mr Boulton; and they carried on at Soho a manufactory of steam-engines, not less beneficial to the public than lucrative to themselves. This valuable machine, the nature and excellencies of which are described in another place (see *STEAM-Engine*), Mr Boulton proposed to apply to the operation of coining, and suitable apparatus was erected at a great expence, for the purpose of being employed by government to make a new copper-coinage for the kingdom. Artists of merit were engaged, and specimens of exquisite delicacy were exhibited; the works were also employed upon highly finished medals and private coins. To enumerate all the productions of this manufactory would be tedious (A).

In a national view, Mr Boulton's undertakings are highly valuable and important. By collecting around him artists of various descriptions, rival talents have been called forth, and by successive competition have been multiplied to an extent highly beneficial to the public. The manual arts partook of the benefit, and became proportionably improved.

A barren heath has been covered with plenty and population; and Mr Boulton's works, which in their infancy were little known and attended to, now cover several acres, give employment to more than 600 persons, and are said to be the first of their kind in Europe.

SOIL, the mould covering the surface of the earth, in which vegetables grow. It serves as a support for vegetables, and as a reservoir for receiving and communicating their nourishment.

Soils are commonly double or triple compounds of the several reputed primitive earths, except the barytic. The magnesian likewise sparingly occurs. The more fertile soils afford also a small proportion of coally substance arising from putrefaction, and some traces of marine acid and gypsum. The vulgar division into clay, chalk, sand, and gravel, is well understood. Loam denotes any soil moderately adhesive; and, according to the ingredient that predominates, it receives the epithets of clayey, chalky, sandy, or gravelly. The intimate mixture of clay with the oxydes of iron is called *till*, and is of a hard consistence and a dark reddish colour. Soils are found by analysis to contain their earthy ingredients in very different proportions. According to M. Giobert, fertile mould in the vicinity of Turin, where the fall of rain amounts yearly to 40 inches, affords for each 100 parts, from 77 to 79 of silex, from 8 to 14 of argill, and from 5 to 12 of calx; besides about one-half of carbonic matter, and nearly an equal weight of gas, partly carbonic and partly hydrocarbonic. The same experimenter represents the composition of barren soils in similar situations to be from 42 to 88 per cent. of silex,

(A) It was at this place, in the year 1772, that Mr Eginton invented an expeditious method of copying pictures in oil; but we do not know how far this method has succeeded.

lex, from 20 to 30 of argill, and from 4 to 20 of calx. The celebrated Bergman found rich soils in the valleys of Sweden, where the annual quantity of rain is 24 inches, to contain, for each 100 parts, 56 of siliceous sand, 14 of argill, and 30 of calx. In the climate of Paris, where the average fall of rain is 20 inches, fertile mixtures, according to M. Tillet, vary from 46 to 52 per cent. of silex, and from 11 to 17 of argill, with 37 of calx. Hence it appears that in dry countries rich earths are of a closer texture, and contain more of the calcareous ingredient, with less of the siliceous. Mr Arthur Young has discovered, that the value of fertile lands is nearly proportioned to the quantities of gas which equal weights of their soil afford by distillation. See AGRICULTURE *Index*.

SOISSONS, an ancient, large, and considerable city of France, in the department of Aisne and late province of Soissonnois. It was the capital of a kingdom of the same name, under the first race of the French monarchs. It contains about 12,000 inhabitants, and is a bishop's see. The environs are charming, but the streets are narrow, and the houses ill-built. The fine cathedral has one of the most considerable chapters in the kingdom; and the bishop, when the archbishop of Rheims was absent, had a right to crown the king. The castle, though ancient, is not that in which the kings of the first race resided. Soissons is seated in a very pleasant and fertile valley, on the river Aisne, 30 miles west by north of Rheims, and 60 north-east of Paris. E. Long. 3. 24. N. Lat. 49. 23.

SOKE, or SOK. See SOCAGE.

SOKEMANS. See SOC and SOCAGE.

SOL, in *Music*, the fifth note of the gamut, *ut*, *re*, *mi*, *fa*, *sol*, *la*. See GAMUT.

SOL, or *Sou*, a French coin made up of copper mixed with a little silver, and is worth upwards of an English halfpenny, or the 23d part of an English shilling. The sol when first struck was equal in value to 12 deniers Tournois, whence it was also called *douzain*, a name it still retains, though its ancient value be changed; the sol having been since augmented by three deniers, and struck with a puncheon of a fleur-de-lis, to make it current for 15 deniers. Soon after the old sols were coined over again, and both old and new were indifferently made current for 15 deniers. In 1709, the value of the same sols was raised to 18 deniers. Towards the latter end of the reign of Louis XIV. the sol of 18 deniers was again lowered to 15; and by the late king it was reduced to the original value of 12. What it is at present posterity may perhaps discover.

The Dutch have also two kinds of sols: the one of silver, called *sols de gros*, and likewise *schelling*; the other of copper, called also the *stuyver*.

SOL, the *Sun*, in *Astronomy*, *Astrology*, &c. See ASTRONOMY, *passim*.

SOL, in *Chemistry*, is gold; thus called from an opinion that this metal is in a particular manner under the influence of the sun.

SOL, in *Heraldry*, denotes Or, the golden colour in the arms of sovereign princes.

SOLÆUS, or SOLEUS, in *Anatomy*, one of the extensor muscles of the foot, rising from the upper and hinder parts of the tibia and fibula.

SOLAN-GOOSE. See PELICANUS, ORNITHOLOGY *Index*.

SOLANDRA, a genus of plants belonging to the class of monadelphia, and to the order of polyandria; and in the natural system arranged under the 38th order, *Tricoccæ*. See BOTANY *Index*.

SOLANUM, a genus of the monogynia order, belonging to the pentandria class of plants; and in the natural method ranking under the 28th order, *Luridæ*. See BOTANY *Index*.

SOLAR, something belonging to the SUN.

SOLAR-Spots. See ASTRONOMY *Index*.

SOLDAN. See SULTAN.

SOLDANELLA, a genus of plants belonging to the class of pentandria, and order of monogynia; and in the natural system arranged under the 21st order, *Preciæ*. See BOTANY *Index*.

SOLDER, SODDER, or *Soder*, a metallic or mineral composition used in soldering or joining together other metals.

Solders are made of gold, silver, copper, tin, bismuth, and lead; usually observing, that in the composition there be some of the metal that is to be soldered mixed with some higher and finer metals. Goldsmiths usually make four kinds of solder, viz. solder of eight, where to seven parts of silver there is one of brass or copper; solder of six, where only a sixth part is copper; solder of four, and solder of three. It is the mixture of copper in the solder that makes raised plate come always cheaper than flat.

As mixtures of gold with a little copper are found to melt with less heat than pure gold itself, these mixtures serve as solders for gold: two pieces of fine gold are soldered by gold that has a small admixture of copper; and gold alloyed with copper is soldered by such as is alloyed with more copper: the workmen add a little silver as well as copper, and vary the proportions of the two to one another, so as to make the colour of the solder correspond as nearly as may be to that of the piece. A mixture of gold and copper is also a solder for fine copper as well as for fine gold. Gold being particularly disposed to unite with iron, proves an excellent solder for the finer kinds of iron and steel instruments.

The solder used by plumbers is made of two pounds of lead to one of block-tin. Its goodness is tried by melting it, and pouring the bigness of a crown-piece on a table; for, if good, there will arise little bright shining stars therein. The solder for *copper* is made like that of the plumbers; only with copper and tin; and for very nice works, instead of tin, they sometimes use a quantity of silver. Solder for *tin* is made of two-thirds of tin and one of lead, or of equal parts of each; but where the work is any thing delicate, as in organ-pipes, where the juncture is scarce discernible, it is made of one part of bismuth and three parts of pewter. The pewterers use a kind of solder made with two parts of tin and one of bismuth; this composition melts with the least heat of any of the solders.

Silver solder is that which is made of two parts of silver and one of brass, and used in soldering those metals. Spelter solder is made of one part of brass and two of spelter or zinc, and is used by the braziers and coppersmiths for soldering brass, copper, and iron. This solder is improved by adding to each ounce of it one pennyweight of silver; but as it does not melt without a considerable degree of heat, it cannot be used when it

Solder || Solecism.

it is inconvenient to heat the work red-hot; in which case copper and brass are soldered with silver.

Though spelter solder be much cheaper than silver-solder, yet workmen in many cases prefer the latter. And Mr Boyle informs us, that he has found it to run with so moderate a heat, as not much to endanger the melting of the delicate parts of the work to be soldered; and if well made, this silver solder will lie even upon the ordinary kind itself; and so fill up those little cavities that may chance to be left in the first operation, which is not easily done without a solder more easily fusible than the first made use of. As to iron, it is sufficient that it be heated to a white heat, and the two extremities, in this state, be hammered together; by which means they become incorporated one with the other.

SOLDERING, the joining and fastening together of two pieces of the same metal, or of two different metals, by the fusion and application of some metallic composition on the extremities of the metals to be joined.

To solder upon silver, brass, or iron: Take silver, five pennyweights; brass, four pennyweights: melt them together for soft solder, which runs soonest. Take silver, five pennyweights; copper, three pennyweights: melt them together for hard solder. Beat the solder thin, and lay it on the place to be soldered, which must be first fitted and bound together with wire as occasion requires; then take borax in powder, and temper it like pap, and lay it upon the solder, letting it dry; then cover it with live coals, and blow, and it will run immediately; take it presently out of the fire, and it is done. It is to be observed, that if any thing is to be soldered in two places, which cannot well be done at one time, you must first solder with the harder solder, and then with the soft; for if it be first done with the soft, it will unsolder again before the other is fastened. Let it be observed, that if you would not have your solder run about the piece that is to be soldered, you must rub such places over with chalk.—In the soldering either of gold, silver, copper, or either of the metals above mentioned, there is generally used borax in powder, and sometimes rosin. As to iron, it is sufficient that it be heated red-hot, and the two extremities thus hammered together, by which means they will become incorporated with each other. For the finer kinds of iron and steel instruments, however, gold proves an excellent solder. This metal will dissolve twice or thrice its weight of iron in a degree of heat very far less than that in which iron itself melts; hence if a small plate of gold is wrapped round the parts to be joined, and afterwards melted by a blow-pipe, it strongly unites the pieces together without any injury to the instrument, however delicate.

SOLDIER, a military man listed to serve a prince or state in consideration of a certain daily pay.

Soldier-Crab. See Cancer, Entomology *Index*.

Fresh Water Soldier. See Stratiotes, Botany *Index*.

SOLE, in the manege, a sort of horn under a horse's foot, which is much more tender than the other horn that encompasses the foot, and by reason of its hardness is properly called the *horn* or *hoof*.

Sole. See Pleuronectes, Ichthyology *Index*.

SOLEA. See Sandal and Shoe.

SOLECISM, in *Grammar*, a false manner of speaking, contrary to the rules of grammar, either in respect of declension, conjugation, or syntax.—The word is Greek, σολοικισμος, derived from the *Soli*, a people of Attica, who being transplanted to Cilicia, lost the purity of their ancient tongue, and became ridiculous to the Athenians for the improprieties into which they fell.

Solecism || Solfaing.

SOLEMN, something performed with much pomp, ceremony, and expence. Thus we say, solemn feasts, solemn funerals, solemn games, &c.—In law, *solemn* signifies something authentic, or what is clothed in all its formalities.

SOLEN, Razor-sheath, or *Knife-handle Shell*; a genus belonging to the class of *vermes*, and order of *testacea*. See Conchology *Index*.

SOLEURE, a canton of Swisserland, which holds the 11th rank in the Helvetic confederacy, into which it was admitted in the year 1481. It stretches partly through the plain, and partly along the chains of the Jura, and contains about 50,000 inhabitants. It is 35 miles in length from north to south, and 35 in breadth from east to west. The soil for the most part is exceedingly fertile in corn; and the districts within the Jura abound in excellent pastures. The trade both of the town and canton is of little value, although they are very commodiously situated for an extensive commerce. It is divided into 11 bailiwicks, the inhabitants of which are all Roman Catholics except those of the bailiwick of Buckegberg, who profess the reformed religion. The sovereign power resides in the great council, which, comprising the senate or little council of 36, consists of 102 members, chosen by the senate in equal proportions from the 11 tribes or companies into which the ancient burghers are distributed; and, owing to the distinction between the ancient and the new burghers (the former consisting of only 85 families) the government was formerly a complete aristocracy.

Soleure, an ancient and extremely neat town of Swisserland, capital of the canton of the same name. It contains about 4000 inhabitants, and is pleasantly seated on the Aar, which here expands into a noble river. Among the most remarkable objects of curiosity in this town is the new church of St Urs, which was begun in 1762 and finished in 1772. It is a noble edifice of a whitish grey stone, drawn from the neighbouring quarries, which admits a polish, and is a species of rude marble. The lower part of the building is of the Corinthian, the upper of the Composite order. The façade, which consists of a portico, surmounted by an elegant tower, presents itself finely at the extremity of the principal street. It cost at least 80,000l. a considerable sum for such a small republic, whose revenue scarcely exceeds 12,000l. a-year. Soleure is surrounded by regular stone fortifications, and is 20 miles north-north-east of Bern, 27 south-south-west of Basle, and 45 west of Zurich. E. Long. 7. 20. N. Lat. 47. 15.

SOLFAING, in *Music*, the naming or pronouncing the several notes of a song by the syllables *ut*, *re*, *mi*, *fa*, *sol*, &c. in learning to sing it.

Of the seven notes in the French scale *ut*, *re*, *mi*, *fa*, *sol*, *la*, *si*, only four are used among us in singing, as *mi*, *fa*, *sol*, *la*: their office is principally, in singing, that by applying them to every note of the scale, it may not only be pronounced with more ease, but chiefly that by them the tones and semitones of the natural scale may be better marked out and distinguished. This design is obtained by the four syllables *fa*, *sol*, *la*, *mi*.

Thus from *fa* to *ſol* is a tone, alſo from *ſol* to *la*, and from *la* to *mi*, without diſtinguiſhing the greater or leſs tone; but from *la* to *fa*, alſo from *mi* to *fa*, is only a ſemitone. If then theſe be applied in this order, *fa*, *ſol*, *la*, *fa*, *ſol*, *la*, *mi*, *fa*, &c. they expreſs the natural ſeries from C; and if that be repeated to a ſecond or third octave, we ſee by them how to expreſs all the different orders of tones and ſemitones in the diatonic ſcale; and ſtill above *mi* will ſtand, *fa*, *ſol*, *la*, and below it the ſame inverted *la*, *ſol*, *fa*, and one *mi* is always diſtant from another an octave; which cannot be ſaid of any of the reſt, becauſe after *mi* aſcending come always *fa*, *ſol*, *la*, which are repeated invertedly deſcending.

To conceive the uſe of this, it is to be remembered, that the firſt thing in learning to ſing, is to make one raiſe a ſcale of notes by tones and ſemitones to an octave, and deſcend again by the ſame; and then to riſe and fall by greater intervals at a leap, as thirds and fourths, &c. and to do all this by beginning at notes of different pitch. Then thoſe notes are repreſented by lines and ſpaces, to which theſe ſyllables are applied, and the learners taught to name each line and ſpace thereby, which makes what we call *ſolfaing*; the uſe whereof is, that while they are learning to tune the degrees and intervals of ſound expreſſed by notes on a line or ſpace, or learning a ſong to which no words are applied, they may not only do it the better by means of articulate ſounds, but chiefly that by knowing the degrees and intervals expreſſed by thoſe ſyllables, they may more readily know the places of the ſemitones, and the true diſtance of the notes. See the article SINGING.

SOLFATERRA, a mountain of Italy in the kingdom of Naples, and Terra di Lavoro. This mountain appears evidently to have been a volcano in ancient times; and the ſoil is yet ſo hot, that the workmen employed there in making alum need nothing elſe beſides the heat of the ground for evaporating their liquids. Of this mountain we have the following account by Sir William Hamilton. "Near Aſtruni (another mountain, formerly a volcano likewiſe) riſes the Solfaterra, which not only retains its cone and crater, but much of its former heat. In the plain within the crater, ſmoke iſſues from many parts, as alſo from its ſides: here, by means of ſtones and tiles heaped over the crevices, through which the ſmoke paſſes, they collect in an aukward manner what they call *ſale armoniaco*; and from the ſand of the plain they extract ſulphur and alum. This ſpot, well attended to, might certainly produce a good revenue, whereas I doubt if they have hitherto ever cleared 200l. a-year by it. The hollow ſound produced by throwing a heavy ſtone on the plain of the crater of the Solfaterra, ſeems to indicate that it is ſupported by a ſort of arched natural vault; and one is induced to think that there is a pool of water beneath this vault (which boils by the heat of a ſubterraneous fire ſtill deeper), by the very moiſt ſteam that iſſues from the cracks in the plain of the Solfaterra, which, like that of boiling water, runs off a ſword or knife, preſented to it, in great drops. On the outſide, and at the foot of the cone of the Solfaterra, towards the lake of Agnano, water ruſhes out of the rocks ſo hot as to raiſe the quickſilver in Fahrenheit's thermometer to the degree of boiling water (A); a fact of which I was myſelf an eye-witneſs. This place, well worthy the obſervation of the curious, has been taken little notice of; it is called the *Piſciarelli*. The common people of Naples have great faith in the efficacy of this water; and make much of it in all cutaneous diſorders, as well as for another diſorder that prevails here. It ſeems to be impregnated chiefly with ſulphur and alum. When you approach your ear to the rocks of the Piſciarelli, from whence this water ouzes, you hear a horrid boiling noiſe, which ſeems to proceed from the huge cauldron that may be ſuppoſed to be under the plain of the Solfaterra. On the other ſide of the Solfaterra, next the ſea, there is a rock which has communicated with the ſea, till part of it was cut away to make the road to Puzzole; this was undoubtedly a conſiderable lava, that ran from the Solfaterra when it was an active volcano. Under this rock of lava, which is more than 70 feet high, there is a ſtratum of pumice and aſhes. This ancient lava is about a quarter of a mile broad; you meet with it abruptly before you come in ſight of Puzzole, and it finiſhes as abruptly within about 100 paces of the town. The ancient name of the Solfaterra was *Forum Vulcani*; a ſtrong proof of its origin from ſubterraneous fire. The degree of heat that the Solfaterra has preſerved for ſo many ages, ſeems to have calcined the ſtones upon its cone and in its crater, as they are very white and crumble eaſily in the hotteſt parts.

SOLICITOR, a perſon employed to take care of and manage ſuits depending in the courts of law or equity. Solicitors are within the ſtatute to be ſworn, and admitted by the judges, before they are allowed to practiſe in our courts, in like manner as attorneys.

There is alſo a great officer of the law, next to the attorney-general, who is ſtyled the king's ſolicitor-general; who holds his office by patent during the king's pleaſure, has the care and concern of managing the king's affairs, and has fees for pleading, beſides other fees ariſing by patents, &c. He attends on the privy-council; and the attorney-general and he were anciently reckoned among the officers of the exchequer; they have their audience, and come within the bar in all other courts.

SOLID, in *Philoſophy*, a body whoſe parts are ſo firmly connected together, as not eaſily to give way or ſlip from each other; in which ſenſe *ſolid* ſtands oppoſed to *fluid*.

Geometricians define a ſolid to be the third ſpecies of magnitude, or that which has three dimenſions, viz. length, breadth, and thickneſs or depth.

Solids are commonly divided into regular and irregular. The regular ſolids are thoſe terminated by regular and

(A) "I have remarked, that after a great fall of rain, the degree of heat in this water is much leſs; which will account for what Padre Torre ſays (in his book, intitled *Hiſtoire et Phenomenes du Veſuve*), that when he tried it in company with Monſieur de la Condamine, the degree of heat, upon Reaumur's thermometer, was 68°.

and equal planes, and are only five in number, viz. the tetrahedron, which consists of four equal triangles; the cube or hexahedron, of six equal squares; the octahedron, of eight equal triangles; the dodecahedron, of twelve; and the icosihedron, of twenty equal triangles.

The irregular solids are almost infinite, comprehending all such as do not come under the definition of regular solids; as the sphere, cylinder, cone, parallelogram, prism, parallelopiped, &c.

Solids, in *Anatomy*, are the bones, ligaments, membranes, muscles, nerves and vessels, &c.

The solid parts of the body, though equally composed of vessels, are different with regard to their consistence; some being hard and others soft. The hard, as the bones and cartilages, give firmness and attitude to the body, and sustain the other parts: the soft parts, either alone or together with the hard, serve to execute the animal functions. See Anatomy.

SOLIDAGO, a genus of plants belonging to the class of *syngenesia*, and to the order of *polygamia superflua*; and in the natural system ranging under the 49th order, *Compositæ*. See Botany *Index*.

SOLIDITY, that property of matter, or body, by which it excludes all other bodies from the place which itself possesses; and as it would be absurd to suppose that two bodies could possess one and the same place at the same time, it follows, that the softest bodies are equally solid with the hardest. See Metaphysics, N° 44. 173, &c.

Among geometricians, the solidity of a body denotes the quantity or space contained in it, and is called also its solid content.

The solidity of a cube, prism, cylinder, or parallelopiped, is had by multiplying its basis into its height. The solidity of a pyramid or cone is had by multiplying either the whole base into a third part of the height, or the whole height into a third part of the base.

SOLILOQUY, a reasoning or discourse which a man holds with himself; or, more properly, according to Papias, it is a discourse by way of answer to a question that a man proposes to himself.

Soliloquies are become very common on the modern stage; yet nothing can be more inartificial, or more unnatural, than an actor's making long speeches to himself, to convey his intentions to the audience. Where such discoveries are necessary to be made, the poets should rather take care to give the dramatic persons such confidants as may necessarily share their inmost thoughts; by which means they will be more naturally conveyed to the audience; yet even this is a shift which an accurate poet would not have occasion for. The following lines of the duke of Buckingham concerning the use and abuse of soliloquies deserve attention:

> Soliloquies had need be very few,
> Extremely short, and spoke in passion too.
> Our lovers talking to themselves, for want
> Of others, make the pit their confidant:
> Nor is the matter mended yet, if thus
> They trust a friend, only to tell it us.

SOLIMAN II. emperor of the Turks, surnamed the *Magnificent*, was the only son of Selim I. whom he succeeded in 1520. He was educated in a manner very different from the Ottoman princes in general; for he was instructed in the maxims of politics and the secrets of government. He began his reign by restoring those persons their possessions whom his father had unjustly plundered. He re-established the authority of the tribunals, which was almost annihilated, and bestowed the government of provinces upon none but persons of wealth and probity: "I would have my viceroys (he used to say) resemble those rivers that fertilize the fields through which they pass, not those torrents which sweep every thing before them."

After concluding a truce with Ismael Sophy of Persia, and subduing Gozeli Bey, who had raised a rebellion in Syria, he turned his arms against Europe. Belgrade was taken in 1521, and Rhodes fell into his hands the year following, after an obstinate and enthusiastic defence. In 1526 he defeated and slew the king of Hungary in the famous battle of Mohatz. Three years after he conquered Buda, and immediately laid siege to Vienna itself. But after continuing 20 days before that city, and assaulting it 20 times, he was obliged to retreat with the loss of 80,000 men. Some time after he was defeated by the Persians, and disappointed in his hopes of taking Malta. He succeeded, however, in dispossessing the Genoese of Chio, an island which had belonged to that republic for more than 200 years.

He died at the age of 76, while he was besieging Sigeth, a town in Hungary, on the 30th August 1566.

He was a prince of the strictest probity, a lover of justice, and vigorous in the execution of it; but he tarnished all his glory by the cruelty of his disposition. After the battle of Mohatz he ordered 1500 prisoners, most of them gentlemen, to be ranged in a circle, and beheaded in presence of his whole army.

Soliman thought nothing impossible which he commanded: A general having received orders to throw a bridge over the Drave, wrote him, that it was impossible. The sultan sent him a long band of linen with these words written on it: "The emperor Soliman, thy master, orders thee to build a bridge over the Drave in spite of the difficulties thou mayest meet with. He informs thee at the same time, that if the bridge be not finished upon his arrival, he will hang thee with the very linen which informs thee of his will."

SOLIPUGA, or Solifuga, in *Natural History*, the name given by the Romans to a small venomous insect of the spider-kind, called by the Greeks *heliocentros*; both words signifying an animal which stings most in the country and seasons where the sun is most hot. Solinus makes this creature peculiar to Sardinia; but this is contrary to all the accounts given us by the ancients. It is common in Africa and some parts of Europe. Almost all the hot countries produce this venomous little creature. It lies under the sand to seize other insects as they go by; and if it meet with any uncovered part of a man, produces a wound which proves very painful; it is said that the bite is absolutely mortal, but probably this is not true. Solinus writes the word *solifuga*, and so do many others, erroneously deriving the name from the notion that this animal flies from the sun's rays, and buries itself in the sand.

SOLIS, Antonio de, an ingenious Spanish writer, of an ancient and illustrious family, born at Placenza an Old Castile, in 1610. He was intended for the law; but his inclination toward poetry prevailed, and he cultivated it with great success. Philip IV. of Spain made

made him one of his secretaries; and after his death the queen-regent appointed him historiographer of the Indies, a place of great profit and honour: his History of the Conquest of Mexico shows that she could not have named a fitter person. He is better known by this history at least abroad, than by his poetry and dramatic writings, though in these he was also distinguished. He turned priest at 57 years of age, and died in 1686.

SOLITARY, that which is remote from the company or commerce of others of the same species.

SOLITARIES, a denomination of nuns of St Peter of Alcantara, instituted in 1676, the design of which was to imitate the severe penitent life of that saint. Thus they are to keep a continual silence, never to open their mouths to a stranger; to employ their time wholly in spiritual exercises, and leave their temporal concerns to a number of maids, who have a particular superior in a separate part of the monastery: they always go bare-footed, without sandals; gird themselves with a thick cord, and wear no linen.

SOLO, in the Italian music, is frequently used in pieces consisting of several parts, to mark those that are to perform alone; as *flauto solo, violino solo*. It is also used for sonatas composed for one violin, one German flute, or other instrument, and a bass; thus we say, *Corelli's solos, Geminiani's solos*, &c. When two or three parts play or sing separately from the grand chorus, they are called a *doi soli*, a *tre soli*, &c. Solo is sometimes denoted by *S*.

SOLOMON, the son of David king of Israel, renowned in Scripture for his wisdom, riches, and magnificent temple and other buildings. Towards the end of his life he sullied all his former glory by his apostacy from God; from which cause vengeance was denounced against his house and nation. He died about 975 B. C.

SOLOMON's Seal, a species of CONVALLARIA, which see, BOTANY *Index*.

SOLON, one of the seven wise men of Greece, was born at Salamis, of Athenian parents, who were descended from Codrus. His father leaving little patrimony, he had recourse to merchandise for his subsistence. He had, however, a greater thirst after knowledge and fame than after riches, and made his mercantile voyages subservient to the increase of his intellectual treasures. He very early cultivated the art of poetry, and applied himself to the study of moral and civil wisdom. When the Athenians, tired out with a long and troublesome war with the Megarensians, for the recovery of the isle of Salamis, prohibited any one, under pain of death, to propose the renewal of their claim to that island, Solon thinking the prohibition dishonourable to the state, and finding many of the younger citizens desirous to revive the war, feigned himself mad, and took care to have the report of his insanity spread through the city. In the mean time he composed an elegy adapted to the state of public affairs, which he committed to memory. Every thing being thus prepared, he sallied forth into the market-place with the kind of cap on his head which was commonly worn by sick persons, and, ascending the herald's stand, he delivered, to a numerous crowd, his lamentation for the desertion of Salamis. The verses were heard with general applause; and Pisistratus seconded his advice, and urged the people to renew the war. The decree was immediately repealed; the claim to Salamis was resumed; and the conduct of the war was committed to Solon and Pisistratus, who, by means of a stratagem, defeated the Megarensians, and recovered Salamis.

His popularity was extended through Greece in consequence of a successful alliance which he formed among the states in defence of the temple at Delphos against the Cirrhæans. When dissensions had arisen at Athens between the rich creditors and their poor debtors, Solon was created archon, with the united powers of supreme legislator and magistrate. He soon restored harmony between the rich and poor: He cancelled the debts which had proved the occasion of so much oppression; and ordained that in future no creditor should be allowed to seize the body of the debtor for his security: He made a new distribution of the people, instituted new courts of judicature, and framed a judicious code of laws, which afterwards became the basis of the laws of the twelve tables in Rome. Among his criminal laws are many wise and excellent regulations; but the code is necessarily defective with respect to those principles which must be derived from the knowledge of the true God, and of pure morality, as the certain foundations of national happiness. Two of them in particular were very exceptionable; the permission of a voluntary exile to persons that had been guilty of premeditated murder, and the appointment of a less severe punishment for a rape than for seduction. Those who wish to see accurately stated the comparative excellence of the laws of Moses, of Lycurgus, and Solon, may consult Prize Dissertations relative to Natural and Revealed Religion by Teyler's Theological Society, vol. ix.

The interview which Solon is said to have had with Crœsus king of Lydia, the solid remarks of the sage after surveying the monarch's wealth, the recollection of those remarks by Crœsus when doomed to die, and the noble conduct of Cyrus on that occasion, are known to every schoolboy. Solon died in the island of Cyprus, about the 80th year of his age. Statues were erected to his memory both at Athens and Salamis. His thirst after knowledge continued to the last: "I grow old (said he) learning many things." Among the apophthegms and precepts which have been ascribed to Solon, are the following: Laws are like cobwebs, that entangle the weak, but are broken through by the strong. He who has learned to obey, will know how to command. In all things let reason be your guide. Diligently contemplate excellent things. In every thing that you do, consider the end.

SOLSTICE, in *Astronomy*, that time when the sun is in one of the solstitial points; that is, when he is at his greatest distance from the equator; thus called because he then appears to stand still, and not to change his distance from the equator for some time; an appearance owing to the obliquity of our sphere, and which those living under the equator are strangers to.

The solstices are two in each year; the æstival or summer solstice, and the hyemal or winter solstice. The summer solstice is when the sun seems to describe the tropic of cancer, which is on June 22. when he makes the longest day: the winter solstice is when the sun enters the first degree, or seems to describe the tropic of capricorn, which is on December 22. when he makes the shortest day. This is to be understood as in our northern hemisphere; for in the southern, the sun's entrance

trance into capricorn makes the summer solstice, and that into cancer the winter solstice. The two points of the ecliptic, wherein the sun's greatest ascent above the equator, and his descent below it, are terminated, are called the *solstitial points*; and a circle, supposed to pass through the poles of the world and these points, is called the *solstitial colure*. The summer solstitial point is in the beginning of the first degree of cancer; and is called the *æstiv l* or *summer point*; and the winter solstitial point is in the beginning of the first degree of capricorn, and is called the *winter point*. These two points are diametrically opposite to each other.

SOLUTION, in *Chemistry*, denotes an intimate union of solid with fluid bodies, so as to form a transparent liquor. See CHEMISTRY *passim*.

SOLVENT, that which dissolves a solid body into a transparent fluid.

SOLWAY MOSS. See *Moving Moss*.

SOMBRERO, the name of an uninhabited island in the West Indies in the form of an hat, whence the name is derived. It is also the name of one of the Nicobar islands in the East Indies.

Wonderful Plant of SOMBRERO, is a strange kind of sensitive plant growing in the East Indies, in sandy bays and in shallow water. It appears like a slender straight stick; but when you attempt to touch it, immediately withdraws itself into the sand. Mr Miller gives an account of it in his description of Sumatra. He says, the Malays call it *lolan lout*, that is, sea grass. He never could observe any tentacula; but, after many unsuccessful attempts, drew out a broken piece about a foot long. It was perfectly straight and uniform, and resembled a worm drawn over a knitting needle. When dry it appears like a coral.

Philosophical Transactions, vol. lxviii. p. 178.

SOMERS, JOHN, lord high chancellor of England, was born at Worcester in 1652. He was educated at Oxford, and afterwards entered himself at the Middle-Temple, where he studied the law with great vigour. In 1688 he was one of the counsel for the seven bishops at their trial, and argued with great learning and eloquence against the dispensing power. In the convention which met by the prince of Orange's summons, January 22. 1689, he represented Worcester; and was one of the managers for the House of Commons, at a conference with the House of Lords upon the word *abdicated*. Soon after the accession of King William and Queen Mary to the throne, he was appointed solicitor-general, and received the honour of knighthood. In 1692 he was made attorney general, and in 1693 advanced to the post of lord keeper of the great seal of England. In 1695 he proposed an expedient to prevent the practice of clipping the coin. In 1697 he was created lord Somers, baron of Evesham, and made lord high chancellor of England. In the beginning of 1700 he was removed from his post of lord chancellor, and the year after was impeached of high crimes and misdemeanors by the House of Commons, of which he was acquitted upon trial by the House of Lords. He then retired to a studious course of life, and was chosen president of the Royal Society. In 1706 he proposed a bill for the regulation of the law; and the same year was one of the principal managers for the union between England and Scotland. In 1708 he was made lord president of the council; from which post he was removed in 1710, upon the change of the ministry. In the latter end of Queen Anne's reign his lordship grew very infirm in his health; which is supposed to be the reason that he held no other post than a seat at the council-table, after the accession of King George I. He died of an apoplectic fit in 1716. Mr Addison has drawn his character very beautifully in the Freeholder.

SOMERSETSHIRE, a county of England, taking its name from Somerton, once the capital, between 50° and 51° 27′ north latitude, and between 1° 25′ and 2° 59′ west longitude. It is bounded on the west by Devonshire, on the south by Dorsetshire, on the north by Bristol channel or the Severn sea, on the north east by a small part of Gloucestershire, and on the east by Wiltshire. It is one of the largest counties in England, extending in length from east to west about 68 miles; in breadth, where broadest, from south to north, about 47; and 240 in circumference. It is divided into 42 hundreds, in which are 3 cities, 32 market-towns, 1700 villages, 385 parishes of which 132 are vicarages, containing more than 1,000,000 of acres, and about 273,750 souls. It sends 18 members to parliament, viz. two for the county, two for Bristol, two for Bath, two for Wells, two for Taunton, two for Bridgewater, two for Ilchester, two for Milbourn-port, and two for Minehead.

The air of this county is very mild and wholesome, especially that of the hilly part. The soil in general is exceeding rich, so that single acres very commonly produce forty or fifty bushels of wheat, and there have been instances of some producing sixty of barley. As there is very fine pasture both for sheep and black cattle, it abounds in both, which are as large as those of Lincolnshire, and their flesh of a finer grain. In consequence of this abundance of black cattle, great quantities of cheese are made in it, of which that of Cheddar is thought equal to Parmesan. In the hilly parts are found coal, lead, copper, and lapis calaminaris. Wood thrives in it as well as in any county of the kingdom. It abounds also in pease, beans, beer, cyder, fruit, wildfowl, and salmon; and its mineral waters are celebrated all over the world.

The riches of this county, both natural and acquired, exceed those of any other in the kingdom, Middlesex and Yorkshire excepted. The woollen manufacture in all its branches is carried on to a very great extent; and in some parts of the county great quantities of linen are made. If to these the produce of various other commodities in which it abounds is added, the amount of the whole must undoubtedly be very great. Its foreign trade must also be allowed to be very extensive, when it is considered that it has a large trade for sea-coal, and possesses, besides other ports, that of Bristol, a town of the greatest trade in England, next to London.

Besides small streams, it is well watered and supplied with fish by the rivers Severn, Avon, Parrel, Froome, Ax, Torre, and Tone. Its greatest hills are Mendip, Pouldon, and Quantock, of which the first abounds in coal, lead, &c. The rivers Severn and Parrel breed very fine salmon. The chief town is Bristol.

SOMERTON, an ancient town in Somersetshire, from whence the county derives its name. It is 123 miles from London; it has five streets, containing 251 houses, which are mostly built of the blue stone from the quarries in the neighbourhood. It is governed by constables, and has a hall for petty sessions. The market for corn is considerable, and it has several fairs for cattle. The church has, what is not very frequent, an *octangular* tower with six bells. N. Lat. 51. 4. W. Long. 1. 53.

SOMNAMBULI, persons who walk in their sleep. See SLEEPWALKERS.

SOMNER, WILLIAM, an eminent English antiquary, was born at Canterbury in 1606. His first treatise was The Antiquities of Canterbury, which he dedicated to Archbishop Laud. He then applied himself to the study of the Saxon language; and having made himself master of it, he perceived that the old glossary prefixed to Sir Roger Twisden's edition of the laws of King Henry I. printed in 1644, was faulty in many places; he therefore added to that edition notes and observations valuable for their learning, with a very useful glossary. His Treatise of Gavelkind was finished about 1648, though not published till 1660. Our author was zealously attached to King Charles I. and in 1648 he published a poem on his sufferings and death. His skill in the Saxon tongue led him to inquire into most of the European languages ancient and modern. He assisted Dugdale and Dodsworth in compiling the *Monasticon Anglicanum*. His Saxon Dictionary was printed at Oxford in 1659. He died in 1669.

SON, an appellation given to a male child considered in the relation he bears to his parents. See PARENT and FILIAL *Piety*.

SONATA, in *Music*, a piece or composition, intended to be performed by instruments only; in which sense it stands opposed to *cantata*, or a piece designed for the voice. See CANTATA.

The sonata then, is properly a grand, free, humorous composition, diversified with a great variety of motions and expressions, extraordinary and bold strokes, figures, &c. And all this purely according to the fancy of the composer; who, without confining himself to any general rules of counterpoint, or to any fixed number or measure, gives a loose to his genius, and runs from one mode, measure, &c. to another, as he thinks fit. This species of composition had its rise about the middle of the 17th century; those who have most excelled in it were Bassani and Corelli. We have sonatas of 1, 2, 3, 4, 5, 6, 7, and even 8 parts, but usually they are performed by a single violin, or with two violins, and a thorough bass for the harpsichord; and frequently a more figured bass for the bass viol, &c.

There are a thousand different species of sonatas; but the Italians usually reduce them to two kinds. *Suonate de chiesa*, that is, sonatas proper for church music, which usually begin with a grave solemn motion, suitable to the dignity and sanctity of the place and the service, after which they strike into a brisker, gayer, and richer manner. These are what they more peculiarly call sonatas. *Suonate de camera*, or sonatas for the chamber, are properly serieses of several little pieces, for dancing, only composed to the same tune. They usually begin with a prelude or little sonata, serving as an introduction to all the rest: afterwards come the allemand, pavane, courant, and other serious dances; then jigs, gavots, minuets, chacons, passecailles, and other gayer airs: the whole composed in the same tune or mode.

SONCHUS, SOW-THISTLE, in *Botany*, a genus of

plants belonging to the class of *syngenesia*, and to the order of *polygamia æqualis*; and in the natural system ranged under the 49th order, *Compositæ*. The receptacle is naked; the calyx is imbricated, bellying and conical; the down of the seed is simple, sessile, and very soft; the seed is oval and pointed. There are 13 species; the maritimus, palustris, fruticosus, arvensis, oleraceus, tenerrimus, plumieri, alpinus, floridanus, sibiricus, tataricus, tuberosus, and canadensis. Four of these are natives of Britain.—1. *Palustris*, marsh sow-thistle. The stem is erect, from six to ten feet high, branched and hairy towards the top: the leaves are firm, broad, half pinnated, serrated, and sharp-pointed; the lower ones sagittate at the base: the flowers are of a deep yellow, large, and dispersed on the tops of the branches: the calyx is rough. It is frequent in marshes, and flowers in July or August.—2. *Arvensis*, corn sow-thistle. The leaves are alternate, runcinate, and heart-shaped at the base; the root creeps under ground; the stem is three or four feet high, and branched at the top. It grows in corn-fields, and flowers in August.—3. *Oleraceus*, common sow-thistle. The stalk is succulent, pistular, and a cubit high or more; the leaves are broad, embracing the stem, generally deeply sinuated, smooth, or prickly at the edges; the flowers are of a pale yellow, numerous, in a kind of umbel, and terminal; the calyx is smooth. It is frequent in waste places and cultivated grounds.—4. *Alpinus*, blue-flowered sow-thistle. The stem is erect, purplish, branched, or simple, from three to six feet high: the leaves are large, smooth, and sinuated; the extreme segment large and triangular: the flowers are blue, and grow on hairy viscid pedicles, in long spikes: the calyx is brown. This species is found in Northumberland.

SONG, in *Poetry*, a little composition, consisting of easy and natural verses, set to a tune in order to be sung. See POETRY, N° 120.

SONG, in *Music*, is applied in general to a single piece of music, whether contrived for the voice or an instrument. See AIR.

SONG of Birds, is defined by the honourable Daines Barrington to be a succession of three or more different notes, which are continued without interruption, during the same interval, with a musical bar of four crotchets in an adagio movement, or whilst a pendulum swings four seconds.

It is affirmed, that the notes of birds are no more innate than language in man, and that they depend upon imitation, as far as their organs will enable them to imitate the sounds which they have frequent opportunities of hearing: and their adhering so steadily, even in a wild state, to the same song, is owing to the nestlings attending only to the instruction of the parent bird, whilst they disregard the notes of all others that may perhaps be singing round them.

Birds in a wild state do not commonly sing above 10 weeks in the year, whereas birds that have plenty of food in a cage sing the greatest part of the year; and we may add, that the female of no species of birds ever sings. This is a wise provision of nature, because her song would discover her nest. In the same manner, we may rationally account for her inferiority in plumage. The faculty of singing is confined to the cock birds; and accordingly Mr Hunter, in dissecting birds of several species, found the muscles of the larynx to be stronger

Song.

ftronger in the nightingale than in any other bird of the fame fize; and in all thofe inftances, where he diffected both cock and hen, the fame mufcles were ftronger in the cock. To the fame purpofe, it is an obfervation as ancient as the time of Pliny, that a capon does not crow.

Some have afcribed the finging of the cock-bird in the fpring folely to the motive of pleafing his mate during incubation; others, who allow that it is partly for this end, believe it is partly owing alfo to another caufe, viz. the great abundance of plants and infects in the fpring, which, as well as feeds, are the proper food of finging birds at that time of the year.

Mr Barrington remarks, that there is no inftance of any finging bird which exceeds our blackbird in fize; and this, he fuppofes, may arife from the difficulty of its concealing itfelf, if it called the attention of its enemies, not only by its bulk, but by the proportionable loudnefs of its notes. This writer farther obferves, that fome paffages of the fong in a few kinds of birds correfpond with the intervals of our mufical fcale, of which the cuckoo is a ftriking and known inftance; but the greater part of their fong cannot be reduced to a mufical fcale; partly, becaufe the rapidity is often fo great, and it is alfo fo uncertain when they may ftop, that we cannot reduce the paffages to form a mufical bar in any time whatfoever; partly alfo, becaufe the pitch of moft birds is confiderably higher than the moft fhrill notes of thofe inftruments which have the greateft compafs; and principally, becaufe the intervals ufed by birds are commonly fo minute, that we cannot judge of them from the more grofs intervals into which we divide our mufical octave. This writer apprehends, that all birds fing in the fame key; and in order to difcover this key, he informs us, that the following notes have been obferved in different birds, A, B flat, C, D, F, and G; and therefore E only is wanting to complete the fcale: now thefe intervals, he fays, can only be found in the key of F with a fharp third, or that of G with a flat third; and he fuppofes it to be the latter, becaufe admitting that the firft mufical notes were learned from birds, thofe of the cuckoo, which have been moft attended to, form a flat third, and moft of our compofitions are in a flat third, where mufic is fimple, and confifts merely of melody. As a farther evidence that birds fing always in the fame key, it has been found by attending to a nightingale, as well as a robin which was educated under him, that the notes reducible to our intervals of the octave were always precifely the fame.

Moft people, who have not attended to the notes of birds, fuppofe, that every fpecies fing exactly the fame notes and paffages: but this is by no means true; though it is admitted that there is a general refemblance. Thus the London bird-catchers prefer the fong of the Kentifh goldfinches, and Effex chaffinches; and fome of the nightingale fanciers prefer a Surry bird to thofe of Middlefex.

Of all finging birds, the fong of the nightingale has been moft univerfally admired: and its fuperiority (deduced from a caged bird) confifts in the following particulars; its tone is much more mellow than that of any other bird, though at the fame time, by a proper exertion of its mufical powers, it can be very brilliant. Another point of fuperiority is its continuance of fong without a paufe, which is fometimes no lefs than 20 feconds; and when refpiration becomes neceffary, it takes it with as much judgment as an opera-finger. The fky-lark in this particular, as well as in compafs and variety, is only fecond to the nightingale. The nightingale alfo fings (if the expreffion may be allowed) with fuperior judgment and tafte. Mr Barrington has obferved, that his nightingale, which was a very capital bird, began foftly like the ancient orators, referving its breath to fwell certain notes, which by thefe means had a moft aftonifhing effect. This writer adds, that the notes of birds, which are annually imported from Afia, Africa, and America, both fingly and in concert, are not to be compared to thofe of European birds.

Song || Soontaburdar.

The following table, formed by Mr Barrington, agreeably to the idea of M. de Piles in eftimating the merits of painters, is defigned to exhibit the comparative merit of the Britifh finging birds; in which 20 is fuppofed to be the point of abfolute perfection.

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	Mellownefs of tone.	Sprightly notes.	Plaintive notes.	Compafs.	Execution.
Nightingale	19	14	19	19	19
Sky-lark	4	19	4	18	18
Wood-lark	18	4	17	12	8
Tit-lark	12	12	12	12	12
Linnet	12	16	12	16	18
Goldfinch	4	19	4	12	12
Chaffinch	4	12	4	8	8
Greenfinch	4	4	4	4	6
Hedge-fparrow	6	0	6	4	4
Aberdavine or fifkin	2	4	0	4	4
Red-poll	0	4	0	4	4
Thrufh	4	4	4	4	4
Blackbird	4	4	0	2	2
Robin	6	16	12	12	14
Wren	0	12	0	4	2
Reed fparrow	0	4	0	2	2
Black cap, or Norfolk mock nightingale	14	12	12	14	14

SONNA, a book of Mahometan traditions, which the orthodox muffulmans are required to believe.

SONNERATIA, a genus of plants belonging to the clafs of *icofandria*, and to the order of *monogynia*. See BOTANY *Index*.

SONNET, in *Poetry*, a compofition contained in 14 verfes, viz. two ftanzas or meafures of four verfes each, and two of three, the firft eight verfes being all in three rhimes.

SONNITES, among the Mahometans, an appellation given to the orthodox muffulmans or true believers; in oppofition to the feveral heretical fects, particularly the Shiites, or followers of Ali.

SOOJU, or SOY. See DOLICHOS.

SOONTABURDAR, in the Eaft Indies; an attendant, who carries a filver bludgeon in his hand about two or three feet long, and runs before the palanquin. He is inferior to the chubdar; the propriety of an Indian newaury requiring two foontaburdars for every chubdar in the train. The chubdar proclaims the approach of vifitors, &c. He generally carries a large filver

ver staff about five feet long in his hands; and among the Nabobs he proclaims their praises aloud as he runs before their palanquins.

SOOT, a volatile matter arising from wood and other fuel along with the smoke; or rather, it is the smoke itself condensed and gathered to the sides of the chimney. Though once volatile, however, soot cannot be again resolved into vapour; but, if distilled by a strong fire, yields a volatile alkali and empyreumatic oil, a considerable quantity of fixed matter remaining at the bottom of the distilling vessel. If burnt in an open fire, it flames with a thick smoke, whence other soot is produced. It is used as a material for making sal ammoniac, and as a manure. See AMMONIA, *muriate of*, CHEMISTRY *Index*.

SOOT-Black. See *COLOUR-Making*.

SOPHI, or SOFI, a title given to the emperor of Persia, importing as much as wise, sage, or philosopher.

The title is by some said to have taken its rise from a young shepherd named *Sophi*, who attained to the crown of Persia in 1370; others derive it from the *sophoi* or sages anciently called *magi*. Vossius gives a different account of the word: sophi in Arabic, he observes, signifies *wool*; and he adds, that it was applied by the Turks out of derision, to the kings of Persia ever since Ishmael's time; because, according to their scheme of religion, he is to wear no other covering on his head but an ordinary red woollen stuff; whence the Persians are also called *hezelbaschs*, q. d. *red-heads*. But Bochart assures us, that sophi in the original Persian language, signifies one that is pure in his religion, and who prefers the service of God in all things: and derives it from an order of religious called by the same name. The sophis value themselves on their illustrious extraction. They are descended in a right line from Houssein, second son of Ali, Mahomet's cousin, and Fatima, Mahomet's daughter.

SOPHIS, or *Sofees*, a kind of order of religious among the Mahometans in Persia, answering to what are otherwise called *dervises*, and among the Arabs and Indians *faquirs*. Some will have them called sophis from a kind of coarse camblet which they wear, called *souf*, from the city Souf in Syria, where it is principally manufactured. The more eminent of those sophis are complimented with the title *schiek*, that is, *reverend*, much as in Romish countries the religious are called *reverend fathers*. Schiek Sophi, who laid the foundation of the grandeur of the royal house of Persia, was the founder, or rather the restorer of this order: Ishmael, who conquered Persia, was himself a sophi, and greatly valued himself on his being so. He chose all the guards of his person from among the religious of this order; and would have all the great lords of his court sophis. The king of Persia is still grandmaster of the order; and the lords continue to enter into it, though it be now fallen under some contempt.

SOPHISM, in *Logic*, a specious argument having the appearance of truth, but leading to falsehood. Sophisms are reduced by Aristotle into eight classes, an arrangement so just and comprehensive, that it is equally proper in present as in former times. 1. *Ignoratio elenchi*, in which the sophist seems to determine the question, while he does it only in appearance. Thus the question, "Whether the excess of wine be hurtful?" seems to be determined by proving, that wine revives the spirits and gives a man courage: but the principal point is here kept out of sight; for still it may be hurtful to health, to fortune, and reputation. 2. *Petitio principii*, a begging of the question, or taking for granted that which remains to be proved, as if any one should undertake to prove that the soul is extended through all the parts of the body, because it resides in every member. This is affirming the same thing in different words. 3. Reasoning in a circle; as when the Roman Catholics prove the Scriptures to be the word of God by the authority of the church, and the authority of the church from the Scriptures. 4. *Non causa pro causa*, or the assigning of a false cause to any effect. Thus the supposed principle, that nature abhors a vacuum, was applied to explain the rising of water in a pump before Galileo discovered that it was owing to the pressure of the atmosphere. In this way the vulgar ascribe accidents to divine vengeance, and the heresies and infidelity of modern times are said to be owing to learning. 5. *Fallacia accidentis*, in which the sophist represents what is merely accidental as essential to the nature of the subject. This is nearly allied to the former, and is committed by the Mahometans and Roman Catholics. The Mahometans forbid wine, because it is sometimes the occasion of drunkenness and quarrels; and the Roman Catholics prohibit the reading of the Bible, because it has sometimes promoted heresies. 6. By deducing an universal assertion from what is true only in particular circumstances, and the reverse: thus some men argue, "transcribers have committed many errors in copying the Scriptures, therefore they are not to be depended on." 7. By asserting any thing in a compound sense which is only true in a divided sense; so when the Scriptures assure us, that the worst of sinners may be saved, it does not mean that they shall be saved while they remain sinners, but that if they repent they may be saved. 8. By an abuse of the ambiguity of words. Thus Mr Hume reasons in his Essay on Miracles: "Experience is our only guide in reasoning concerning matters of fact; now we know from experience, that the laws of nature are fixed and invariable. On the other hand, testimony is variable and often false; therefore since our evidence for the reality of miracles rests solely on testimony which is variable, and our evidence for the uniformity of the laws of nature is invariable, miracles are not to be believed." The sophistry of this reasoning depends on the ambiguity of the word *experience*, which in the first proposition signifies the maxims which we form from our own observation and reflection; in the second it is confounded with testimony; for it is by the testimony of others, as well as our own observation, that we learn whether the laws of nature are variable or invariable. The Essay on Miracles may be recommended to those who wish to see more examples of sophistry; as we believe most of the eight species of sophisms which we have mentioned are well illustrated by examples in that essay.

SOPHIST, an appellation assumed in the early periods of Grecian history by those who devoted their time to the study of science. This appellation appearing too arrogant to Pythagoras, he declined it, and wished to be called a *philosopher*; declaring that, though he could not consider himself as a wise man, he was indeed a lover of wisdom. True wisdom and modesty are generally

generally united. The example of Pythagoras was followed by every man of eminence; while the name *sophist* was retained only by thoſe who with a pomp of words made a magnificent diſplay of wiſdom upon a very ſlight foundation of knowledge. Thoſe men taught an artificial ſtructure of language, and a falſe method of reaſoning, by which, in argument, the worſe might be made to appear the better reaſon (ſee SOPHISM). In Athens they were long held in high repute, and ſupported, not only by contributions from their pupils, but by a regular ſalary from the ſtate. They were among the bittereſt enemies of the illuſtrious Socrates, becauſe he embraced every opportunity of expoſing to contempt and ridicule their vain pretenſions to ſuperior knowledge, and the pernicious influence of their doctrines upon the taſte and morals of the Athenian youth.

SOPHISTICATION, the mixing of any thing with what is not genuine; a practice too common in the making up of medicines for ſale; as alſo among vintners, diſtillers, and others, who are accuſed of ſophiſticating their wines, ſpirits, oils, &c. by mixing with them cheaper and coarſer materials; and in many caſes the cheat is carried on ſo artfully as to deceive the beſt judges.

SOPHOCLES, the celebrated Greek tragic poet, the ſon of Sophilus an Athenian, was born at Colonn, and educated with great attention. Superior vigour and addreſs in the exerciſes of the paleſtra, and ſkill in muſic, were the great accompliſhments of young men in the ſtates of Greece. In theſe, Sophocles excelled; nor was he leſs diſtinguiſhed by the beauty of his perſon. He was alſo inſtructed in the nobleſt of all ſciences, civil polity and religion: from the firſt of theſe he derived an unſhaken love of his country, which he ſerved in ſome embaſſies, and in high military command with Pericles; from the latter he was impreſſed with a pious reverence for the gods, manifeſted by the inviolable integrity of his life. But his ſtudies were early devoted to the tragic muſe; the ſpirit of Eſchylus lent a fire to his genius, and excited that noble emulation which led him to contend with, and ſometimes to bear away the prize from, his great maſter. He wrote 43 tragedies, of which 7 only have eſcaped the ravages of time: and having teſtified his love of his country by refuſing to leave it, though invited by many kings; and having enjoyed the uninterrupted eſteem and affection of his fellow citizens, which neither the gallant actions and ſublime genius of Eſchylus, nor the tender ſpirit and philoſophic virtue of Euripides, could ſecure to them, he died in the 91ſt year of his age, about 406 years before Chriſt. The burial-place of his anceſtors was at Decelia, which the Lacedemonians had at that time ſeized and fortified; but Lyſander, the Spartan chief, permitted the Athenians to inter their deceaſed poet; and they paid him all the honours due to his love of his country, integrity of life, and high poetic excellence. Eſchylus had at once ſeized the higheſt poſt of honour in the field of poetry, the true ſublime; to that eminence his claim could not be diſputed. Sophocles had a noble elevation of mind, but tempered with ſo fine a taſte, and ſo chaſtened a judgement, that he never paſſed the bounds of propriety. Under his conduct the tragic muſe appeared with the chaſte dignity of ſome noble matron at a religious ſolemnity; harmony is in her voice, and grace in all her motions. From him the theatre received ſome additional embelliſhments; and the drama the introduction of a third ſpeaker, which made it more active and intereſting: but his diſtinguiſhed excellence is in the judicious diſpoſition of the fable, and ſo nice a connection and dependence of the parts on each other, that they all agree to make the event not only probable, but even neceſſary. This is peculiarly admirable in his "Oedipus King of Thebes;" and in this important point he is far ſuperior to every other dramatic writer.

The ingratitude of the children of Sophocles is well known. They wiſhed to become immediate maſters of their father's poſſeſſions; and therefore tired of his long life, they accuſed him before the Areopagus of inſanity. The only defence the poet made was to read his tragedy of Oedipus at Colonos, which he had lately finiſhed; and then he aſked his judges, whether the author of ſuch a performance could be taxed with inſanity! The father upon this was acquitted, and the children returned home covered with ſhame and confuſion. The ſeven tragedies of Sophocles which ſtill remain, together with the Greek Scholia which accompany them, have been tranſlated into Latin by Johnſon, and into Engliſh by Dr Franklin and Mr Potter.

SOPHORA, a genus of plants belonging to the claſs of decandria, and to the order of monogynia; and in the natural ſyſtem arranged under the 32d order, *Papilionaceæ*. See BOTANY *Index*.

SOPORIFIC, or SOPORIFEROUS, a medicine that produces ſleep. Such are opium, laudanum, the ſeed of poppies, &c. The word is formed from the Latin *ſopor* "ſleep." The Greeks in place of it uſe the word *hypnotic*.

SORBONNE, or SORBON, the houſe or college of the faculty of theology eſtabliſhed in the univerſity of Paris. It was founded in 1252 by St Louis, or rather by Robert de Sorbon his confeſſor and almoner, firſt canon of Cambray, and afterwards of the church of Paris; who gave his own name to it, which he himſelf took from the village of Sorbon or Serbon, near Sens, where he was born. The foundation was laid in 1250; Queen Blanche, in the abſence of her huſband, furniſhing him with a houſe which had formerly been the palace of Julian the apoſtate, of which ſome remains are ſtill ſeen. Afterwards the king gave him all the houſes he had in the ſame place, in exchange for ſome others. The college has been ſince magnificently rebuilt by the cardinal de Richelieu. The deſign of its inſtitution was for the uſe of poor ſtudents in divinity. There are lodgings in it for 36 doctors, who are ſaid to be of the *ſociety of the Sorbonne*; thoſe admitted into it without being doctors, are ſaid to be of the *hoſpitality of the Sorbonne*. Six regent doctors formerly held lectures every day for an hour and a half each; three in the morning, and three in the afternoon.

SORBONNE, is alſo uſed in general for the whole faculty of theology at Paris; as the aſſemblies of the whole body are held in the houſe of the Sorbonne; and the bachelors of the other houſes of the faculty, as the houſe of Navarre, &c. come hither to hold their *ſorbonnique*, or act for being admitted doctor in divinity.

SORBUS, SERVICE-TREE, a genus of plants belonging to the claſs of icoſandria, and to the order of trigynia. See BOTANY *Index*.—The *aucuparia*, mountain-aſh, quicken-tree, quick-beam, or roan-tree, riſes with a ſtraight upright ſtem and regular branching head, twenty or thirty feet high or more, covered with a ſmooth grayiſh brown bark; pinnated leaves of eight or ten pair of long, narrow, ſerrated folioles, and an odd one, ſmooth on both ſides; and large umbellate cluſters of white flowers at the ſides and ends of the branches, ſucceeded by cluſters of fine red berries, ripe in autumn and winter. There is a variety with yellow ſtriped leaves. This ſpecies grows wild in many parts of this iſland in mountainous places, woods, and hedge-rows, often growing to the ſize of timber; and is admitted into moſt ornamental plantations, for the beauty of its growth, foliage, flowers, and fruit; the latter, in particular, being produced in numerous red large bunches all over the tree, exhibit a fine appearance in autumn and winter, till devoured by the birds, eſpecially the blackbird and thruſh, which are ſo allured by this fruit as to flock from all parts and feed on it voraciouſly.—In the iſland of Jura the juice of the berries is employed as an acid for punch. It is probable that this tree was in high eſteem with the Druids; for it is more abundant than any other tree in the neighbourhood of thoſe Druidical circles of ſtones, ſo common in North Britain. It is ſtill believed by ſome perſons, that a branch of this tree can defend them from enchantment or witchcraft. Even the cattle are ſuppoſed to be preſerved by it from danger. The dairy-maid drives them to the ſummer paſtures with a rod of the roan-tree, and drives them home again with the ſame. In Strathſpey, we are told, a hoop is made of the wood of this tree on the 1ſt of May, and all the ſheep and lambs are made to paſs through it.

The *domeſtica*, or cultivated ſervice-tree, with eatable fruit, grows with an upright ſtem, branching 30 or 40 feet high or more, having a browniſh bark, and the young ſhoots in ſummer covered with a mealy down; pinnated leaves of eight or ten pair of broadiſh deeply ſerrated lobes and an odd one, downy underneath; and large umbellate cluſters of white flowers at the ſides and ends of the branches, ſucceeded by bunches of large, fleſhy, edible red fruit, of various ſhapes and ſizes. This tree is a native of the ſouthern warm parts of Europe, where its fruit is uſed at table as a deſert, and it is cultivated here in many of our gardens, both as a fruit-tree and as an ornament to diverſify hardy plantations.

SORCERY, or MAGIC; the power which ſome perſons were formerly ſuppoſed to poſſeſs of commanding the devil and the infernal ſpirits by ſkill in charms and invocations, and of ſoothing them by fumigations. Sorcery is therefore to be diſtinguiſhed from witchcraft; an art which was ſuppoſed to be practiſed, not by commanding evil ſpirits, but by compact with the devil. As an inſtance of the power of bad ſmells over demons or evil ſpirits, we may mention the flight of the evil ſpirit mentioned in Tobit into the remote parts of Egypt, produced, it is ſaid, by the ſmell of the burnt liver of a fiſh. Lilly informs us, that one Evans having raiſed a ſpirit at the requeſt of Lord Bothwell and Sir Kenelm Digby, and forgetting a fumigation, the ſpirit, vexed at the diſappointment, pulled him without the circle, and carried him from his houſe in the Minories into a field near Batterſea Cauſeway.

King James, in his *Dæmonologia*, has given a very full account of the art of ſorcery. "Two principal things (ſays he) cannot well in that errand be wanted: holy water (whereby the devill mockes the papiſts), and ſome preſent of a living thing unto him. There are likewiſe certaine daies and houres that they obſerve in this purpoſe. Theſe things being all ready and prepared, circles are made, triangular, quadrangular, round, double, or ſingle, according to the forme of the apparition they crave. When the conjured ſpirit appeares, which will not be while after many circumſtances, long prayers, and much muttering and murmurings of the conjurors, like a papiſt prieſt diſpatching a hunting maſſe—how ſoone, I ſay, he appeares, if they have miſſed one jote of all their rites; or if any of their feete once ſlyd over the circle, through terror of his fearfull apparition, he paies himſelf at that time, in his owne hand, of that due debt which they ought him, and otherwiſe would have delaied longer to have paied him: I mean, he carries them with him, body and ſoule." How the conjurors made triangular or quadrangular circles, his majeſty has not informed us, nor does he ſeem to imagine there was any difficulty in the matter. We are therefore led to ſuppoſe, that he learned his mathematics from the ſame ſyſtem as Dr Sacheverell, who, in one of his ſpeeches or ſermons, made uſe of the following ſimile: "They concur like parallel lines, meeting in one common centre."

Another mode of conſulting ſpirits was by the beryl, by means of a ſpeculator or ſeer; who, to have a complete ſight, ought to be a pure virgin, a youth who had not known woman, or at leaſt a perſon of irreproachable life and purity of manners. The method of ſuch conſultation is this: The conjuror having repeated the neceſſary charms and adjurations, with the litany or invocation peculiar to the ſpirits or angels he wiſhes to call (for every one has his particular form), the ſeer looks into a cryſtal or beryl, wherein he will ſee the anſwer, repreſented either by types or figures; and ſometimes, though very rarely, will hear the angels or ſpirits ſpeak articulately. Their pronunciation is, as Lilly ſays, like the Iriſh, much in the throat. Lilly deſcribes one of theſe beryls or cryſtals. It was, he ſays, as large as an orange, ſet in ſilver, with a croſs at the top, and round about engraved the names of the angels Raphael, Gabriel, and Uriel. A delineation of another is engraved in the frontiſpiece to Aubery's Miſcellanies.

Theſe ſorcerers or magicians do not always employ their art to do miſchief; but, on the contrary, frequently exert it to cure diſeaſes inflicted by witches; to diſcover thieves; recover ſtolen goods; to foretel future events, and the ſtate of abſent friends. On this account they are frequently called *white witches*. See MAGIC, WITCHCRAFT, &c.

Our forefathers were ſtrong believers when they enacted, by ſtatute 33 Hen. VIII. c. 8. all witchcraft and ſorcery to be felony without benefit of clergy; and again, by ſtatute 1 Jac. I. c. 12. that all perſons invoking any evil ſpirit, or conſulting, covenanting with, entertaining, employing, feeding, or rewarding any evil ſpirit; or taking up dead bodies from their graves to be uſed in any witchcraft, ſorcery, charm, or inchantment; or killing or otherwiſe hurting any perſon by ſuch infernal arts; ſhould be guilty of felony without benefit of clergy, and ſuffer death. And if any perſon ſhould attempt by ſorcery to diſcover hidden treaſure, or or to reſtore ſtolen goods, or to provoke unlawful love, or to hurt any man or beaſt, though the ſame were not effected, he or ſhe ſhould ſuffer impriſonment and pillory for the firſt offence, and death for the ſecond. Theſe acts continued in force till lately, to the terror of all ancient females in the kingdom; and many poor wretches were ſacrificed thereby to the prejudice of their neighbours and their own illuſions, not a few having by ſome means or other confeſſed the fact at the gallows. But all executions for this dubious crime are now at an end; our legiſlature having at length followed the wiſe example of Louis XIV. in France, who thought proper by an edict to reſtrain the tribunals of juſtice from receiving informations of witchcraft. And accordingly it is with us enacted, by ſtatute 9 Geo. II. c. 5. that no proſecution ſhall for the future be carried on againſt any perſon for conjuration, witchcraft, ſorcery, or inchantment: But the miſdemeanor of perſons pretending to uſe witchcraft, tell fortunes, or diſcover ſtolen goods, by ſkill in the occult ſciences, is ſtill deſervedly puniſhed with a year's impriſonment, and ſtanding four times in the pillory.

SOREX, the SHREW, a genus of animals belonging to the claſs of *mammalia*, and order of *feræ*. See MAMMALIA *Index*.

SORITES, in *Logic*, a ſpecies of reaſoning in which a great number of propoſitions are ſo linked together, that the predicate of the one becomes continually the ſubject of the next following, till at laſt a concluſion is formed by bringing together the ſubject of the firſt propoſition and the predicate of the laſt. Such was that merry argument of Themiſtocles, to prove that his little ſon under ten years old governed the whole world. Thus: *My ſon governs his mother; his mother me; I the Athenians; the Athenians the Greeks; Greece commands Europe; Europe the whole world: therefore my ſon commands the whole world.* See LOGIC, N° 96, 97.

SORNING, in *Scots Law*. See LAW, N° clxxxvi. 30.

SORREL, in *Botany*, a ſpecies of the RUMEX, which grows in paſtures and meadows, and is well known. The natives of Lapland boil large quantities of the leaves in water, and mix the juice when cold with the milk of their rein-deer, which they eſteem an agreeable and wholeſome food. The Dutch are ſaid to cultivate this plant for its uſefulneſs in the dyeing of woollen cloths black; and we know that by means of the common broad-leaved ſorrel an excellent black colour is, in many places of Scotland, given to woollen ſtuffs without the aid of copperas. As this mode of dyeing does not in the ſmalleſt degree injure the texture of the cloth, which continues to the laſt ſoft and ſilky, without that hardneſs to the touch which it acquires when dyed black by means of copperas, our readers will probably thank us for the following receipt, with which we have been favoured by a learned phyſician:

Let the ſtuff to be dyed be well waſhed with ſoap and water, and afterwards completely dried. Then of the common broad-leaved ſorrel boil as much as ſhall make an acid decoction of ſufficient quantity to let the ſtuff to be dyed lie in it open and eaſy to be ſtirred. The greater quantity of ſorrel that is uſed, the better will the colour be; and therefore if the pot or cauldron will not hold enough at once, when part has been ſufficiently boiled, it muſt be taken out and wrung, and a freſh quantity be boiled in the ſame juice or decoction. When the liquor is made ſufficiently acid, ſtrain it from the ſorrel through a ſieve, put the cloth or yarn into it, and let it boil for two hours, ſtirring it frequently. If ſtockings be among the ſtuff to be dyed, it will be expedient, after they have been an hour in the boiling liquor, to turn them inſide out, and at the end of the ſecond hour let the whole be poured into a tub or any other veſſel. The pot or cauldron muſt then be waſhed, and water put into it, with half a pound of logwood chips for every pound of dry yarn or cloth. The logwood and water ſhould boil ſlowly for four hours; and then the cloth or yarn being wrung from the ſour liquor, and put into the logwood decoction, the whole muſt be ſuffered to boil ſlowly for four hours, ſtockings, if there be any, being turned inſide out at the end of two hours. Of this laſt decoction there muſt, as of the former, be enough to let the cloth lie open and eaſy to be ſtirred while boiling. At the end of the four hours the cloth muſt be taken out, and among the boiling liquor, firſt removed from the fire, muſt be poured a Scotch pint or half an Engliſh gallon of ſtale urine for every pound of dry cloth or other ſtuff to be dyed. When this compound liquor has been ſtirred and become cold, the cloth muſt be put into it and ſuffered to remain well covered for 12 hours, and then dried in the ſhade; after which, to diveſt it of ſmell or any other impurity, it may be waſhed in cold water, and dried for uſe.

Wood-SORREL. See OXALIS, BOTANY *Index*.

SORREL-Colour, in the manege, is a reddiſh colour, generally thought to be a ſign of a good horſe.

SORRENTO, a ſea-port town of the kingdom of Naples, with an archbiſhop's ſee. It is ſeated in a peninſula, on the bay of Naples, at the foot of a mountain of the ſame name, 17 miles ſouth-eaſt of Naples. It is the birth-place of Torquato Taſſo. E. Long. 14. 24. N. Lat. 40. 36.

SORTILEGE, (*Sortilegium*) a ſpecies of divination performed by means of *ſortes* or lots.

The *ſortes Preneſtinæ*, famous in antiquity, conſiſted in putting a number of letters, or even whole words, into an urn; and then, after ſhaking them together, they were thrown on the ground; and whatever ſentences could be made out from them, conſtituted the anſwer of the oracle. To this method of divination ſucceeded that which has been called the *ſortes Homerianæ* and *ſortes Virgilianæ*, a mode of inquiring into futurity, which undoubtedly took its riſe from a general cuſtom of the oracular prieſts of delivering their anſwers in verſe; it ſubſiſted a long time among the Greeks and Romans; and being from them adopted by the Chriſtians, it was not till after a long ſucceſſion of centuries that it became exploded. Among the Romans it conſiſted in opening ſome celebrated poet at random, and among the Chriſtians the Scriptures, and drawing, from the firſt paſſage which preſented itſelf to the eye, a prognoſtic of what would befal one's ſelf or others, or direction for conduct when under any exigency. There is good evidence that this was none of the vulgar errors; the greateſt perſons, philoſophers of the beſt repute, admitted this ſuperſtition. Socrates, when in priſon, hearing this line of Homer,

> Within three days I Phthia's ſhore ſhall ſee,

immediately ſaid, within three days I ſhall be out of the world;

Sortilege.

world; gathering it from the double meaning of the word *Phthia*, which in Greek is both the name of a country and signifies corruption or death. This prediction, addressed to Æschines, was not easily forgotten, as it was verified.

When this superstition passed from Paganism into Christianity, the Christians had two methods of consulting the divine will from the Scriptures; the one, casually, to open the divine writings, and take their direction, as above mentioned; the other, to go to church with a purpose of receiving, as a declaration of the will of heaven, the words of the Scripture, which were singing at the instant of one's entrance.

This unwarrantable practice of inquiring into futurity prevailed very generally in England till the beginning of the 18th century; and sometimes the books of Scripture, and sometimes the poems of Virgil, were consulted for oracular responses. One remarkable instance is that of King Charles I. who being at Oxford during the civil wars, went one day to see the public library, where he was shown, among other books, a Virgil nobly printed and exquisitely bound. The lord Falkland, to divert the king, would have his majesty make a trial of his fortune by the *Sortes Virgilianæ*. Whereupon the king opening the book, the passage which happened to come up was this:

At, bello audacis populi vexatus et armis,
Finibus extorris, complexu avulsus Iuli,
Auxilium imploret; videatque indigna suorum
Funera: nec, cum se sub leges pacis iniquæ
Tradiderat, regno aut optata luce fruatur;
Sed cadat ante diem, mediaque inhumatus arena.
Æneid, lib. iv.

Yet let a race, untamed and haughty foes,
His peaceful entrance with dire arms oppose;
Oppressed with numbers in the unequal field,
His men discouraged, and himself expelled,
Let him for succour sue from place to place,
Torn from his subjects, and his son's embrace:
First let him see his friends in battle slain,
And their untimely fate lament in vain;
And when at length the cruel war shall cease,
On hard conditions may he buy his peace.
Nor let him then enjoy supreme command,
But fall untimely by some hostile hand,
And lie unburied on the barren sand.

Lord Falkland observing that the king was concerned at this accident, would likewise try his own fortune in the same manner, hoping he might fall upon some passage that would have no relation to his case, and thereby divert the king's thoughts from any impression which the other might have upon him; but the place he stumbled upon was as much suited to his destiny as the other had been to the king's; being the lamentation of Evander for the untimely death of his son Pallas*: for this lord's eldest son, a young man of an amiable character, had been slain in the first battle of Newbury.

* Æneid. lib. xi.

We have ourselves known several whose devotion has not always been regulated by judgement pursue this method of divination; and have generally observed, that the consequence has been despair or presumption. To such we beg leave to recommend one passage in Scripture which will never disappoint them: *Thou shalt not tempt the Lord thy God.*

Soteria || Souffriere.

SOTERIA, in antiquity, sacrifices offered to the gods for delivering a person from danger; as also poetical pieces composed for the same purpose.

SOUBISE, a town of France, in the department of Lower Charente, and late territory of Saintonge. It is seated on the river Charente, 22 miles south of Rochelle, in W. Long. 1. 2. N. Lat. 45. 57.

SOUDAN, a kingdom of Africa, situated between 11° and 16° N. Lat. and 26° and 30° E. Long. See Dar Fur.

SOUGH, among miners, denotes a passage dug under ground, to convey off waters from mines. See Mine.

SOVEREIGN, in matters of government, is applied to the supreme magistrate or magistrates of an independent government or state; because their authority is only bounded by the laws of God and the laws of the state: such are kings, princes, &c. See Prerogative, &c.

Sovereign Power, or *Sovereignty*, is the power of making laws; for wherever that power resides, all others must conform to it, and be directed by it, whatever appearance the outward form and administration of the government may put on. For it is at any time in the option of the legislature to alter that form and administration by a new edict or rule, and to put the execution of the laws into whatever hands it pleases: and all the other powers of the state must obey the legislative power in the execution of their several functions, or else the constitution is at an end. In our constitution the law ascribes to the king the attribute of sovereignty: but that is to be understood in a qualified sense, i. e. as supreme magistrate, not as sole legislator; as the legislative power is vested in the king, lords, and commons, not in any of the three estates alone.

SOU. See Sol.

SOUFFRIERE, a small town, situated at the bottom of a bay, near the leeward extremity of the island of St Lucia. Of itself it is not entitled to much notice, but the adjacent ground is very remarkable. The declivities of the surrounding hills are cultivated, and afford sugar-cane of a good quality.

The extremity of the south side of Souffriere bay runs into two steep hills of a conical shape, and nearly perpendicular, reckoned the highest on the island, and known by the appellation of the *Sugar-Loaf Hills*. It is impossible to ascend them; for although it was once attempted by two negroes, it is said that they never returned. Passing the hills to the windward of Souffriere, a fine level country presents itself, extending from 15 to 20 miles from the back of the Sugar-Loaf Hills along the sea coast, being wholly cultivated, and divided into rich estates. It is intersected by numerous rivers of very clear water, which, by art, are made subservient to the purpose of sugar-making. The rains here are less frequent than on any other part of the island, and the wind blows from the sea, or nearly so.

There is a volcano in the vicinity of this town. After passing one or two small hills, the smell of sulphur is sensibly felt before any vestige of the place is perceived. The first thing discerned is a rivulet of black running water, sending forth streams nearly in a state of ebullition, from which the volcano soon comes into view, situated

tuated in a hollow, and furrounded by hills on every fide. There are many pits in the hollow, of a black and thick boiling matter, which appears to work with great force. Lava is ejected by flow degrees, and there is a large mafs of it in the centre of the hollow, forming a fort of hill. The lava is faid to be a fulphur mixed with calcareous earth and fome faline body. Small quantities of alum have been found in a perfect ftate; and there is a rivulet of good water in the opening, at the north fide of the hollow. When the bottom of it is ftirred, the water is very hot, fo much fo as not to be touched. The liquid running from the pits is ftrongly impregnated with fulphur, and very much refembles the preparation fold in the fhops, called *aqua fulphurata*.

SOUL, the principle of perception, memory, intelligence, and volition, in man; which, fince the earlieft era of philofophy, has furnifhed queftions of difficult inveftigation, and materials of keen and important controverfy (fee METAPHYSICS, Part III. chap. ii. iii. iv. v.; and RESURRECTION, N° 42—48.). In the 4th volume of the Memoirs of the Literary and Philofophical Society of Manchefter, the reader will find a very valuable paper by Dr Ferriar, proving, by evidence apparently complete, that every part of the brain has been injured without affecting the act of thought. An abridgement of that memoir would weaken its reafoning; which, built on matters of fact and experience, appears to us to have fhaken the modern theory of the Materialifts from its very foundation.

SOUL of Brutes. See BRUTES.

SOUND, in *Phyfics*, a term which expreffes a fimple idea; it is that primary information which we obtain of external things by means of the fenfe of hearing. See ACOUSTICS.

SOUND, in *Geography*, denotes in general any ftrait or inlet of the fea between two headlands. It is given by way of eminence to the ftrait between Sweden and Denmark, joining the German ocean to the Baltic, being about three miles over. See DENMARK, N° 32. and ELSINORE.

SOUND-Board, the principal part of an organ, and that which makes the whole machine play. It is a refervoir into which the wind, drawn in by the bellows, is conducted by a port-vent, and thence diftributed into the pipes placed over the holes of its upper part. The wind enters them by valves, which open by preffing on the keys, after the regifters are drawn, by which the air is prevented from going into any of the other pipes, befides thofe in which it is required.

SOUND-Board alfo denotes a thin broad board placed over the head of a public fpeaker, to enlarge or extend and ftrengthen his voice.

Sound-boards are found by experience to be of no ufe in theatres, as their diftance from the fpeaker is too great to be impreffed with fufficient force. But foundboards over a pulpit have frequently a good effect, when the cafe is conftructed of a proper thicknefs, and according to particular principles.

SOUND-Poft, is a poft placed in the infide of a violin, &c. as a prop between the back and belly of the inftrument, and nearly under the bridge.

SOUNDING, the operation of trying the depth of the fea, and the nature of the bottom, by means of a plummet funk from a fhip to the bottom.

There are two plummets ufed for this purpofe in navigation; one of which is called the *hand-lead*, weighing about 8 or 9 pounds; and the other the *deep fea-lead*, which weighs from 25 to 30 pounds; and both are fhaped like the fruftum of a cone or pyramid. The former is ufed in fhallow waters, and the latter at a great diftance from the fhore; particularly on approaching the land after a fea-voyage. Accordingly the lines employed for this purpofe are called the *deep-fea lead-line*, and the *hand lead-line*.

The hand lead-line, which is ufually 20 fathoms in length, is marked at every two or three fathoms; fo that the depth of the water may be afcertained either in the day or night. At the depth of two and three fathoms, there are marks of black leather; at 5 fathoms, there is a white rag; at 7, a red rag; at 10, black leather; at 13, black leather; at 15, a white rag; and at 17, a red ditto.

Sounding with the hand lead, which is called *heaving the lead* by feamen, is generally performed by a man who ftands in the main-chains to windward. Having the line quite ready to run out without interruption, he holds it nearly at the diftance of a fathom from the plummet; and having fwung the latter backwards and forwards three or four times, in order to acquire the greater velocity, he fwings it round his head, and thence as far forward as is neceffary; fo that, by the lead's finking whilft the fhip advances, the line may be almoft perpendicular when it reaches the bottom. The perfon founding then proclaims the depth of the water in a kind of fong refembling the cries of hawkers in a city. Thus if the mark of five fathoms is clofe to the furface of the water, he calls, 'By the mark five!" and as there is no mark at four, fix, eight, &c. he eftimates thofe numbers, and calls, 'By the dip four,' &c. If he judges it to be a quarter or an half more than any particular number, he calls, 'And a quarter five! and a half four,' &c. If he conceives the depth to be three quarters more than a particular number, he calls it a quarter lefs than the next: thus, at four fathoms and three fourths he calls 'A quarter lefs five!' and fo on.

The deep fea lead is marked with two knots at 20 fathoms, three at 30, four at 40, and fo on to the end. It is alfo marked with a fingle knot in the middle of each interval, as at 25, 35, 45 fathoms, &c. To ufe this lead more effectually at fea, or in deep water on the fea coaft, it is ufual previoufly to bring to the fhip, in order to retard her courfe: the lead is then thrown as far as poffible from the fhip on the line of her drift, fo that, as it finks, the fhip drives more perpendicularly over it. The pilot, feeling the lead ftrike the bottom, readily difcovers the depth of the water by the mark on the line neareft its furface. The bottom of the lead being alfo well rubbed over with tallow, retains the diftinguifhing marks of the bottom, as fhells, ooze, gravel, &c. which naturally adhere to it.

The depth of the water, and the nature of the ground, which is called the *foundings*, are carefully marked in the log-book, as well to determine the diftance of the place from the fhore, as to correct the obfervations of former pilots.

A machine for the fame purpofe has been invented by Mr Maffey, of which the following defcription is given:

"The importance of obtaining true foundings at fea muft be

Sounding.

be admitted by every ſeaman; and it is rather ſingular, that no other method than the common lead has hitherto been brought into uſe; as its imperfections are very generally acknowledged.

"Many veſſels have been loſt, by depending upon the ſoundings taken in the uſual way. The difficulty of obtaining the true perpendicular, and the uncertainty as to the exact moment when the lead ſtrikes the bottom, upon which the accuracy of the reſult depends, muſt always prevent the poſſibility of obtaining the true depth, while the ſhip has any conſiderable way upon her. Indeed, it has been acknowledged by experienced ſeamen, during ſome experiments, made at various times, in the river Merſey, that they could not depend upon the common lead, when going five or ſix knots in the hour, in ten or twelve fathoms of water. When the depth is conſiderable, the veſſel muſt be hove to, which is an operation attended with great loſs of time, and ſometimes conſiderable injury to the ſails; and during a chaſe, this inconvenience muſt be particularly felt.

"True ſoundings may be taken with this machine in thirty fathoms water, without the trouble of heaving the veſſel to, although ſhe may be going at the rate of ſix miles in the hour. True ſoundings may alſo thus be obtained in very deep water, where it is not poſſible to take them by the common lead.

Plate CCCCXCVII. Fig. 1.

"Fig. 1. repreſents the ſounding machine. *a* is the ſounding weight, containing a regiſter, 1, 2, with two dials: the hand of the dial 1 makes one revolution when the weight has deſcended twenty fathoms, the other revolves once when the deſcent amounts to five hundred fathoms. A rotator, *b*, ſimilar to that attached to the log, communicates with the wheel work of the dials 1, 2, by means of the rod *c*, on which there are three univerſal joints, 3, 4, and 5. This rod is ſupported during the deſcent of the weight, by the drop, *d*, at the end of which is a fork, 6, and a friction wheel, 7.

"When the machine is to be uſed, a ſounding line is faſtened to the ring, *e*; and one of the vanes of the rotator is ſlipped into the ſpring 8: the rotator will then be in the poſition indicated by the dotted lines, *x*. The indices muſt be ſet at 0, and the cover or lid, *f*, be ſhut. The machine muſt then be projected perpendicularly into the ſea. As ſoon as it reaches the ſurface, the reſiſtance of the water forces the dotted rotator, *x*, out of the ſpring 8, and it aſſumes its perpendicular direction as repreſented by the rotator *b*. As the machine deſcends, it is evident the rotator will revolve, and its motion be communicated freely paſt the friction wheel 7, and the univerſal joint 5, to the wheel work of the dials 1, 2, and thus indicate the ſpace paſſed through in fathoms. When the machine has arrived at the bottom, the rotator, as it is no longer buoyed up by the reaction of the water, will fall to the bottom, quitting the fork of the drop *d*, which will alſo fall from its horizontal poſition, and in its deſcent, by means of the locking rod 9, prevent the rotator from revolving as the machine is drawn up. When at the bottom, the rotator will be in the poſition of the dotted lines *y*.

"This machine, ſimple in its conſtruction, and ſcarcely more liable to accident than the common lead, aſcertains, with the utmoſt preciſion, the perpendicular depth, by the mere act of deſcent through the water. No miſtake can ariſe from that common ſource of errour, the drift or lee-way of the ſhip during the time of deſcent; nor does an operation of ſuch importance depend upon the uncertain ſenſation cauſed by the lead ſtriking the bottom, on which the accuracy of the common log altogether depends, and which, it is well known, frequently and materially miſleads the beſt ſeaman: for though a thouſand fathoms of line were paid out, in the ſmalleſt depth of water, no inaccuracy could ariſe, as the perpendicular depth, at the point of heaving, would be regiſtered on the index. The only inconvenience experienced would be the additional labour neceſſary for hauling in the exceſs of line. The moſt inexperienced perſon may uſe this machine, without riſk of error, in the moſt turbulent ſea, and during the night.

"The advantages already enumerated would render the ſounding machine of great importance; but there are other properties of ſtill more conſequence.

"To heave a ſhip to, in order to obtain ſoundings, on a lee ſhore, in ſtormy weather, is a very diſagreeable operation, attended with much trouble, and loſs of way; alſo with conſiderable danger to the ſhip's ſails; indeed, it would often, under ſuch circumſtances, be attended with great hazard to the ſafety of the ſhip. To avoid theſe unpleaſant conſequences, the maſter ſometimes adopts a meaſure, which he conceives to be the leſs exceptionable alternative, by running on without ſounding at all.

"To prove how much inconvenience and danger are avoided by Maſſey's lead, it is enough to ſtate, that ſoundings may be taken in depth from 60 to 80 fathoms, while the ſhip is under way, at the rate of three miles an hour; and as the rate of ſailing may be ſtill materially reduced, without entirely ſtopping the veſſel, or altering her courſe, ſo may ſoundings be had, to any depth required, while ſhe is under way.

"In order more clearly to ſhow the ſuperiority of this machine, and make it apparent, that the quantity of ſtray-line veered out does not at all affect the truth of the reſult: ſuppoſe the common lead thrown from the mizen chains of the ſhip, which may be repreſented by the point *a* of the triangle *a b c*, (fig. 2.), and that the ſhip has moved forwards through the ſpace equal to the line *b c*, while the lead has deſcended through the line *a c*; it is evident, that it is impoſſible, in this caſe, to aſcertain the exact depth, as a quantity of line, equal to *a b*, would be paid out, whereas the true depth is equal only to the line *a c*, which is much leſs. But the caſe is very different when the patent ſounding machine is uſed, as the operation ceaſes when it has reached the bottom; nor is the ſtray-line, *a b*, whatever its length, at all taken into the account. Fig. 2.

"It has been extremely difficult, and ſometimes impoſſible, to obtain ſoundings in very deep water with the common lead, which may perhaps be thus accounted for. The common line which is uſed for ſounding, though, if left to itſelf, it would ſink in water, yet its deſcent would be much ſlower than that of the lead, ſeparately; it conſequently follows, that the lead muſt be ſo much impeded by carrying the line with it, that when it does reach the bottom, there will be ſcarcely any ſenſible check to enable the ſeaman to know the preciſe moment. Indeed, if he can aſcertain even this to a certainty, he ſtill cannot depend upon the truth of his ſoundings; for if there be the leaſt drift or current, the line itſelf will aſſume a curve, ſimilar to that of the line of a kite in the air. Theſe two cauſes will always operate

rate againſt the perfection of the common mode of ſounding.

"After ſo fully deſcribing the principle of the patent ſounding machine, it is ſcarcely neceſſary to prove, that is liable to neither of the foregoing objections; and it may be ſufficient to ſay, that, as it will certainly find its way to the bottom, if a ſufficient portion of ſtray-line be allowed to guard againſt its being checked in its progreſs, and the certainty of its having reached the bottom may be aſcertained by the arming, there can be no doubt of the practicability of its obtaining ſoundings, in any depth, and no reaſonable doubt of their correctneſs when obtained.

"From the conſtruction of this machine, it might be imagined, that the rotator would impede its motion through the water, and that it could not deſcend ſo rapidly as the common lead; but during repeated trials, in thirteen fathoms water, in which the rotator was frequently detached, and the lead ſuffered to deſcend alone, there was no difference perceptible in the time of their deſcent, though an excellent quarter-ſecond ſtop watch was uſed during the experiment, to detect any change. The following table ſhows how very uniformly the times of deſcent correſponded with the depths in fathoms, during a ſeries of trials made on the river Merſey, with the patent lead, weighing 14 pounds.

"The manner of conducting theſe experiments was ſuch as is deſerving of perfect reliance. Two pilots, of well-known ability and experience, were employed: one threw the lead, and the other, the moment he found, by the ſlackening of the rope, that the weight had arrived at the bottom, cried 'ſtop,' to a third perſon who held the watch.

Time of deſcent.	Fathoms.	Time of deſcent.	Fathoms.
2 ſeconds	$2\frac{1}{2}$	$7\frac{1}{4}$ ſeconds	$11\frac{1}{2}$
$2\frac{1}{2}$	3	$7\frac{1}{4}$	$11\frac{1}{2}$
3	4	$7\frac{1}{4}$	$11\frac{1}{2}$
5	8	$7\frac{1}{2}$	12
$5\frac{1}{2}$	$8\frac{1}{2}$	$7\frac{3}{4}$	$12\frac{3}{4}$
6	10	8	13
6	10	$8\frac{1}{2}$	$13\frac{1}{2}$
7	$11\frac{1}{2}$	6	10

"Taken when under ſail, at upwards of five knots in the hour.

"Several captains and maſters in the navy have made trial of the log and ſounding machine, and given very favourable reports of their performance; and it has been adopted by order of the Navy Board in the Britiſh navy *."

* *Nichol. Journal*, xxi. 250.

SOUP, a ſtrong decoction of fleſh or other ſubſtances.

Portable or dry ſoup is a kind of cake formed by boiling the gelatinous parts of animal ſubſtances till the watery parts are evaporated. This ſpecies of ſoup is chiefly uſed at ſea, and has been found of great advantage. The following receipt will ſhow how it is prepared.

Of calves feet take 4; leg of beef 12 lbs.; knuckle of veal 3 lbs; and leg of mutton 10 lbs. Theſe are to be boiled in a ſufficient quantity of water, and the ſcum taken off as uſual; after which the ſoup is to be ſeparated from the meat by ſtraining and preſſure. The meat is then to be boiled a ſecond time in other water; and the two decoctions, being added together, muſt be left to cool, in order that the fat may be exactly ſeparated. The ſoup muſt then be clarified with five or ſix whites of eggs, and a ſufficient quantity of common ſalt added. The liquor is then ſtrained through flannel, and evaporated on the water-bath to the conſiſtence of a very thick paſte; after which it is ſpread rather thin upon a ſmooth ſtone, then cut into cakes, and laſtly dried in a ſtove until it becomes brittle; theſe cakes are kept in well cloſed bottles. The ſame proceſs may be uſed to make a portable ſoup of the fleſh of poultry; and aromatic herbs may be uſed as a ſeaſoning, if thought proper.

Theſe tablets or cakes may be kept four or five years. When intended to be uſed, the quantity of half an ounce is put into a large glaſs of boiling water, which is to be covered, and ſet upon hot aſhes for a quarter of an hour, or until the whole is entirely diſſolved. It forms an excellent ſoup, and requires no addition but a ſmall quantity of ſalt.

SOUR-CROUTE. See CROUTE.

SOUR-Gourd, or *African Calabaſh-tree*. See ADANSONIA, BOTANY *Index*.

SOUTH, DR ROBERT, an eminent divine, was the ſon of Mr William South a merchant of London, and was born at Hackney near that city in 1633. He ſtudied at Weſtminſter ſchool, and afterwards in Chriſt-church college, Oxford. In 1654, he wrote a copy of Latin verſes to congratulate Cromwell upon the peace concluded with the Dutch; and the next year a Latin poem, entitled *Muſica Incantans*. In 1660 he was elected public orator of the univerſity; and the next year became domeſtic chaplain to Edward earl of Clarendon, lord-high chancellor of England. In 1663 he was inſtalled prebendary of Weſtminſter, admitted to the degree of doctor of divinity, and had a ſinecure beſtowed on him in Wales by his patron the earl of Clarendon; after whoſe retirement into France in 1667 he became chaplain to the duke of York. In 1670 he was inſtalled canon of Chriſt church in Oxford; and in 1676 attended as chaplain to Laurence Hyde, Eſq. ambaſſador extraordinary to the king of Poland. In 1678 he was preſented to the rectory of Iſlip in Oxfordſhire; and in 1680 rebuilt the chancel of that church, as he afterwards did the rectory-houſe belonging to it. After the revolution he took the oath of allegiance to King William and Queen Mary, though he excuſed himſelf from accepting a great dignity in the church, vacated by the perſonal refuſal of that oath. His health began to decline ſeveral years before his death, which happened in 1716. He was interred in Weſtminſter Abbey, where a monument is erected to his memory. He publiſhed, 1. Animadverſions on Dr Sherlock's Vindication of the Holy and Ever Bleſſed Trinity. 2. A Defence of his Animadverſions. 3. Sermons, 8 vols 8vo. And after his deceaſe were publiſhed his *Opera Poſthuma Latina*, and his poſthumous Engliſh works. Dr South was remarkable for his wit, which abounds in all his writings, and particularly in his ſermons; but at the ſame time they equally abound in ill-humour, ſpleen, and ſatire. He was remarkable for being a time-ſerver. During the life of Cromwell he was a ſtaunch Preſbyterian, and then railed againſt the Independents: at the Reſtoration

tion he exerted his pulpit-eloquence againſt the Preſbyterians; and in the reign of Queen Anne, was a warm advocate for Sacheverel.

SOUTH, one of the four cardinal points from which the winds blow.

SOUTH Sea, or *Pacific Ocean*, is that vaſt body of water interpoſed between Aſia and America. It does not, however, ſtrictly ſpeaking, reach quite to the continent of Aſia, excepting to the northward of the peninſula of Malacca: for the water interpoſed between the eaſtern coaſt of Africa and the peninſula juſt mentioned has the name of the *Indian ocean*. The South ſea then is bounded on one ſide by the weſtern coaſt of America, through its whole extent, from the unknown regions in the north to the ſtraits of Magellan and Terra del Fuego, where it communicates with the ſouthern part of the Atlantic. On the other ſide, it is bounded by the coaſt of Aſia, from the northern promontory of Tſchukotſkoi Noſs, to the peninſula of Malacca already mentioned. Thence it is bounded to the ſouthward by the northern coaſts of Borneo, Celebes, Macaſſar, New Guinea, New Holland, and the other iſlands in that quarter, which divide it from the Indian ocean. Then, waſhing the eaſtern coaſt of the great iſland of New Holland, it communicates with that vaſt body of water encompaſſing the whole ſouthern part of the globe, and which has the general name of the *Southern ocean* all round. Thus does this vaſt ocean occupy almoſt the ſemicircumference of the globe, extending almoſt from one pole to the other, and about the equatorial parts extending almoſt 180° in longitude, or 12,500 of our miles.

The northern parts of the Pacific ocean are entirely deſtitute of land; not a ſingle iſland having yet been diſcovered in it from the latitude of 40° north and upwards, excepting ſuch as are very near the coaſt either of Aſia or America; but in the ſouthern part there are a great number.

Till very lately the South ſea was in a great meaſure unknown. From the great extent of ice which covers the ſouthern part of the globe, it was imagined that much more land exiſted there than in the northern regions: but that this could not be juſtly inferred merely from that circumſtance, is plain from what has been advanced under the article AMERICA, N° 3—24; and the ſouthern continent, long known by the name of *Terra Auſtralis*, has eluded the ſearch of the moſt expert navigators ſent out from Britain and France by royal authority. See TERRA AUSTRALIS.

SOUTH Sea Company. See COMPANY.

SOUTHAMPTON, a ſea-port town of Hampſhire in England. It is commodiouſly ſeated on an arm of the ſea; is a place of good trade, and well inhabited. It is ſurrounded by walls and ſeveral watch-towers, and had a ſtrong caſtle to defend the harbour, now in ruins. It is a corporation and a county of itſelf, with the title of an earldom, and ſends two members to parliament. W. Long. 1. 26. N. Lat. 50. 55.

SOUTHERN, THOMAS, an eminent dramatic writer, was born at Dublin in 1660, and received his education in the univerſity there. He came young to London to ſtudy law; but inſtead of that devoted himſelf to poetry and the writing of plays. His Perſian Prince, or Loyal Brother, was introduced in 1682, when the Tory intereſt was triumphant in England; and the character of the Loyal Brother being intended to compliment James duke of York, he rewarded the author when he came to the throne with a commiſſion in the army. On the Revolution taking place, he retired to his ſtudies, and wrote ſeveral plays, from which he is ſuppoſed to have derived a very handſome ſubſiſtence, being the firſt who raiſed the advantage of play-writing to a ſecond and third night. The moſt finiſhed of all his plays is Oroonoko, or the Royal Slave, which is built on a true ſtory related in one of Mrs Behn's novels. Mr Southern died in 1746, in the 86th year of his age; the latter part of which he ſpent in a peaceful ſerenity, having, by his commiſſion as a ſoldier, and the profits of his dramatic works, acquired a handſome fortune; and being an exact economiſt, he improved what fortune he gained to the beſt advantage. He enjoyed the longeſt life of all our poets; and died the richeſt of them, a very few excepted. His plays are printed in two vols 12mo.

SOUTHERN Continent. See AMERICA, N° 3—24, and *TERRA Auſtralis*.

SOUTHERNWOOD. See ARTEMISIA, BOTANY *Index*.

SOUTHWARK, a town of Surry, and a ſuburb of the city of London, being ſeparated from that metropolis only by the Thames. See LONDON, N° 96.

SOW. See SUS, MAMMALIA *Index*.

SOW, in the iron works, the name of the block or lump of metal they work at once in the iron furnace.

SOW-Thiſtle. See SONCHUS, BOTANY *Index*.

SOWING, in *Agriculture* and *Gardening*, the depoſiting any kind of ſeed in the earth for a future crop. See AGRICULTURE.

Drill-SOWING. See *DRILL-Sowing*.

SOY. See DOLICHOS.

SOZOMENUS, HERMIAS, an eccleſiaſtical hiſtorian of the 5th century, was born in Bethelia, a town of Paleſtine. He was educated for the law, and became a pleader at Conſtantinople. He wrote an Abridgment of Eccleſiaſtical Hiſtory, in two books, from the aſcenſion of our Saviour to the year 323. This compendium is loſt; but a continuation of it in nine books, written at greater length, down to the year 440, is ſtill extant. He ſeems to have copied Socrates, who wrote a hiſtory of the ſame period. The ſtyle of Sozomenus is perhaps more elegant; but in other reſpects he falls far ſhort of that writer, diſplaying throughout his whole book an amazing credulity and a ſuperſtitious attachment to monks and the monaſtic life. The beſt edition of Sozomenus is that of Robert Stephen in 1544. He has been tranſlated and publiſhed by Valeſius, and republiſhed with additional notes by Reading at London, 1720, in 3 vols folio.

SPA, a town of Germany, in the circle of Weſtphalia and biſhopric of Liege, famous for its mineral waters, lies in E. Long. 5. 50. N. Lat. 50. 30. about 21 miles ſouth-eaſt from Liege, and 7 ſouth-weſt from Lomburg. It is ſituated at one end of a deep valley on the banks of a ſmall rivulet, and is ſurrounded on all ſides by high mountains. The ſides of theſe mountains next to Spa are rude and uncultivated, preſenting a rugged appearance as if ſhattered by the convulſions of earthquakes; but as they are ſtrewed with tall oaks and abundance of ſhrubs, the country around forms a wild, romantic, and beautiful landſcape. The acceſs to the town

Spa.

town is very beautiful. The road winds over the mountains till it descends to their bottom, when it runs along a smooth valley for a mile or a mile and a half.

The town consists of four streets in form of a cross, and contains about 400 inhabitants. Spa has no wealth to boast of. It can scarcely furnish the necessaries of life to its own inhabitants during the winter, and almost all the luxuries which are requisite for the great concourse of affluent visitors during the summer are carried from Liege by women. Its only source of wealth is its mineral waters. No sooner does the warm season commence, than crowds of valetudinarians arrive, as well as many other persons who are attracted solely by the love of amusement, and some from less honourable motives. The inhabitants, who spend seven or eight months of the year without seeing the face of a stranger, wait for the return of this period with impatience. The welcome sound of the carriages brings multitudes from the town, either to gratify their curiosity, or to offer their services in the hopes of securing your employment while you remain at Spa. Immediately after your arrival, your name and designation is added to the printed list of the annual visitors; for which you pay a stated sum to the booksellers, who has a patent for this purpose from the prince bishop of Liege. This list not only enables one to know at a glance whether any friends or acquaintance are residing there, but also to distinguish persons of rank and fashion from adventurers, who seldom have the effrontery to insert their names.

There are two different ways of accommodating the visitors at Spa with lodging and necessaries. People may either lodge at a hotel, where every thing is furnished them in a splendid and expensive style; or they may take up their residence in private lodgings, from which they may send for provisions to a cook's shop.

Among the people who visit Spa, there are many persons of the first rank and fashion in Europe. Perhaps indeed there is no place in Europe to which so many kings and princes resort; but it is also visited by many self-created nobility, who, under the titles of counts, barons, marquises, and knights, contrive by their address, and artifices, to prey upon the rich and unexperienced.

The manners established at Spa are conducive both to health and amusement. Every body rises early in the morning, at six o'clock or before it, when a great many horses stand ready saddled for those who choose to drink the Sauveniere or Geronstere waters at a little distance from Spa. After this healthy exercise a part of the company generally breakfast together at Vauxhall, a magnificent and spacious building. At this place a number of card-tables are opened every forenoon, round which many persons assemble and play for stakes to a very considerable amount. A ball too is generally held once a week at Vauxhall, besides two balls at the assembly rooms near the Pouhon in the middle of the town.

The most remarkable waters at Spa are, 1. The Pouhon, situated in the middle of the town; 2. The Sauveniere, a mile and a half east from it; 3. Groisbeck, near to the Sauveniere; 4. Tonnelet, situated a little to the left of the road which leads to the Sauveniere; 5. Geronstere, two miles south from Spa; 6. Wartroz, near to the Tonnelet; 7. Sarts or Niveset, in the district of Sarts; 8. Chevron or Bru, in the principality of Slavelot; 9. Couve; 10. Beverse; 11. Sige; 12. Geremont. These four last are near Malmedy.

Dr Brownrigg was the first person who discovered that fixed air, or, as it is now generally called, *carbonic acid gas*, forms a principal ingredient in the composition of the Spa waters, and actually separated a quantity of this elastic fluid, by exposing it to different degrees of heat from 110° to 170° of Fahrenheit. From 20 ounces 7 drams and 14 grains apothecaries weight of the Pouhon water, he obtained 8 ounces 2 drams and 50 grains. Since June 1765, when Dr Brownrigg read a paper on this subject before the Royal Society of London, the waters of Spa have been often analysed, but perhaps by none with more accuracy than by Dr Ash, who published a book on the chemical and medicinal properties of these waters in 1788. We shall present the result of his analysis of the five principal springs in the following table.

Fountains.	Quantity of Water.	Ounce measures of Gas.	Solid contents.	Aerated Lime.	Aerated Magnesia.	Aerated Mineral Alkali.	Aerated iron.	Selenite	Aerated Vegetab. Alkali.
	Ounces.		Grains.						
Pouhon	33.	35.75	16.25	2.75	9.50	2.25	1.75	—	—
Geronstere	32.75	24.75	5.50	2.50	—	1.75	0.75	0.50	—
Sauveniere	32.50	33.50	3.75	1.50	—	0.75	0.50	—	1.
Groisbeck	32.25	35.50	5.25	1.50	—	1.	0.75	—	2.
Tonnelet	32.	40.75	2.00	0.25	—	0.75	1.	—	—

The Pouhon spring rises from the hill to the north of Spa, which consists of argillaceous schistus and ferrugineous slate. The other fountains rise from the surrounding hills to the south-east, south, west, and north-west of the town; and this ridge of mountains is formed of calcareous earths mixed with siliceous substances. The surface of the mountains is covered with woods, interspersed with large boggy swamps filled with mud and water. The Pouhon is considered as the principal spring at Spa, being impregnated with a greater quantity of iron than any of the rest, and containing more fixed air than any except the Tonnelet. It is from this spring that the Spa water for exportation is bottled; for which the demand is so great, that, according to the best information which Mr Thicknesse could obtain, the quantity exported amounts to 200,000 or 250,000 bottles annually. This exported water is inferior in its virtue to that which is drunk on the spot; for the vessels into which it is collected are injudiciously exposed to the sun, rain, wind, and dust, for several hours before they are corked, by which means a considerable part of its volatile ingredients must be evaporated; for it has been

Thicknesse's Journey through the Pais Bas.

been found by experiment, that by expofing it to a gentle heat, air-bubbles afcend in great numbers. It is in its greateft perfection when collected in cold dry weather; it is then pellucid, colourlefs, and without fmell, and almoft as light as diftilled water. It varies in its heat from 52° or 53° to 67° of Fahrenheit's thermometer.

The Geronftere is a much weaker chalybeate water than the Pouhon; and as it is exceedingly naufeous, and taftes and fmells like rotten eggs, it certainly contains fome hepatic gas. This is a circumftance which Dr Afh feems not to have attended to fufficiently. The Sauveniere water alfo, when newly taken from the well, fmells a little of fulphur. The Groifbeck contains more alkali, and almoft as much gas as the Pouhon, and has been celebrated for its good effects in the cafe of calculous concretions. The Tonnelet contains more gas than any of the reft. So fmall is the quantity of any foffil body held in fufpenfion by the aerial acid in it, and fo volatile is the gas, that it begins to pafs off very rapidly the moment it is taken out of the well, and in a fhort time is entirely gone. Dr Afh informs us, that in the neighbourhood of this well, the cellars, on any approaching change of weather, are found to contain much fixed air; and the beft prognoftic which they have of rain is the averfion which cats fhow to be carried into thefe cellars.

The Spa waters are diuretic, and fometimes purgative. They exhilarate the fpirits with an influence much more benign than wine or fpirituous liquors, and they are more cooling, and allay thirft more effectually than common water. They are found beneficial in cafes of weaknefs and relaxation, either partial or univerfal; in nervous diforders; in obftructions of the liver and fpleen; in cafes where the blood is too thin and putrefcent; in cafes of exceffive difcharges proceeding from weaknefs; in the gravel and ftone; and in moft cafes where a ftrengthening remedy is wanted. But they are hurtful in confirmed obftructions attended with fever, where there is no free outlet to the matter, as in ulcerations of the lungs. They are alfo injurious to bilious and plethoric conftitutions, when ufed before the body is cooled by proper evacuations.

SPACE. See METAPHYSICS, Part II. Chap. iv.

SPACE, in *Geometry*, denotes the area of any figure, or that which fills the interval or diftance between the lines that terminate it.

SPADIX, in *Botany*, anciently fignified the receptacle of the palms. It is now ufed to exprefs every flower-ftalk that is protruded out of a fpatha or fheath.

The fpadix of the palms is branched; that of all other plants fimple. This laft cafe admits of fome variety; in *calla*, *dracontium*, and *pothos*, the florets cover it on all fides; in *arum*, they are difpofed on the lower part only; and in *zoftera* on one fide. See BOTANY.

SPAGIRIC ART, a name given by old authors to that fpecies of chemiftry which works on metals, and is employed in the fearch of the philofopher's ftone.

SPAHIS, horfemen in the Ottoman army, chiefly raifed in Afia. The great ftrength of the grand feignior's army confifts in the janifaries, who are the foot; and the fpahis, who are the horfe.

SPAIN. The kingdom of Spain, which occupies by far the greater portion of the fouth-weftern peninfula of Europe, is bounded on the north by the bay of Bifcay and Pyrenean mountains, which feparate it from France; on the eaft by the Mediterranean fea; on the fouth by the ftraits of Gibraltar, which divide it from the African kingdom of Morocco; and on the weft, partly by the Atlantic ocean, but chiefly by the narrow kingdom of Portugal. This laft is the only artificial boundary of the Spanifh territory, and confifts of ideal lines, except in three parts, where the river Minho to the north, and the Douro and the Chanca, till its junction with the Guadiana to the eaft, form rather more natural limits. 1 Situation and boundary.

From Cape Ortegal in N. Lat. 43° 44′, to the rock of Gibraltar, in N. Lat. 35° 57′, the continent of Spain extends through nearly 8° of latitude, while its extent from weft to eaft, viz. from Cape Finifterre in Long. 9° 17′ W. from Greenwich to Cape Creus, or Croix, in Long. 3° 30′ E. from the fame meridian, comprehends nearly 13° of longitude. In Britifh miles, its length from north to fouth, viz. from Cape Penas to Gibraltar, may be eftimated at 550 miles, while its medium breadth may be computed at 440. According to De Laborde, its fuperficial extent, exclufive of Portugal, is 25,137 fquare French leagues, or about 21,000 fquare Englifh leagues. 2 Extent.

Befides the continental part of Spain, this monarchy comprehends feveral iflands in the Mediterranean, efpecially Majorca, Minorca, and Iviça; the Canary iflands, and feveral places on the north-weftern coaft of Africa; the Philippine and Ladrone iflands; together with an immenfe territory both in North and South America, comprehending Mexico, or New Spain, New Mexico, the ifland of Cuba, Porto Rico, &c. in North America, and in the fouthern part of that continent, the greateft portion of *Terra Firma*, Peru, Chili, almoft the whole of Paraguay, with an extenfive territory lying on the banks of the river Plate.

The ufual divifion of the Spanifh continent is into fourteen provinces, viz. thofe of CATALONIA, ARAGON, and NAVARRE, on the confines of France; BISCAY, ASTURIAS, and GALLICIA, on the fhores of the Atlantic; LEON and ESTREMADURA, on the fide of Portugal; ANDALUSIA chiefly on the ftraits of Gibraltar; GRANADA, MURCIA, and VALENCIA, on the fhores of the Mediterranean; OLD and NEW CASTILE in the centre. 3 Divifion.

The lateft writer on the geography of Spain, De Laborde, reckons only 13 provinces, as he includes Granada under Andalufia. In the following table we have brought together the moft important circumftances refpecting each of thefe provinces, viz. their fubdivifions, extent in fquare Britifh miles, population at the end of the 18th century, and chief towns; and we have arranged the provinces in the order followed by Laborde.


SPAIN
AND
PORTUGAL.
W. Train Sculpt.
ATLANTIC OCEAN
BAY of BISCAY
MEDITERRANEAN SEA
AFRICA
FRANCE
Pyrenean Mountains
GALICIA
ASTURIAS
BISCAY
NAVARRA
ALAVA
ENTRE DOURO E MINHO
TRAS OS MONTES
BEIRA
ESTREMADURA
ALENTEJO
ALGARVE
ARAGON
CATALONIA
VALENCIA
MURCIA
GRANADA
ANDALUSIA
Kdom OF SEVILLE
Kdom OF CORDOVA
Kdom OF JAEN
CUENCA
LA MANCHA
NEW CASTILE
OLD CASTILE
KINGDOM OF LEON
PROVINCE OF SALAMANCA
BURGOS
MADRID
Toledo
Lisbon
Oporto
Coimbra
Cadiz
Gibraltar
STRAIT OF GIBRALTAR
Ceuta
Tangier
Barcelona
Zaragoza
Valencia
Murcia
Carthagena
Granada
Malaga
Sevilla
Cordova
Valladolid
Salamanca
Pampeluna
Bilboa
MAJORCA
MINORCA
Iviza
Fromentera
Cabrera I.
Palma
Mahon
ALGIER
Oran
Cabo Ortegal
C. de Finisterra
C. S.t Vincent
C. S.t Mary
Trafalgar
Tortosa
Tarragona
Alicante
Almeria
Rosas
Perpignan
Narbonne
Toulouse
Montpellier
Nismes
The Coast 5 from Tofino 4 The interior 3 part from 2 Lopez 1 0 Longitude East 1 from Greenwich 2 3

Provinces.	Subdivisions.	Extent in square miles.	Population.	Chief Towns.
Province of CATALONIA.	County of Rouſſillon ———— Cerdagne	10,400	814,412	BARCELONA, Tarragona, Urgel, Lerida, Gerona, Salſona, Vich, Tortoſa, Figueras, &c.
Kingdom of VALENCIA.		7,800	932,150	VALENCIA, Alicant, Elche, Orihuela, Caſtellan, Alzira, Carcaxente, Gandia, Xaciva, Otiniente, Alcoy, Segorbe, &c.
Province of ESTREMADURA.		16,000	416,922	BADAJOZ, Placencia, Coria, Merida, Truxillo, Xera de los Cavalleros, Llerina, Almatona, Zafra, &c.
Province of ANDALUSIA.	Kingdom of Seville	12,600	754,293	SEVILLE, Xeres de la Frontera, Arcos, Cadiz, Real Ejo, Ayamonte, Nivela, &c.
	———— Granada	4,500	661,661	GRANADA, Malaga, Loxa, Santa Fé, *Antiquera*, Ronda, Guadix, Baza, &c.
	———— Cordova	1,080	236,016	CORDOVA, and Archidona, &c.
	———— Jaen	2,400	177,136	JAEN, Ubeda, Baeza, Anduxar, &c.
Kingdom of MURCIA.		8,812	337,686	MURCIA, Carthagena, Lorca, Chinchilla, Alba Cete, Villena, Almanza, &c.
Kingdom of ARAGON.		16,500	623,308	ZARAGOZA, Iaca, Barbaſtro, Hueſca, Tarazona, Albarrazin, Teruel, &c.
Kingdom of NAVARRE.		2,287	287,382	PAMPELUNA, Tudela, &c.
Province of BISCAY.	Biſcay Proper	4,000	116,042	BILBOA, Vermijo, &c.
	Alava		74,000	VITTORIA, Trevino, Onate, &c.
	Guipuzcoa		12,076	ST SEBASTIAN, Fuenaraba, Toloſa, Placentia, &c.
Principality of the ASTURIAS.	Oviedo	3,375	350,000	OVIEDO, Aviles, Luarca, Gijon, &c.
	Santillana	1,200		SANTILLANA, San Vincente, Riva de Sella, &c.
Kingdom of GALLICIA.		11,500	1,350,000	SAN JAGO DE COMPOSTELLA, Bayona, Lugo, Orenſe, Mondonedo, Corunna, Vigo, &c.
Kingdom of LEON.	Leon Palencia Zamora Salamanca	10,750	665,432	LEON, Duero, Aſtorga, Salamanca, Zamora, &c.
Kingdom of OLD CASTILE.	Burgos Avila Segovia	10,800	1,190,180	BURGOS, Oſma, Siguenza, Avila, Valladolid, Segovia, Calahorra, Soria, &c.
Kingdom of NEW CASTILE.	Toledo	22,000	1,146,809	MADRID, Toledo, Aranjuez, Talavera della Reyna, &c.
	Cuença			CUENÇA, Guete, Alacon, &c.
	Lamanca			OCANA, Hucles, Laguardia, Tarrazona, &c.
Kingdom of MAJORCA.	Iſlands of Majorca	1,440	136,000	PALMA, Alcudia, &c.
	———— Cabrera			
	———— Iviça	110		IVIÇA.
Iſland of MINORCA.		360	27,000	MAHON, Cittadella.
			10,308,505	

Some account of theſe provinces will be found under the articles ANDALUSIA, ARAGON, ASTURIAS, BISCAY, CASTILE, CATALONIA, ESTREMADURA, GALLICIA, GRANADA, LEON, MURCIA, NAVARRE, VALENCIA, IVICA, MAJORCA and MINORCA; but, for the beſt view of their preſent ſtate, we muſt refer our readers to De Laborde's *View of Spain*, vols i. ii. and iii. or to Playfair's *Geography*, vol. i.

In its general appearance, Spain preſents a pleaſing variety of hill and dale, mountain and valley. It muſt be regarded as a mountainous country, its plains being few in number and of ſmall extent. The moſt remarkable of theſe occupies the centre of the kingdom, eſpecially New Caſtile, which forms the moſt elevated tract of level country to be found in Europe, having a mean elevation of more than 300 fathoms above the level of the ſea. The country is well wooded, and abounds with rivers; but theſe are often very deficient in water, and Spain,

4 Face of the country.

Spain, eſpecially on its eaſtern coaſt, is remarkable for the dryneſs of its ſoil. Notwithſtanding this aridity, however, moſt parts of the kingdom teem with fertility, and native verdure and high cultivation render the ſcenery delightful. Here and there, indeed, occurs a tract of deſert utterly incapable of cultivation; but, in general, nature has done much more for the country than the labour of its inhabitants.

5 Soil.

The ſoil is ſaid to be in general light, and eaſily wrought; but on many parts of the eaſtern coaſt it is compoſed chiefly of a ſtiff loam or clay. The moſt fertile parts of the kingdom are in Valencia, on the coaſt of Granada, in the kingdom of Old Caſtile, and in ſeveral parts of thoſe of New Caſtile and Leon. The ſoil of Catalonia is very diſcouraging, except in the valleys, and the ſame may be ſaid of all the provinces bordering on the Pyrenees; the ſoil of Eſtremadura, though naturally good, has been ſo long abandoned to itſelf, that it has almoſt ceaſed to produce, and that of Andaluſia has a very mixed character. The ſoil of Murcia is uncommonly arid; that of the Aſturias cold; that of Gallicia extremely wet. In the neighbourhood of Carthagena there is an extenſive tract, which is ſo covered with ſtones as to form a deſert as ſterile and untameable as any on the ſandy plains of Africa or Arabia.

6 Mountains.

We have ſaid that Spain is a mountainous country. The chain of the Pyrenees, common to it and France, is by no means the moſt conſiderable in point either of elevation or extent; though that chain may be regarded as the common root or origin of all the reſt. From the weſtern corner of the Pyrenees a vaſt ridge branches off through Navarre, Biſcay, Aſturias, and Gallicia, terminating only at Cape Finiſterre, and Cape Ortegal. This ridge is the *Cantabrian* mountains, and is diſtinguiſhed into ſeveral ſubordinate groups, denominated from the principal towns ſituated in their vicinity. Thus we have the mountains of Mondonedo in Gallicia. In general, theſe groups are called *Sierras*, from the jagged or *ſerrated* appearance of their tops; as the *Sierra de la Aſturias*, *Sierra d'Avila*, &c. The ſubordinate mountains that extend from the Sierra of the Aſturias in the north, to the Alpuxaras in the ſouth, run in parallel lines; and the ſame direction prevails in the mountains of Saint Andero, which join the Pyrenees.

From the mountains of Biſcay ariſes a main ridge, which, after proceeding a little to the ſouth, divides into three or four branches. Of theſe the moſt northerly chain ſeparates the provinces of Old Caſtile and New Caſtile, extending to the confines of Portugal, and called the mountains of Guadarrama. A ſecond branch divides the principal part of New Caſtile from the province of La Mancha, running from the north-eaſt to the ſouth-weſt, as far as Badajos in Eſtremadura. The moſt remarkable part of this chain is the Sierra of Guadalupe. South of theſe runs the Sierra Morena, or Sable mountains, rendered claſſical by the inimitable pen of Cervantes. This is the laſt chain till we reach the Alpuxaras, that extend through the provinces of Granada and Andaluſia.

Of theſe mountains there are two points, which, in elevation, exceed Mont Perdu, the higheſt of the Pyrenees, viz. the Pico de Venleta, in the Sierra Nevada, or ſnowy mountains of Granada, which is elevated more than 1781 fathoms above the level of the ocean, and the peak of Mulahaſen, in the ſame chain, raiſed above 1824 fathoms, which is within 76 fathoms of the peak of Teneriffe.

The principal capes and promontories of the Spaniſh continent are, Cape Creus, Cape St Antoine, oppoſite the iſland of Iviça; Cape Palas, near Carthagena; Cape de Gatte, near Almeria, and the promontory on which ſtands the town of Gibraltar, all on the coaſt of the Mediterranean; and Cape Machicaco, Cape Penas, Cape Ortegal, the promontory of Ferrol, Cape Finiſterre, and Cape Trafalgar, on the coaſts of the Atlantic. 7 Capes and promontories.

The principal bays and gulfs on the coaſt of Spain, purſuing the ſame courſe, are the following; the bay of Valencia, the bay of Alicant, the gulf of Carthagena, the bay of Almeria, the bay of Gibraltar, the harbour of Cadiz, the bay of Corunna, commonly called the Groyne, and the bay of Biſcay. 8 Bays and gulfs.

The rivers of Spain are intimately connected with the mountains from which they derive their ſource, and between the chains of which they generally flow. The moſt important are, the Ebro, riſing in the mountains of Santillana in the Aſturias, and running in a ſouth-eaſtern direction between the Caſtiles and Valencia on the one hand, and the provinces of Navarre, Aragon, and Catalonia, on the other, till it reaches the Mediterranean, at a ſmall diſtance from Tortoſa; the Xacar, riſing in the Sierra of Cuença in New Caſtile, and flowing into the Mediterranean conſiderably to the ſouthward of Valencia; the Segura, riſing in a mountain of the ſame name, traverſing the province of Murcia, and meeting the Mediterranean about midway in the capital of that province, and Alicant. Theſe flow into the Mediterranean, and there are ſeveral other rivers of leſs note, which pour their waters into the ſame ſea, and which we can merely enumerate. Theſe are the Ter at Gerona, the Lobregate at Barcelona, and the Mijares, paſſing by Segorbe. The rivers which flow into the Atlantic are, the Guadalquiver, riſing at the foot of Mount Segura, from the oppoſite ſide of which originates the river of the ſame name, flowing with a ſluggiſh courſe through the province of Andaluſia, and meeting the Atlantic a little to the north-weſt of Xeres; the Guadiana, riſing among ſome lakes to the north-weſt of Alcaraz in New Caſtile, and paſſing between the Sierra Morena and the Sierra de Guadalupe, till, near Badajos, it enters the kingdom of Portugal, and runs nearly in a ſoutherly direction, till it meets the Atlantic at Ayamonte; the Tagus, riſing among the mountains of Albaraçin in New Caſtile, and running weſterly till, at Alcantara, it becomes a river of Portugal; the Douro, riſing in Old Caſtile near Soria, and paſſing by Valladolid and Zamora, near which it forms a part of the boundary of Portugal; the Minho, riſing in the mountains of Gallicia, and running to the ſouth-weſt, till it meets the Atlantic to the north of Camina. The only other river of any importance in this direction is the Lima, ſuppoſed to be the Lethe of the poets, which riſes in Gallicia, and flows into the ſea below Viara. 9 Rivers.

If we except the ſeries of ſmall lakes from which we have ſaid the river Guadiana takes its riſe, there are, in Spain, few lakes that merit particular notice. The moſt remarkable of theſe is the lake of Abulfera, in the province of Valencia. This lake begins near the village of Catarroija, about a league ſouth of the city of Valencia, and extends nearly four leagues as far as Cullera. When 10 Lakes.

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it is full, it is about four leagues long, two in breadth, and ſix in circumference; but it is ſo ſhallow, that ſmall boats can ſcarcely float in it. To ſupply the deficiency of water, an engine is employed, by which the neighbouring waters are drawn into the bed of the lake; and any ſuperabundant water occaſioned by heavy rains, is carried off into the ſea by means of an artificial opening. This lake contains a great many fiſh, and numerous aquatic birds make it their haunt. On certain days in the year the inhabitants of Valencia make incurſions hither to ſhoot the birds, and the ſurface of the lake is at theſe times covered with boats.

11 Foreſts. Many parts of the kingdom of Spain abound in large tracts of wood. Extenſive foreſts are found in Catalonia, the Aſturias, Gallicia, and in the Sierra Morena. It is in the mountainous chains that the foreſts of Spain are moſt remarkable; and there are few of theſe heights, except in the ſnowy regions of the Sierra Nevada, but what are covered with wood almoſt to their ſummits.

12 Climates and ſeaſons. The climate of Spain is as delightful as that of any part of Europe; and though at certain ſeaſons of the year the eaſtern coaſt is ſubject to exceſſive heat and drought, and the north-weſtern to almoſt perpetual rains, the temperature is in general mild, and the air ſalubrious.

The climate of Spain has been admirably depicted by M. A. de Humboldt; and we ſhall here preſent to our readers the ſubſtance of his remarks, as they are related by De Laborde, in his view of Spain.

No country of Europe preſents a configuration ſo ſingular as Spain. It is this extraordinary form which accounts for the dryneſs of the ſoil in the interior of the Caſtiles, for the power of evaporation, the want of rivers, and that difference of temperature which is obſervable between Madrid and Naples, two towns ſituated under the ſame degree of latitude.

The interior of Spain is, as we have ſeen, an elevated plane, which is higher than any of the ſame kind in Europe, occupying ſo large an extent of country. The mean height of the barometer at Madrid is 26 inches $2\frac{2}{3}$ lines. It is therefore $\frac{1}{14}$ lower than the mean height of the mercury at the level of the ocean. This is the difference of the preſſure of the atmoſphere that is experienced by all bodies expoſed to the air at Madrid, and at Cadiz and Bourdeaux. At Madrid the barometer falls as low as 25 inches 6 lines, and ſometimes even lower.

The following is a table of the variations in the height of the barometer during the firſt nine months of the year 1793.

Months.	Maximum.		Minimum.		Mean Height of the Mercury	
1793.	Inches.	Lines.	Inches.	Lines	Inches.	Lines
January,	26	5.8	25	9.8	26	2.6
February,	26	5.3	25	6.2	26	1.6
March,	26	4.7	25	6.	25	11.6
April,	26	2.4	25	6.9	25	11.6
May,	26	4.6	25	10.5	26	0.8
June,	26	4.	25	11.8	26	1.6
July,	26	4 3	26	0.7	26	2.4
Auguſt,	26	3.2	25	11.5	26	1.4
September,	26	4.3	25	11.	26	1.7

From the mean height of the barometer at Madrid, we find that capital to be elevated $309\frac{6}{10}$ fathoms above the level of the ocean. Madrid, conſequently, ſtands as high as the town of Inſpruck, ſituated in one of the higheſt defiles of the Tyrol, while its elevation is 15 times greater than that of Paris, and three times greater than that of Geneva.

According to M. Thalacker, the mineralogiſt, who has taken ſeveral heights with the barometer in the environs of Madrid, the elevation of the king's palace at San Ildefonſo is 593 fathoms, which is higher than the edge of the crater of Mount Veſuvius, and is, ſtrictly ſpeaking, in the regions of the clouds, which generally float from 550 to 600 fathoms high.

The height of the plain of the Caſtiles has an evident effect on its temperature. We are aſtoniſhed at not finding oranges in the open air under the ſame latitude as that of Tarentum, part of Calabria, Theſſaly, and Aſia Minor; but the mean temperature of Madrid is very little ſuperior to that of Marſeilles, Paris, and Berlin, and is nearly the ſame with that of Genoa and Rome. The following table ſhews the mean temperature at Madrid and at Rome, during the firſt nine months of the years 1793 and 1807.

	At Madrid.	At Rome.
Months.	Deg. of Fahrenheit.	Deg. of Fahrenheit.
January,	39° 3	40° 11′ 15″
February,	43 24	47 49 30
March,	47 54	50 15 45
April,	52 19 30″	54 34 30
May,	59 4 30	65 56 15
June,	72 32 15	72 30
July,	77 13 30	79 15
Auguſt,	81 34 30	79 15
September,	65 45	72 34 30

Thus, the mean temperature at Madrid appears to be 59° of Fahrenheit, while that of the coaſts of Spain, from the 41° to the 36° of Lat. is between $63\frac{1}{2}$° and 68° of Fahrenheit. In the former climate we find that orange trees will not flouriſh in perfection, while in the latter we ſee banana trees, heliconias, and even ſugar-canes, growing in ſituations that are ſheltered from the cold winds.

Spain preſents few ſpecies of animals that are not found in the other parts of ſouthern Europe. Among the quadrupeds, we may remark, as peculiar to Spain, the genet, (*viverra genetta*). The bear is found in ſeveral parts of the great Pyrenean chain, eſpecially on ſome of the mountains of Aragon, as well as thoſe of Occar and Reynoſa in Old Caſtile. Wolves are met with in all the higher and mountainous parts of the country, and wild boars on the mountains of Navarre, on the Pinar, and the Sierra de Caraſcoy, in the kingdom of Valencia. The roebuck is found on ſome of the mountains of Navarre, and the lynx and the ibex on thoſe of Cuença in New Caſtile, in the valleys of Aure and Giſtau, as well as in the Pyrenees. The glory of Spaniſh zoology is the horſe, for which this kingdom has been famous in all ages. The Spaniſh horſes 13 Animals.

Spain.

horſes have probably originated from the Barbs of the north of Africa, ſuppoſed to be the immediate offspring of the Arabian breed. The Spaniſh mules are alſo excellent, and the aſs is here no ignoble animal, though not equal to thoſe of Arabia. There is little remarkable in the breed of cattle, but the Merino ſheep have long been diſtinguiſhed, and are perhaps ſuperior to any in the world for the beauty of the fleece, if not for the delicacy of the mutton. The flocks of Merino ſheep are ſometimes extremely large, and Mr Townſend mentions one nobleman who poſſeſſed not fewer than 40,000. The whole number in the kingdom may be eſtimated at about 5,000,000. Theſe animals were, by a ſpecial code, called the *Meſta*, authoriſed to travel from one province to another, according as the ſeaſon preſented the beſt paſturage in the mountains or the plains. The fleece of the Merino ſheep is eſteemed double in value to that of any other breed.

Of the birds more peculiarly found in Spain, the *vulture, percnopterus*, the *cuculus glandarius*, *cuculus tridactyla*, *motacilla hiſpanica*, *hirundo mellia*, and *hirundo rupeſtris*, are the moſt remarkable.

Freſh-water fiſhes are very plentiful in the Spaniſh rivers; but thoſe in moſt eſteem are from the ſmall river Tormes in Old Caſtile, where have been taken trout of 20 lbs. weight. The tench of the lakes near Tobar in New Caſtile, are remarkably fine and delicate, and are taken in great abundance every year, during the months of May and June. The fiſh taken on the coaſts are much the ſame as thoſe of the other countries bordering on the Mediterranean and the Atlantic. The tunny was formerly taken on the eaſtern coaſt, where it formed a particular branch of the fiſhery, but is now, we believe, little regarded.

Among the Spaniſh inſects, the moſt remarkable are, the cantharides, (*meloë veſicatorius*), and the kermes inſect (*coccus ilicis*). The latter inſect is much cultivated as an article of dyeing, eſpecially in the territory of Bujalance, and of Fernan Nunes in the kingdom of Cordova, as alſo in the vicinity of the town of De las Aguas, four leagues from Alicant, and near the river Henares, in New Caſtile. The evergreen oaks on which theſe animals feed, preſent in the ſpring, a moſt ſingular appearance, from the red *nidi* of the kermes, with which their leaves are covered.

14
Vegetables.

No country of Europe of the ſame extent, furniſhes ſuch an ample field for the reſearches of the botaniſt, as Spain; and indeed its botany conſtitutes a very important part of its natural hiſtory. The mountainous diſtricts are clothed with the ever-green oak, the common oak, the cheſnut, and in ſome places various ſpecies of pine; but their moſt uſeful production is the cork tree. The ſmaller heights produce the wild olive, the almond, the ſhumac, the laurel, the bay, the cypreſs, Canary and Portugal broom, the yellow jeſſamine, and the Provence roſe. The vine, the palm tree, the orange, the lemon and the olive, are ſo nearly naturalized as to require but little cultivation; and the ſame may be ſaid of the kali (*ſalſola ſoda*), which is produced in large quantities on the coaſts, and furniſhes the beſt kind of kelp, commonly called *barilla*, uſed in the manufacture of ſoap and glaſs. The plains and valleys are covered with many of thoſe plants which form ſome of the greateſt ornaments of our flower gardens, as the tulip, ſeveral ſpecies of iris, the pæony, the paſſion flower, the orange and martagon lily, the jonquil, ſeveral ſpecies of narciſſus and hyacinth, and above all the rhododendron. The mountains, however, exhibit the greateſt variety of botanical riches. Thoſe moſt worthy of the viſits and reſearches of the enterpriſing botaniſt, are, the Sierra de Guadalupe in Eſtremadura; the mountains of Moncayo in Aragon; of Pineda, Guadarrama, and Cuença, in New Caſtile; of Caroſcoy, in the kingdom of Murcia; of Pena-Coloſa, Mongi, Aytona, and Mariola, in the kingdom of Valencia, and the Pyrenees.

The ſugar-cane, was, before the diſcovery of the Weſt India iſlands, one of the moſt important objects of Spaniſh cultivation, and numerous ſugar mills were eſtabliſhed along the coaſt of the Mediterranean, eſpecially in the kingdom of Granada. At the conqueſt of that Mooriſh kingdom, not fewer than fourteen ſugar plantations and two mills, were found within the province. Some ſugar canes are ſtill cultivated in the kingdom of Valencia, but the manufacture of ſugar is diſcontinued, and the canes are uſed only for diſtillation. There is, we believe, ſtill a manufactory for ſugar from Spaniſh canes in Granada.

15
Minerals.

Spain has long been celebrated for the riches of its mineral kingdom, and it may ſtill be conſidered as the Mexico and Peru of Europe. There are few metals which may not be found in this kingdom; and, till the diſcovery of America put the Spaniards in poſſeſſion of mines which far ſurpaſs their own in produce, the gold and ſilver mines of Spain were thought to be nearly the richeſt in the world. At preſent, no gold mines are wrought, but grains of that metal are found diſſeminated in ferruginous quartz, forming a vein that paſſes through a mountain near the village of San Ildefonſo in Old Caſtile. Spangles of gold are found intermixed with emery, in a mine near Alocer in Eſtremadura, and in the territory of Molena in Aragon; and this metal is occaſionally found in the ſand of two rivers; the Agneda, in the kingdom of Leon, which riſes from the mountains of Xalamo, and the Tagus in New Caſtile, eſpecially in the vicinity of Toledo.

Silver is much more abundant, but moſt of its mines have alſo been abandoned. We believe the only ſilver mine now in work is that of the Sierra de Guadalupe, near the village of Logrozen, where the ſilver is found mixed with micaceous ſchiſtus. The moſt remarkable ſilver mines formerly worked are thoſe of Alrodoval del Campo; of Zalamea on the road to Alocer in Eſtremadura; of Almazaron near Carthagena; three in the Sierra Morena, about a league from Guadalcanal, in the kingdom of Seville, and another about two leagues from Linarez, in the kingdom of Jaen. This laſt mine was well known both to the Carthaginians and the Romans; while Spain was under the dominion of the former it belonged to Himilca, the wife of Aſdrubal. After having been long abandoned, it was again wrought in the 17th century, when a vein of ore five feet in diameter was diſcovered; at preſent, however, it is no longer in a ſtate of activity.

Mines of copper are found near Pampeluna in Navarre, near Salva Tierra in Alava; near Eſcarray, and at the foot of the mountains of Guadarama in Old Caſtile; near Lorea in Murcia; near the Chartreuſe of the Val de Chriſto in Valencia; in the Sierra de Guadalupe in Eſtremadura; in the mountains near Cordova; near Riotinto, and at la Canada de los Conejos in Seville; in

Spain. in the district of Albuladui in Granada, and near Lenarez in the kingdom of Jaen.

There are numerous lead mines, especially near Tortosa in Catalonia; at Zoma, Benasques, and Plan in Aragon; near Logrosen and Alcoser in Estremadura; in the mountain Guadarrama in Old Castile; near los Alumbres and Lorca in Murcia; at Alcaniz and Constantina in Seville, and at the district of Linarez in Jaen.

The mines of iron are abundant, and need not be enumerated. Of antimony there are two mines, both in the district of La Mancha. One of these is at Alendia, near Almodovar; the other at the foot of the Sierra Morena. There is only one mine of cobalt, viz. in the province of Aragon, found in the valley of Geston. There are two mines of cinnabar in Valencia; one about two leagues from Alicant in the limestone mountains of Alcoray; the other between Valencia and San Felipe; and two others in the same province, that produce native mercury, but none of these are worked. The most abundant mine of mercury and cinnabar united is in the district of La Mancha, on the borders of Cordova. It is situated in a hill of sandstone which rests on slate. The whole length of the hill is traversed by two principal veins, both of which were wrought by the Romans. The whole of this mine was lately wrought by the agents of the king, and its produce was very abundant.

Plumbago is found in a thick vein intermixed with feldspar, about a league from the village of Real Monasterio, in the kingdom of Seville. Mines of sulphur occur, both in Aragon and Murcia; jet has been found in the district of Old Colmenar, in Old Castile; and there is good evidence of the presence of coal at several places in Catalonia, in the Asturias, New Castile, and Aragon; but it is said that no coal mines have as yet been opened.

The marbles of Spain are very numerous and valuable. A black marble, veined with white, is procured near Barcelona; many dendritic marbles occur near Tortosa. Near the town of Molina, in Aragon, is found a granular marble spotted with red, yellow, and white. At the village of Salinos, in the district of Guipuzcoa, is a beautiful blue pyritical marble, containing marine shells. From Monte Sagarra, near Segorbia, in the province of Valencia, are procured several fine marbles, which were held in great estimation even by the Romans. The province of Granada, however, contains more valuable varieties of this beautiful mineral than all the rest of Spain; of these some of the principal are the following. A pure white statuary marble, of which the whole mountain of Filabra, near Almeria, is composed; a flesh-coloured marble from a mountain near Antiquera; an exquisitely beautiful wax-coloured alabaster, from the vicinity of the city of Granada; and a finely veined marble from the Sierra Nevada.

16 Mineral waters.

Of the Spanish mineral waters the following are the most celebrated. The principal cold springs are, a hepatic water in the town of Buron, in Valencia; a carbonated water at Gerona, in Catalonia; a saline purgative water at Vacia-Madrid, three leagues from the capital, and another of a similar nature near Toledo.

The principal hot springs are, the baths of Abu-Zulena, at Javal-Cohol, near Bæza; a hepatic spring used for bathing near Alhama de Granada; another near Almeria, in the province of Granada, to which are attached both bathing and vapour baths: all these were discovered, or at least brought into general use, by the Moors. A very copious hot spring near Merida, in Estremadura, made use of by the Romans. The Calda de Bonar, in the neighbourhood of Leon, a spring of tepid water frequented by the Romans, and still exhibiting the ruins of baths and ancient inscriptions. A very hot spring near Orense, in Gallicia. A spring at Alhama, near Calatayud, in Aragon, formerly much frequented, but now in a state of neglect. The Fuente de Buzot, near Alicant, a saline spring of the temperature of 104° Fahrenheit. A very copious and hot spring at Archena, near Murcia, where still remain the ruins of Roman and Moorish baths. A hepatic spring near Arnedillo, in Old Castile.

17 Natural curiosities.

Among the natural curiosities of Spain, we may particularize the mountain of Montferrat in Catalonia (see MONTSERRAT); the insulated hill of rock salt near the town of Cardona, in Catalonia (see GEOLOGY, N° 102.); the subterranean lake contained within a cavern in the neighbourhood of the Cava Perella, in the island of Minorca; the stalactitic cave called St Michael's, on the west side of the rock of Gibraltar, and the river Guadiana, which appears and disappears several times in the course of its progress to the sea.

18 Spanish islands.

The various groups of islands that are subject to Spain have long been distinguished by particular names. Thus *Majorca*, *Minorca*, *Cabrera* and *Dragonera*, were called by the ancients *Insulæ Baleares*, and are still named the *Balearic Isles*; while Iviça and *Feromentara* form a lesser group, denominated the *Pityuse Isles*. Of these islands, the latter were taken possession of by the Carthaginians nearly 700 years before the Christian era; and about 200 years after that enterprising people made themselves masters of the Balearic isles. After the fall of Carthage, all these islands long maintained a state of piratical independence, and only Majorca was ever completely subject to the Romans. In the time of Augustus we are told that the Balearic isles were so infested with rabbits, that the inhabitants sent deputies to Rome for assistance to destroy these formidable invaders of their plantations. In the year 426 of the Christian era, these islands came into the possession of the Vandals, from whom they were taken at the end of the 8th century by the African Moors. At the beginning of the 9th century they were seized on by a fleet sent into the Mediterranean by Charlemagne; but they were soon after reconquered by the Moors, who maintained the sovereignty in these islands till, in 1228, they were finally dispossessed by Don James grandson of Alphonso II. king of Aragon.

19 Names of Spain.

Though Spain appears to have been known to the Phœnicians nearly 1000 years before the birth of Christ, it seems to have been little regarded by the Greeks till after the period when Herodotus composed his history. Some part of this country was probably the Tarshish of Scripture, from which the Phœnicians imported gold, silver, and other precious commodities into Judea. When the Greeks had established a colony at Marseilles, they must have been well acquainted with at least the northern part of this peninsula, to which they gave the names of Iberia and Celtiberia, from two nations who then inhabited the country, and of Hesperia, from its extreme situation in the west of the then known world. The name Hispania, from which its modern appellation

is

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is derived, was bestowed on it by the Romans; but the etymology of this name is uncertain.

20 Original population.

The Aborigines of Spain were doubtless a Celtic tribe, which probably passed into this peninsula from the adjoining continent of Gaul, though at a very early period they appear to have been mixed with a colony of Mauritani, or Moors from the coast of Africa. The Celtic inhabitants, or Celtiberi, seem to have possessed the north-east of the peninsula, while the Mauritani occupied the southern and south-western districts.

21 Spain invaded by the Carthaginians. An. 240. B. C.

Nothing certain is known respecting the early state of Spain, till the commencement of the first Punic war between the Romans and the Carthaginians, in the middle of the third century before Christ. Not long before this date, probably at the beginning of the century, the latter people had possessed themselves of Catalonia, when their general Hamilcar Barcas is said to have founded the city of Barceno, the modern Barcelona. The Carthaginian colony, however, seems to have been rather a mercantile than a warlike settlement, and the Celtiberi were more the allies than the subjects of their African neighbours. Of the contests carried on between the Carthaginians and the Romans, till the final subjugation of the former, and the consequent occupation of all their territories by the Roman republic, we have given an account under the articles CARTHAGE and ROME. We shall here briefly consider the state of Spain at the time of its occupation by the Romans, and relate the events to which that occupation gave rise, and which are less connected with the more immediate transactions of the Punic wars.

22 State of Spain at the Roman conquest.

At the time of the Roman conquest, Spain, though prodigious quantities of silver had been carried out of it by the Carthaginians and Tyrians, was yet a very rich country. In the most ancient times, indeed, its riches are said to have exceeded what is related of the most wealthy country in America. Aristotle assures us, that when the Phenicians first arrived in Spain, they exchanged their naval commodities for such immense quantities of silver, that their ships could neither contain nor sustain its load, though they used it for ballast, and made their anchors and other implements of silver. When the Carthaginians first came to Spain, they found the quantity of silver nothing lessened, since the inhabitants at that time made all their utensils, and even mangers, of that precious metal. In the time of the Romans this amazing plenty was very much diminished; however, their gleanings were by no means despicable, since in the space of nine years they carried off 111,542 pounds of silver, and 4095 of gold, besides an immense quantity of coin and other things of value (A). The Spaniards were always remarkable for their bravery, and some of Hannibal's best troops were brought from thence; but as the Romans penetrated farther into the country than the Carthaginians had done, they met with nations whose love of liberty was equal to their valour, and whom the whole strength of their empire was scarcely able to subdue. Of these the most formidable were the Numantines, Cantabrians, and Asturians.

23 Successes of Viriathus against the Romans.

In the time of the third Punic war, one Viriathus, a celebrated hunter, and afterwards the captain of a gang of banditti, took upon him the command of some nations who had been in alliance with Carthage, and ventured to oppose the Roman power in that part of Spain called *Lusitania*, now Portugal. The prætor, named *Vetilius*, who commanded in those parts, marched against him with 10,000 men; but was defeated and killed, with the loss of 4000 of his troops. The Romans immediately dispatched another prætor with 10,000 foot and 1300 horse: but Viriathus having first cut off a detachment of 4000 of them, engaged the rest in a pitched battle; and having entirely defeated them, reduced great part of the country. Another prætor, who was sent with a new army, met with the same fate; so that, after the destruction of Carthage, the Romans thought proper to send a consul named *Quintus Fabius*, who defeated the Lusitanians in several battles, and regained two important places which had long been in the hands of the rebels. After the expiration of Fabius's consulate, Viriathus continued the war with his usual success, till the senate thought proper to send against him the consul Q. Cæcilius Metellus, an officer of great valour and experience. With him Viriathus did not choose to venture a pitched battle, but contented himself with acting on the defensive; in consequence of which the Romans recovered a great many cities, and the whole of Tarraconian Spain was obliged to submit to their yoke. The other consul, named *Servilianus*, did not meet with the same success; his army was defeated in the field, and his camp was nearly taken by Viriathus. Notwithstanding the good fortune of Metellus, however, he could not withstand the intrigues of his countrymen against him, and he was not allowed to finish the war he had begun with so much success. In resentment for this he took all imaginable pains to weaken the army under his command: he disbanded the flower of his troops, exhausted the magazines, let the elephants die, broke in pieces the arrows which had been provided for the Cretan archers, and threw them into a river. Yet, after all, the army which he gave up to his successor Q. Pompeius, consisting of 30,000 foot and 2000 horse, was sufficient to have crushed Viriathus if the general had known how to use it. But, instead of opposing Viriathus with success, the imprudent consul procured much more formidable enemies. The Termantians and Numantines, who had hitherto kept themselves independent, offered very advantageous terms of peace and alliance with Rome; but Pompeius insisted on their delivering up their arms. Upon this war was immediately commenced. The consul with great confidence invested Numantia; but being repulsed with considerable loss, he sat down before Termantia, where he was attended with still worse success. The very first day, the Termantines killed 700 of his legionaries; took a great convoy which was coming to the

(A) In this account we must allow something for the exaggerations of fabulous historians. There is no doubt, however, that Spain was at this time immensely rich, and if we may believe Strabo, there was then a mine near Carthage which yielded every day 25,000 drams of silver, or about 300,000l. per annum.

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the Roman camp: and having defeated a considerable body of their horse, pushed them from post to post till they came to the edge of a precipice, where they all tumbled down, and were dashed to pieces. In the mean time Servilius, who had been continued in his command with the title of *proconsul*, managed matters so ill, that Viriathus surrounded him on all sides, and obliged him to sue for peace. The terms offered to the Romans were very moderate; being only that Viriathus should keep the country he at that time possessed, and the Romans remain masters of all the rest. This peace the proconsul was very glad to sign, and afterwards procured its ratification by the senate and people of Rome.

24 The Romans surrounded on all sides, and forced to conclude a peace with Viriathus.

The next year Q. Pompeius was continued in his command against the Numantines in Farther Spain, while Q. Servilius Cæpio, the new consul, had for his province Hither Spain, where Viriathus had established his new state. Pompeius undertook to reduce Numantia by turning aside the stream of the Durius, now the Douro, by which it was supplied with water; but, in attempting this, such numbers of his men were cut off, that, finding himself unable to contend with the enemy, he was glad to make peace with them on much worse terms than they had offered of their own accord. The peace, however, was ratified at Rome; but in the mean time Cæpio, desirous of showing his prowess against the renowned Viriathus, prevailed on the Romans to declare war against him without any provocation. As Cæpio commanded an army greatly superior to the Lusitanians, Viriathus thought proper to sue for peace; but finding that Cæpio would be satisfied with nothing less than a surrender at discretion, he resolved to stand his ground. In the mean time, the latter having bribed some of the intimate companions of Viriathus to murder him in his sleep, he by that infamous method put an end to a war which had lasted 14 years, very little to the honour of the republic.

25 Viriathus treacherously murdered.

After the death of Viriathus, the Romans with like treachery ordered their new consul Popilius to break the treaty with the Numantines. His infamous conduct met with the reward it deserved; the Numantines sallying out, put the whole Roman army to flight with such slaughter, that they were in no condition to act during the whole campaign. Mancinus, who succeeded Popilius, met with still worse success; his great army, consisting of 30,000 men, was utterly defeated by 4000 Numantines, and 20,000 of them killed in the pursuit. The remaining 10,000, with their general, were pent up by the Numantines in such a manner that they could neither advance nor retreat, and would certainly have been all put to the sword or made prisoners, had not the Numantines, with a generosity which their enemies never possessed, offered to let them depart upon condition that a treaty should be concluded with them upon very moderate terms. This the consul very willingly promised, but found himself unable to perform. On the contrary, the people, not satisfied with declaring his treaty null and void, ordered him to be delivered up to the Numantines. The latter refused to accept him, unless he had along with him the 10,000 men whom they had relieved as before related. At last, after the consul had remained a whole day before the city, his successor Furius, thinking this a sufficient recompense to the Numantines for breaking the treaty, ordered him to be received again into the camp. However, Furius did not chuse to engage with such a desperate and resolute enemy as the Numantines had showed themselves; and the war with them was discontinued till the year 133 B. C. when Scipio Æmilianus, the destroyer of Carthage, was sent against them. Against this renowned commander the Numantines with all their valour were not able to contend. Scipio, having with the utmost care introduced strict discipline among his troops, and reformed the abuses which his predecessors had suffered in their armies, by degrees brought the Romans to face their enemies, which at his arrival they had absolutely refused to do. Having then ravaged all the country round the town, it was soon blocked up on all sides, and the inhabitants began to feel the want of provisions. At last they resolved to make one desperate attempt for their liberty, and either to break through their enemies, or perish in the attempt. With this view they marched out in good order by two gates, and fell upon the works of the Romans with the utmost fury. The Romans, unable to stand this desperate shock, were on the point of yielding, when Scipio, hastening to the places attacked, with no fewer than 20,000 men, the unhappy Numantines were at last driven into the city, where they sustained for a little longer the miseries of famine. Finding at last, however, that it was altogether impossible to hold out, it was resolved by the majority to submit to the pleasure of the Roman commander. But this resolution was not universally approved. Many shut themselves up in their houses, and died of hunger, while even those who had agreed to surrender repented their offer, and setting fire to their houses, perished in the flames with their wives and children, so that not a single Numantine was left alive to grace the triumph of the conqueror of Carthage.

26 The Romans defeated by the Numantines.

27 Scipio Æmilianus sent against them.

An. 133, B. C.

28 Miserable end of the people.

After the destruction of Numantia the whole of Spain submitted to the Roman yoke; and nothing remarkable happened till the times of the Cimbri, when a prætorian army was cut off in Spain by the Lusitanians. From this time nothing remarkable occurs in the history of Spain till the civil war between Marius and Sylla. The latter having crushed the Marian faction, as related under the article ROME, proscribed all those that had sided against him whom he could not immediately destroy. Among these was Sertorius, a man of consummate valour and experience in war. He had been appointed prætor of Spain by Marius; and upon the overthrow of Marius, retired to that province. Sylla no sooner heard of his arrival in that country, than he sent thither one Caius Annius with a powerful army to drive him out. As Sertorius had but few troops along with him, he dispatched one Julius Salinator with a body of 6000 men to guard the passes of the Pyrenees, and to prevent Annius from entering the country. But Salinator having been treacherously murdered by assassins hired by Annius for that purpose, he no longer met with any obstacle; and Sertorius was obliged to embark for the coast of Africa with 3000 men, being all he had now remaining. With these he landed in Mauritania; but as his men were straggling carelessly about, great numbers of them were cut off by the Barbarians. This new misfortune obliged Sertorious to re-embark for Spain; but finding the whole coast lined with the troops of Annius, he put to sea again, not knowing what course to steer. In this new voyage he met with a small fleet of Cilician pirates; and having prevailed with

29 Sertorius supports the Marian faction in Spain.

30 Is driven out, and undergoes many hardships.

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with them to join him, he made a deſcent on the coaſt of Iviça, overpowered the garriſon left there by Annius, and gained a conſiderable booty. On the news of this victory Annius ſet ſail for Iviça, with a conſiderable ſquadron, having 5000 land forces on board. Sertorius, not intimidated by the ſuperiority of the enemy, prepared to give them battle. But a violent ſtorm ariſing, moſt of the ſhips were driven on ſhore and daſhed to pieces, Sertorius himſelf with great difficulty eſcaping with the ſmall remains of his fleet. For ſome time he continued in great danger, being prevented from putting to ſea by the fury of the waves, and from landing by the enemy; at laſt, the ſtorm abating, he paſſed the ſtraits of Gades, now Gibraltar, and landed near the mouth of the river Bætis. Here he met with ſome ſeamen newly arrived from the Atlantic or Fortunate iſlands; and was ſo charmed with the account which they gave him of thoſe happy regions, that he reſolved to retire thither to ſpend the reſt of his life in quiet and happineſs. But having communicated this deſign to the Cilician pirates, they immediately abandoned him, and ſet ſail for Africa, with an intention to aſſiſt one of the barbarous kings againſt his ſubjects who had rebelled. Upon this Sertorius ſailed thither alſo, but took the oppoſite ſide; and having defeated the king named *Aſcalis*, obliged him to ſhut himſelf up in the city of Tingis, now Tangier, which he cloſely beſieged. But in the mean time Pacianus, who had been ſent by Sylla to aſſiſt the king, advanced with a conſiderable army againſt Sertorius. Upon this the latter, leaving part of his forces before the city, marched with the reſt to meet Pacianus, whoſe army, though greatly ſuperior to his own in number, he entirely defeated; killed the general, and took all his forces priſoners.—The fame of this victory ſoon reached Spain; and the Luſitanians, being threatened with a new war from Annius, invited Sertorius to head their armies. With this requeſt he very readily complied, and ſoon became very formidable to the Romans. Titus Didius, governor of that part of Spain called *Bætica*, firſt entered the liſts with him; but he being defeated, Sylla next diſpatched Metellus, reckoned one of the beſt commanders in Rome, to ſtop the progreſs of this new enemy. But Metellus, notwithſtanding all his experience, knew not how to act againſt Sertorius, who was continually changing his ſtation, putting his army into new forms, and contriving new ſtratagems. On his firſt arrival he ſent for L. Domitius, then prætor of Hither Spain, to his aſſiſtance; but Sertorius being informed of his march, detached Hirtuleius, or Herculeius, his quæſtor, againſt him, who gave him a total overthrow. Metellus then diſpatched Lucius Lollius prætor of Narbonne Gaul againſt Hirtuleius; but he met with no better ſucceſs, being utterly defeated, and his lieutenant-general killed.

31 Lands in Africa, and carries on a ſucceſsful war in that country.

32 Returns to Spain, and defeats the Romans there.

33 Erects Luſitania into a republic.

The fame of theſe victories brought to the camp of Sertorius ſuch a number of illuſtrious Roman citizens of the Marian faction, that he formed a deſign of erecting Luſitania into a republic in oppoſition to that of Rome. Sylla was continually ſending freſh ſupplies to Metellus; but Sertorius with a handful of men, accuſtomed to range about the mountains, to endure hunger and thirſt, and live expoſed to the inclemencies of the weather, ſo haraſſed the Roman army, that Metellus himſelf began to be quite diſcouraged. At laſt, Sertorius hearing that Metellus had ſpoken diſreſpectfully of his courage, challenged his antagoniſt to end the war by ſingle combat; but Metellus very prudently declined the combat, as being advanced in years; yet this refuſal brought upon him the contempt of the unthinking multitude, upon which Metellus reſolved to retrieve his reputation by ſome ſignal exploit, and therefore laid ſiege to Lacobriga, a conſiderable city in thoſe parts. This he hoped to reduce in two days, as there was but one well in the place; but Sertorius having previouſly removed all thoſe who could be of no ſervice during the ſiege, and conveyed 6000 ſkins full of water into the city, Metellus continued a long time before it without making any impreſſion. At laſt, his proviſions being almoſt ſpent, he ſent out Aquinus at the head of 6000 men to procure a new ſupply; but Sertorius falling unexpectedly upon them, cut in pieces or took the whole detachment; the commander himſelf being the only man who eſcaped to carry the news of the diſaſter; upon which Metellus was obliged to raiſe the ſiege with diſgrace.

34 Obliges Metellus to raiſe the ſiege of Lacobriga.

35 Civilizes the Luſitanians.

And now Sertorius, having gained ſome intervals of eaſe in conſequence of the many advantages he had obtained over the Romans, began to civilize his new ſubjects. Their ſavage and furious manner of fighting he changed for the regular order and diſcipline of a well-formed army; he beſtowed liberally upon them gold and ſilver to adorn their arms, and by converſing familiarly with them, prevailed with them to lay aſide their own dreſs for the Roman *toga*. He ſent for all the children of the principal people, and placed them in the great city of Oſca, now Hueſca, in the kingdom of Aragon, where he appointed them maſters to inſtruct them in the Roman and Greek learning, that they might, as he pretended, be capable of ſharing with him the government of the republic. Thus he made them really hoſtages for the good behaviour of their parents; however, the latter were greatly pleaſed with the care he took of their children, and all Luſitania were in the higheſt degree attached to their new ſovereign. This attachment he took care to heighten by the power of ſuperſtition; for having procured a young hind of a milk-white colour, he made it ſo tame that it followed him wherever he went; and Sertorius gave out to the ignorant multitude, that this hind was inſpired by Diana, and revealed to him the deſigns of his enemies, of which he always took care to be well informed by the great numbers of ſpies whom he employed.

36 Pompey the Great ſent againſt him.

While Sertorius was thus employed in eſtabliſhing his authority, the republic of Rome, alarmed at his ſucceſs, reſolved to cruſh him at all events. Sylla was now dead, and all the eminent generals in Rome ſolicited this honourable though dangerous employment. After much debate a decree was paſſed in favour of Pompey the Great, but without recalling Metellus. In the mean time, the troops of one Perpenna, or Perperna, had, in ſpite of all that their general could do, abandoned him, and taken the oath of allegiance to Sertorius. This was a moſt ſignal advantage to Sertorius; for Perpenna commanded an army of 33,000 men, and had come into Spain with a deſign to ſettle there as Sertorius had done; but as he was deſcended from one of the firſt families of Rome, he thought it below his dignity to ſerve under any general, however eminent he might be. But the troops of Perperna were of a different opinion; and therefore declaring that they would ſerve

ſerve none but a general who could defend himſelf, they to a man joined Sertorius; upon which Perperna himſelf finding he could do no better, conſented to ſerve alſo as a ſubaltern.

On the arrival of Pompey in Spain, ſeveral of the cities which had hitherto continued faithful to Sertorius began to waver; upon which the latter reſolved, by ſome ſignal exploit, to convince them that Pompey could no more ſcreen them from his reſentment than Metellus.

37 Sertorius beſieges Lauron.

With this view he laid ſiege to Lauron, now Lirias, a place of conſiderable ſtrength. Pompey, not doubting but he ſhould be able to raiſe the ſiege, marched quite up to the enemy's lines, and found means to inform the garriſon that thoſe who beſieged them were themſelves beſieged, and would ſoon be obliged to retire with loſs and diſgrace. On hearing this meſſage, "I will teach Sylla's diſciple (ſaid Sertorius), that it is the duty of a general to look behind as well as before him." Having thus ſpoken, he ſent orders to a detachment of 6000 men, who lay concealed among the mountains, to come down and fall upon his rear if he ſhould offer to force the lines. Pompey, ſurpriſed at their ſudden appearance, durſt not ſtir out of his camp; and in

38 Takes and burns it in the ſight of Pompey.

the mean time the beſieged, deſpairing of relief, ſurrendered at diſcretion; upon which Sertorius granted them their lives and liberty, but reduced their city to aſhes.

While Sertorius was thus ſucceſsfully contending with Pompey, his queſtor Hirtuleius was entirely defeated by Metellus, with the loſs of 40,000 men; upon which Sertorius advanced with the utmoſt expedition to the banks of the Sucro in Tarraconian Spain, with a

39 Defeats Pompey on the banks of the Sucro.

deſign to attack Pompey before he could be joined by Metellus. Pompey, on his part, did not decline the combat; but, fearing that Metellus might ſhare the glory of the victory, advanced with the greateſt expedition. Sertorius put off the battle till towards the evening; Pompey, though he knew that the night would prove diſadvantageous to him, whether vanquiſhed or victorious, becauſe his troops were unacquainted with the country, reſolved to venture an engagement, eſpecially as he feared that Metellus might arrive in the mean time, and rob him of part of the glory of conquering ſo great a commander. Pompey, who commanded his own right wing, ſoon obliged Perperna, who commanded Sertorius's left, to give way. Hereupon Sertorius himſelf, taking upon him the command of that wing, brought back the fugitives to the charge, and obliged Pompey to fly in his turn. In his flight he was overtaken by a gigantic African, who had already lifted up his hand to diſcharge a blow at him with his broad ſword; but Pompey prevented him by cutting off his right hand at one blow. As he ſtill continued his flight, he was wounded and thrown from his horſe; ſo that he would certainly have been taken priſoner, had not the Africans who purſued him quarrelled about the rich furniture of his horſe. This gave an opportunity to the general to make his eſcape; ſo that at length he reached his camp with much difficulty. But in the mean time Afranius, who commanded the left wing of the Roman army, had entirely defeated the wing which Sertorius had left, and even purſued them ſo cloſe that he entered the camp along with them. Sertorius, returning ſuddenly, found the Romans buſy in plundering the tents; when taking advantage of their ſituation, he drove them out with great ſlaughter, and retook their camp. Next day he offered battle a ſecond time to Pompey; but Metellus then coming up with all his forces, he thought proper to decline an engagement with both commanders. In a few

40 Pompey defeated a ſecond time.

days, however, Pompey and Metellus agreed to attack the camp of Sertorius. The event was ſimilar to that of the former battle; Metellus defeated Perperna, and Sertorius routed Pompey. Being then informed of Perperna's misfortune, he haſtened to his relief; rallied the fugitives, and repulſed Metellus in his turn, wounded him with his lance, and would certainly have killed him, had not the Romans, aſhamed to leave their general in diſtreſs, haſtened to his aſſiſtance, and renewed the fight with great fury. At laſt Sertorius was obliged to quit the field, and retire to the mountains. Pompey

41 Pompey and Metellus driven from Spain by Sertorius.

and Metellus haſtened to beſiege him; but while they were forming their camp, Sertorius broke through their lines, and eſcaped into Luſitania. Here he ſoon raiſed ſuch a powerful army, that the Roman generals, with their united forces, did not think proper to venture an engagement with him. They could not, however, reſiſt the perpetual attacks of Sertorius, who now drove them from place to place, till he obliged them to ſeparate; the one went into Gaul, and the other to the foot of the Pyrenees.

42 Sertorius treacherouſly murdered.

Thus did this celebrated commander triumph over all the power of the Romans; and there is little doubt but he would have continued to make head againſt all the other generals whom the republic could have ſent, had he not been aſſaſſinated at an entertainment by the infamous treachery of Perperna, in 73 B. C. after he had made head againſt the Roman forces for almoſt 10 years. An. 73. B. C. Pompey was no ſooner informed of his death, than, without waiting for any new ſuccours, he marched againſt the traitor, whom he eaſily defeated and took priſoner; and having cauſed him to be executed, thus put an end, with very little glory, to a moſt dangerous war.

Many of the Spaniſh nations, however, ſtill continued to bear the Roman yoke with great impatience; and as the civil wars which took place firſt between Julius Cæſar and Pompey, and afterwards between Octavianus and Antony, diverted the attention of the republic from Spain, by the time that Auguſtus had become ſole maſter of the Roman empire, they were again in a condition to aſſert their liberty. The CANTABRIANS and ASTURIANS were the moſt powerful and valiant nations at that time in Spain; but, after incredible efforts, they were obliged to lay down their arms, or rather were almoſt exterminated by Agrippa, as related under theſe articles.

43 Spain under the Romans.

When the Romans firſt became maſters of the weſtern peninſula of Europe, to which, as we have ſaid, they gave the name of Hiſpania, it was divided into two provinces, called *Citerior* and *Ulterior*, which were governed, ſometimes by prætors, and ſometimes by proconſuls. In the diſtribution of the empire by Auguſtus, *Hiſpania Citerior* contained the modern provinces of Gallicia, the Aſturias, Biſcay, Navarre, Leon, the two Caſtiles, Aragon, Catalonia, Murcia, and Valencia; and was denominated *Provincia Tarraconenſis*, from the city of Tarragona in Catalonia, which was then the ſeat of government. *Hiſpania Ulterior* was ſubdivided into Bœtica, including the provinces now called Granada and

Spain.

and Andalusia; and Lusitania, comprehending the greatest part of Estremadura, and the modern kingdom of Portugal. The province called *Tarraconensis* was then inhabited by the following tribes, viz. the *Ausetani*, occupying the sea coast, at the north-east, between the Ter and the Lobregat, and having for their capital Germa; the *Ceretani*, inhabiting the district of Cerdana, at the foot of the Pyrenees, whose capital was *Julia*, the modern Llivia; the *Valetani*, occupying the sea coast between the rivers Ter and Lobregat, in the immediate neighbourhood of the *Ausetani*, and whose capital was Barcelona; the *Cosetani* to the left of the mouth of the Ebro, with Tarragona for their capital; the *Locetani*, on the left bank of the river *Sicoris*; the *Illergetes*, extending from that river to the small stream Gallego, which joins the Ebro near Zaragoza, whose capital was Lerida; the *Jacetani* in the northern extremity of Aragon, having their seat of government at Jaca; the *Vascones* in Navarre, and the *Varduii* in the modern Guipuzcoa. These nations occupied the southern and eastern parts of the province. The northern was possessed by the *Caristi*, the *Ostregones*, both in Biscay; the *Cantabri*, cantoned near the source of the Ebro, and along the bay of Biscay; the *Astures* in Asturias and part of Leon; the *Callæci* in Gallicia; the *Vacceni* along the Douro; the *Arebaci* in Old Castile; the *Celtiberi*, between the Ebro and the source of the Tagus, and many others of inferior note.

Lusitania was held by three principal tribes, the *Lusitani*, occupying the greater part of the province, and having for their capital the modern Lisbon; the *Vettones* and the *Celtici*.

Bætica was inhabited by the *Turdetani*, the *Turduli*, the *Bastitani*, and the *Bastuli*.

All these districts, with their principal towns, are minutely treated of by Dr Playfair, in the first volume of his geography.

44 State of Roman Spain.

When incorporated with the Roman empire, Spain partook of its tranquillity, and received in exchange for her liberty, at least wise laws and a mild government. If she could not prevent herself from falling under the dominion of the masters of the world, she was at least the most powerful, the richest, and the happiest province of their empire. Columella has left us an interesting account of her agriculture under the first emperors. The tradition of her ancient population is probably exaggerated, but the ruins of several towns prove it to have been considerable. It was increased by a great many Roman families after the conquest; several legions were established in Spain; 25 colonies were distributed in the most fertile parts of the country, and intermarried with the inhabitants. After a while the Spaniards, seeing in their masters only countrymen, were the first to solicit the rights of Roman citizens, by which they were completely consolidated. Some municipal towns went so far as to desire permission to take the title of colonies, though in the change they lost their independence, nearly in the same manner as certain proprietors of lands under the feudal system converted their domains into fiefs, in order to enjoy the honours attached to them. The government was, in general, milder in Spain than in the other Roman provinces. The administration was carried on in the towns by magistrates named by themselves, and the different provinces were under the superintendance of prætors, proconsuls, and legates or deputies, according to the different eras of the Roman empire; those in their respective departments took care of all the works of public utility, the aqueducts, baths, circuses, and highways, whose magnificent ruins are still existing; but they were principally employed in collecting the revenues of the state, which were singularly analogous to those of the present times. They principally arose from dues, fines, or alienations of property, and the produce of the mines. Spain at that time drew from her own mines the same riches she now draws from the new world, and they were distributed in nearly the same manner. One part belonged to the state, and the other to the inhabitants of the country, who paid a certain duty on the metals which they procured from the mines. Their returns went on increasing, and depended entirely on the number of hands which could be devoted to work in the mines. An employment, so laborious, however, which required a numerous population, tended to diminish that population by the excessive fatigues which it occasioned. Agriculture also suffered by the accumulation of estates in the hands of a few wealthy landholders. By the little attention paid to it by the proprietors, and by the defects inseparable from the system of cultivation by means of slaves, commerce and industry languished; and Spain, after having shared in the splendor of the Roman empire, was beginning to participate in its decline, when a new calamity, by completing her ruin, prepared her regeneration.

This calamity was the irruption of the northern hordes, which soon involved Spain in the general attack. This province was invaded first by the Franks, who in the third century had entered Gaul with a formidable force.

45 Spain invaded by the Franks. A. D. 260.

The Rhine, though dignified by the title of Safeguard of the Provinces, was an imperfect barrier against the daring spirit of enterprise with which the Franks were actuated. Their rapid devastations stretched from the river to the foot of the Pyrenees; nor were they stopped by those mountains. Spain, which had never dreaded, was unable to resist the inroads of the Germans. During 12 years, the greatest part of the reign of Gallienus, that opulent country was the theatre of unequal and destructive hostilities. Tarragona, the flourishing capital of a peaceful province, was sacked and almost destroyed; and so late as the days of Orosius, who wrote in the 5th century, wretched cottages, scattered amidst the ruins of magnificent cities, still recorded the rage of the barbarians. When the exhausted country no longer supplied a variety of plunder, the Franks seized on some vessels, and retreated to Mauritania.

46 By the Suevi, Vandals, &c. An. 409.

The situation of Spain, separated, on all sides, from the enemies of Rome, by the sea, by the mountains, and by intermediate provinces, had secured the long tranquillity of that remote and sequestered country; and we may observe, as a sure symptom of domestic happiness, that, in a period of 400 years, Spain furnished very few materials to the history of the Roman empire. The footsteps of the Barbarians, who, in the reign of Gallienus, had penetrated beyond the Pyrenees, were soon obliterated by the return of peace; and in the 4th century of the Christian era, the cities of Emerita or Merida, of Corduba, Seville, Bracara, and Tarragona, were numbered with the most illustrious of the Roman world.

The

Spain.

The various plenty of the animal, the vegetable, and the mineral kingdoms, was improved and manufactured by the ſkill of an induſtrious people; and the peculiar advantages of naval ſtores contributed to ſupport an extenſive and profitable trade. The arts and ſciences flouriſhed under the protection of the emperors; and if the character of the Spaniards was enfeebled by peace and ſervitude, the hoſtile approach of the Germans, who had ſpread terror and deſolation from the Rhine to the Pyrenees, ſeemed to rekindle ſome ſparks of military ardour. As long as the defence of the mountains was intruſted to the hardy and faithful militia of the country, they ſucceſsfully repelled the frequent attempts of the Barbarians. But no ſooner had the national troops been compelled to reſign their poſt to the Honorian bands, in the ſervice of Conſtantine, than the gates of Spain were treacherouſly betrayed to the public enemy, about ten months before the ſack of Rome by the Goths. The conſciouſneſs of guilt, and the thirſt of rapine, prompted the mercenary guards of the Pyrenees to deſert their ſtation; to invite the arms of the Suevi, the Vandals, and the Alani; and to ſwell the torrent which was poured with irreſiſtible violence from the frontiers of Gaul to the ſea of Africa. The misfortunes of Spain may be deſcribed in the language of its moſt eloquent hiſtorian, who has conciſely expreſſed the paſſionate, and perhaps exaggerated, declamations of contemporary writers. "The irruption of theſe nations was followed by the moſt dreadful calamities; as the Barbarians exerciſed their indiſcriminate cruelty on the fortunes of the Romans and the Spaniards; and ravaged with equal fury the cities and the open country. The progreſs of famine reduced the miſerable inhabitants to feed on the fleſh of their fellow creatures; and even the wild beaſts, who multiplied, without controul, in the deſert, were exaſperated, by the taſte of blood, and the impatience of hunger, boldly to attack and devour their human prey. Peſtilence ſoon appeared, the inſeparable companion of famine; a large proportion of the people was ſwept away; and the groans of the dying excited only the envy of their ſurviving friends. At length the Barbarians, ſatiated with carnage and rapine, and afflicted by the contagious evil which they themſelves had introduced, fixed their permanent ſeats in the depopulated country. The ancient Gallicia, whoſe limits included the kingdom of Old Caſtile, was divided between the Suevi and the Vandals, the Alani were ſcattered over the provinces of Carthagena and Luſitania, and from the Mediterranean to the Atlantic ocean; and the fruitful territory of Bætica was allotted to the Silingi, another branch of the Vandalic nation. After regulating this partition, the conquerors contracted with their new ſubjects ſome reciprocal engagements of protection and obedience: the lands were again cultivated; and the towns and villages were again occupied by a captive people. The greateſt part of the Spaniards was even diſpoſed to prefer this new condition of poverty and barbariſm, to the ſevere oppreſſions of the Roman government; yet there were many who ſtill aſſerted their native freedom, and who refuſed, more eſpecially in the mountains of Gallicia, to ſubmit to the barbarian yoke *."

* *Mariana de reb. Hiſpan.* lib. v.

An. 414. The important preſent of the heads of Jovinus and Sebaſtian, had approved the friendſhip of Adolphus, and reſtored Gaul to the obedience of his brother Honorius. Peace was incompatible with the ſituation and temper of the king of the Goths. He readily accepted the propoſal of turning his victorious arms againſt the barbarians of Spain; the troops of Conſtantius intercepted his communication with the ſea-ports of Gaul, and gently preſſed his march towards the Pyrenees. He paſſed the mountains, and ſurpriſed, in the name of the emperor, the city of Barcelona. The fondneſs of Adolphus for his Roman bride, Placidia, was not abated by time or poſſeſſion; and the birth of a ſon, ſurnamed, from his illuſtrious grandſire, Theodoſius, appeared to fix him for ever in the intereſt of the republic. The loſs of that infant, whoſe remains were depoſited in a ſilver coffin in one of the churches near Barcelona, afflicted his parents; but the grief of the Gothic king was ſuſpended by the labours of the field: and the courſe of his victories was ſoon interrupted by domeſtic treaſon. He had imprudently received into his ſervice one of the followers of Sarus; a barbarian of a daring ſpirit, but of a diminutive ſtature; whoſe ſecret deſire of revenging the death of his beloved patron, was continually irritated by the ſarcaſms of his inſolent maſter. Adolphus was An. 415. aſſaſſinated in the palace of Barcelona; the laws of the ſucceſſion were violated by a tumultuous faction; and a ſtranger to the royal race, Singeric, the brother of Sarus himſelf, was ſeated on the Gothic throne. The firſt act of his reign was the inhuman murder of the ſix children of Adolphus, the iſſue of a former marriage, whom he tore, without pity, from the feeble arms of a venerable biſhop. The unfortunate Placidia, inſtead of the reſpectful compaſſion, which ſhe might have excited in the moſt ſavage breaſts, was treated with cruel and wanton inſult. The daughter of the emperor Theodoſius, confounded among a crowd of vulgar captives, was compelled to march on foot above 12 miles, before the horſe of a barbarian, the aſſaſſin of a huſband whom Placidia loved and lamented.

47 Conquered by the Goths. An. 415—418.

But Placidia ſoon obtained the pleaſure of revenge; and the view of her ignominious ſufferings might rouſe an indignant people againſt the tyrant, who was aſſaſſinated on the ſeventh day of his uſurpation. After the death of Singeric, the free choice of the nation beſtowed the Gothic ſceptre on Wallia, whoſe warlike and ambitious temper appeared, in the beginning of his reign, extremely hoſtile to the republic. He marched, in arms, from Barcelona to the ſhores of the Atlantic ocean, which the ancients revered and dreaded as the boundary of the world. But when he reached the ſouthern promontory of Spain, and, from the rock now covered by the fortreſs of Gibraltar, contemplated the neighbouring and fertile coaſt of Africa, Wallia reſumed the deſigns of conqueſt, which had been interrupted by the death of Alaric. The winds and waves diſappointed the enterpriſes of the Goths; and the minds of a ſuperſtitious people were deeply affected by the repeated diſaſters of ſtorms and ſhipwrecks. In this diſpoſition, the ſucceſſor of Adolphus no longer refuſed to liſten to a Roman ambaſſador, whoſe propoſals were enforced by the real, or ſuppoſed, approach of a numerous army, under the conduct of the brave Conſtantius. A ſolemn treaty was ſtipulated and obſerved: Placidia was honourably reſtored to her brother; 600,000 meaſures of wheat were delivered to the hungry Goths; and Wallia engaged to draw his ſword in the ſervice of the empire. A bloody war was inſtantly excited among the barbarians of Spain; and the contending princes are ſaid to have

have addreſſed their letters, their ambaſſadors, and their hoſtages, to the throne of the weſtern emperor, exhorting him to remain a tranquil ſpectator of their conteſt; the events of which muſt be favourable to the Romans, by the mutual ſlaughter of their common enemies. The Spaniſh war was obſtinately ſupported, during three campaigns, with deſperate valour, and various ſucceſs; and the martial achievements of Wallia diffuſed through the empire the ſuperior renown of the Gothic hero. He exterminated the Silingi, who had irretrievably ruined the elegant plenty of the province of Bætica. He ſlew in battle the king of the Alani; and the remains of thoſe Scythian wanderers, who eſcaped from the field, inſtead of chooſing a new leader, humbly ſought a refuge under the ſtandard of the Vandals, with whom they were ever afterwards confounded. The Vandals themſelves, and the Suevi, yielded to the efforts of the invincible Goths. The promiſcuous multitude of barbarians, whoſe retreat had been intercepted, were driven into the mountains of Gallicia, where they ſtill continued, in a narrow compaſs, and on a barren ſoil, to exerciſe their domeſtic and implacable hoſtilities. In the pride of victory, Wallia was faithful to his engagements; he reſtored his Spaniſh conqueſts to the obedience of Honorius; and the tyranny of the imperial officers ſoon reduced an oppreſſed people to regret the time of their barbarian ſervitude. While the event of the war was ſtill doubtful, the firſt advantages obtained by the arms of Wallia, had encouraged the court of Ravenna to decree the honours of a triumph to their feeble ſovereign. He entered Rome like the ancient conquerors of nations; and if the monuments of ſervile corruption had not long ſince met with the fate which they deſerved, we ſhould probably find that a crowd of poets, and orators, of magiſtrates and biſhops, applauded the fortune, the wiſdom, and the invincible courage, of the emperor Honorius.

An. 428. After the retreat of the Goths, the authority of Honorius had obtained a precarious eſtabliſhment in Spain; except only in the province of Gallicia, where the Suevi and the Vandals had fortified their camps, in mutual diſcord, and hoſtile independence. The Vandals prevailed; and their adverſaries were beſieged in the Nervaſcan hills, between Leon and Oviedo, till the approach of Count Aſterius compelled, or rather provoked, the victorious barbarians to remove the ſcene of the war to the plains of Bætica. The rapid progreſs of the Vandals ſoon required a more effectual oppoſition; and the maſter-general Caſtinus marched againſt them with a numerous army of Romans and Goths. Vanquiſhed in battle by an inferior enemy, Caſtinus fled with diſhonour to Tarragona; and this memorable defeat, which has been repreſented as the puniſhment, was moſt probably the effect, of his raſh preſumption. Seville and Carthagena became the reward, or rather the prey, of the ferocious conquerors; and the veſſels which they found in the harbour of Carthagena, might eaſily tranſport them to the iſles of Majorca and Minorca, where the Spaniſh fugitives, as in a ſecure receſs, had vainly concealed their families and their fortunes. The experience of navigation, and perhaps the proſpect of Africa, encouraged the Vandals to accept the invitation which they received from Count Boniface; and the death of Gonderic ſerved only to forward and animate the bold enterpriſe. In the room of a prince, not conſpicuous for any ſuperior powers of the mind or body, they acquired his baſtard brother, the terrible Genſeric; a name which, in the deſtruction of the Roman empire, has deſerved an equal rank with the names of Alaric and Attila. Almoſt in the moment of his departure he was informed, that Hermanric, king of the Suevi, had preſumed to ravage the Spaniſh territories, which he was reſolved to abandon. Impatient of the inſult, Genſeric purſued the haſty retreat of the Suevi as far as Merida; precipitated the king and his army into the river Anas, and calmly returned to the ſea ſhore, to embark his victorious troops. The veſſels which tranſported the Vandals over the modern ſtraits of Gibraltar, a channel only twelve miles in breadth, were furniſhed by the Spaniards, who anxiouſly wiſhed their departure; and by the African general, who had implored their formidable aſſiſtance.

When Theodoric king of the Viſigoths encouraged Avitus to aſſume the purple, he offered his perſon and his forces, as a faithful ſoldier of the republic. The exploits of Theodoric ſoon convinced the world, that he had not degenerated from the warlike virtues of his anceſtors. After the eſtabliſhment of the Goths in Aquitain, and the paſſage of the Vandals into Africa, the Suevi, who had fixed their kingdom in Gallicia, aſpired to the conqueſt of Spain, and threatened to extinguiſh the feeble remains of the Roman dominion. The provincials of Carthagena and Tarragona, afflicted by an hoſtile invaſion, repreſented their injuries and their apprehenſions. Count Fronto was diſpatched, in the name of the emperor Avitus, with advantageous offers of peace and alliance; and Theodoric interpoſed his weighty mediation, to declare that, unleſs his brother-in-law, the king of the Suevi, immediately retired, he ſhould be obliged to arm in the cauſe of juſtice and of Rome. "Tell him," replied the haughty Rechiarius, "that I deſpiſe his friendſhip and his arms; but that I ſhall ſoon try, whether he will dare to expect my arrival under the walls of Thoulouſe." Such a challenge urged Theodoric to prevent the bold deſigns of his enemy: He paſſed the Pyrenees at the head of the Viſigoths; the Franks and Burgundians ſerved under his ſtandard; and though he profeſſed himſelf the dutiful ſervant of Avitus, he privately ſtipulated, for himſelf and his ſucceſſors, the abſolute poſſeſſion of his Spaniſh conqueſts. The two armies, or rather the two nations, encountered each other on the banks of the river Urbicus, about 12 miles from Aſtorga; and the deciſive victory of the Goths appeared for a while to have extirpated the name and kingdom of the Suevi. From the field of battle Theodoric advanced to Braga, their metropolis, which ſtill retained the ſplendid veſtiges of its ancient commerce and dignity. His entrance was not polluted with blood, and the Goths reſpected the chaſtity of their female captives, more eſpecially of the conſecrated virgins; but the greateſt part of the clergy and people were made ſlaves, and even the churches and altars were confounded in the univerſal pillage. The unfortunate king of the Suevi had eſcaped to one of the ports of the ocean; but the obſtinacy of the winds oppoſed his flight; he was delivered to his implacable rival; and Rechiarius, who neither deſired nor expected mercy, received, with manly conſtancy, the death which he would probably have inflicted. After this bloody ſacrifice to policy or reſentment, Theodoric carried his victorious

An. 456.

Spain.

victorious arms as far as Merida, the principal town of Lusitania, without meeting any resistance, except from the miraculous powers of St Eulalia; but he was stopped in the full career of success, and recalled from Spain, before he could provide for the security of his conquests. In his retreat towards the Pyrenees, he revenged his disappointment on the country through which he passed; and in the sack of Pallentia and Astorga, he shewed himself a faithless ally, as well as a cruel enemy.

48 Introduction of Christianity. An. 586.—589.

Recared was the first Catholic king of Spain. He had imbibed the faith of his unfortunate brother, and he supported it with more prudence and success. Instead of revolting against his father, Recared patiently expected the hour of his death. Instead of condemning his memory, he piously supposed, that the dying monarch had abjured the errors of Arianism, and recommended to his son the conversion of the Gothic nation. To accomplish that salutary end, Recared convened an assembly of the Arian clergy and nobles, declared himself a Catholic, and exhorted them to imitate the example of their prince. The laborious interpretation of doubtful texts, or the curious pursuit of metaphysical arguments, would have excited endless controversy; and the monarch discreetly proposed to his illiterate audience, two substantial and visible arguments, the testimony of Earth and of Heaven. The *Earth* had submitted to the Nicene synod: the Romans, the Barbarians, and the inhabitants of Spain, unanimously professed the same orthodox creed; and the Visigoths resisted, almost alone, the consent of the Christian world. A superstitious age was prepared to reverence, as the testimony of *Heaven*, the preternatural cures which were performed by the skill or virtue of the Catholic clergy; the baptismal fonts of Osset in Bætica, which were spontaneously replenished each year, on the vigil of Easter; and the miraculous shrine of St Martin of Tours, which had already converted the Suevic prince and people of Gallicia. The Catholic king encountered some difficulties on this important change of the national religion. A conspiracy, secretly fomented by the queen-dowager, was formed against his life; and two counts excited a dangerous revolt in the Narbonnese Gaul. But Recared disarmed the conspirators, defeated the rebels, and executed severe justice; which the Arians, in their turn, might brand with the reproach of persecution. Eight bishops, whose names betray their Barbaric origin, abjured their errors; and all the books of Arian theology were reduced to ashes, with the house in which they had been purposely collected. The whole body of the Visigoths and Suevi were allured or driven into the pale of the Catholic communion; the faith, at least, of the rising generation, was fervent and sincere; and the devout liberality of the Barbarians enriched the churches and monasteries of Spain. Seventy bishops assembled in the council of Toledo, received the submission of their conquerors; and the zeal of the Spaniards improved the Nicene creed, by declaring the procession of the Holy Ghost from the Son, as well as from the Father; a weighty point of doctrine, which produced, long afterwards, the schism of the Greek and Latin churches. The royal proselyte immediately saluted and consulted Pope Gregory, surnamed the Great, a learned and holy prelate, whose reign was distinguished by the conversion of heretics and infidels. The ambassadors of Recared respectfully offered on the threshold of the Vatican his rich presents of gold and gems: they accepted, as a lucrative exchange, the hairs of St John the Baptist; a cross, which inclosed a small piece of the true wood; and a key, that contained some particles of iron which had been scraped from the chains of St Peter*.

* Gibbon's Rome, 4to vol. iii. p. 549.

49 Legislative assemblies of the Goths in Spain.

After their conversion from idolatry or heresy, the Franks and the Visigoths were disposed to embrace, with equal submission, the inherent evils, and the accidental benefits of superstition. But the prelates of France, long before the extinction of the Merovingian race, had degenerated into fighting and hunting barbarians. They disdained the use of synods; forgot the laws of temperance and chastity, and preferred the indulgence of private ambition and luxury, to the greatest interest of the sacerdotal profession. The bishops of Spain respected themselves, and were respected by the public: their indissoluble union disguised their vices, and confirmed their authority; and the regular discipline of the church introduced peace, order, and stability into the government of the state. From the reign of Recared, the first Catholic king, to that of Witiza, the immediate predecessor of the unfortunate Roderic, sixteen national councils were successively convened. The six metropolitans, Toledo, Seville, Merida, Braga, Tarragona and Narbonne, presided according to their respective seniority; the assembly was composed of their suffragan bishops, who appeared in person, or by their proxies; and a place was assigned to the most holy, or opulent, of the Spanish abbots. During the first three days of the convocation, as long as they agitated the ecclesiastical questions of doctrine and discipline, the profane laity was excluded from their debates; which were conducted, however, with decent solemnity. But, on the morning of the fourth day, the doors were thrown open for the entrance of the great officers of the palace, the dukes and counts of the provinces, the judges of the cities, and the Gothic nobles; and the decrees of Heaven were ratified by the consent of the people. The same rules were observed in the provincial assemblies, the annual synods, which were empowered to hear complaints, and to redress grievances; and a legal government was supported by the prevailing influence of the Spanish clergy. The bishops who, in each revolution, were prepared to flatter the victorious, and to insult the prostrate, laboured, with diligence and success, to kindle the flames of persecution, and to exalt the mitre above the crown. Yet the national councils of Toledo, in which the free spirit of the Barbarians was tempered, and guided by episcopal policy, have established some prudent laws for the benefit of the king and people. The vacancy of the throne was supplied by the choice of the bishops and palatines; and after the failure of the line of Alaric, the regal dignity was still limited to the pure and noble blood of the Goths. The clergy, who anointed their lawful prince, always recommended, and sometimes practised, the duty of allegiance; and the spiritual censures were denounced on the heads of the impious subjects, who should resist his authority, conspire against his life, or violate, by an indecent union, the chastity even of his widow. But the monarch himself, when he ascended the throne, was bound by a reciprocal oath to God and his people, that he would faithfully execute his important trust. The real or imaginary faults of his administration were subject to the

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the controul of a powerful ariſtocracy; and the biſhops and palatines were guarded by a fundamental privilege that they ſhould not be degraded, impriſoned, tortured, nor puniſhed with death, exile, or confiſcation, unleſs by the free and public judgement of their peers.

50 Code of the Viſigoths.

One of theſe legiſlative councils of Toledo, examined and ratified the code of laws which had been compiled by a ſucceſſion of Gothic kings, from the fierce Eurice, to the devout Egica. As long as the Viſigoths themſelves were ſatisfied with the rude cuſtoms of their anceſtors, they indulged their ſubjects of Aquitaine and Spain in the enjoyment of the Roman law. Their gradual improvement in arts, in policy, and at length in religion, encouraged them to imitate, and to ſuperſede, theſe foreign inſtitutions, and to compoſe a code of civil and criminal juriſprudence, for the uſe of a great and united people. The ſame obligations, and the ſame privileges, were communicated to the nations of the Spaniſh monarchy; and the conquerors, inſenſibly renouncing the Teutonic idiom, ſubmitted to the reſtraints of equity, and exalted the Romans to the participation of freedom. The merit of this impartial policy was enhanced by the ſituation of Spain, under the reign of the Viſigoths. The provincials were long ſeparated from their Arian maſters, by the irreconcileable difference of religion. After the converſion of Recared had removed the prejudices of the Catholics, the coaſts, both of the ocean and Mediterranean, were ſtill poſſeſſed by the Eaſtern emperors, who ſecretly excited a diſcontented people to reject the yoke of the barbarians, and to aſſert the name and dignity of Roman citizens. The allegiance of doubtful ſubjects is indeed moſt effectually ſecured by their own perſuaſion, that they hazard more in a revolt, than they can hope to obtain by a revolution; but it has appeared ſo natural to oppreſs thoſe whom we hate and fear, that the contrary ſyſtem well deſerves the praiſe of wiſdom and moderation.

The Gothic princes continued to reign over a conſiderable part of Spain till the beginning of the 8th century, when their empire was overthrown by the Saracens. During this period, they had entirely expelled the eaſtern emperors from what they poſſeſſed in Spain, and even made conſiderable conqueſts in Barbary; but towards the end of the 7th century the Saracens overran all that part of the world with a rapidity which nothing could reſiſt; and having ſoon poſſeſſed themſelves of the Gothic dominions in Barbary, they made a deſcent upon Spain about the year 711 or 712. The king of the Goths at that time was called *Roderic*, and by his bad conduct had occaſioned great diſaffection among his ſubjects. He therefore determined to put all to the iſſue of a battle, knowing that he could not depend upon the fidelity of his own people if he allowed the enemy time to tamper with them. The two armies met in a plain near Xeres in Andaluſia. The Goths began the attack with great fury; but though they fought like men in deſpair, they were at laſt defeated with exceſſive ſlaughter, and their king himſelf was ſuppoſed to have periſhed in the battle, being never more heard of.

51 The Gothic kingdom overthrown by the Saracens. An. 711.

By this battle the Moors in a ſhort time rendered themſelves maſters of almoſt all Spain. The poor remains of the Goths were obliged to retire into the mountainous parts of Aſturias, Burgos, and Biſcay: the inhabitants of Aragon, Catalonia, and Navarre, though they might have made a conſiderable ſtand againſt the enemy, choſe for the moſt part to retire into France. In 718, however, the power of the Goths began again to revive under Don Pelagio or Pelayo, a prince of the royal blood, who headed thoſe that had retired to the mountains after the fatal battle of Xeres. The place where he firſt laid the foundation of his government was in the Aſturias, in the province of Liebana, about nine leagues in length and four in breadth. This is the moſt inland part of the country, full of mountains enormouſly high, and ſo much fortified by nature, that its inhabitants are capable of reſiſting almoſt any number of invaders. Alakor the Saracen governor was no ſooner informed of this revival of the Gothic kingdom, than he ſent a powerful army, under the command of one Alchaman, to cruſh Don Pelagio before he had time to eſtabliſh his power. The king, though his forces were ſufficiently numerous (every one of his ſubjects arrived at man's eſtate being a ſoldier), did not think proper to venture a general engagement in the open field; but taking poſt with part of them himſelf in a cavern in a very high mountain, he concealed the reſt among precipices, giving orders to them to fall upon the enemy as ſoon as they ſhould perceive him attacked by them. Theſe orders were punctually executed, though indeed Don Pelagio himſelf had repulſed his enemies, but not without a miracle, as the Spaniſh hiſtorians pretend. The ſlaughter was dreadful; for the troops who lay in ambuſcade joining the reſt, and rolling down huge ſtones from the mountains upon the Moors (the name by which the Saracens were known in Spain), no fewer than 124,000 of theſe unhappy people periſhed in one day. The remainder fled till they were ſtopped by a river, and beginning to coaſt it, part of a mountain ſuddenly fell down, ſtopped up the channel of the river, and either cruſhed or drowned, by the ſudden riſing of the water, almoſt every one of that vaſt army.

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52 The power of the Goths revives under Pelagio. An. 718.

53 He gives the Saracens a dreadful overthrow.

The Moors were not ſo much diſheartened by this diſaſter, but that they made a ſecond attempt againſt Don Pelagio. Their ſucceſs was as bad as ever, the greateſt part of their army being cut in pieces or taken; in conſequence of which, they loſt all the Aſturias, and never dared to enter the liſts with Pelagio afterwards. Indeed, their bad ſucceſs had in a great meaſure taken from them the deſire of conquering a country where little or nothing was to be gained; and therefore they rather directed their force againſt France, where they hoped for more plunder. Into this country they poured in prodigious multitudes; but were utterly defeated, in 732, by Charles Martel, with the loſs of 300,000 men, as the hiſtorians of thoſe times pretend.

54 Another army cut in pieces or taken.

The ſubſequent hiſtory of Spain is rendered ſo confuſed by the numerous kingdoms that were eſtabliſhed either by the Chriſtians or the Moors, that ſome chronological guide is neceſſary to make it intelligible. Before purſuing the thread of the narration, we ſhall lay before our readers the following chronological table of the cotemporary monarchs from Pelagio to Ferdinand VII.

Chronological

Chronological Table of the Kings of Spain.

Year.	*Asturias and Leon.*	*Castile.*	*Aragon.*	*Navarre.*	*Saracens.*
718	Pelagius.				
737	Favila.				
739	Alphonso I.				
755	- - -	- - -	- - -	- - -	Abdoulrahman I.
758	Froila I.				
768	Aurelio.				
774	Silo.				
783	Mauregat.				
788	Bermudo I.	- - -	- - -	- - -	Hissem.
791	Alphonso II.				
795	- - -	- - -	- - -	- - -	Hachem.
822	- - -	- - -	- - -	- - -	Abdoulrahman II.
845	Ramiro I.				
851	Ordogno I.	- - -	- - -	Garcias Ximenes.	
853	- - -	- - -	- - -	- - -	Mahomet.
862	Alphonso III.				
880	- - -	- - -	- - -	Fortunio I.	
886	- - -	- - -	- - -	- - -	Almundar.
888	- - -	- - -	- - -	- - -	Abdallah.
905	- - -	- - -	- - -	Sancho I.	
910	Garcias.				
912	- - -	- - -	- - -	- - -	Abdoulrahman III.
913	Ordogno II.				
923	Froila II.				
924	Alphonso IV.				
926	- - -	- - -	- - -	Garcias II.	
927	Ramiro II.				
950	Ordogno III.				
956	Sancho.				
961	- - -	- - -	- - -	- - -	Alhacan.
967	Ramiro III.				
976	- - -	- - -	- - -	- - -	Hissem.
978	- - -	- - -	- - -	Sancho II.	
982	Bermudo II.				
994	- - -	- - -	- - -	Garcias III.	
999	Alphonso V.				
1000	- - -	- - -	- - -	Sancho III.	
1014	- - -	- - -	- - -	- -	Cordova overthrown
1027	Bermudo III.				
1035	- - -	- - -	Ramiro I.	Garcias IV.	
1037	Sancho I. Ferdinand I. of Castile.	Ferdinand I.			
1054	- - -	- - -	- - -	Sancho IV.	
1063	- - -	- - -	Sancho.		
1067	Sancho II.	Sancho I.			
1073	Alphonso VI.	Alphonso I.			
1076	- - -	- - -	- - -	Sancho V.	
1094	- - -	- - -	Pedro I.	Pedro I.	
1104	- - -	- - -	Alphonso I.	Alphonso I.	
1109	Urraca.	Alphonso II.			
1112	Alphonso VII.				

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Year.	Asturias and Leon.	Castile.	Aragon.	Navarre.	Saracens.
1126	Alphonso VIII.	Alphonso III.			
1134	- - -	- - -	Ramiro II.	Garcias V.	
1137	- - -	- - -	Petronilla.		
1150	- - -	- - -	- - -	Sancho VI.	
1157	Ferdinand II.	Sancho II.			
1158	- - -	Alphonso IV.			
1162	- - -	- - -	Alphonso II.		
1188	Alphonso IX.				
1194	- - -	- - -	- - -	Sancho VII.	
1196	- - -	- - -	Pedro II.		
1213	- - -	- - -	James I.		
1214	- - -	Henry.			
1217	- - -	Berenger. Ferd. I.			
1234	- - -	- - -	- - -	Thibaut I.	
1236	- - -	- - -	- - -	- - -	Mahomet.
1252	- - -	Alphonso V. -			
1253	- - -	- - -		Thibaut II.	
1270	- - -	- - -	- - -	Henry.	
1273	- - -	- - -	- - -	- - -	Muley.
1274	- - -	- - -	- - -	Joanna.	
1276	- - -	- - -	Pedro III.		
1284	- - -	Sancho III.			
1285	- - -	- - -	Alphonso III.		
1291	- - -	- - -	James II.		
1295	- - -	Ferdinand II.			
1302	- - -	- - -	- - -	- - -	Mahomet II.
1304	- - -	- - -	- - -	Lewis.	
1310	- - -	- - -	- - -	- -	Nazer.
1312	- - -	Alphonso VI.			
1315	- - -	- - -	- - -	- - -	Ismael.
1316	- - -	- - -	- - -	Philip.	
1322	- - -	- - -	- - -	Charles.	
1326	- - -	- - -	- - -	- - -	Mahomet III.
1327	- - -	- - -	Alphonso IV.		
1328	- - -	- - -	- - -	Joanna II.	
1333	- - -	- - -	- - -	- - -	Juzaf I.
1336	- - -	- - -	Pedro IV.		
1349	- - -	- - -	- - -	Charles II.	
1350	- - -	Pedro.			
1354	- - -	- - -	- - -	- - -	Lago I.
1369	- - -	Henry II.			
1374	- - -	- - -	- - -	- - -	Mahomet IV.
1379	- - -	John.	- - -	- - -	Mahomet V.
1387	- - -	- - -	- - -	Charles III.	
1390	- - -	Henry III.			
1392	- - -	- - -	- - -	- - -	Juzaf II.
1395	- - -	- - -	Martin.		
1396	- - -	- - -	- - -	- - -	Balba.
1404	- - -	John II.			
1408	- - -	- - -	- - -	- - -	Juzaf III.
1412	- - -	- - -	Ferdinand I.		
1416	- - -	- - -	Alphonso V.	- - -	Elaziri.
1423	- - -	- - -	- - -		
1425	- - -	- - -	- - -	Blanche.	
1427	- - -	- - -	- - -	- - -	Zagair.
1432	- - -	- - -	- - -	- - -	Juzaf IV.
1441	- - -	- - -	- - -	John.	
1445	- - -	- - -	- - -	- - -	Ben Osmin.

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Spains | Spain.

Year.	Asturias and Leon.	Castile.	Aragon.	Navarre.	Saracens.
1450	- - -	Henry IV.	- - -	- - -	Ismael.
1453	- - -	- -			
1458	- - -	- -	John II.		
1459	- - -	- -	Ferdinand II.		
1474	- - -	Isabella and Ferdinand V.			
1475	- - -	- - -	- - -	Eleonora.	Abilhussan.
1479	- - -	- - -	- - -	Francis.	
1483	- - -	- - -	- - -	Catherine.	
1485	- - -	- - -	- - -	John.	Abouabdalla.
1504	- - -	Joan.			
1506	- - -	Philip I.			
1516	- - -	Charles I.	- - -	Henry.	
1553	- - -	- - -	- - -	Joanna III.	
1556	- - -	Philip II.	- - -	Anthony.	
1572	- - -	- - -	- - -	Henry.	
1598	- - -	Philip III.			

Kings of Spain.

Years.	Monarchs.
	House of Austria.
1516	Charles I. (V.).
1556	Philip II.
1598	Philip III.
1621	Philip IV.
1665	Charles II.
	House of Bourbon.
1700	Philip V.
1723	Louis I.
1724	Philip V. again.
1746	Ferdinand VI.
1759	Charles III.
1788	Charles IV.
1808	Ferdinand VII.

An. 737. Don Pelagio died in 737; and soon after his death such intestine divisions broke out among the Moors, as greatly favoured the increase of the Christian power. In 745 Don Alonso the Catholic, son-in-law to Pelagio, in conjunction with his brother Froila, passed the mountains, and fell upon the northern part of Gallicia; and meeting with little resistance, he recovered almost the whole of that province in a single campaign. Next year he invaded the plains of Leon and Castile; and before the Moors could assemble any force to oppose him, he reduced Astorgas, Leon, Saldagna, Montes de Oca, Amaya, Alava, and all the country at the foot of the mountains. The year following he pushed his conquests as far as the borders of Portugal, and the next campaign ravaged the country as far as Castile. Being sensible, however, that he was yet unable to defend the flat country which he had conquered, he laid the whole of it waste, obliged the Christians to retire to the mountains, and carried off all the Moors for slaves. Thus secured by a desert frontier, he met with no interruption for some years; during which time, as his kingdom advanced in strength, he allowed his subjects gradually to occupy part of the flat country, and to rebuild Leon and Astorgas, which he had demolished. He died in 758, and was succeeded by his son Don Froila. In his time Abdoulrahman, the khaliff's viceroy in Spain, threw off the yoke, and rendered himself independent, fixing the seat of his government at Cordova. Thus the intestine divisions among the Moors were composed; yet their success seems to have been little better than before; for, soon after, Froila encountered the Moors with such success, that 54,000 of them were killed on the spot, and their general taken prisoner. Soon after he built the city of Oviedo, which he made the

55 Conquests of the Christians. An. 745.

56 The Saracens in Spain throw off the yoke of the khaliffs. An. 758.

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the capital of his dominions, in order to be in a better condition to defend the flat country, which he now determined to people.

57 History of the kingdom of Navarre. An. 850.

In the year 850 the power of the Saracens received another blow by the rise of the kingdom of Navarre. This kingdom, we are told, took its origin from an accidental meeting of gentlemen, to the number of 600, at the tomb of an hermit named *John*, who had died among the Pyrenees. At this place, where they had met on account of the supposed sanctity of the deceased, they took occasion to converse on the cruelty of the Moors, the miseries to which the country was exposed, and the glory that would result from throwing off their yoke; which, they supposed, might easily be done, by reason of the strength of their country. On mature deliberation, the project was approved; one Don Garcias Ximenes was appointed king, as being of illustrious birth, and looked upon as a person of great abilities. He recovered Ainsa, one of the principal towns of the country, out of the hands of the infidels, and his successor Don Garcias Inigas extended his territories as far as Biscay; however, the Moors still possessed Portugal, Murcia, Andalusia, Valencia, Granada, Tortosa, with the interior part of the country as far as the mountains of Castile and Zaragoza. Their internal dissensions, which revived after the death of Abdoulrahman, contributed greatly to reduce the power of the infidels in general. In 778, Charles the Great being invited by some discontented Moorish governors, entered Spain with two great armies; one passing through Catalonia, and the other through Navarre, where he pushed his conquests as far as the Ebro. On his return he was attacked and defeated by the Moors; though this did not hinder him from keeping possession of all those places he had already reduced. At this time he seems to have been master of Navarre: however, in 831 Count Azner, revolting from Pepin son to the emperor Louis, asserted the independency of Navarre; but the sovereigns did not assume the title of kings till the time of Don Garcias, who began to reign in 857.

58 Conquests of Charles the Great.

An. 921.

In the mean time, the kingdom founded by Don Pelagio, now called the kingdom of *Leon* and *Oviedo*, continued to increase rapidly in strength, and many advantages were gained over the Moors, who having two enemies to contend with, lost ground every day. In 921, however, they gained a great victory over the united forces of Navarre and Leon, by which the whole force of the Christians in Spain must have been entirely broken, had not the victors conducted their affairs so wretchedly, that they suffered themselves to be almost entirely cut in pieces by the remains of the Christian army. In short, the Christians became at length so terrible to the Moors, that it is probable they could not long have kept their footing in Spain, had not a great general, named *Mohammed Ebn Amir Almanzor*, appeared, in 979, to support their sinking cause. This man was visir to the king of Cordova, and being exceedingly provoked against the Christians on account of what his countrymen had suffered from them, made war with the most implacable fury. He took the city of Leon, murdered the inhabitants, and reduced the houses to ashes. Barcelona shared the same fate; Castile was reduced to a desert; Gallicia and Portugal ravaged; and he is said to have overcome the Christians in fifty different engagements. At last, having taken and demolished the city of Compostella, and carried off in triumph the gates of the church of St James, a flux happened to break out among his troops, which the superstitious Christians supposed to be a divine judgement on account of his sacrilege. Taking it for granted, therefore, that the Moors were now entirely destitute of all heavenly aid, they fell upon them with such fury in the next engagement, that all the valour and conduct of Almanzor could not prevent a defeat. Overcome with shame and despair at this misfortune, he desired his followers to shift for themselves, while he himself retired to Medina Cœli, and put an end to his life by abstinence in the year 998.

59 Exploits of Almanzor a Saracen general. An. 979

60 He is defeated, and starves himself to death. An. 998.

61 Rise of the kingdom of Castile. An. 1037.

During this period a new Christian principality appeared in Spain, namely that of Castile, which is now divided into the Old and New Castile. The Old Castile was recovered long before that called the *New*. It was separated from the kingdom of Leon on one side by some little rivers; on the other, it was bounded by the Asturias, Biscay, and the province of Rioja. On the south it had the mountains of Segovia and Avila; thus lying in the middle between the Christian kingdom of Leon and Oviedo, and the Moorish kingdom of Cordova. Hence this district soon became an object of contention between the kings of Leon and those of Cordova; and as the former were generally victorious, some of the principal Castilian nobility retained their independence under the protection of the Christian kings, even when the power of the Moors was at its greatest height. In 884 we first hear of Don Rodriguez assuming the title of *count of Castile*, though it does not appear that either his territory or title were given him by the king of Leon. Nevertheless, this monarch having taken upon him to punish some of the Castilian lords as rebels, the inhabitants made a formal renunciation of their allegiance, and set up a new kind of government. The supreme power was now vested in two persons of quality styled *judges*; however, this method did not long continue to give satisfaction, and the sovereignty was once more vested in a single person. By degrees Castile fell entirely under the power of the kings of Leon and Oviedo; and, in 1037, Don Sancho bestowed it on his eldest son Don Ferdinand, with the title of *king*; and thus the territories of Castile were first firmly united to those of Leon and Oviedo, and the sovereigns were thenceforth styled *kings of Leon and Castile*.

62 Rise of Aragon. An. 1035.

Besides all these, another Christian kingdom was set up in Spain about the beginning of the 11th century. This was the kingdom of Aragon. The inhabitants were very brave, and lovers of liberty, so that it is probable they had in some degree maintained their independence, even when the power of the Moors was greatest. The history of Aragon, however, during its infancy, is much less known than that of any of the others hitherto mentioned. We are only assured, that about the year 1035, Don Sancho, surnamed the *Great*, king of Navarre, erected Aragon into a kingdom in favour of his son Don Ramiro, and afterwards it became very powerful. At this time, then, we may imagine the continent of Spain divided into two unequal parts by a straight line drawn from east to west, from the coasts of Valencia to a little below the mouth of the Douro. The country north of this belonged to the Christians, who, as yet, had the smallest and least valuable

63 State of Spain in the beginning of the 11th century.

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able ſhare, and all the reſt to the Moors. In point of wealth and real power, both by land and ſea, the Moors were much ſuperior; but their continual diſſenſions greatly weakened them, and every day facilitated the progreſs of the Chriſtians. Indeed, had either of the parties been united, the other muſt ſoon have yielded; for though the Chriſtians did not make war upon each other conſtantly as the Moors did, their mutual feuds were yet ſufficient to have ruined them, had their adverſaries made the proper uſe of the advantages thus afforded them. But among the Moors almoſt every city was a kingdom; and as theſe petty ſovereignties ſupported one another very indifferently, they fell a prey one after another to their enemies. In 1080, the king of Toledo was engaged in a war with the king of Seville, another Mooriſh potentate; which being obſerved by Alphonſo king of Caſtile, he alſo invaded his territories; and in four years made himſelf maſter of the city of Toledo, with all the places of importance in its neighbourhood; from thenceforth making Toledo the capital of his dominions. In a ſhort time the whole province of New Caſtile ſubmitted; and Madrid, the preſent capital of Spain, fell into the hands of the Chriſtians, being at that time but a ſmall place.

64 Toledo and Madrid taken by the Chriſtians. An. 1080.

The Moors were ſo much alarmed at theſe conqueſts, that they not only entered into a general confederacy againſt the Chriſtians, but invited to their aſſiſtance Mahomet Ben Joſeph the ſovereign of Barbary. He accordingly came, attended by an incredible multitude; but was utterly defeated by the Chriſtians in the defiles of the Black Mountain, or Sierra Morena, on the borders of Andaluſia. This victory happened on the 16th of July 1212, and the anniverſary is ſtill celebrated at Toledo. This victory was not improved; the Chriſtian army immediately diſperſed themſelves, while the Moors of Andaluſia were ſtrengthened by the remains of the African army; yet, inſtead of being taught, by their paſt misfortunes, to unite among themſelves, their diſſenſions became worſe than ever, and the conqueſts of the Chriſtians became daily more rapid. In 1236, Don Ferdinand of Caſtile and Leon took the celebrated city of Cordova, the reſidence of the firſt Mooriſh kings; at the ſame time that James I. of Aragon diſpoſſeſſed them of the iſland of Majorca, and drove them out of Valencia. Two years after, Ferdinand made himſelf maſter of Murcia, and took the city of Seville; and in 1303 Ferdinand IV. reduced Gibraltar.

65 A ſignal victory gained over the Moors. An. 1212.

An. 1236.

66 England interferes in the Spaniſh affairs.

In the time of Edward III. we find England, for the firſt time, interfering in the affairs of Spain, on the following occaſion. In the year 1284 the kingdom of Navarre had been united to that of France by the marriage of Donna Joanna queen of Navarre with Philip the Fair of France. In 1328, however, the kingdoms were again ſeparated, though the ſovereigns of Navarre were ſtill related to thoſe of France. In 1350, Charles, ſurnamed the *Wicked*, aſcended the throne of Navarre, and married the daughter of John king of France. Notwithſtanding this alliance, and that he himſelf was related to the royal family of France, he ſecretly entered into a negociation with England againſt the French monarch, and even drew into his ſchemes the dauphin Charles, afterwards ſurnamed *the Wiſe*. The young prince, however, was ſoon after made fully ſenſible of the danger and folly of the connections into which he had entered; and, by way of atonement, promiſed to ſacrifice his aſſociates. Accordingly he invited the king of Navarre, and ſome of the principal nobility of the ſame party, to a feaſt at Rouen, where he betrayed them to his father. The moſt obnoxious were executed, and the king of Navarre was thrown into priſon. In this extremity, the party of the king of Navarre had recourſe to England. The prince of Wales, ſurnamed *the Black Prince*, invaded France, defeated King John at Poictiers, and took him priſoner*; which unfortunate event produced the moſt violent diſturbances in that kingdom. The dauphin, now about 19 years of age, naturally aſſumed the royal power during his father's captivity: but poſſeſſed neither experience nor authority ſufficient to remedy the prevailing evils. In order to obtain ſupplies, he aſſembled the ſtates of the kingdom: but that aſſembly, inſtead of ſupporting his adminiſtration, laid hold of the preſent opportunity to demand limitations of the prince's power, the puniſhment of paſt malverſations, and the liberty of the king of Navarre. Marcel, provoſt of the merchants of Paris, and firſt magiſtrate of that city, put himſelf at the head of the unruly populace, and puſhed them to commit the moſt criminal outrages againſt the royal authority. They detained the dauphin in a kind of captivity, murdered in his preſence Robert de Clermont and John de Conflans, mareſchals of France; threatened all the other miniſters with the like fate; and when Charles, who had been obliged to temporize and diſſemble, made his eſcape from their hands, they levied war againſt him, and openly rebelled. The other cities of the kingdom, in imitation of the capital, ſhook off the dauphin's authority, took the government into their own hands, and ſpread the contagion into every province.

67 The king of Navarre impriſoned by John king of France.

* See *France*, N° 44.

68 Eſcapes, and heads the French malecontents.

Amidſt theſe diſorders, the king of Navarre made his eſcape from priſon, and preſented a dangerous leader to the furious malecontents. He revived his pretenſions to the crown of France: but in all his operations he acted more like a leader of banditti than one who aſpired to be the head of a regular government, and who was engaged by his ſtation to endeavour the re-eſtabliſhment of order in the community. All the French, therefore, who wiſhed to reſtore peace to their country, turned their eyes towards the dauphin; who, though not remarkable for his military talents, daily gained by his prudence and vigilance the aſcendant over his enemies. Marcel, the ſeditious provoſt of Paris, was ſlain in attempting to deliver that city to the king of Navarre. The capital immediately returned to its duty: the moſt conſiderable bodies of the mutinous peaſants were diſperſed or put to the ſword; ſome bands of military robbers underwent the ſame fate; and France began once more to aſſume the appearance of civil government.

John was ſucceeded in the throne of France by his ſon Charles V. a prince educated in the ſchool of adverſity, and well qualified, by his prudence and experience, to repair the loſſes which the kingdom had ſuſtained from the errors of his predeceſſors. Contrary to the practice of all the great princes of thoſe times, who held nothing in eſtimation but military courage, he ſeems to have laid it down as a maxim, never to appear at the head of his armies; and he was the firſt European monarch that ſhowed the advantage of policy and foreſight over a raſh and precipitate valour.

Before Charles could think of counterbalancing ſo great

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great a power as England, it was neceſſary for him to remedy the many diſorders to which his own kingdom was expoſed. He accordingly turned his arms againſt the king of Navarre, the great diſturber of France during that age; and he defeated that prince, and reduced him to terms, by the valour and conduct of Bertrand du Gueſclin, one of the moſt accompliſhed captains of thoſe times, whom Charles had the diſcernment to chooſe as the inſtrument of his victories. He alſo ſettled the affairs of Britanny, by acknowledging the title of Mountfort, and receiving homage for his dominions. But much was yet to be done. On the concluſion of the peace of Bretigni, the many military adventurers who had followed the fortunes of Edward, being diſperſed into the ſeveral provinces, and poſſeſſed of ſtrong holds, refuſed to lay down their arms, or relinquiſh a courſe of life to which they were now accuſtomed, and by which alone they could earn a ſubſiſtence. They aſſociated themſelves with the banditti, who were already inured to the habits of rapine and violence; and, under the name of *companies* and *companions*, became a terror to all the peaceable inhabitants. Some Engliſh and Gaſcon gentlemen of character were not aſhamed to take the command of theſe ruffians, whoſe number amounted to near 40,000, and who bore the appearance of regular armies rather than bands of robbers. As Charles was not able by power to redreſs ſo enormous a grievance, he was led by neceſſity, as well as by the turn of his character, to correct it by policy; to diſcover ſome method of diſcharging into foreign countries this dangerous and inteſtine evil; and an occaſion now offered.

69 Is defeated and obliged to ſubmit to the terms preſcribed by Charles V. of France.

70 Account of the banditti called *companies* or *companions*.

71 Reign of Pedro the Cruel, king of Caſtile.

Alphonſo XI. king of Caſtile, who took the city of Algezira from the Moors, after a famous ſiege of two years, during which artillery are ſaid firſt to have been uſed by the beſieged, had been ſucceeded by his ſon Pedro I. ſurnamed *the Cruel;* a prince equally perfidious, debauched, and bloody. He began his reign with the murder of his father's miſtreſs, Leonora de Guſman: his nobles fell every day the victims of his ſeverity: he put to death his couſin and one of his natural brothers, from groundleſs jealouſy; and he cauſed his queen Blanche de Bourbon, of the blood of France, to be thrown into priſon, and afterwards poiſoned, that he might enjoy in quiet the embraces of Mary de Padella, with whom he was violently enamoured.

Henry count of Traſtamara, the king's natural brother, alarmed at the fate of his family, and dreading his own, took arms againſt the tyrant; but having failed in the attempt, he fled to France, where he found the minds of men much inflamed againſt Pedro, on account of the murder of the French princeſs. He aſked permiſſion of Charles to enliſt the *companies* in his ſervice, and to lead them into Caſtile againſt his brother. The French king, charmed with the project, employed du Gueſclin in negociating with the leaders of theſe banditti. The treaty was ſoon concluded; and du Gueſclin having completed his levies, led the army firſt to Avignon, where the pope then reſided, and demanded, ſword in hand, abſolution for his ruffian ſoldiers, who had been excommunicated, and the ſum of 200,000 livres for their ſubſiſtence. The firſt was readily promiſed him, but ſome difficulty being made with regard to the ſecond, du Gueſclin replied, "My fellows, I believe, may make a ſhift to do without your abſolution, but the money is abſolutely neceſſary." His holineſs then extorted from the inhabitants of the city and its neighbourhood the ſum of 100,000 livres, and offered it to du Gueſclin. "It is not my purpoſe (cried that generous warrior) to oppreſs the innocent people. The pope and his cardinals can ſpare me double the ſum from their own pockets. I therefore inſiſt, that this money be reſtored to the owners; and if I hear they are defrauded of it, I will myſelf return from the other ſide of the Pyrenees, and oblige you to make them reſtitution." The pope found the neceſſity of ſubmitting, and paid from his own treaſury the ſum demanded.

72 The Companies employed againſt him.

73 He is driven out, but aſſiſted by the Black Prince.

A body of experienced and hardy ſoldiers, conducted by ſo able a general, eaſily prevailed over the king of Caſtile, whoſe ſubjects were ready to join the enemy againſt their oppreſſor. Pedro fled from his dominions, took ſhelter in Guienne, and craved the protection of the prince of Wales, whom his father had inveſted with the ſovereignty of the ceded provinces, under the title of the *principality of Aquitaine*. The prince promiſed his aſſiſtance to the dethroned monarch; and having obtained his father's conſent, he levied an army, and ſet out on his enterpriſe.

The firſt loſs which Henry of Traſtamara ſuffered from the interpoſition of the prince of Wales, was the recalling of the companies from his ſervice; and ſo much reverence did they pay to the name of Edward, that great numbers of them immediately withdrew from Spain, and enliſted under his ſtandard. Henry, however, beloved by his new ſubjects, and ſupported by the king of Arragon, was able to meet the enemy with an army of 100,000 men, three times the number of thoſe commanded by the Black Prince: yet du Gueſclin, and all his experienced officers, adviſed him to delay a deciſive action; ſo high was their opinion of the valour and conduct of the Engliſh hero! But Henry, truſting to his numbers, ventured to give Edward battle on the banks of the Ebro, between Najara and Navarette; where the French and Spaniards were defeated, with the loſs of above 20,000 men, and du Gueſclin and other officers of diſtinction taken priſoners. All Caſtile ſubmitted to the victor; Pedro was reſtored to the throne, and Edward returned to Guienne with his uſual glory; having not only overcome the greateſt general of his age, but reſtrained the moſt blood-thirſty tyrant from executing vengeance on his priſoners.

74 The Spaniards defeated, and Peter reſtored.

This gallant warrior had ſoon reaſon to repent of his connection with a man like Pedro, loſt to all ſenſe of virtue and honour. The ungrateful monſter refuſed the ſtipulated pay to the Engliſh forces. Edward abandoned him: he treated his ſubjects with the utmoſt barbarity; their animoſity was rouſed againſt him; and du Gueſclin having obtained his ranſom, returned to Caſtile with the count of Traſtamara, and ſome forces levied anew in France. They were joined by the Spaniſh malecontents; and having no longer the Black Prince to encounter, they gained a complete victory over Pedro in the neighbourhood of Toledo. The tyrant now took refuge in a caſtle, where he was ſoon after beſieged by the victors, and taken priſoner in endeavouring to make his eſcape. He was conducted to his brother Henry; againſt whom he is ſaid to have ruſhed in a tranſport of rage, diſarmed as he was. Henry ſlew him with his own

75 Is again driven out, defeated, and put to death.

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own hand, in resentment of his cruelties; and, though a bastard, was placed on the throne of Castile, which he transmitted to his posterity.

There is little doubt that the character of Pedro has been greatly misrepresented, and that what is considered by most historians as tyranny and wanton cruelty, was only an inflexible regard to justice, necessary perhaps, in those days of anarchy and rebellion. Perhaps that unfortunate monarch owes to the hatred of those he meant to reduce to order, much of the obloquy which has been so plentifully bestowed upon him by historians, who have painted him to us as a tyrant so bloody, so wicked, as almost to exceed the bounds of probability. In Andalusia, where he fixed his residence and seemed most to delight, his memory is not held in the same abhorrence. The Sevillian writers speak of him very differently; and instead of his usual appellation of *Pedro el cruel*, distinguish him by that of *el justiciero*. It is certain that his bastard-brother and murderer, Henry of Trastamara, was guilty of crimes fully as atrocious as any of those imputed to Don Pedro; but as he destroyed him, his family, and adherents, the friends of the new spurious race of monarchs were left at full liberty to blacken the characters of the adverse party, without the fear of being called to an account for calumny, or even contradicted. Truth is now out of our reach; and for want of proper proofs to the contrary, we must sit down contented with what history has left us; and allow Don Pedro to have been one of the most inhuman butchers that ever disgraced a throne.

After the death of Pedro the Cruel, nothing remarkable happened in Spain for almost a whole century; but the debaucheries of Henry IV. of Castile roused the resentment of his nobles, and produced a most singular insurrection, which led to the aggrandizement of the Spanish monarchy.

76
Reign of Henry the Impotent. An. 1450.

This prince, surnamed the *Impotent*, though continually surrounded with women, began his unhappy reign in 1450. He was totally enervated by his pleasures; and every thing in his court conspired to set the Castilians an example of the most abject flattery and most abandoned licentiousness. The queen, a daughter of Portugal, lived as openly with her parasites and her gallants as the king did with his minions and his mistresses. Pleasure was the only object, and effeminacy the only recommendation to favour: the affairs of the state went every day into disorder; till the nobility, with the archbishop of Toledo at their head, combining against the weak and flagitious administration of Henry, arrogated to themselves, as one of the privileges of their order, the right of trying and passing sentence on their sovereign, which they executed in a manner unprecedented in history.

77
He is formally deposed.

All the malecontent nobility were summoned to meet at Avila: a spacious theatre was erected in a plain without the walls of the town: an image, representing the king, was seated on a throne, clad in royal robes, with a crown on its head, a sceptre in its hand, and the sword of justice by its side. The accusation against Henry was read, and the sentence of deposition pronounced, in presence of a numerous assembly. At the close of the first article of the charge, the archbishop of Toledo advanced, and tore the crown from the head of the image; at the close of the second, the Conde de Placentia snatched the sword of justice from its side; at the close of the third, the Conde de Benavente wrested the sceptre from its hand; and at the close of the last, Don Diego Lopez de Stuniga tumbled it headlong from the throne. At the same instant, Don Alphonso, Henry's brother, a boy of about twelve years of age, was proclaimed king of Castile and Leon in his stead.

This extraordinary proceeding was followed by a civil war, which did not cease till some time after the death of the young prince, on whom the nobles had bestowed the kingdom. The archbishop and his party then continued to carry on war in the name of Isabella the king's sister, to whom they gave the title of *Infanta*; and Henry could not extricate himself out of these troubles, nor remain quiet upon his throne till he had signed one of the most humiliating treaties ever extorted from a sovereign; he acknowledged his sister Isabella the only lawful heiress of his kingdom, in prejudice to the rights of his reputed daughter Joan, whom the malecontents affirmed to be the offspring of an adulterous commerce between the queen and Don la Cueva.

78
Is obliged to acknowledge his sister Isabella to be heiress to the kingdom.

The grand object of the malecontent party now was the marriage of the princess Isabella, upon which, it was evident, the security of the crown and the happiness of the people must in a great measure depend. The alliance was sought by several princes: the king of Portugal offered her his hand; the king of France demanded her for his brother, and the king of Aragon for his son Ferdinand. The malecontents very wisely preferred the Aragonian prince, and Isabella prudently made the same choice: articles were drawn up; and they were privately married by the archbishop of Toledo.

79
She is married to Ferdinand of Aragon.

Henry was enraged at this alliance, which he foresaw would utterly ruin his authority, by furnishing his rebellious subjects with the support of a powerful neighbouring prince. He disinherited his sister, and established the rights of his daughter. A furious civil war desolated the kingdom. The names of Joan and Isabella resounded from every quarter, and were everywhere the summons to arms. But peace was at length brought about. Henry was reconciled to his sister and Ferdinand; though it does not appear that he ever renewed Isabella's right to the succession: for he affirmed in his last moments, that he believed Joan to be his own daughter. The queen swore to the same effect; and Henry left a testamentary deed, transmitting the crown to this princess, who was proclaimed queen of Castile at Placentia. But the superior fortune and superior arms of Ferdinand and Isabella prevailed: the king of Portugal was obliged to abandon his niece and intended bride, after many ineffectual struggles, and several years of war. Joan retired into a convent; and the death of Ferdinand's father, which happened about this time, added the kingdoms of Aragon and Sicily to those of Leon and Castile.

80
Union of the kingdoms of Aragon and Sicily with Leon and Castile. An. 1474.

81
Administration of Ferdinand and Isabella.

Ferdinand and Isabella were persons of great prudence, and, as sovereigns, highly worthy of imitation: but they do not seem to have merited all the praises bestowed upon them by the Spanish historians. They did not live like man and wife, having all things in common under the direction of the husband; but like two princes in close alliance; they neither loved nor hated each other; were seldom in company together; had each a separate council; and were frequently jealous of one another in the administration. But they were

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were inseparably united in their common interests; always acting upon the same principles, and forwarding the same ends. Their first object was the regulation of their government, which the civil wars had thrown into the greatest disorder. Rapine, outrage, and murder, were become so common, as not only to interrupt commerce, but in a great measure to suspend all intercourse between one place and another. These evils the joint sovereigns suppressed by their wise policy, at the same time that they extended the royal prerogative.

82 Institution of the Holy Brotherhood,

About the middle of the 13th century, the cities in the kingdom of Aragon, and after their example those in Castile, had formed themselves into an association, distinguished by the name of the *Holy Brotherhood*. They exacted a certain contribution from each of the associated towns; they levied a considerable body of troops, in order to protect travellers and pursue criminals; and they appointed judges, who opened courts in various parts of the kingdom. Whoever was guilty of murder, robbery, or any act that violated the public peace, and was seized by the troops of the Brotherhood, was carried before their judges; who, without paying any regard to the exclusive jurisdiction which the lord of the place might claim, who was generally the author or abettor of the injustice, tried, and condemned the criminals. The nobles often murmured against the salutary institution; they complained of it as an encroachment on one of their most valuable privileges, and endeavoured to get it abolished. But Ferdinand and Isabella, sensible of the beneficial effects of the Brotherhood, not only in regard to the police of their kingdom, but in its tendency to abridge, and by degrees annihilate, the territorial jurisdiction of the nobility, countenanced the institution upon every occasion, and supported it with the whole force of royal authority; by which means the prompt and impartial administration of justice was restored, and with it tranquillity and order returned.

83 and of the Inquisition.

But at the same time that their Catholic majesties (for such was the title they now bore) were giving vigour to their civil government, and securing their subjects from violence and oppression, an intemperate zeal led them to establish an ecclesiastical tribunal, equally contrary to the natural rights of humanity and the mild spirit of the gospel. This was the court of inquisition; which decides upon the honour, fortune, and even the life, of the unhappy wretch who happens to fall under the suspicion of heresy, or a contempt of any thing prescribed by the church, without his knowing, being confronted with his accusers, or permitted either defence or appeal. Six thousand persons were burnt by order of this sanguinary tribunal within four years after the appointment of Torquemada, the first inquisitor-general; and upwards of 100,000 felt its fury. The same furious and blinded zeal which led to the depopulation of Spain, led also to its aggrandizement.

84 Conquest of Granada. An. 1492.

The kingdom of Granada now alone remained of all the Mahometan possessions in Spain. Princes equally zealous and ambitious were naturally disposed to turn their eyes to that fertile territory, and to think of increasing their hereditary dominions, by expelling the enemies of Christianity, and extending its doctrines. Every thing conspired to favour their project: the Moorish kingdom was a prey to civil wars; when Ferdinand, having obtained the bull of Sixtus IV. authorizing a crusade, put himself at the head of his troops, and entered Granada. He continued the war with rapid success: Isabella attended him in several expeditions; and they were both in great danger at the siege of Malaga; an important city, which was defended with great courage, and taken in 1487. Baza was reduced in 1489, after the loss of 20,000 men. Gaudix and Almeria were delivered up to them by the Moorish king Alzagel, who had first dethroned his brother Alboacen, and afterwards been chased from his capital by his nephew Abdali. That prince engaged in the service of Ferdinand and Isabella; who, after reducing every other place of eminence, undertook the siege of Granada. Abdali made a gallant defence; but all communication with the country being cut off, and all hopes of relief at an end, he capitulated, after a siege of eight months, on condition that he should enjoy the revenue of certain places in the fertile mountains of Alpuxarras; that the inhabitants should retain the undisturbed possession of their houses, goods, and inheritances; the use of their laws, and the free exercise of their religion (B). Thus ended the empire of the Arabs in Spain, after it had continued about 800 years. They introduced the arts and sciences into Europe at a time when it was lost in darkness; they possessed many of the luxuries of life, when they were not even known among the neighbouring nations; and they seem to have given birth to that romantic gallantry which so eminently prevailed in the ages of chivalry, and which, blending itself with the veneration of the northern nations for the softer sex, still particularly distinguishes ancient from modern manners. But the Moors, notwithstanding these advantages, and the eulogies bestowed upon them by some writers, appear always to have been destitute of the essential qualities of a polished people, humanity, generosity, and mutual sympathy.

The overthrow of the last Moorish kingdom was soon followed by the expulsion of the Saracens from Spain. This expulsion did not entirely take place till the 17th century. Vast numbers of the Moors, indeed, oppressed by their conquerors, abandoned a country where they could not reside with comfort and with freedom. From the reign of Ferdinand of Castile, to that of Philip III. of Spain, more than 3,000,000 of those people quitted Spain, and carried with them, not only a great part of their acquired wealth, but that industry and love of labour which are the foundation of national prosperity.

85 Prosperous state of Spain under the Moorish dominion.

The state of Spain has never been so flourishing at any period of its civilization, as during the period when it was chiefly possessed by the Moors. The first Saracen invaders, and the twenty successive lieutenants of the caliphs of Damascus, were attended by a numerous train of civil and military followers, who preferred a distant

(B) The particulars of the conquest of Granada are involved in much obscurity. If we were to credit the narrative of Giles Perez, as related by Mr Swinburne, the circumstances which led to that conquest were of a most romantic nature. See Swinburne's Travels, Letter xxi.

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distant fortune to narrow circumstances at home; the private and public interest was promoted by the establishment of faithful colonies, and the cities of Spain were proud to commemorate the tribe or the country of their eastern progenitors. Ten years after the conquest, a map of the province was presented to the caliph, shewing the seas, the rivers, and the harbours, the inhabitants and cities, the climate, the soil, and the mineral productions of the earth. In the space of two centuries, the gifts of nature were improved by agriculture, the manufactures, and the commerce of an industrious people; though the effects of their diligence have been magnified by the idleness of their fancy. The first of the Ommiades who reigned in Spain solicited the support of the Christians; and in his edict of peace and protection, he contents himself with a modest imposition of 10,000 ounces of gold, 10,000 pounds of silver, 10,000 horses, as many mules, 1000 cuirasses, with an equal number of helmets and lances. The most powerful of his successors derived from the same kingdom the annual tribute of 12,045,000 dinars or pieces of gold, about 6,000,000l. of sterling money; a sum which, in the 10th century, most probably surpassed the united revenues of the Christian monarchs. His royal seat of Cordova contained 600 mosques, 900 baths, and 200,000 houses; he gave laws to 80 cities of the first, to 300 of the second and third order; and the fertile banks of the Guadalquivir were adorned with 12,000 villages and hamlets. The Arabs might exaggerate the truth; but they created and they describe the most prosperous era of the riches, the cultivation, and the populousness of Spain (c).

86
Jews expelled from Spain.

The conquest of Granada was followed by the expulsion, or rather the pillage and banishment, of the Jews, who had engrossed all the wealth and commerce of Spain. The inquisition exhausted its rage against these unhappy people, many of whom pretended to embrace Christianity, in order to preserve their property. About the same time their Catholic majesties concluded an alliance with the emperor Maximilian, and a treaty of marriage for their daughter Joan with his son Philip, archduke of Austria and sovereign of the Netherlands. About this time also the contract was concluded with Christopher Columbus for the discovery of new countries; and the counties of Roussillon and Cerdagne were agreed to be restored by Charles VIII. of France, before his expedition into Italy. The discovery of America was soon followed by extensive conquests in that quarter, as is related under the articles MEXICO, PERU, CHILI, &c. which tended to raise the Spanish monarchy above any other in Europe.

87
Discovery of America, &c.

88
Accession of Charles V.
An. 1516.

On the death of Isabella, which happened in 1506, Philip archduke of Austria came to Castile in order to take possession of that kingdom as heir to his mother-in-law; but he dying in a short time after, his son Charles V. afterwards emperor of Germany, became heir to the crown of Spain. His father at his death left the king of France governor to the young prince, and Ferdinand at his death left Cardinal Ximenes sole regent of Castile, till the arrival of his grandson. This man, whose character is no less singular than illustrious, who united the abilities of a great statesman with the abject devotion of a superstitious monk, and the magnificence of a prime minister with the severity of a mendicant, maintained order and tranquillity in Spain, notwithstanding the discontents of a turbulent and high-spirited nobility. When they disputed his right to the regency, he coolly shewed them the testament of Ferdinand, and the ratification of that deed by Charles; but these not satisfying them, and argument proving ineffectual, he led them insensibly towards a balcony, whence they had a view of a large body of troops under arms, and

(c) Abdoulrahman III. monarch of Cordova, surpassed all his predecessors in splendour, riches, and expence; and his subjects vied with each other in profusion and magnificence. Some idea may be entertained of the opulence and grandeur of the Moors of Cordova in the 10th century, by perusing the following enumeration of the presents made to Abdoulrahman by Abumelik his grand vizir, on his appointment to that office. We are told that the minister caused to be brought before the throne, and laid at the feet of his master,

400 lbs. of virgin gold.
Ingots of silver to the value of 420,000 sequins.
400 lbs. of lignum aloes, one piece weighing 140 lb.
500 oz. of ambergris.
300 oz. of camphor.
30 pieces of gold tissue, so rich that none but the caliph could wear it.
10 suits of Khorassan sables.
100 suits of fur of a less valuable sort.
48 sets of gold and silk long trappings for horses.
4000 lbs. of silk.
30 Persian carpets.
800 iron coats-of-mail for war horses.
1000 shields.
100,000 arrows.
15 led horses of Arabia, as richly caparisoned as those on which the caliph was wont to ride.
100 horses of an inferior price.
20 mules with all their accoutrements.

40 young men, and 20 girls of exquisite beauty, and most sumptuously apparelled. This display of riches was accompanied with a most flattering poem, composed by the minister in praise of his sovereign, who in return for his homage, assigned him a pension of 100,000 pieces of gold, about 50,000l. sterling.

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and a formidable train of artillery. "Behold (ſaid the cardinal) the powers which I have received from his Catholic majeſty: by theſe I govern Caſtile; and will govern it, till the king, your maſter and mine, ſhall come to take poſſeſſion of his kingdom." A declaration ſo bold and determined ſilenced all oppoſition; and Ximenes maintained his authority till the arrival of Charles in 1517.

89 Diſgrace and death of Cardinal Ximenes.

The young king was received with univerſal acclamations of joy; but Ximenes found little cauſe to rejoice. He was ſeized with a violent diſorder, ſuppoſed to be the effect of poiſon; and when he recovered, Charles, prejudiced againſt him by the Spaniſh grandees and his Flemiſh courtiers, ſlighted his advice, and allowed him every day to ſink into neglect. The cardinal did not bear this treatment with his uſual fortitude of ſpirit. He expected a more grateful return from a prince to whom he delivered a kingdom more flouriſhing than it had been in any former age, and authority more extenſive and better eſtabliſhed than the moſt illuſtrious of his anceſtors had ever poſſeſſed. Conſcious of his own integrity and merit, he could not therefore refrain from giving vent, at times, to indignation and complaint. He lamented the fate of his country, and foretold the calamities to which it would be expoſed from the inſolence, the rapaciouſneſs, and the ignorance of ſtrangers. But in the mean time he received a letter from the king, diſmiſſing him from his councils, under pretence of eaſing his age of that burden which he had ſo long and ſo ably ſuſtained. This letter proved fatal to the miniſter; for he expired in a few hours after reading it.

90 Maximilian attempts to get Charles elected emperor.

While Charles was taking poſſeſſion of the throne of Spain, in conſequence of the death of one grandfather, another was endeavouring to obtain for him the imperial crown. With this view Maximilian aſſembled a diet at Augſburg, where he cultivated the favour of the electors by many acts of beneficence, in order to engage them to chooſe that young prince as his ſucceſſor. But Maximilian himſelf never having been crowned by the pope, a ceremony deemed eſſential in that age, as well as in the preceding, he was conſidered only as king of the Romans, or emperor elect; and no example occurring in hiſtory of any perſon being choſen ſucceſſor to a king of the Romans, the Germans, always tenacious of their forms, obſtinately refuſed to confer upon Charles a dignity for which their conſtitution knew no name.

But though Maximilian could not prevail upon the German electors to chooſe his grandſon of Spain king of the Romans, he had diſpoſed their minds in favour of that prince; and other circumſtances, on the death of the emperor, conſpired to the exaltation of Charles. The imperial crown had ſo long continued in the Auſtrian line, that it began to be conſidered as hereditary in that family; and Germany, torn by religious diſputes, ſtood in need of a powerful emperor, not only to preſerve its own internal tranquillity, but alſo to protect it againſt the victorious arms of the Turks, who under Selim I. threatened the liberties of Europe. This fierce and rapid conqueror had already ſubdued the Mamelukes, and made himſelf maſter of Egypt and Syria. The power of Charles appeared neceſſary to oppoſe that of Selim. The extenſive dominions of the houſe of Auſtria, which gave him an intereſt in the preſervation of Germany; the rich ſovereignty of the Netherlands and Franche Compté; the entire poſſeſſion of the great and warlike kingdom of Spain, together with that of Naples and Sicily, all united to hold him up to the firſt dignity among Chriſtian princes; and the new world ſeemed only to be called into exiſtence that its treaſures might enable him to defend Chriſtendom againſt the infidels. Such was the language of his partiſans.

91 Francis I. aſpires to the ſame dignity.

Francis I. however, no ſooner received intelligence of the death of Maximilian, than he declared himſelf a candidate for the empire; and with no leſs confidence of ſucceſs than Charles. He truſted to his ſuperior years and experience; his great reputation in arms; and it was farther urged in his favour, that the impetuoſity of the French cavalry, added to the firmneſs of the German infantry, would prove irreſiſtible, and not only be ſufficient, under a warlike emperor, to ſet limits to the ambition of Selim, but to break entirely the Ottoman power, and prevent it from ever becoming dangerous again to Germany.

Both claims were plauſible. The dominions of Francis were leſs extenſive, but more united than thoſe of Charles. His ſubjects were numerous, active, brave, lovers of glory, and lovers of their king. Theſe were ſtrong arguments in favour of his power, ſo neceſſary at this juncture: but he had no natural intereſt in the Germanic body; and the electors, hearing ſo much of military force on each ſide, became more alarmed for their own privileges than the common ſafety. They determined to reject both candidates, and offered the imperial crown to Frederic, ſurnamed the *Wiſe*, duke of Saxony. But he, undazzled by the ſplendour of an object courted with ſo much eagerneſs, by two mighty monarchs, rejected it with a magnanimity no leſs ſingular than great.

92 Speech of Frederic duke of Saxony in favour of Charles.

"In times of tranquillity (ſaid Frederic), we wiſh for an emperor who has no power to invade our liberties; times of danger demand one who is able to ſecure our ſafety. The Turkiſh armies, led by a warlike and victorious monarch, are now aſſembling: they are ready to pour in upon Germany with a violence unknown in former ages. New conjunctures call for new expedients. The imperial ſceptre muſt be committed to ſome hand more powerful than mine or that of any other German prince. We poſſeſs neither dominions, nor revenues, nor authority, which enable us to encounter ſuch a formidable enemy. Recourſe muſt be had, in this exigency, to one of the rival monarchs. Each of them can bring into the field forces ſufficient for our defence. But as the king of Spain is of German extraction, as he is a member and prince of the empire by the territories which deſcend to him from his grandfather, and as his dominions ſtretch along that frontier which lies moſt expoſed to the enemy, his claim, in my opinion, is preferable to that of a ſtranger to our language, to our blood, and to our country." Charles was elected in conſequence of this ſpeech in the year 1520.

93 He is elected in conſequence of this ſpeech. An. 1520.

The two candidates had hitherto conducted their rivalſhip with emulation, but without enmity. They had even mingled in their competition many expreſſions of friendſhip and regard. Francis in particular declared with his uſual vivacity, that his brother Charles and he were fairly and openly ſuitors to the ſame miſtreſs: "The moſt aſſiduous and fortunate (added he) will win her; and the other muſt reſt contented." But the preference was no ſooner given to his rival, than Francis diſcovered

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discovered all the passions natural to disappointed ambition. He could not suppress his chagrin and indignation at being baulked in his favourite pursuit, and rejected, in the face of all Europe, for a youth yet unknown to fame. The spirit of Charles resented such contempt; and from this jealousy, as much as from opposition of interests, arose that emulation between those two great monarchs which involved them in almost perpetual hostilities, and kept their whole age in constant agitation.

94
A mutual hatred takes place between Charles and Francis.

Charles and Francis had many interfering claims in Italy; and the latter thought himself bound in honour to restore the king of Navarre to his dominions, unjustly seized by the crown of Spain. They immediately began to negotiate; and as Henry VIII. of England was the third prince of the age in power and in dignity, his friendship was eagerly courted by each of the rivals. He was the natural guardian of the liberties of Europe. Sensible of the consequence which his situation gave him, and proud of his pre-eminence, Henry knew it to be his interest to keep the balance even between the contending powers, and to restrain both, by not joining entirely with either; but he was seldom able to reduce his ideas to practice. Vanity and resentment were the great springs of all his undertakings; and his neighbours, by touching these, found an easy way to draw him into their measures, and force him upon many rash and inconsiderate enterprises.

95
Both court the friendship of Henry VIII. of England.

All the impolitic steps in Henry's government must not, however, be imputed to himself; many of them were occasioned by the ambition and avarice of his prime minister and favourite Cardinal Wolsey. This man, who, by his talents and accomplishments, had risen from one of the lowest conditions in life to the highest employments both in church and state, enjoyed a greater degree of power and dignity than any English subject ever possessed, and governed the haughty, presumptuous, and untractable spirit of Henry, with absolute authority. Francis was equally well acquainted with the character of Henry and of his minister. He had successfully flattered Wolsey's pride, by honouring him with particular marks of his confidence, and bestowing upon him the appellations of *Father*, *Tutor*, and *Governor*; and he had obtained the restitution of Tournay, by adding a pension to those respectful titles. He now solicited an interview with the king of England near Calais; in hopes of being able, by familiar conversation, to attach him to his friendship and interest, while he gratified the cardinal's vanity, by affording him an opportunity of displaying his magnificence in the presence of two courts, and of discovering to the two nations his influence over their monarchs. Charles dreaded the effects of this projected interview between two gallant princes, whose hearts were no less susceptible of friendship than their manners were of inspiring it. Finding it impossible, however, to prevent a visit, in which the vanity of all parties was so much concerned, he endeavoured to defeat its purpose, and to pre-occupy the favour of the English monarch, and of his minister, by an act of complaisance still more flattering and more uncommon. Relying wholly upon Henry's generosity for his safety, he landed at Dover, in his way from Spain to the Low Countries. The king of England, who was on his way to France, charmed with such an instance of confidence, hastened to receive his royal guest; and Charles, during his short stay, had the address not only to give Henry favourable impressions of his character and intentions, but to detach Wolsey entirely from the interest of Francis. The tiara had attracted the eye of that ambitious prelate; and as the emperor knew that the papacy was the sole point of elevation, beyond his present greatness, at which he could aspire, he made him an offer of his interest on the first vacancy.

96
An interview projected between Francis and Henry.

97
Charles visits Henry in England.

98
Henry visits Francis in France.

The day of Charles's departure, Henry went over to Calais with his whole court, in order to meet Francis. Their interview was in an open plain between Guisnes and Ardres; where the two kings and their attendants displayed their magnificence with such emulation and profuse expence, as procured it the name of the *Field of the Cloth of Gold*. Here Henry erected a spacious house of wood and canvas, framed in London, on which, under the figure of an English archer, was the following motto, "He prevails whom I favour;" alluding to his own political situation, as holding in his hands the balance of power among the potentates of Europe. Feats of chivalry however, parties of gallantry, and such exercises as were in that age reckoned manly or elegant, rather than serious business, occupied the two courts during the time that they continued together, which was 18 days.

After taking leave of this scene of dissipation, the king of England paid a visit to the emperor and Margaret of Savoy at Gravelines, and engaged them to go along with him to Calais; where the artful and politic Charles completed the impression which he had begun to make on Henry and his favourite, and effaced all the friendship to which the frank and generous nature of Francis had given birth. He renewed his assurances of assisting Wolsey in obtaining the papacy; and he put him in present possession of the revenues belonging to the sees of Badajoz and Palencia in Spain. He flattered Henry's pride, by convincing him of his own importance, and of the justness of the motto which he had chosen; offering to submit to his sole arbitration any difference that might arise between him and Francis.

99
Charles invested with the imperial crown at Aix-la-Chapelle.

This important point being secured, Charles repaired to Aix-la-Chapelle, where he was solemnly invested with the crown and sceptre of Charlemagne, in presence of a more splendid and numerous assembly than had appeared on any former inauguration. About the same time Solyman the Magnificent, one of the most accomplished, enterprising, and victorious of the Turkish princes, and a constant and formidable rival to the emperor, ascended the Ottoman throne.

The first act of Charles's administration was to appoint a diet of the empire, to be held at Worms, in order to concert with the princes proper measures for checking the progress of "those new and dangerous opinions which threatened to disturb the peace of Germany, and to overturn the religion of their ancestors." The opinions propagated by Luther and his followers were here meant. But all his efforts for that purpose were insufficient, as is related under the articles LUTHER and REFORMATION.

100
War between Francis and Charles. An. 1521.

In 1521, the Spaniards, dissatisfied with the departure of their sovereign, whose election to the empire they foresaw would interfere with the administration of his own kingdom, and incensed at the avarice of the Flemings, to whom the direction of public affairs had been

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been committed since the death of Cardinal Ximenes, several grandees, in order to shake off this oppression, entered into an association, to which they gave the name of the *Sancta Juncta;* and the sword was appealed to as the means of redress. This seemed to Francis a favourable juncture for reinstating the family of John d'Albert in the kingdom of Navarre. Charles was at a distance from that part of his dominions, and the troops usually stationed there had been called away to quell the commotions in Spain. A French army, under Andrew de Foix, speedily conquered Navarre; but that young and inexperienced nobleman, pushed on by military ardour, ventured to enter Castile. The Spaniards, though divided among themselves, united against a foreign enemy, routed his forces, took him prisoner, and recovered Navarre in a shorter time than he had spent in subduing it.

Hostilities thus begun in one quarter, between the rival monarchs, soon spread to another. The king of France encouraged the duke of Bouillon to make war against the emperor, and to invade Luxembourg. Charles, after humbling the duke, attempted to enter France; but was repelled and worsted before Mezieres by the famous Chevalier Bayard, distinguished among his cotemporaries by the appellation of *The Knight without fear and without reproach;* and who united the talents of a great general to the punctilious honour and romantic gallantry of the heroes of chivalry. Francis broke into the Low Countries, where, by an excess of caution, an error not natural to him, he lost an opportunity of cutting off the whole imperial army; and, what was of still more consequence, he disgusted the constable Bourbon, by giving the command of the van to the duke of Alençon.

During these operations in the field, an unsuccessful congress was held at Calais, under the mediation of Henry VIII. It served only to exasperate the parties which it was intended to reconcile. A league was soon after concluded, by the intrigues of Wolsey, between the pope, Henry, and Charles, against France. Leo had already entered into a separate league with the emperor, and the French were fast losing ground in Italy.

The insolence and exactions of Mareshal de Lautrec, governor of Milan, had totally alienated the affections of the Milanese from France. They resolved to expel the troops of that nation, and put themselves under the government of Francis Sforza, brother to Maximilian their late duke. In this resolution, they were encouraged by the pope, who excommunicated Lautrec, and took into his pay a considerable body of Swiss. The papal army, commanded by Prosper Colonna, an experienced general, was joined by supplies from Germany and Naples; while Lautrec, neglected by his court, and deserted by the Swiss in its pay, was unable to make head against the enemy. The city of Milan was betrayed by the inhabitants to the confederates; Parma and Placentia were united to the ecclesiastical state; and of their conquests in Lombardy, only the town of Cremona, the castle of Milan, and a few inconsiderable forts, remained in the hands of the French.

101
Rapid conquests of Charles.

Leo X. received the accounts of this rapid success with such transports of joy, as are said to have brought on a fever, which occasioned his death. The spirit of the confederacy was broken, and its operations suspended by this accident. The Swiss were recalled; some other mercenaries disbanded for want of pay; and only the Spaniards, and a few Germans in the emperor's service, remained to defend the duchy of Milan. But Lautrec, who with the remnant of his army had taken shelter in the Venetian territories, destitute both of men and money, was unable to improve this favourable opportunity as he wished. All his efforts were rendered ineffectual by the vigilance and ability of Colonna and his associates.

Meantime much discord prevailed in the conclave. Wolsey's name, notwithstanding all the emperor's magnificent promises, was scarcely mentioned there. Julio de Medici, Leo's nephew, thought himself sure of the election; when, by an unexpected turn of fortune, Cardinal Adrian of Utrecht, Charles's preceptor, who at that time governed Spain in the emperor's name, was unanimously raised to the papacy, to the astonishment of all Europe and the great disgust of the Italians.

102
Francis invades Italy.

Francis, roused by the rising consequence of his rival, resolved to exert himself with fresh vigour, in order to wrest from him his late conquests in Lombardy. Lautrec received a supply of money, and a reinforcement of 10,000 Swiss. With this reinforcement he was enabled once more to act offensively, and even to advance within a few miles of the city of Milan; when money again failing him, and the Swiss growing mutinous, he was obliged to attack the imperialists in their camp at Bicocca, where he was repulsed with great slaughter, having lost his bravest officers and best troops. Such of the Swiss as survived set out immediately for their own country; and Lautrec, despairing of being able to keep the field, retired into France. Genoa, which still remained subject to Francis, and made it easy to execute any scheme for the recovery of Milan, was soon after taken by Colonna: the authority of the emperor and his faction was everywhere established in Italy. The citadel of Cremona was the sole fortress which remained in the hands of the French.

The affliction of Francis for such a succession of misfortunes was augmented by the unexpected arrival of an English herald, who in the name of his sovereign declared war against France. The courage of this excellent prince, however, did not forsake him; though his treasury was exhausted by expensive pleasures, no less than by hostile enterprises, he assembled a considerable army, and put his kingdom in a posture of defence for resisting this new enemy, without abandoning any of the schemes which he was forming against the emperor. He was surprised, but not alarmed, at such a denunciation.

103
Charles visits England a second time.

Meanwhile Charles, willing to draw as much advantage as possible from so powerful an ally, paid a second visit to the court of England in his way to Spain, where his presence was become necessary. His success exceeded his most sanguine expectations. He not only gained the entire friendship of Henry, who publicly ratified the treaty of Bruges; but disarmed the resentment of Wolsey, by assuring him of the papacy on Adrian's death; an event seemingly not distant, by reason of his age and infirmities. In consequence of these negociations an English army invaded France, under the command of the earl of Surrey; who, at the end of the campaign, was obliged to retire, with his forces greatly reduced,

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reduced, without being able to make himſelf maſter of one place within the French frontier. Charles was more fortunate in Spain: he ſoon quelled the tumults which had there ariſen in his abſence.

While the Chriſtian princes were thus waſting each other's ſtrength, Solyman the Magnificent entered Hungary, and made himſelf maſter of Belgrade, reckoned the chief barrier of that kingdom againſt the Turkiſh power. Encouraged by this ſucceſs, he turned his victorious arms againſt the iſland of Rhodes, at that time the ſeat of the knights of St John of Jeruſalem;
104 Rhodes taken by Solyman.
and though every prince in that age acknowledged Rhodes to be the great bulwark of Chriſtendom in the eaſt, ſo violent was their animoſity againſt each other, that they ſuffered Solyman without diſturbance to carry on his operations againſt that city and iſland. Liſle Adam, the grandmaſter, made a gallant defence; but, after incredible efforts of courage, patience, and military conduct, during a ſiege of ſix months, he was obliged to ſurrender the place, having obtained an honourable capitulation from the ſultan, who admired and reſpected his heroic qualities (ſee RHODES and MALTA). Charles and Francis were equally aſhamed of having occaſioned ſuch a loſs to Chriſtendom by their conteſts; and the emperor, by way of reparation, granted to the knights of St John the ſmall iſland of Malta, where they fixed their reſidence, and continued long to retain their ancient ſpirit, though much diminiſhed in power and ſplendour.

Adrian VI. though the creature of the emperor, and devoted to his intereſt, endeavoured to aſſume the impartiality which became the common father of Chriſtendom, and laboured to reconcile the contending princes, that they might unite in a league againſt Solyman, whoſe conqueſt of Rhodes rendered him more formidable than ever to Europe. The Italian ſtates were no leſs deſirous of peace than the pope: and ſo much regard was paid by the hoſtile powers to the exhortations of his holineſs, and to a bull which he iſſued, requiring all Chriſtian princes to conſent to a truce for three years, that the imperial, the French, and the Engliſh ambaſſadors at Rome, were empowered to treat of that matter; but while they waſted their time in fruitleſs negociations, their maſters were continuing their preparations for war; and other negociations ſoon took place.
105 A powerful confederacy againſt Francis.
The confederacy againſt France became more formidable than ever.

The Venetians, who had hitherto adhered to the French intereſt, formed engagements with the emperor for ſecuring Francis Sforza in the poſſeſſion of the duchy of Milan; and the pope, from a perſuaſion that the ambition of the French monarch was the only obſtacle to peace, acceded to the ſame alliance. The Florentines, the dukes of Ferrara and Mantua, and all the Italian powers, followed this example. Francis was left without a ſingle ally, to reſiſt the efforts of a multitude of enemies, whoſe armies everywhere threatened, and whoſe territories encompaſſed his dominions. The emperor in perſon menaced France with an invaſion on the ſide of Guienne; the forces of England and the Netherlands hovered over Picardy, and a numerous body of Germans was preparing to ravage Burgundy.

The dread of ſo many and ſuch powerful adverſaries, it was thought, would have obliged Francis to keep wholly on the defenſive, or at leaſt have prevented him from entertaining any thoughts of marching into Italy. But before his enemies were able to ſtrike a blow, Francis had aſſembled a great army, with which he hoped to diſconcert all the emperor's ſchemes, by marching it in perſon into Italy: and this bold meaſure, the more formidable becauſe unexpected, could ſcarcely have failed of the deſired effect, had it been immediately carried into execution. But the diſcovery of a domeſtic conſpiracy, which threatened the deſtruction of his kingdom, obliged Francis to ſtop ſhort at Lyons.
106 Francis marches towards Italy, but is obliged to return by a domeſtic conſpiracy.

Charles duke of Bourbon, lord high conſtable of France, was a prince of the moſt ſhining merit: his great talents equally fitted him for the council or the field, while his eminent ſervices to the crown intitled him to its firſt favour. But unhappily Louiſa ducheſs of Angouleme, the king's mother, had contracted a violent averſion againſt the houſe of Bourbon, and had taught her ſon, over whom ſhe had acquired an abſolute aſcendant, to view all the conſtable's actions with a jealous eye. After repeated affronts he retired from court, and began to liſten to the advances of the emperor's miniſters. Meantime the ducheſs of Bourbon died; and as the conſtable was no leſs amiable than accompliſhed, the ducheſs of Angouleme, ſtill ſuſceptible of the tender paſſions, formed the ſcheme of marrying him. But Bourbon, who might have expected every thing to which an ambitious mind can aſpire, from the doating fondneſs of a woman who governed her ſon and the kingdom, incapable of imitating Louiſa in her ſudden tranſition from hate to love, or of meanly counterfeiting a paſſion for one who had ſo long purſued him with unprovoked malice, rejected the match with diſdain, and turned the propoſal into ridicule. At once deſpiſed and inſulted by the man whom love only could have made her ceaſe to perſecute, Louiſa was filled with all the rage of diſappointed woman; ſhe reſolved to ruin, ſince ſhe could not marry, Bourbon. For this purpoſe ſhe commenced an iniquitous ſuit againſt him; and by the chicanery of Chancellor du Prat, the conſtable was ſtripped of his whole family-eſtate. Driven to deſpair by ſo many injuries, he entered into a ſecret correſpondence with the emperor and the king of England; and he propoſed, as ſoon as Francis ſhould have croſſed the Alps, to raiſe an inſurrection among his numerous vaſſals, and introduce foreign enemies into the heart of France.

Happily Francis got intimation of this conſpiracy before he left the kingdom; but not being ſufficiently convinced of the conſtable's guilt, he ſuffered ſo dangerous a foe to eſcape; and Bourbon entering into the emperor's ſervice, employed all the force of his enterpriſing genius, and his great talents for war, to the prejudice of his prince and his native country.

In conſequence of the diſcovery of this plot, and the eſcape of the powerful conſpirator, Francis relinquiſhed his intention of leading his army in perſon into Italy. He was ignorant how far the infection had ſpread among his ſubjects, and afraid that his abſence might encourage them to make ſome deſperate attempt in favour of a man ſo much beloved. He did not, however, abandon his deſign on the Milaneſe, but ſent forward an army of 30,000 men, under the command of Admiral Bonnivet.
107 A French army enters Italy.
Colonna, who was entruſted with the defence of that duchy, was in no condition to reſiſt ſuch a force; and the city of Milan, on which the whole territory depends,

Spain.

pends, muſt have fallen into the hands of the French, had not Bonnivet, who poſſeſſed none of the talents of a general, waſted his time in frivolous enterpriſes, till the inhabitants recovered from their conſternation. The imperial army was reinforced. Colonna died; and Lannoy, viceroy of Naples, ſucceeded him in the command: but the chief direction of military operations was committed to Bourbon and the marquis de Peſcara, the greateſt generals of their age. Bonnivet, deſtitute of troops to oppoſe this new army, and ſtill more of the talents which could render him a match for its leaders, after various movements and encounters, was reduced to the neceſſity of attempting a retreat into France.
108 He was followed by the imperial generals, and routed
Defeated at Biagraſſa. at Biagraſſa, where the famous Chevalier Bayard was killed.

The emperor and his allies were leſs ſucceſsful in their attempts upon France. They were baffled in every quarter: and Francis, though ſtripped of his Italian dominions, might ſtill have enjoyed in ſafety the glory of having defended his native kingdom againſt one half of Europe, and have bid defiance to all his enemies; but underſtanding that the king of England, diſ-
109 couraged by his former fruitleſs enterpriſes, and diſguſt-
Francis determines to enter Italy in perſon. ed with the emperor, was making no preparations for any attempt on Picardy, his ancient ardour ſeized him for the conqueſt of Milan, and he determined, notwithſtanding the advanced ſeaſon, to march into Italy.

The French army no ſooner appeared in Piedmont, than the whole Milaneſe was thrown into conſternation. The capital opened its gates. The forces of the emperor and Sforza retired to Lodi: and had Francis been ſo fortunate as to purſue them, they muſt have abandoned that poſt, and been totally diſperſed; but his evil genius led him to beſiege Pavia, a town of conſiderable ſtrength, well garriſoned, and defended by An-
110 tonio de Leyva, one of the braveſt officers in the Spa-
Is defeated and taken priſoner at Pavia. niſh ſervice; before which place he was defeated and taken priſoner on the twenty-fourth day of February 1524.

An. 1524. The captivity of Francis filled all Europe with alarm. Almoſt the whole French army was cut off; Milan was immediately abandoned; and in a few weeks not a Frenchman was left in Italy. The power of the emperor, and ſtill more his ambition, became an object of univerſal terror; and reſolutions were everywhere taken to ſet bounds to it. Meanwhile Francis, deeply impreſſed with a ſenſe of his misfortune, wrote to his mother Louiſa, whom he had left regent of the kingdom, the following ſhort but expreſſive letter: "All, Madam,
111 is loſt but honour." The ſame courier that carried this
Hypocritical conduct of Charles. letter, carried alſo diſpatches to Charles; who received the news of the ſignal and unexpected ſucceſs which had crowned his arms with the moſt hypocritical moderation. He would not ſuffer any public rejoicings to be made on account of it; and ſaid, he only valued it, as it would prove the occaſion of reſtoring peace to Chriſtendom. Louiſa, however, did not truſt to thoſe appearances; if ſhe could not preſerve what was yet left, ſhe determined at leaſt that nothing ſhould be loſt through her negligence or weakneſs. Inſtead of giving herſelf up to ſuch lamentations as were natural to a woman ſo remarkable for maternal tenderneſs, ſhe diſcovered all the foreſight, and exerted all the activity, of a conſummate politician. She took every poſſible meaſure for

putting the kingdom in a poſture of defence, while ſhe employed all her addreſs to appeaſe the reſentment and to gain the friendſhip of England; and a ray of comfort from that quarter ſoon broke in upon the French affairs.

Though Henry VIII. had not entered into the war againſt France from any concerted political views, he had always retained ſome imperfect idea of that balance of power which it was neceſſary to maintain between Charles and Francis; and the preſervation of which he boaſted to be his peculiar office. By his alliance with the emperor, he hoped to recover ſome part of thoſe territories on the continent which had belonged to his anceſtors; and therefore willingly contributed to give him the aſcendency above his rival; but having never dreamt of any event ſo deciſive and fatal as the victory at Pavia, which ſeemed not only to have broken, but to have annihilated the power of Francis, he now became ſenſible of his own danger, as well as that of all Europe, from the loſs of a proper counterpoiſe to the power of 112
Charles. Inſtead of taking advantage of the diſtreſſed France aſſiſted by Henry VIII.
condition of France, Henry therefore determined to aſſiſt her in her preſent calamities. Some diſguſts alſo had taken place between him and Charles, and ſtill more between Charles and Wolſey. The elevation of the cardinal of Medici to St Peter's chair, on the death of Adrian, under the name of Clement VII. had made the Engliſh miniſter ſenſible of the inſincerity of the emperor's promiſes, while it extinguiſhed all his hopes of the papacy; and he reſolved on revenge. Charles, too, had ſo ill ſupported the appearance of moderation which he aſſumed, when firſt informed of his good fortune, that he had already changed his uſual ſtyle to Henry; and inſtead of writing to him with his own hand, and ſubſcribing himſelf "your affectionate ſon and couſin," he dictated his letters to a ſecretary, and ſimply ſubſcribed himſelf "Charles." Influenced by all theſe motives, together with the glory of raiſing a fallen enemy, Henry liſtened to the flattering ſubmiſſions of Louiſa; entered into a defenſive alliance with her as regent of France, and engaged to uſe his beſt offices in order to procure the deliverance of her ſon from a ſtate of captivity.

Meanwhile Francis was rigorouſly confined; and ſe- 113
vere conditions being propoſed to him as the price of Francis ſeverely uſed by his conqueror.
his liberty, he drew his dagger, and, pointing it at his breaſt, cried, "'Twere better that a king ſhould die thus!" His hand was withheld: and flattering himſelf, when he grew cool, that ſuch propoſitions could not come directly from Charles, he deſired that he might be removed to Spain, where the emperor then reſided. His requeſt was complied with; but he languiſhed long before he obtained a ſight of his conqueror. At laſt he was favoured with a viſit; and the emperor dreading a general combination againſt him, or that Francis, as he threatened, might, in the obſtinacy of his heart, reſign his crown to the dauphin, agreed to abate ſomewhat of his former demands. A treaty was accordingly concluded at Madrid; in conſequence of which Francis obtained his liberty. The chief article in this treaty was, that Burgundy ſhould be reſtored to Charles as the rightful inheritance of his anceſtors, and 114
that Francis's two eldeſt ſons ſhould be immediately de- Is at laſt releaſed.
livered up as hoſtages for the performance of the conditions ſtipulated. The exchange of the captive monarch

Spain.

narch for his children was made on the borders between France and Spain. The moment that Francis entered his own dominions, he mounted a Turkiſh horſe, and putting it to its ſpeed, waved his hand, and cried aloud ſeveral times, "I am yet a king! I am yet a king."

115
Refuſes to execute the conditions of his releaſe.

Francis never meant to execute the treaty of Madrid: he had even left a proteſt in the hands of notaries before he ſigned it, that his conſent ſhould be conſidered as an involuntary deed, and be deemed null and void. Accordingly, as ſoon as he arrived in France, he aſſembled the ſtates of Burgundy, who proteſted againſt the article relative to their province; and Francis coldly replied to the imperial ambaſſadors, who urged the immediate execution of the treaty, that he would religiouſly perform the articles relative to himſelf, but in thoſe affecting the French monarchy, he muſt be directed by the ſenſe of the nation. He made the higheſt acknowledgements to the king of England for his friendly interpoſition, and offered to be entirely guided by his counſels. Charles and his miniſters ſaw that they were over-reached in thoſe very arts of negotiation in which they ſo much excelled, while the Italian ſtates obſerved with pleaſure, that Francis was reſolved not to execute a treaty which they conſidered as dangerous to the liberties of Europe. Clement abſolved him from the oath which he had taken at Madrid; and the kings of France and England, the pope, the Swiſs, the Venetians, the Florentines, and the duke of Milan, entered into an alliance, to which they gave the name of the *Holy League*, becauſe his Holineſs was at the head of it, in order to oblige the emperor to deliver up Francis's two ſons on the payment of a reaſonable ranſom, and to re-eſtabliſh Sforza in the quiet poſſeſſion of the Milaneſe.

In conſequence of this league, the confederate army took the field, and Italy once more became the ſcene of war. But Francis, who it was thought would have infuſed ſpirit and vigour into the whole body, had gone through ſuch a ſcene of diſtreſs, that he was become diffident of himſelf, diſtruſtful of his fortune, and deſirous of tranquillity. He flattered himſelf, that the dread alone of ſuch a confederacy would induce Charles to liſten to what was equitable, and therefore neglected to ſend due reinforcements to his allies in Italy. Meantime the duke of Bourbon, who commanded the Imperialiſts, had made himſelf maſter of the whole Milaneſe, of which the emperor had promiſed him the inveſtiture;

116
Rome taken by the imperialiſts,

and his troops beginning to mutiny for want of pay, he led them to Rome, and promiſed to enrich them with the ſpoils of that city. He was as good as his word; for though he himſelf was ſlain in planting a ſcaling ladder againſt the walls, his ſoldiers, rather enraged than diſcouraged by his death, mounted to the aſſault with the utmoſt ardour, animated by the greatneſs of the prize, and, entering the city ſword in hand, plundered it for ſeveral days.

117
and moſt cruelly plundered.

Never did Rome in any age ſuffer ſo many calamities, not even from the Barbarians, by whom ſhe was often ſubdued, the Huns, Vandals, or Goths, as now from the ſubjects of a Chriſtian and Catholic monarch. Whatever was reſpectable in modeſty, or ſacred in religion, ſeemed only the more to provoke the rage of the ſoldiery. Virgins ſuffered violation in the arms of their parents, and upon thoſe altars to which they had fled for ſafety. Venerable prelates, after enduring every indignity and every torture, were thrown into dungeons, and menaced with the moſt cruel death, in order to make them reveal their ſecret treaſures. Clement himſelf, who had neglected to make his eſcape in time, was taken priſoner, and found that the ſacredneſs of his character could neither procure him liberty nor reſpect.

118
The pope confined.

He was confined till he ſhould pay an enormous ranſom impoſed by the victorious army, and ſurrender to the emperor all the places of ſtrength belonging to the church.

119
Shameful hypocriſy of Charles.

Charles received the news of this extraordinary event with equal ſurpriſe and pleaſure; but in order to conceal his joy from his Spaniſh ſubjects, who were filled with horror at the inſult offered to the ſovereign pontiff, and to leſſen the indignation of the reſt of Europe, he expreſſed the moſt profound ſorrow for the ſucceſs of his arms. He put himſelf and his court into mourning; ſtopped the rejoicings for the birth of his ſon Philip, and ordered prayers to be put up in all the churches of Spain for the recovery of the pope's liberty, which he could immediately have procured by a letter to his generals.

The concern expreſſed by Henry and Francis for the calamity of their ally was more ſincere. Alarmed at the progreſs of the imperial arms, they had, even before the taking of Rome, enter into a cloſer alliance, and agreed to invade the Low Countries with a powerful army; but no ſooner did they hear of the pope's captivity, than they changed, by a new treaty, the ſcene of the projected war from the Netherlands to Italy, and reſolved to take the moſt vigorous meaſures for reſtoring him to liberty. Henry, however, contributed only money.

120
A French army enters Italy, but is utterly ruined.

A French army entered Italy, under the command of Marſhal Lautrec; Clement obtained his freedom; and war was for a time carried on by the confederates with ſucceſs; but the death of Lautrec, and the revolt of Andrew Doria, a Genoeſe admiral in the ſervice of France, entirely changed the face of affairs. The French army was utterly ruined; and Francis, diſcouraged and almoſt exhauſted by ſo many unſucceſsful enterpriſes, began to think of peace, and of obtaining the releaſe of his ſons by conceſſions, not by the terror of his arms.

At the ſame time Charles, notwithſtanding the advantages he had gained, had many reaſons to wiſh for an accommodation. Sultan Solyman having overrun Hungary, was ready to break in upon the Auſtrian territories with the whole force of the Eaſt; and the progreſs of the Reformation in Germany threatened the tranquillity of the empire. In conſequence of this ſituation of affairs, though pride made both parties conceal or diſſemble their real ſentiments, two ladies were permitted to reſtore peace to Europe.

121
Peace concluded at Cambray.

Margaret of Auſtria, Charles's aunt, and Louiſa, Francis's mother, met in 1529 at Cambray, and ſettled the terms of accommodation between the French king and the emperor. Francis agreed to pay two millions of crowns as the ranſom of his two ſons, to reſign the ſovereignty of Flanders and Artois, and to forego all his Italian claims; and Charles ceaſed to demand the reſtitution of Burgundy.

All the ſteps of this negociation had been communicated to the king of England; and Henry was, on that occaſion, ſo generous to his friend and ally Francis, that he ſent him an acquittal of near ſix hundred thouſand crowns, in order to enable him to fulfil his agreement with

Spain.

with Charles. But Francis's Italian confederates were less satisfied with the treaty of Cambray. They were almost wholly abandoned to the will of the emperor; and seemed to have no other means of security left but his equity and moderation. Of these, from his past conduct, they had not formed the most advantageous idea. But Charles's present circumstances, more especially in regard to the Turks, obliged him to behave with a generosity inconsistent with his character. The Florentines alone, whom he reduced under the dominion of the family of Medici, had reason to complain of his severity. Sforza obtained the investiture of Milan and his pardon: and every other power experienced the lenity of the conqueror.

122 Charles goes into Germany.

After having received the imperial crown from the hands of the pope at Bologna, Charles proceeded on his journey to Germany, where his presence was become highly necessary; for although the conduct and valour of his brother Ferdinand, on whom he had conferred the hereditary dominions of the house of Austria, and who had been elected king of Huagary, had obliged Solyman to retire with infamy and loss, his return was to be feared, and the disorders of religion were daily increasing; an account of which, and of the emperor's transactions with the Protestants, is given under the article REFORMATION.

123 He undertakes an expedition against the state of Barbary. An. 1541.

Charles having exerted himself as much as he could against the reformers, undertook his first expedition against the piratical states of Africa. Barbary, or that part of the African continent lying along the coast of the Mediterranean sea, was then nearly in the same condition which it is at present. Morocco, Algiers, and Tunis, were its principal states; and the two last were nests of pirates. Barbarossa, a famous corsair, had succeeded his brother in the kingdom of Algiers, which he had formerly assisted him to usurp. He regulated with much prudence the interior police of his kingdom, carried on his piracies with great vigour, and extended his conquests on the continent of Africa; but perceiving that the natives submitted to his government with impatience, and fearing that his continual depredations would one day draw upon him a general combination of the Christian powers, he put his dominions under the protection of the grand seignior. Solyman, flattered by such an act of submission, and charmed with the boldness of the man, offered him the command of the Turkish fleet. Proud of this distinction, Barbarossa repaired to Constantinople, and made use of his influence with the sultan to extend his own dominion. Partly by force, partly by treachery, he usurped the kingdom of Tunis; and being now possessed of greater power, he carried on his depredations against the Christian states with more destructive violence than ever.

Daily complaints of the piracies and ravages committed by the galleys of Barbarossa were brought to the emperor by his subjects, both in Spain and Italy; and all Christendom seemed to look up to him, as its greatest and most fortunate prince, for relief from this new and odious species of oppression. At the same time Muley-Hascen, the exiled king of Tunis, finding none of the African princes able or willing to support him in recovering his throne, applied to Charles for assistance against the usurper. Equally desirous of delivering his dominions from the dangerous neighbourhood of Barbarossa, of appearing as the protector of an unfortunate prince, and of acquiring the glory annexed in that age to every expedition against the Mahometans, the emperor readily concluded a treaty with Muley Hascen, and set sail for Tunis with a formidable armament. The Goletta, a sea-port town, fortified with 300 pieces of cannon, was taken, together with all Barbarossa's fleet: he was defeated in a pitched battle, and 10,000 Christian slaves, having knocked off their fetters, and made themselves masters of the citadel, Tunis was preparing to surrender. But while Charles was deliberating on the conditions, his troops fearing that they would be deprived of the booty which they had expected, broke suddenly into the town, and pillaged and massacred without distinction. Thirty thousand persons perished by the sword, and 10,000 were made prisoners. The sceptre was restored to Muley Hascen, on condition that he should acknowledge himself a vassal of the crown of Spain, put into the emperor's hands all the fortified sea-ports in the kingdom of Tunis, and pay annually 12,000 crowns for the subsistence of the Spanish garrison in the Goletta. These points being settled, and 20,000 Christian slaves freed from bondage either by arms or by treaty, Charles returned to Europe, where his presence was become necessary; while Barbarossa, who had retired to Bona, recovered new strength, and again became the tyrant of the ocean.

124 Tunis taken, and the inhabitants cruelly massacred.

125 Francis attempts in vain to revive his pretensions to Italy.

The king of France took advantage of the emperor's absence to revive his pretensions in Italy. The treaty of Cambray had repressed but not extinguished the flames of discord. Francis in particular, who waited only for a favourable opportunity of recovering the territories and reputation which he had lost, continued to negotiate against his rival with different courts. But all his negotiations were disconcerted by unforeseen accidents. The death of Clement VII. (whom he had gained by marrying his son the duke of Orleans, afterwards Henry II. to Catharine of Medici, the niece of that pontiff), deprived him of all the support which he hoped to receive from the court of Rome. The king of England, occupied with domestic cares and projects, declined engaging in the affairs of the continent; and the Protestant princes, associated by the league of Smalkalde, to whom Francis had also applied, and who seemed disposed at first to listen to him, filled with indignation and resentment at the cruelty with which some of their reformed brethren had been treated in France, refused to have any connection with the enemy of their religion.

126 His barbarity to the Protestants.

Francis was neither cruel nor bigotted: he was too indolent to concern himself about religious disputes; but his principles becoming suspected, at a time when the emperor was gaining immortal glory by his expedition against the infidels, he found it necessary to vindicate himself by some extraordinary demonstration of reverence for the established faith. The indiscreet zeal of some Protestant converts furnished him with the occasion. They had affixed to the gates of the Louvre and other public places papers containing indecent reflections on the rites of the Romish church. Six of the persons concerned in this rash action were seized; and the king, pretending to be struck with horror at their blasphemies, appointed a solemn procession, in order to avert the wrath of heaven. The holy sacrament was carried through the city of Paris in great pomp: Francis walked uncovered before it, bearing a torch in his hand;

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hand; the princes of the blood supported the canopy over it; the nobles walked behind. In presence of this numerous assembly, the king declared, that if one of his hands were infected with heresy, he would cut it off with the other; "and I would sacrifice (added he) even my own children, if found guilty of that crime." As an awful proof of his sincerity, the six unhappy persons who had been seized were publicly burnt, before the procession was finished, and in the most cruel manner. They were fixed upon a machine which descended into the flames, and retired alternately, until they expired.—No wonder that the Protestant princes were incensed at such barbarity!

127
Causes an army march towards Italy.

Francis, though unsupported by any ally, commanded his army to advance towards the frontiers of Italy, under pretence of chastising the duke of Milan for a breach of the law of nations, in putting to death his ambassador. The operations of war, however, soon took a new direction. Instead of marching directly to the Milanese, Francis commenced hostilities against the duke of Savoy, with whom he had cause to be dissatisfied, and on whom he had some claims; and before the end of the campaign, this feeble prince saw himself stripped of all his dominions, except the province of

128
Geneva throws off the yoke of the duke of Savoy.

Piedmont. To complete his misfortunes, the city of Geneva, the sovereignty of which he claimed, and where the reformed opinions had already got footing, threw off his yoke; and its revolt drew along with it the loss of the adjacent territory. Geneva was then an imperial city, and till lately remained entirely free *.

* See *Geneva.*

In this extremity the duke of Savoy saw no resource but in the emperor's protection; and as his misfortunes were chiefly occasioned by his attachment to the imperial interest, he had a title to immediate assistance. But Charles, who was just returned from his African expedition, was not able to lend him the necessary support. His treasury was entirely drained, and he was obliged to disband his army till he could raise new supplies. Mean time the death of Sforza duke of Milan entirely changed the nature of the war, and afforded the emperor full leisure to prepare for action. The French monarch's pretext for taking up arms was at once cut off; but as the duke died without issue, all Francis's rights to the duchy of Milan, which he had yielded only to Sforza and his descendants, returned to him in full force. He instantly renewed his claim to it; and if he had ordered his army immediately to advance, he might have

129
Charles takes possession of Milan.

made himself master of it. But he unfortunately wasted his time in fruitless negotiations, while his more politic rival took possession of the duchy as a vacant fief of the empire; and though Charles seemed still to admit the equity of Francis's claim, he delayed granting the investiture under various pretences, and was secretly taking every possible measure to prevent him from regaining footing in Italy.

During the time gained in this manner, Charles had recruited his finances, and of course his armies; and finding himself in a condition for war, he at last threw off the mask under which he had so long concealed his designs from the court of France. Entering Rome with great pomp, he pronounced before the pope and cardinals, assembled in full consistory, a violent invective against Francis, by way of reply to his propositions con-

130
Weakness of Francis.

cerning the investiture of Milan. Yet Francis, by an unaccountable fatality, continued to negotiate, as if it had been still possible to terminate their differences in an amicable manner; and Charles, finding him so eager to run into the snare, favoured the deception, and, by seeming to listen to his proposals, gained yet more time for the execution of his ambitious projects.

131
Charles attempts to subvert the French monarchy,

If misfortunes had rendered Francis too diffident, success had made Charles too sanguine. He presumed on nothing less than the subversion of the French monarchy; nay, he considered it as a certain event. Having chased the forces of his rival out of Piedmont and Savoy, he pushed forward at the head of 50,000 men, contrary to the advice of his most experienced ministers and generals, to invade the southern provinces of France; while two other armies were ordered to enter it, the one on the side of Picardy, the other on the side of Champagne. He thought it impossible that Francis could resist so many unexpected attacks on such different quarters; but he found himself mistaken.

132
but is disappointed in his designs.

The French monarch fixed on the most effectual plan for defeating the invasion of a powerful enemy; and he prudently persevered in following it, though contrary to his own natural temper and to the genius of his people. He determined to remain altogether upon the defensive, and to deprive the enemy of subsistence by laying waste the country before them. The execution of this plan was committed to the mareschal Montmorency its author, a man happily fitted for such a trust by the inflexible severity of his disposition. He made choice of a strong camp, under the walls of Avignon, at the confluence of the Rhone and Durance, where he assembled a considerable army; while the king, with another body of troops, encamped at Valence, higher up the Rhone. Marseilles and Arles were the only towns he thought it necessary to defend; and each of these he furnished with a numerous garrison of his best troops. The inhabitants of the other towns were compelled to abandon their habitations: the fortifications of such places as might have afforded shelter to the enemy were thrown down; corn, forage, and provisions of every kind, were carried off or destroyed; the mills and ovens were ruined, and the wells filled up or rendered useless.

This devastation extended from the Alps to Marseilles, and from the sea to the confines of Dauphiny; so that the emperor, when he arrived with the van of his army on the confines of Provence, instead of that rich and populous country which he expected to enter, beheld nothing but one vast and desert solitude. He did not, however, despair of success, though he saw that he would have many difficulties to encounter; and as an encouragement to his officers, he made them liberal promises of lands and honours in France. But all the land which any of them obtained was a grave, and their master lost much honour by this rash and presumptuous enterprise. After unsuccessfully investing Marseilles and Arles, after attempting in vain to draw Montmorency from his camp at Avignon, and not daring to attack it, Charles having spent two inglorious months in Provence, and lost one half of his troops by disease or by famine, was under the necessity of ordering a retreat; and though he was some time in motion before the enemy suspected his intention, it was conducted with so much precipitation and disorder, as to deserve the name of a flight, since the light troops of France turned it into a perfect rout. The invasion of Picardy

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Picardy was not more successful: the imperial forces were obliged to retire without effecting any conquest of importance.

Charles had no sooner conducted the shattered remains of his army to the frontiers of Milan, than he set out for Genoa; and unwilling to expose himself to the scorn of the Italians after such a reverse of fortune, he embarked directly for Spain.

133 Violent animosity between him and Francis.

Meanwhile Francis gave himself up to that vain resentment which had formerly disgraced the prosperity of his rival. They had frequently, in the course of their quarrels, given each other the lie, and mutual challenges had been sent; which, though productive of no serious consequences between the parties, had a powerful tendency to encourage the pernicious practice of duelling. Charles, in his invective pronounced at Rome, had publicly accused Francis of perfidy and breach of faith; Francis now exceeded Charles in the indecency of his accusations. The dauphin dying suddenly, his death was imputed to poison: Montecuculi his cup-bearer was put to the rack; and that unhappy nobleman, in the agonies of torture, accused the emperor's generals Gonzaga and de Leyva, of instigating him to the detestable act. The emperor himself was suspected; nay, this extorted confession, and some obscure hints, were considered as incontestable proofs of his guilt; though it was evident to all mankind, that neither Charles nor his generals could have any inducement to perpetrate such a crime, as Francis was still in the vigour of life himself, and had two sons besides the dauphin, grown up to a good age.

But the incensed monarch's resentment did not stop here. Francis was not satisfied with endeavouring to blacken the character of his rival by an ambiguous testimony which led to the most injurious suspicions, and upon which the most cruel constructions had been put; he was willing to add rebellion to murder. For this purpose he went to the parliament of Paris; where being seated with the usual solemnities, the advocate-general appeared, and accused Charles of Austria (so he affected to call the emperor) of having violated the treaty of Cambray, by which he was freed from the homage due to the crown of France for the counties of Artois and Flanders; adding, that this treaty being now void, he was still to be considered as a vassal of France, and consequently had been guilty of rebellion

134 Charles summoned to appear at Paris.

in taking arms against his sovereign. The charge was sustained, and Charles was summoned to appear before the parliament of Paris at a day fixed. The term expired; and no person appearing in the emperor's name, the parliament gave judgement, that Charles of Austria had forfeited, by rebellion and contumacy, the counties of Flanders and Artois, and declared these fiefs reunited to the crown of France.

Francis, soon after this vain display of his animosity, marched into the Low Countries, as if he had intended to execute the sentence pronounced by his parliament; but a suspension of arms took place, through the interposition of the queens of France and Hungary, before any thing of consequence was effected: and this cessation of hostilities was followed by a truce, concluded at Nice, through the mediation of the reigning pontiff Paul III. of the family of Farnese, a man of a venerable character and pacific disposition.

Each of these rival princes had strong reasons to incline them to peace. The finances of both were exhausted; and the emperor, the more powerful of the two, was deeply impressed with the dread of the Turkish arms, which Francis had drawn upon him by a league with Solyman. In consequence of this league, Barbarossa with a great fleet appeared on the coast of Naples; filled that kingdom with consternation; landed without resistance near Taranto; obliged Castro, a place of some strength, to surrender; plundered the adjacent country; and was taking measures for securing and extending his conquests, when the unexpected arrival of Doria, the famous Genoese admiral, together with the pope's galleys and a squadron of the Venetian fleet, made it prudent for him to retire. The sultan's forces also invaded Hungary, where Mahmet the Turkish general, after gaining several inferior advantages, defeated the Germans in a great battle at Essek on the Drave. Happily for Charles and Europe it was not in Francis's power at this juncture either to join the Turks or assemble an army strong enough to penetrate into the Milanese. The emperor, however, was sensible that he could not long resist the efforts of two such powerful confederates, nor expect that the same fortunate circumstances would concur a second time in his favour; he therefore thought it necessary, both for his safety and reputation, to give his consent to a truce: and Francis chose rather to run the risk of disobliging his new ally the sultan, than to draw on his head the indignation, and perhaps the arms, of all Christendom, by obstinately obstructing the re-establishment of tranquillity, and contributing to the aggrandizement of the Infidels.

135 Francis leagues with the Turks.

136 A truce concluded.

These considerations inclined the contending monarchs to listen to the arguments of the holy father; but he found it impossible to bring about a final accommodation between them, each inflexibly persisting in asserting his own claims. Nor could he prevail on them to see one another, though both came to the place of rendezvous: so great was the remains of distrust and rancour, or such the difficulty of adjusting the ceremonial! Yet, improbable as it may seem, a few days after signing the truce, the emperor, in his passage to Barcelona, being driven on the coast of Provence, Francis invited him to come ashore; frankly visited him on board his galley, and was received and entertained with the warmest demonstrations of esteem and affection. Charles, with an equal degree of confidence, paid the king next day a visit at Aigues-mortes; where these two hostile rivals and vindictive enemies, who had accused each other of every kind of baseness, conversing together with all the cordiality of brothers, seemed to vie with each other in expressions of respect and friendship.

137 Interview between Francis and Charles.

Besides the glory of having restored tranquillity to Europe, the pope gained a point of much consequence to his family. He obtained for his grandson, Margaret of Austria, the emperor's natural daughter, formerly wife of Alexander de Medici, whom Charles had raised to the supreme power in Florence. Laurenein de Medici, the kinsman and intimate companion of Alexander, had assassinated him by one of the blackest treasons recorded in history. Under pretence of having secured him an assignation with a lady of the highest rank and great beauty, he drew him into a secret apartment of his house, and there stabbed him as he lay carelessly on a couch, expecting the embrace of the lovely fair, whom he had often

138 Advantage gained by the pope from this pacification.

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often ſolicited in vain. Laurenein, however, did not reap the fruits of his crime; for though ſome of his countrymen extolled him as a third Brutus, and endeavoured to ſeize this occaſion for recovering their liberties, the government of Florence paſſed into the hands of Coſmo II. another kinſman of Alexander. Coſmo was deſirous of marrying the widow of his predeceſſor; but the emperor choſe rather to oblige the pope, by beſtowing his daughter upon Octavio Farneſe, ſon of the duke of Parma.

139 Charles diſtreſſed.

Charles had ſoon farther cauſe to be ſenſible of his obligations to the holy father for bringing about the treaty of Nice. His troops everywhere mutinied for want of pay, and the ability of his generals only could have prevented a total revolt. He had depended, as his chief reſource for diſcharging the arrears due to his ſoldiers, upon the ſubſidies which he expected from his Caſtilian ſubjects. For this purpoſe he aſſembled the Cortes of Caſtile at Toledo; and having repreſented to them the great expence of his military operations, he propoſed to levy ſuch ſupplies as the preſent exigency of affairs demanded, by a general exciſe on commodities; but the Spaniards, who already felt themſelves oppreſſed by a load of taxes unknown to their anceſtors, and who had often complained that their country was drained of its wealth and inhabitants, in order to proſecute quarrels in which they had no intereſt, determined not to add voluntarily to their own burdens. The nobles, in particular, inveighed with great vehemence againſt the impoſition propoſed, as an encroachment on the valuable and diſtinguiſhing privilege of their order, that of being exempted from the payment of any tax. After employing arguments and promiſes in vain, Charles diſmiſſed the aſſembly with indignation; and from that period neither the nobles nor the prelates have been called to the Cortes, on pretence that ſuch as pay no part of the public taxes ſhould not claim a vote in laying them on. Theſe aſſemblies have ſince conſiſted merely of the procurators or repreſentatives of 18 cities, two from each; in all 36 members, who are abſolutely at the devotion of the crown.

140 The Spaniards refuſe to aſſiſt him with money.

141 Inhabitants of Ghent rebel.

The citizens of Ghent, ſtill more bold, broke out not long after into open rebellion againſt the emperor's government, on account of a tax which they judged contrary to their ancient privileges, and a deciſion of the council of Mechlin in favour of the imperial authority. Enraged at an unjuſt impoſition, and rendered deſperate on ſeeing their rights betrayed by that very court which was bound to protect them, they flew to arms, ſeized ſeveral of the emperor's officers, and drove ſuch of the nobility as reſided among them out of the city. Senſible, however, of their inability to ſupport what their zeal had prompted them to undertake, and deſirous of ſecuring a protector againſt the formidable forces with which they might expect ſoon to be attacked, they offered to acknowledge the king of France as their ſovereign, to put him into immediate poſſeſſion of their city, and to aſſiſt him in recovering thoſe provinces in the Netherlands which had anciently belonged to his crown. True policy directed Francis to comply with this propoſal. The counties of Flanders and Artois were more valuable than the duchy of Milan, for which he had ſo long contended; and their ſituation in regard to France made it more eaſy to conquer or to defend them. But Francis over-rated the Milaneſe. He had lived in friendſhip with the emperor ever ſince their interview at Aigues-mortes, and Charles had promiſed him the inveſtiture of that duchy. Forgetting, therefore, all his paſt injuries, and the deceitful promiſes by which he had been ſo often duped, the credulous, generous Francis, not only rejected the propoſitions of the citizens of Ghent, but communicated to the emperor his whole negociation with the malecontents.

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142 Extreme credulity of Francis.

Judging of Charles's heart by his own, Francis hoped by this ſeemingly diſintereſted proceeding to obtain at once the inveſtiture of Milan; and the emperor, well acquainted with the weakneſs of his rival, flattered him in this apprehenſion, for his own ſelfiſh purpoſes. His preſence being neceſſary in the Netherlands, he demanded a paſſage through France. It was immediately granted him; and Charles, to whom every moment was precious, ſet out, notwithſtanding the remonſtrances of his council and the fears of his Spaniſh ſubjects, with a ſmall but ſplendid train of 100 perſons. He was met on the frontiers of France by the dauphin and the duke of Orleans, who offered to go into Spain, and remain there as hoſtages, till he ſhould reach his own dominions; but Charles replied, that the king's honour was ſufficient for his ſafety, and proſecuted his journey without any other ſecurity. The king entertained him with the utmoſt magnificence at Paris, and the two young princes did not take leave of him till he entered the Low Countries; yet he ſtill found means to evade his promiſe, and Francis continued to believe him ſincere.

143 He allows Charles to paſs through his dominions.

144 Severity of Charles to the city of Ghent.

The citizens of Ghent, alarmed at the approach of the emperor, who was joined by three armies, ſent ambaſſadors to implore his mercy, and offered to throw open their gates. Charles only condeſcended to reply, "That he would appear among them as a ſovereign and a judge, with the ſceptre and the ſword." He accordingly entered the place of his nativity on the anniverſary of his birth; and inſtead of that lenity which might have been expected, exhibited an awful example of his ſeverity. Twenty-ſix of the principal citizens were put to death: a greater number was baniſhed: the city was declared to have forfeited its privileges; a new ſyſtem of laws and political adminiſtration was preſcribed; and a large fine was impoſed on the inhabitants, in order to defray the expence of erecting a citadel, together with an annual tax for the ſupport of a garriſon. They were not only deſpoiled of their ancient immunities, but made to pay, like conquered people, for the means of perpetuating their own ſlavery.

145 His baſe treatment of Francis.

Having thus re-eſtabliſhed his authority in the Low Countries, and being now under no neceſſity of continuing that ſcene of falſehood and diſſimulation with which he had amuſed the French monarch, Charles began gradually to throw aſide the veil under which he had concealed his intentions with reſpect to the Milaneſe, and at laſt peremptorily refuſed to give up a territory of ſuch value, or voluntarily to make ſuch a liberal addition to the ſtrength of an enemy by diminiſhing his own power. He even denied that he had ever made any promiſe which could bind him to an action ſo fooliſh, and ſo contrary to his own intereſt.

This tranſaction expoſed the king of France to as much ſcorn as it did the emperor to cenſure. The credulous ſimplicity of Francis ſeemed to merit no other return, after experiencing ſo often the duplicity and artifices of his rival. He remonſtrated, however, and exclaimed

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claimed as if this had been the firſt circumſtance in which the emperor had deceived him. The inſult offered to his underſtanding affected him even more ſenſibly than the injury done to his intereſt; and he diſcovered ſuch reſentment as made it obvious that he would ſeize on the firſt opportunity of revenge, and that a new war would ſoon deſolate the European continent.

146
He is obliged to make conceſſions to the Proteſtants.

Meanwhile Charles was obliged to turn his attention towards the affairs of Germany. The Proteſtants having in vain demanded a general council, preſſed him earneſtly to appoint a conference between a ſelect number of divines of each party, in order to examine the points in diſpute. For this purpoſe a diet was aſſembled at Ratiſbon: and ſuch a conference, notwithſtanding the oppoſition of the pope, was held with great ſolemnity in the preſence of the emperor. But the divines choſen to manage the controverſy, though men of learning and moderation, were only able to ſettle a few ſpeculative opinions, all points relative to worſhip and juriſdiction ſerving to inflame the minds of the diſputants. Charles, therefore, finding his endeavours to bring about an accommodation ineffectual, and being impatient to cloſe the diet, prevailed on a majority of the members to approve of the following edict of receſs; viz. that the articles concerning which the divines had agreed, ſhould be held as points decided; that thoſe about which they had differed, ſhould be referred to the determination of a general council, or if that could not be obtained, to a national ſynod: and ſhould it prove impracticable alſo to aſſemble a ſynod of Germany, that a general diet of the empire ſhould be called within 18 months, in order to give final judgement on the whole controverſy; that, in the mean time, no innovations ſhould be attempted, nor any endeavours employed to gain proſelytes.

This diet gave great offence to the pope. The bare mention of allowing a diet, compoſed chiefly of laymen, to paſs judgement in regard to articles of faith, appeared to him no leſs criminal and profane than the worſt of thoſe hereſies which the emperor ſeemed ſo zealous to ſuppreſs. The Proteſtants alſo were diſſatisfied with it, as it conſiderably abridged the liberty which they at that time enjoyed. They murmured loudly againſt it; and Charles, unwilling to leave any ſeeds of diſcontent in the empire, granted them a private declaration, exempting them from whatever they thought injurious or oppreſſive in the receſs, and aſcertaining to them the full poſſeſſion of all their former privileges.

The ſituation of the emperor's affairs at this juncture made theſe extraordinary conceſſions neceſſary. He foreſaw a rupture with France to be unavoidable, and he was alarmed at the rapid progreſs of the Turks in Hungary. A great revolution had happened in that kingdom. John Zapol Scæpus, by the aſſiſtance of Solyman, had wreſted from the king of the Romans a conſiderable part of the country. John died, and left an infant ſon. Ferdinand attempted to take advantage of the minority, in order to repoſſeſs himſelf of the whole kingdom; but his ambition was diſappointed by the activity and addreſs of George Martinuzzi, biſhop of Waradin, who ſhared the regency with the queen. Senſible that he was unable to oppoſe the king of the Romans in the field, Martinuzzi ſatisfied himſelf with holding out the fortified towns, all of which he provided with every thing neceſſary for defence; and at the ſame time he ſent ambaſſadors to Solyman, beſeeching him to extend towards the ſon that imperial protection which had ſo generouſly maintained the father on his throne. Ferdinand uſed his utmoſt endeavours to thwart this negotiation, and even meanly offered to hold the Hungarian crown on the ſame ignominious condition by which John had held it, that of paying tribute to the Porte. But the ſultan ſaw ſuch advantages from eſpouſing the intereſt of the young king, that he inſtantly marched into Hungary; and the Germans, having formed the ſiege of Buda, were defeated with great ſlaughter before that city. Solyman, however, inſtead of becoming the protector of the infant ſovereign whom he had relieved, made uſe of this ſucceſs to extend his own dominions: he ſent the queen and her ſon into Tranſilvania, which province he allotted them, and added Hungary to the Ottoman empire.

Happily for the Proteſtants, Charles received intelligence of this revolution ſoon after the diet at Ratiſbon; and by the conceſſions which he made them, he obtained ſuch liberal ſupplies, both of men and money, as left him under little anxiety about the ſecurity of Germany. He therefore haſtened to join his fleet and army in Italy, in order to carry into execution a great and favourite enterpriſe which he had concerted againſt Algiers: though it would certainly have been more conſiſtent with his dignity to have conducted the whole force of the empire againſt Solyman, the common enemy of Chriſtendom, who was ready to enter his Auſtrian dominions. But many reaſons induced Charles to prefer the African expedition: he wanted ſtrength, or at leaſt money, to combat the Turks in ſo diſtant a country as Hungary; and the glory which he had formerly acquired in Barbary led him to hope for the like ſucceſs, while the cries of his Spaniſh ſubjects rouſed him to take vengeance on their ravagers. But the unfortunate event of this expedition has already been related under the article ALGIERS, N° 14—20.

147
Undertakes an unſucceſsful expedition againſt Algiers.

148
War between Francis and Charles.

The loſs which the emperor ſuffered in this calamitous expedition encouraged the king of France to begin hoſtilities, on which he had been for ſome time reſolved; and an action diſhonourable to civil ſociety furniſhed him with too good a pretext for taking arms. The marquis del Guaſto, governor of the Milaneſe, having got intelligence of the motions and deſtination of two ambaſſadors, Rincon and Fergoſo, whom Francis had diſpatched, the one to the Ottoman Porte, the other to the republic of Venice; knowing how much his maſter wiſhed to diſcover the intentions of the French monarch, and of what conſequence it was to retard the execution of his meaſures, he employed ſome ſoldiers belonging to the garriſon of Pavia to lie in wait for theſe ambaſſadors as they failed down the Po, who murdered them and moſt of their attendants, and ſeized their papers. Francis immediately demanded reparation for this barbarous outrage; and as Charles endeavoured to put him off with an evaſive anſwer, he appealed to all the courts of Europe, ſetting forth the heinouſneſs of the injury, the iniquity of the emperor in diſregarding his juſt requeſt, and the neceſſity of vengeance. But Charles, who was a more profound negotiator, defeated in a great meaſure the effects of theſe repreſentations: he ſecured the fidelity of the Proteſtant princes in Germany, by granting them new conceſſions; and he engaged the king of England to eſpouſe his cauſe, under pretence

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pretence of defending Europe againſt the Infidels; while Francis was only able to form an alliance with the kings of Denmark and Sweden (who for the firſt time intereſted themſelves in the quarrels of the more potent monarchs of the ſouth), and to renew his treaty with Solyman, which drew on him the indignation of Chriſtendom.

But the activity of Francis ſupplied all the defects of his negotiation. Five armies were ſoon ready to take the field, under different generals, and with different deſtinations. Nor was Charles wanting in his preparations. He and Henry a ſecond time made an ideal diviſion of the kingdom of France. But as the hoſtilities which followed terminated in nothing deciſive, and were diſtinguiſhed by no remarkable event, except the battle of Ceriſoles (gained by Count d'Enguien over the imperialiſts, and in which 10,000 of the emperor's beſt troops fell), at laſt Francis and Charles, mutually tired of haraſſing each other, concluded at Creſpy a treaty of peace, in which the king of England was not mentioned; and from being implacable enemies, became once more, to appearance, cordial friends, and even allies by the ties of blood.

149 Peace concluded at Creſpy.

The chief articles of this treaty were, that all the conqueſts which either party had made ſince the truce of Nice ſhould be reſtored; that the emperor ſhould give in marriage to the duke of Orleans, either his own eldeſt daughter, with the Low Countries, or the ſecond daughter of his brother Ferdinand, with the inveſtiture of the Milaneſe; that Francis ſhould renounce all pretenſions to the kingdom of Naples, as well as to the ſovereignty of Flanders and Artois, and Charles give up his claim to the duchy of Burgundy; and that both ſhould unite in making war againſt the Turks.

The emperor was chiefly induced to grant conditions ſo advantageous to France, by a deſire of humbling the Proteſtant princes in Germany. With the papal juriſdiction, he foreſaw they would endeavour to throw off the imperial authority; and he determined to make his zeal for the former a pretence for enforcing and extending the latter. However, the death of the duke of Orleans before the conſummation of his marriage, diſentangled the emperor from the moſt troubleſome ſtipulation in the treaty of Creſpy; and the French monarch, being ſtill engaged in hoſtilities with England, was unable to obtain any reparation for the loſs which he ſuffered by this unforeſeen event. Theſe hoſtilities, like thoſe between Charles and Francis, terminated in nothing deciſive. Equally tired of a ſtruggle attended with no glory or advantage to either, the contending princes concluded, at Campe, near Ardies, a treaty of peace; in which it was ſtipulated, that France ſhould pay the arrears due by former treaties to England. But theſe arrears did not exceed one-third of the ſums expended by Henry on his military operations; and Francis being in no condition to diſcharge them, Boulogne (a chargeable pledge) was left in the hands of the Engliſh as a ſecurity for the debt.

150 Charles obliged to conclude a diſadvantageous peace with the Turks and Proteſtants.

In conſequence of the emperor's reſolution to humble the Proteſtant princes, he concluded a diſhonourable peace with the Porte, ſtipulating that his brother Ferdinand ſhould pay tribute for that part of Hungary which he ſtill poſſeſſed; while the ſultan enjoyed the imperial and undiſturbed poſſeſſion of all the reſt. At the ſame time he entered into a league with Pope Paul III. for the extirpation of hereſy; but in reality with a view to oppreſs the liberties of Germany. Here, however, his ambition met with a ſevere check; for though he was ſucceſsful at firſt, he was obliged in 1552 to conclude a peace with the Proteſtants on their own terms; as has been related under the article REFORMATION, N° 26—32.

151 Attempts to recover ſome of his provinces.

By the peace concluded on this occaſion the emperor loſt Metz, Toul, and Verdun, which had formed the barrier of the empire on that quarter; and therefore ſoon after put himſelf at the head of an army, in order to recover theſe three biſhoprics. In order to conceal the deſtination of his army, he gave out, that he intended to lead it into Hungary, to ſecond Maurice in his operations againſt the Infidels; and as that pretext failed him, when he began to advance towards the Rhine, he propagated a report that he was marching firſt to chaſtiſe Albert of Brandenburg, who had refuſed to be included in the treaty of Paſſau, and whoſe cruel exactions in that part of Germany called loudly for redreſs.

152 Is obliged to raiſe the ſiege of Metz.

The French, however, were not deceived by theſe arts. Henry immediately gueſſed the true object of Charles's armament, and reſolved to defend his conqueſts with vigour. The defence of Metz, againſt which it was foreſeen the whole weight of the war would be turned, was committed to Francis of Lorraine, duke of Guiſe, who poſſeſſed in an eminent degree all the qualities that render men great in military command. He repaired with joy to the dangerous ſtation; and many of the French nobility, and even princes of the blood, eager to diſtinguiſh themſelves under ſuch a leader, entered Metz as volunteers. The city was of great extent, ill fortified, and the ſuburbs large. For all theſe defects the duke endeavoured to provide a remedy. He repaired the old fortifications with all poſſible expedition, labouring with his own hands; the officers imitated his example; and the ſoldiers, thus encouraged, cheerfully ſubmitted to the moſt ſevere toils; he erected new works, and he levelled the ſuburbs with the ground. At the ſame time he filled the magazines with proviſions and military ſtores, compelled all uſeleſs perſons to leave the place, and laid waſte the neighbouring country; yet ſuch were his popular talents, as well as his arts of acquiring an aſcendant over the minds of men, that the citizens not only refrained from murmuring, but ſeconded him with no leſs ardour than the ſoldiers in all his operations—in the ruin of their eſtates, and in the havoc of their public and private buildings.

Meanwhile the emperor continued his march towards Lorraine, at the head of 60,000 men. On his approach Albert of Brandenburg, whoſe army did not exceed 20,000 withdrew into that principality, as if he intended to join the French king; and Charles, notwithſtanding the advanced ſeaſon, it being towards the end of October, laid ſiege to Metz, contrary to the advice of his moſt experienced officers.

The attention of both the beſiegers and the beſieged was turned for ſome time towards the motions of Albert, who ſtill hovered in the neighbourhood, undetermined which ſide to take, though reſolved to ſell his ſervice. Charles at laſt came up to his price, and he joined the imperial army. The emperor now flattered himſelf that nothing could reſiſt his force; but he found himſelf deceived. After a ſiege of almoſt 60 days, during

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ring which he had attempted all that was thought poſſible for art or valour to effect, and had loſt upwards of 30,000 men by the inclemency of the weather, diſeaſes, or the ſword of the enemy, he was obliged to abandon the enterpriſe.

153
Miſerable condition of his army.

When the French ſallied out to attack the enemy's rear, the imperial camp was filled with the ſick and wounded, with the dead and the dying. All the roads by which the army retired were ſtrewed with the ſame miſerable objects; who, having made an effort beyond their ſtrength to eſcape, and not being able to proceed, were left to periſh without aſſiſtance. Happily that, and all the kind offices which their friends had not the power to perform, they received from their enemies. The duke of Guiſe ordered them all to be taken care of, and ſupplied with every neceſſary; he appointed phyſicians to attend, and direct what treatment was proper for the ſick and wounded, and what refreſhments for the feeble; and ſuch as recovered he ſent home, under an eſcort of ſoldiers, and with money to bear their charges. By theſe acts of humanity, leſs common in that age, the duke of Guiſe completed that heroic character which he had juſtly acquired by his brave and ſucceſsful defence of Metz.

154
His further misfortunes.

The emperor's misfortunes were not confined to Germany. During his reſidence at Villach, he had been obliged to borrow 200,000 crowns of Coſmo de Medici; and ſo low was his credit, that he was obliged to put Coſmo in poſſeſſion of the principality of Piombino as a ſecurity for that inconſiderable ſum; by which means he loſt the footing he had hitherto maintained in Tuſcany. Much about the ſame time he loſt Sienna. The citizens, who had long enjoyed a republican government, roſe againſt the Spaniſh garriſon, which they had admitted as a check upon the tyranny of the nobility, but which they found was meant to enſlave them; forgetting their domeſtic animoſities, they recalled the exiled nobles; they demoliſhed the citadel, and put themſelves under the protection of France.

To theſe unfortunate events one ſtill more fatal had almoſt ſucceeded. The ſevere adminiſtration of the viceroy of Naples had filled that kingdom with murmuring and diſſatisfaction. The prince of Salerno, the head of the malecontents, fled to the court of France. The French monarch, after the example of his father, applied to the grand ſignior; and Solyman, at that time highly incenſed againſt the houſe of Auſtria on account of the proceedings in Hungary, ſent a powerful fleet into the Mediterranean, under the command of the corſair Dragut, an officer trained up under Barbaroſſa, and ſcarcely inferior to his maſter in courage, talents, or in good fortune. Dragut appeared on the coaſt of Calabria at the time appointed; but not being joined by the French fleet according to concert, he returned to Conſtantinople, after plundering and burning ſeveral places, and filling Naples with conſternation.

155
Is ſucceſsful in the Low Countries.

Highly mortified by ſo many diſaſters, Charles retired into the Low Countries, breathing vengeance againſt France: and here the war was carried on with conſiderable vigour. Impatient to efface the ſtain which his military reputation had received before Metz, Charles laid ſiege to Terouane; and the fortifications being in diſrepair, that important place was carried by aſſault. Heſdin alſo was inveſted, and carried in the ſame manner. The king of France was too late in aſſembling his forces to afford relief to either of theſe places; and the emperor afterwards cautiouſly avoided an engagement.

156
But not ſo in other places.

The imperial arms were leſs ſucceſsful in Italy. The viceroy of Naples failed in an attempt to recover Sienna; and the French not only eſtabliſhed themſelves more firmly in Tuſcany, but conquered part of the iſland of Corſica. Nor did the affairs of the houſe of Auſtria go on better in Hungary during the courſe of this year. Iſabella and her ſon appeared once more in Tranſylvania, at a time when the people were ready for revolt, in order to revenge the death of Martinuzzi, whoſe loſs they had ſeverely felt. Some noblemen of eminence declared in favour of the young king; and the baſhaw of Belgrade, by Solyman's order, eſpouſing his cauſe, in oppoſition to Ferdinand, Caſtaldo, the Auſtrian general, was obliged to abandon Tranſylvania to Iſabella and the Turks.

157
Marriage between Philip of Spain and Mary of England.
An. 1554.

In order to counterbalance theſe and other loſſes, the emperor, in 1554, concerted a marriage between his ſon Philip and Mary of England, in hopes of adding that kingdom to his other dominions. Meanwhile the war between Henry and Charles was carried on with various ſucceſs in the Low Countries, and in Italy much to the diſadvantage of France. The French, under the command of Strozzi, were defeated in the battle of Merciano; Sienna was reduced by Medicino, the Florentine general, after a ſiege of ten months; and the gallant Sienneſe were ſubjected to the Spaniſh yoke. Much about the ſame time a plot was formed by the Franciſcans, but happily diſcovered before it could be carried into execution, to betray Metz to the Imperialiſts. The father guardian, and twenty other monks, received ſentence of death on account of this conſpiracy; but the guardian, before the time appointed for his execution, was murdered by his incenſed accomplices, whom he had ſeduced; and ſix of the youngeſt were pardoned.

While war thus raged in Italy and the Low Countries, Germany enjoyed ſuch profound tranquillity, as afforded the diet full leiſure to confirm and perfect the plan of religious pacification agreed upon at Paſſau, and referred to the conſideration of the next meeting of the Germanic body. During the negociation of this treaty, an event happened which aſtoniſhed all Europe, and confounded the reaſonings of the wiſeſt politicians.

158
Charles reſigns his dominions to his ſon Philip.
An. 1556.

The emperor Charles V. though no more than 56, an age when objects of ambition operate with full force on the mind, and are generally purſued with the greateſt ardour, had for ſome time formed the reſolution of reſigning his hereditary dominions to his ſon Philip. He now determined to put it in execution. Various have been the opinions of hiſtorians concerning a reſolution ſo ſingular and unexpected; but the moſt probable ſeem to be, the diſappointments which Charles had met with in his ambitious hopes, and the daily decline of his health. He had early in life been attacked with the gout; and the fits were now become ſo frequent and ſevere, that not only the vigour of his conſtitution was broken, but the faculties of his mind were ſenſibly impaired. He therefore judged it more decent to conceal his infirmities in ſome ſolitude, than to expoſe them any longer to the public eye; and as he was unwilling to

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to forfeit the fame, or lose the acquisitions of his better years, by attempting to guide the reins of government when he was no longer able to hold them with steadiness, he determined to seek in the tranquillity of retirement, that happiness which he had in vain pursued amidst the tumults of war and the intrigues of state.

In consequence of this resolution, Charles, who had already ceded to his son Philip the kingdom of Naples and the duchy of Milan, assembled the states of the Low Countries at Brussels; and seating himself for the last time in the chair of state, he explained to his subjects the reasons of his resignation, and solemnly devolved his authority upon Philip. He recounted with dignity, but without ostentation, all the great things which he had undertaken and performed since the commencement of his administration. "I have dedicated (observed he), from the 17th year of my age, all my thoughts and attention to public objects, reserving no portion of my time for the indulgence of ease, and very little for the enjoyment of private pleasure. Either in a pacific or hostile manner, I have visited Germany nine times, Spain six times, France four times, Italy seven times, the Low Countries ten times, England twice, Africa as often; and while my health permitted me to discharge the duty of a sovereign, and the vigour of my constitution was equal in any degree to the arduous office of governing such extensive dominions, I never shunned labour, nor repined under fatigue; but now, when my health is broken, and my vigour exhausted by the rage of an incurable distemper, my growing infirmities admonish me to retire; nor am I so fond of reigning, as to retain the sceptre in an impotent hand, which is no longer able to protect my subjects. Instead of a sovereign worn out with diseases (continued he), and scarce half alive, I give you one in the prime of life, already accustomed to govern, and who adds to the vigour of youth all the attention and sagacity of maturer years." Then turning towards Philip, who fell on his knees, and kissed his father's hand, "It is in your power (said Charles), by a wise and virtuous administration, to justify the extraordinary proof which I give this day of my paternal affection, and to demonstrate that you are worthy of the extraordinary confidence which I repose in you. Preserve (added he) an inviolable regard for religion; maintain the Catholic faith in its purity; let the laws of your country be sacred in your eyes; encroach not on the rights of your people; and if the time should ever come when you shall wish to enjoy the tranquillity of private life, may you have a son to whom you can resign your sceptre with as much satisfaction as I give up mine to you." A few weeks after, he resigned to Philip the sovereignty of Spain and America; reserving nothing to himself out of all these vast possessions but an annual pension of 100,000 crowns.

Charles was now impatient to embark for Spain, where he had fixed on a place of retreat; but by the advice of his physicians, he put off his voyage for some months, on account of the severity of the season; and, by yielding to their judgment, he had the satisfaction before he left the Low Countries of taking a considerable step towards a peace with France. This he ardently longed for; not only on his son's account, whose administration he wished to commence in quietness, but that he might have the glory, when quitting the world, of restoring to Europe that tranquillity which his ambition had banished out of it almost from the time that he assumed the reins of government.

The great bar to such a pacification, on the part of France, was the treaty which Henry had concluded with the Pope; and the emperor's claims were too numerous to hope for adjusting them suddenly. A truce of five years was therefore proposed by Charles; during which term, without discussing their respective pretensions, each should retain what was in his possession; and Henry, through the persuasion of the constable Montmorency, who represented the imprudence of sacrificing the true interests of his kingdom to the rash engagements that he had come under with Paul, authorised his ambassadors to sign at Vaucelles a treaty, which would insure to him for so considerable a period the important conquest which he had made on the German frontier, together with the greater part of the duke of Savoy's dominions.

159 A truce of five years concluded with France.

The Pope, when informed of this transaction, was no less filled with terror and astonishment than rage and indignation. But he took equal care to conceal his fear and his anger. He affected to approve highly of the truce; and he offered his mediation, as the common father of Christendom, in order to bring about a definitive peace. Under this pretext, he appointed Cardinal Rebibo his nuncio to the court of Brussels, and his nephew Cardinal Caraffa to that of Paris. The public instructions of both were the same; but Caraffa, besides these, received a private commission, to spare neither intreaties, promises, nor bribes, in order to induce the French monarch to renounce the truce and renew his engagements with the holy see. He flattered Henry with the conquest of Naples; he gained by his address the Guises, the queen, and even the famous Diana of Poictiers, duchess of Valentinois, the king's mistress; and they easily swayed the king himself, who already leaned to that side towards which they wished to incline him. All Montmorency's prudent remonstrances were disregarded; the nuncio (by powers from Rome) absolved Henry from his oath of truce; and that weak prince signed a new treaty with the Pope; which rekindled with fresh violence the flames of war, both in Italy and the Low Countries.

160 Quarrel betwixt the pope and King Philip.

No sooner was Paul made acquainted with the success of this negotiation than he proceeded to the most indecent extremities against Philip. He ordered the Spanish ambassador to be imprisoned; he excommunicated the Colonnas, because of their attachment to the imperial house; and he considered Philip as guilty of high treason, and to have forfeited his right to the kingdom of Naples, which he was supposed to hold of the holy see, for afterward affording them a retreat in his dominions.

Alarmed at a quarrel with the Pope, whom he had been taught to regard with the most superstitious veneration, as the vicegerent of Christ and the common father of Christendom, Philip tried every gentle method before he made use of force. He even consulted some Spanish divines on the lawfulness of taking arms against a person so sacred. They decided in his favour; and Paul continuing inexorable, the duke of Alva, to whom the

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the negotiations as well as the war had been committed, entered the ecclesiastical state at the head of 10,000 veterans, and carried terror to the gates of Rome.

The haughty pontiff, though still inflexible and undaunted himself, was forced to give way to the fears of the cardinals, and a truce was concluded for 40 days. Mean time the duke of Guise arriving with a supply of 20,000 French troops, Paul became more arrogant than ever, and banished all thoughts from his mind but those of war and revenge. The duke of Guise, however, who had precipitated his country into this war, chiefly from a desire of gaining a field where he might display his own talents, was able to perform nothing in Italy worthy of his former fame. He was obliged to abandon the siege of Civetella; he could not bring the duke of Alva to a general engagement; his army perished by diseases; and the Pope neglected to furnish the necessary reinforcements. He begged to be recalled; and France stood in need of his abilities.

Philip, though willing to have avoided a rupture, was no sooner informed that Henry had violated the truce of Vaucelles, than he determined to act with such vigour, as should convince Europe that his father had not erred in resigning to him the reins of government. He immediately assembled in the Low Countries a body of 50,000 men, and obtained a supply of 10,000 from England, which he had engaged in his quarrel; and as he was not ambitious of military fame, he gave the command of his army to Emanuel Philibert duke of Savoy, one of the greatest generals of that warlike age.

The duke of Savoy kept the enemy for some time in suspense with regard to his destination; at last he seemed to threaten Champagne; towards which the French drew all their troops; then turning suddenly to the right, he advanced by rapid marches into Picardy, and laid siege to St Quintin. It was deemed in those times a town of considerable strength; but the fortifications had been much neglected, and the garrison did not amount to a fifth part of the number requisite for its defence: it must therefore have surrendered in a few days, if the admiral de Coligny had not taken the gallant resolution of throwing himself into it with such a body of men as could be collected on a sudden. This he effected in spite of the enemy, breaking through their main body. The place, however, was closely invested; and the constable Montmorency, anxious to extricate his nephew out of that perilous situation, in which his zeal for the public had engaged him, as well as to save a town of such importance, rashly advanced to its relief with forces one half inferior to those of the enemy. His army was cut in pieces, and he himself made prisoner.

161 The French entirely defeated at St Quintin. An. 1557.

The cautious temper of Philip on this occasion saved France from devastation, if not ruin. The duke of Savoy proposed to overlook all inferior objects, and march speedily to Paris, which, in its present consternation, he could not have failed to make himself master of; but Philip, afraid of the consequences of such a bold enterprise, desired him to continue the siege of St Quintin, in order to secure a safe retreat in case of any disastrous event. The town, long and gallantly defended by Coligny, was at last taken by storm; but not till France was in a state of defence.

Philip was now sensible that he had lost an opportunity which could never be recalled, of distressing his enemy, and contented himself with reducing Horn and Catelet; which petty towns, together with St Quintin, were the sole fruits of one of the most decisive victories gained in the 16th century. The Catholic king, however, continued in high exultation on account of his success; and as all his passions were tinged with superstition, he vowed to build a church, a monastery, and a palace, in honour of St Laurence, on the day sacred to whose memory the battle of St Quintin had been fought. He accordingly laid the foundation of an edifice, in which all these were included, and which he continued to forward at vast expence, for 22 years. The same principle which dictated the vow directed the building. It was so formed as to resemble a gridiron—on which culinary instrument, according to the legendary tale, St Lawrence had suffered martyrdom. Such is the origin of the famous Escurial near Madrid, the royal residence of the kings of Spain.

The first account of that fatal blow which France had received at St Quintin, was carried to Rome by the courier whom Henry had sent to recal the duke of Guise. Paul remonstrated warmly against the departure of the French army; but Guise's orders were peremptory. The arrogant pontiff therefore found it necessary to accommodate his conduct to the exigency of his affairs, and to employ the mediation of the Venetians, and of Cosmo de Medici, in order to obtain peace. The first overtures of this nature were eagerly listened to by the Catholic king, who still doubted the justice of his cause, and considered it as his greatest misfortune to be obliged to contend with the Pope. Paul agreed to renounce his league with France; and Philip stipulated on his part, that the duke of Alva should repair in person to Rome, and after asking pardon of the holy father in his own name and in that of his master, for having invaded the patrimony of the church, should receive absolution from that crime. Thus Paul, through the superstitious timidity of Philip, finished an unpropitious war not only without any detriment to the apostolic see, but saw his conqueror humbled at his feet: and so excessive was the veneration of the Spaniards in that age for the papal character, that the duke of Alva, the proudest man perhaps of his time, and accustomed from his infancy to converse with princes, acknowledged, that when he approached Paul, he was so much overawed, that his voice failed, and his presence of mind forsook him.

162 Peace concluded.

163 Consequences of the war in Italy.

But though this war, which at its commencement threatened mighty revolutions, was terminated without occasioning any alteration in those states which were its immediate object, it produced effects of considerable consequence in other parts of Italy. In order to detach Octavio Farnese, duke of Parma, from the French interest, Philip restored to him the city of Placentia and its territory, which had been seized by Charles V. and he granted to Cosmo de Medici the investiture of Sienna, as an equivalent for the sums due to him. By these treaties, the balance of power among the Italian states was poised with more equality, and rendered less variable than it had been since it received the first violent shock from the invasion of Charles VIII. and Italy henceforth ceased to be the theatre on which the monarchs of Spain, France, and Germany, contended for fame and dominion. Their hostilities, excited by new objects, stained other regions of Europe with blood, and

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and made other states feel, in their turn, the miseries of war.

164 The French unsuccessful in the Low Countries. The duke of Guise, who left Rome the same day that his adversary the duke of Alva made his humiliating submission to the Pope, was received in France as the guardian angel of the kingdom. He was appointed lieutenant-general in chief, with a jurisdiction almost unlimited; and, eager to justify the extraordinary confidence which the king had reposed in him, as well as to perform something suitable to the high expectations of his countrymen, he undertook in winter the siege of Calais. Having taken that place, he next invested Thionville in the duchy of Luxembourg, one of the strongest towns on the frontiers of the Netherlands; and forced it to capitulate after a siege of three weeks. But the advantages on this quarter were more than balanced by an event which happened in another part of the Low Countries. The mareschal de Termes governor of Calais, who had penetrated into Flanders and taken Dunkirk, was totally routed near Gravelines, and taken prisoner by Count Egmont. This disaster obliged the duke of Guise to relinquish all his other schemes, and hasten towards the frontiers of Picardy, that he might there oppose the progress of the enemy.

The eyes of all France were now turned towards the duke of Guise, as the only general on whose arms victory always attended, and in whose conduct as well as good fortune they could confide in every danger. His strength was nearly equal to the duke of Savoy's, each commanding about 40,000 men. They encamped at the distance of a few leagues from one another; and the French and Spanish monarchs having joined their respective armies, it was expected that, after the vicissitudes of war, a decisive battle would at last determine which of the rivals should take the ascendency for the future in the affairs of Europe. But both monarchs, as if by agreement, stood on the defensive; neither of them discovering any inclination, though each had it in his power, to rest the decision of a point of such importance on the issue of a single battle.

165 Peace concluded between Henry and Philip. During this state of inaction, peace began to be mentioned in each camp, and both Henry and Philip discovered an equal disposition to listen to any overture that tended to re-establish it. The private inclinations of both kings concurred with their political interests and the wishes of their people. Philip languished to return to Spain, the place of his nativity, and peace only could enable him, either with decency or safety, to quit the Low Countries. Henry was now desirous of being freed from the avocations of war, that he might have leisure to turn the whole force of his government towards suppressing the opinions of the reformers, which were spreading with such rapidity in Paris and the other great towns, that they began to grow formidable to the established church. Court-intrigues conspired with these public and avowed motives to hasten the negociation, and the abbey of Cercamp was fixed on as the place of congress.

While Philip and Henry were making these advances towards a treaty which restored tranquillity to Europe, Charles V. whose ambition had so long disturbed it, but who had been for some time dead to the world,

166 Death of Charles V. ended his days in the monastery of St Justus in Estremadura, which he had chosen as the place of his retreat, as is particularly related under the article CHARLES V.

After the death of Charles, the kingdom of Spain soon lost great part of its consequence. Though Charles had used all his interest to get his son Philip elected emperor of Germany, he had been totally disappointed; and thus the grandeur of Philip II. never equalled that of his father. His dominions were also considerably abridged by his tyrannical behaviour in the Netherlands. In consequence of this, the United Provinces revolted; 167 Revolt of the United Provinces.
and after a long and bloody war obtained their liberty *. In this quarrel Elizabeth of England took part against Philip, which brought on a war with Spain. The great losses he sustained in these wars exhausted the kingdom both of men and money, notwithstanding the great sums imported from America. Indeed the discovery of that country has much impoverished, instead of enriching Spain; for thus the inhabitants have been rendered lazy and averse to every kind of manufacture or traffic, which only can be a durable source of riches and strength to any nation. 168 Expulsion of the Moors, and its bad consequences to Spain.
The ruin of the kingdom in this respect, however, was completed by Philip III. who, at the instigation of the inquisition, and by the advice of his prime minister the duke of Lerma, expelled from the kingdom all the Morescoes or Moors, descendants of the ancient conquerors of Spain. Thirty days only were allowed them to prepare for their departure, and it was death to remain beyond that time. The reason for this barbarous decree was, that these people were still Mahometans in their hearts, though they conformed externally to the rites of Christianity, and thus might corrupt the true faith. The Morescoes, however, chose themselves a king, and attempted to oppose the royal mandate; but, being almost entirely unprovided with arms, they were soon obliged to submit, and were all banished the kingdom. By this violent and impolitic measure, Spain lost almost a million of industrious inhabitants; and as the kingdom was already depopulated by bloody wars, by repeated emigrations to America, and enervated by luxury, it now sank into a state of languor from which it has never recovered.

* See *United Provinces*.

The reign of Philip IV. the successor of Philip III. 169 Philip IV. An. 1621.
commenced in 1621. He had not been long seated on the throne before the expiration of the 12 years truce which Philip III. had concluded with the United Provinces, again involved Spain in the calamities of war. The renewed contest was carried on with vigour by both the contending powers, till in the year 1648 the Spanish monarch was compelled to sign the treaty of Munster, by which the United Provinces were declared free and independent. 170 Final loss of the United Provinces.
From this period the power of the Spanish monarchy began to decline, as it had already been severely shaken by the loss of Portugal.

This event took place in 1640, when the Portuguese finally threw off the Spanish yoke, and that country remained an independent kingdom, till the power of Bonaparte compelled its lawful monarch to abandon his European territories. 171 Revolt of Portugal. An. 1640.
Philip IV. also prosecuted an unsuccessful war with France. This war was terminated in 1659, and Philip died about six years after.

The new monarch, Charles II. was only four years old when he succeeded to the throne. 172 Charles II. An. 1665.
He was of a feeble constitution, and a weak capacity. The war which had been occasioned by the revolt of Portugal, continued till the year 1668, when a peace was concluded, and the independence of that kingdom was acknowledged. Hostilities had been renewed with France, but

Spain. but greatly to the diſadvantage of the Spaniards, who loſt ſome of the richeſt and beſt fortified towns which they ſtill poſſeſſed in Flanders. The peace of Nimeguen between France and Spain was ſigned in the year 1678. Charles II. died in 1700, and with him ended the male line of the houſe of Auſtria; a dynaſty to which Spain owes leſs than to any other race of its monarchs.

Hiſtorians have been fond of repreſenting the dominion of the Auſtrian princes in Spain as productive of the greateſt glory and advantage to that kingdom. The reign of Charles V. may indeed be ſaid to have been a glorious reign; but little of its glory belonged to Spain, and the emperor certainly neglected her intereſts in advancing thoſe of his more favoured territories. The picture given by the Spaniſh hiſtorians of the ſtate of Spain at the acceſſion and during the reign of Philip II. fully evinces how little that kingdom had profited by the change in the line of its ſucceſſion. Agriculture was neglected; commerce was fettered by enormous duties, and the people were held in the chains of ignorance and ſuperſtition.

173 Acceſſion of the Houſe of Bourbon. An. 1700.

Charles II. was ſucceeded by Philip V. duke of Anjou, and grandſon to Louis XIV. of France, who had been nominated heir to the Spaniſh throne by the late monarch. The tranſactions of the war which was ſoon declared againſt France and Spain, by England, Holland, and the empire, aſſiſted by Savoy, Portugal, and Pruſſia, have been already related under the article BRITAIN, from N° 345 to N° 371. The treaty of Utrecht, which terminated the differences between the principal contending powers, was ſigned in 1713, and in 1715 a permanent peace was concluded between Spain and Portugal. Hoſtilities, however, ſtill continued with Savoy and Sardinia, and in 1715 the iſland of Sardinia was taken by a Spaniſh fleet, and the year following another fleet belonging to the ſame nation invaded Sicily, but was defeated by the Britiſh admiral Byng. By a new treaty in 1720, Sardinia was given to the duke of Savoy, and Sicily to the emperor; and by the treaty of Seville, concluded in 1729, the duchies of Tuſcany, Parma, and Placentia, were ceded to Spain. In 1731, the Spaniſh king invaded Naples, took poſſeſſion of that kingdom, and conferred it on his ſon Don Carlos, in conſequence of which war was declared between Spain and the empire in 1733. At the end of that year the palace of Madrid was conſumed by fire, and all the archives relating to the Indies periſhed in the flames.

In 1739, hoſtilities were renewed between Spain and Britain, (ſee BRITAIN, N° 403); but the only ſucceſſes acquired by the latter power were the capture of Porto Bello by Admiral Vernon, and that of the Manilla galeon by Commodore Anſon. After a long and turbulent reign, Philip V. died in 1746.

174 Ferdinand VI. An. 1746.

Ferdinand VI. a mild, prudent, and beneficent prince, reformed abuſes in the adminiſtration of juſtice, and management of the finances. He revived commerce, eſtabliſhed manufactures, and promoted the proſperity of his kingdom. In April A. D. 1755, Quito in South America was deſtroyed by an earthquake.

175 Charles III. An. 1759.

Charles III. ſucceeded Ferdinand in 1759. The famous family compact was concluded at Verſailles, A. D. 1761, among the four kings of the houſe of Bourbon. The Engliſh, alarmed by the naval preparations of Spain, declared war in 1762 (ſee BRITAIN, N° 450), and took Havannah in the iſland of Cuba, and Manilla in the East Indies. Notwithſtanding this ſucceſs, peace was haſtily concluded at Fountainbleau, in November, by which the Havannah was reſtored. In 1767 the Jeſuits were expelled from Spain. An unſucceſsful expedition was concerted againſt Algiers, A. D. 1775, the particulars of which are related in M. Swinburne's Travels, letter v. In the war between Great Britain and her American colonies, Spain, by the intrigues of the French court, was prevailed on to take up arms in ſupport of the latter. At the concluſion of that calamitous war, Great Britain in a treaty with Spain, ceded to this power, Eaſt and Weſt Florida, and the iſland of Minorca. Charles died in 1788, and was ſucceeded by his ſecond ſon Charles Anthony prince of Aſturias, the eldeſt having been declared incapable of inheriting the crown.

176 Charles IV. An. 1788.

Charles IV. had not long been ſeated on the throne before the portentous revolution in France involved Europe in a general ſcene of political and military conteſt. The king of Spain joined the general confederacy againſt the new republic, and in conſequence was numbered among the objects of its reſentment, by a declaration of war in 1793. The military operations of Spain, however, were extremely languid; and after two campaigns, in which ſhe might be ſaid to carry on rather a defenſive than offenſive war, againſt the republican armies (ſee FRANCE, N° 411), ſhe was compelled to conclude a treaty of peace, which was ſigned at Baſil on the 22d July 1795. By this treaty the French republic reſtored to the king of Spain all the conqueſts which ſhe had made from him ſince the commencement of hoſtilities, and received in exchange all right and property in the Spaniſh part of St Domingo.

177 Engages in the confederation againſt France. An. 1793.

178 War between Spain and Britain. An. 1796.

This treaty was ſoon followed by a rupture with Great Britain. On 5th October 1796, the court of Spain publiſhed a manifeſto againſt this country, to which the court of London made a ſpirited reply; and about the ſame time was publiſhed a treaty of offenſive and defenſive alliance, which had been concluded about two months before, between the king of Spain and the French republic. In the war which followed between Spain and Great Britain, his Catholic majeſty could boaſt of but little honour or ſucceſs; and the French republic gained little from its new ally, but the contributions of money, which ſhe from time to time compelled him to advance. On the 14th of February 1797, a Spaniſh fleet of 27 ſail of the line was defeated by Sir John Jervis off Cape St Vincent (ſee FRANCE, N° 482); and four of the Spaniſh line of battle ſhips were left in the hands of the victors. From this time till the temporary termination of hoſtilities by the peace of Amiens in 1802, there is nothing remarkable in the tranſactions of Spain. An. 1797.

On the renewal of the war in 1803, Spain was again compelled, by the overbearing power of France, to take an active part againſt Great Britain, and fitted out a formidable fleet, which was united to a conſiderable naval force of the new-made emperor of the French. The Spaniſh declaration of war againſt Britain is dated at Madrid on the 12th of December 1804; and on the 21ſt of October 1805, the combined fleets of France and Spain were nearly annihilated by Lord Nelſon's deciſive victory off Cape Trafalgar. An. 1803. An. 1805.

After this terrible blow to the naval power of Spain, nothing

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nothing of importance took place till 1808, when the deſigns of Bonaparte againſt the independence of Spain,

179 Revolution in favour of the prince of Aſturias. An. 1808.

which had been long ſuſpected, were openly avowed, in conſequence of a domeſtic diſpute, probably fomented by the emiſſaries of France, which took place between Charles IV. and the prince of Aſturias. During the winter of 1807-8 the public mind in Spain had been greatly agitated. Some accuſed the prince of the Peace, Don Manuel Godoy, (who had long held the helm of ſtate, and was the richeſt and moſt powerful ſubject in the kingdom), of having concerted with the queen to deſtroy the prince of Aſturias. Others accuſed the prince of Aſturias of being at the head of a party to dethrone his father. Solemn councils and long proceedings, followed up by exiles and violent acts, far from calming opinions, ſerved to agitate them ſtill more.

In March 1808, ſeveral diſturbances happened at Aranjuez. Theſe diſturbances were excited by a report that the royal family were about to quit Spain and emigrate to America. In conſequence of this report, the populace of the neighbouring villages repaired in crowds to Aranjuez, where they found the attendants of the court packing up the baggage of the royal houſehold; and underſtood that relays of horſes were ſtationed on the road to Seville, and that every thing was prepared for the departure of the royal fugitives, who were to take ſhipping at that port. It was ſuſpected that Don Manuel Godoy, or, as he has commonly been called, the prince of the Peace, was the chief inſtigator of this unpopular meaſure; and the fury of the people was directed chiefly againſt that nobleman, whoſe palace they attacked on the 18th of March. He, however, found means to eſcape for the preſent, but was afterwards arreſted in a garret of his own houſe. In the mean time the king iſſued two decrees with a view to allay the popular ferment; but as this ſtill continued, he on the 19th took the extraordinary reſolution of abdicating the throne in favour of the prince of Aſturias. This reſolution was made known by a royal decree, in which Charles declared that, as his natural infirmities no longer permitted him to ſupport the weight of government, and the re-eſtabliſhment of his health required a change of climate, he had after the moſt mature deliberation reſolved to abdicate his crown in favour of his heir the prince of Aſturias; and this reſolution he declared to be the reſult of his own free will.

180 Ferdinand VII.

The new ſovereign was accordingly proclaimed by the title of Ferdinand VII. and iſſued an edict confiſcating the effects of Don Manuel Godoy, and announcing the appointment of the duke of Infantado, a nobleman deſervedly popular for his talents and virtues, to the preſidency of Caſtile and the command of the royal guards.

Theſe diſturbances have commonly been attributed to the machinations of the French emperor, who had gained a complete aſcendency over the weak Charles; and had rendered the prince of the Peace entirely ſubſervient to the views which he had formed on the independence and the liberties of Spain. How far this ſuppoſition is correct, it is impoſſible for us at this time to determine; but it is rendered probable by the active meaſures taken about this time by Napoleon to awe by a French force the Spaniſh nation. Murat the grand duke of Berg was at this time on his march towards the capital with a body of French troops; and his march was haſtened by the information which he had received of the tumults at Aranjuez. This general cauſed it to be intimated to Ferdinand, that the emperor of the French was on his journey to Spain, and adviſed him to meet his maſter on the road. In the mean time he was tampering with the ſelf-depoſed monarch, whom he aſſured of the aſſiſtance of Bonaparte in reinſtating him on the throne. Charles accordingly addreſſed a letter to Bonaparte, in which he contradicts the aſſertion of his decree of the 19th; and declares that his abdication was a meaſure of compulſion; and throws himſelf on the protection of that great monarch, his friend and ally, from whom alone he and his ſubjects can hope to derive tranquillity and happineſs.

181 Deſigns of Bonaparte on the independence of Spain.

It appears to have been the deſign of Murat to draw out of Spain the whole of the royal family, and in this deſign he completely ſucceeded. Ferdinand ſet out to meet Bonaparte, accompanied by the French general Savary, and had advanced as far as Vittoria, where he was left by Savary, and where he found himſelf ſurrounded by French troops. He was compelled to remain at Vittoria, until Savary, who had proceeded to Bayonne, where Bonaparte then was, ſhould return and intimate to him the pleaſure of his maſter. When the general returned, he brought with him a letter from Napoleon to Ferdinand. In this letter, which is addreſſed to Ferdinand as prince of Aſturias, and not as king of Spain, Bonaparte aſſured the prince, that the ſole object of his journey into Spain was to make ſuch reforms in that kingdom as would be agreeable to the public feelings. Without pretending to judge reſpecting the late revolution, he cautions Ferdinand againſt the danger to be apprehended from ſovereigns permitting their ſubjects to take juſtice into their own hands. After inſinuating his own power over the royal family of Spain, and adverting to the tumults that had taken place, in which ſome of his troops had fallen, he makes uſe of the following expreſſion, "a few of my ſoldiers may be murdered; but the ſubjugation of Spain ſhall be the conſequence of it."

Ferdinand confounded at the conduct of the French emperor, and alarmed for his own perſonal ſafety, was compelled to proceed on his journey. When he arrived at Bayonne he was received by the prince of Neufchatel and Duroc, and was conducted to a place by no means ſuited to his rank or his character as ally of Bonaparte. He however dined with the emperor; but after he had retired, General Savary brought a meſſage from his maſter, intimating his determination that the preſent royal family of Spain ſhould give up to him all right and title to the crown of that kingdom, and that they ſhould be ſucceeded by a branch of his own family. Aſtoniſhed at this intimation, Ferdinand ſent his prime miniſter Cevallos, to canvaſs the matter with M. Champagny, the confidential ſecretary of Napoleon. The conference was held in an apartment adjoining the cabinet of the emperor, and, as it appeared, within his hearing: for when Cevallos was arguing with great warmth and ſtrength of reaſoning on the injuſtice and even impolicy of the propoſed meaſures, both he and Champagny were ordered into the emperor's preſence; and the former was reviled in the groſſeſt terms, branded with the appellation of a traitor, accuſed of having maintained that the recognition of Bonaparte was not neceſſary to the validity of his maſter's title to the throne of Spain, and of

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having affirmed that if the French dared to attack the independence of the Spanish monarchy, three hundred thousand men would rise to defend it and repel the invaders. After Napoleon had thus indulged the violence of his temper, he entered in a harsh and arrogant style on a discussion of the points in dispute between his secretary and Cevallos; and finding that he could neither convince nor silence the Spanish minister, he abruptly concluded with the following peremptory declaration: "I have a system of policy of my own; you ought to adopt more liberal ideas, to be less susceptible on the point of honour, and not sacrifice the prosperity of Spain to the interest of the House of Bourbon." From this time the destiny of the Spanish royal family was fixed. Ferdinand the monarch of the people's choice was already a captive, and not many days elapsed before the rest of the royal family was in the same situation. On the first of May, Ferdinand had made a conditional renunciation of his crown in favour of his father, and on the fifth of the same month Bonaparte had a long conversation with Charles the fourth and his queen. Ferdinand was called in by his father, to hear, in the presence of him and the queen, the disgusting and humiliating expressions which were uttered by the French emperor, expressions of such a nature, that Cevallos says he dares not record them. All the parties were seated except Ferdinand; he was ordered by his father to make an absolute renunciation of the crown, on pain of being treated as an usurper and a conspirator against the right of his parents. With this requisition Ferdinand complied, and thus completed the abdication of his family; for it appeared that on the preceding day Charles had executed the deed of resignation, which transferred to the emperor of the French his title to the crown of Spain, on consideration of receiving during his life an annuity of eighty millions of reals, of a dowry to his queen of two millions of reals, and to the infantes of Spain the annual sum of four hundred thousand livres.

Thus had Bonaparte effected the transference of the Spanish nation from the Bourbon dynasty to his own family, so far at least as that transference could be effected by the formal renunciation in his favour of the royal family, and by a strong but suspicious recommendation from them to the Spanish nation to receive their new sovereign, whoever he should be, with submission and obedience. Filled as the annals of mankind are with examples of treachery, perfidy, and violence, it would be difficult to point out a deed which in every part of its performance, in its own nature, or in the character of the means by which it was effected, bears such strong marks of unjust and lawless tyranny.

It was soon understood that Napoleon designed the crown of Spain for his brother Joseph, who had some time before been placed on the throne of Naples. In an address to the Spanish nation, which Bonaparte published immediately after the abdication of Charles and Ferdinand, he informed them that he did not mean to reign over them in person, but that he would give them a sovereign every way resembling himself. In the beginning of June Joseph Bonaparte arrived in the neighbourhood of Bayonne, where he was received by a deputation of the grandees of Spain and from the council of Castile, and presented with a congratulatory address, written in the most fulsome style of adulation, on his accession to the Spanish throne.

But though the nomination of Joseph Bonaparte was easily effected, it was not so easy to place him on the throne in opposition to the almost unanimous will of the Spanish nation. Ferdinand the seventh was the darling of the people; and his accession to the crown had been hailed by them, both as placing them under the dominion of a beloved monarch, and as releasing them from the tyranny of Godoy, who was an object of almost universal detestation. They had hitherto submitted with patience to the influence and power of France, hopeless of rescuing themselves while Charles possessed the throne, and while the prince of the Peace directed his councils; but the accession of Ferdinand, and the consequent disgrace of the favourite, had led them to hope that they should now find a sovereign willing to direct and assist their efforts to regain their independence. Under these expectations, a great part of the nation had come forward to offer their assistance in supporting the claims of the new monarch. The province of Catalonia, the most industrious and the most warlike of the Spanish nation, particularly distinguished itself by the promptitude and extent of its offers. Soon after Ferdinand had ascended the throne, the captain-general of Catalonia, relying on the well known resources and dispositions of the inhabitants, had come forward with an offer of a military force of above a hundred thousand men; and other provinces would have followed this example, but Ferdinand had discouraged these military preparations, and appeared willing to submit quietly to French bondage.

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Opposed by a general insurrection of the Spaniards.

The spirit which had animated the Spaniards thus boldly to support their favourite sovereign, was not of a nature to be chilled and repressed by his timidity or example. The hatred which they had conceived against the French daily found fresh sources of nourishment. They saw Ferdinand, who had rejected their proffered services lest he should expose himself to the suspicion or displeasure of Bonaparte, enticed by deceit, or compelled by violence, to relinquish his kingdom and commit himself to the power of his enemy. They anticipated the consequences, and prepared to resist them with vigour and unanimity. The renunciation of the royal family in favour of Bonaparte was no sooner known in Spain, than the northern provinces burst into open insurrection. Asturias and Gallicia set the glorious example; and it was soon followed by almost every part of Spain, not immediately occupied or overawed by the armies of France.

One of the first steps taken by the leaders of the insurrection was, to assemble the juntas or general assemblies of the provinces. When these were organized, they issued proclamations, calling on the Spaniards to rise in defence of their sovereign, and in the assertion of their own independence. Besides these proclamations from the provincial juntas, addresses were published in almost every province by the leaders of the popular cause; in particular, the province of Aragon was addressed by Palafox, a name celebrated in the annals of the Spanish revolution, in a bold and spirited manifesto. The junta of Seville, which assembled on the 27th of May, formed itself into a supreme junta of government, caused Ferdinand to be proclaimed king of Spain, took possession of the military stores, and issued an order for all males from 16 to 45, who had not children, to enroll themselves in the national armies.

It was natural that, when entering on so determined an

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an oppofition to the meafures of Bonaparte, the Spaniards fhould turn their eyes towards that nation, by whom alone the ambitious views of that potentate had been fuccefsfully combated. A peace and alliance with Britain was evidently not only a meafure of policy, but would afford them the moft effectual affiftance in the formidable ftruggle in which they were about to engage. Accordingly, deputies were difpatched to Great Britain from feveral of the provinces, to folicit the aid and friendfhip of that country, and to concert meafures with the Britifh miniftry for executing the plans which had been contrived for freeing the kingdom from the French yoke. The junta of Seville iffued a declaration of war with France, and declared the Spanifh nation on terms of peace and amity with Britain. The Spanifh deputies were empowered to folicit fupplies of arms, ammunition, clothing and money; but it was thought that a fupply of Britifh troops would be unneceffary, the Spanifh patriots confidering themfelves as fully equal to the defence of their country. The caufe of the Spanifh patriots was eagerly embraced by the court of London, and by the Britifh nation at large, and the moft active meafures were quickly taken to fend them effectual aid.

183 Peace and alliance with Britain.

184 Statement of the French and Spanifh forces.

While thefe preparations were making on the part of the Spaniards, the French forces were collecting in great numbers, both on the frontiers, and in the neighbourhood of the capital. Above 25,000 men, under the command of Beffieres and Laffoles, threatened the provinces of Afturias and Bifcay, or occupied the plains of Caftile. Ten thoufand men were fhut up in the citadel of Barcelona; and to relieve them, a ftrong body of French troops had marched from the frontiers, and laid fiege to Zaragoza. A confiderable body under General Moncey attacked the city of Valencia; while the grand duke of Berg, after having detached General Dupont at the head of 20,000 men, to quiet the infurrection of the fouthern provinces, held Madrid with about 15,000 troops. Junot, with about 25,000 men, had entered Portugal, and taken poffeffion of the capital. The whole French force at this time in Spain cannot be computed at lefs than 100,000 men. Thefe were oppofed by a very numerous, but undifciplined force, commanded by generals of acknowledged bravery, but differing widely from each other in experience and military prudence. General Palafox commanded in Aragon; General Caftanos in the fouthern provinces; and General Blake in the north.

185 Succeffes of the Spanifh patriots.

The firft exertions of the Spanifh patriots were eminently fuccefsful, though they have been greatly exaggerated in the newfpapers publifhed under authority of the juntas. The harbour of Cadiz, which contained a numerous and well-appointed fleet, was under the command of the marquis de Solano, a man notorioufly attached to the French intereft; and here lay a French fleet, confifting of five fhips of the line and a frigate. One of the firft efforts of the patriots was, to obtain poffeffion both of Cadiz and the French fleet, and in this they completely fucceeded. Solano was arrefted and put to death, and Don Morla was appointed in his room. In the beginning of June the French fleet was fummoned to furrender, and on the admiral's refufal, was furioufly attacked by the batteries on fhore, and obliged to capitulate. The force detached by Murat, under Dupont, was attacked near Baylen, on the 22d July, by Major-general Reding, fecond in command under Caftanos, and after having been defeated, was compelled to furrender at difcretion. The French force befieging Zaragoza, was repeatedly attacked by General Palafox, and fuffered confiderable loffes, while that city held out with the moft heroic bravery. Perhaps there are few inftances in the annals of modern warfare, in which fuch perfevering and fuccefsful courage has been difplayed, as by the defenders of Zaragoza. All the means of attack which were in poffeffion of the French, directed by the fkill with which their long experience and fuccefs had fupplied them, were made ufe of. The inhabitants were obliged continually to be upon their guard, and to be prepared to refift the moft unexpected and fecret, as well as the moft open and violent affaults. The city was frequently bombarded in the middle of the night, at the fame time that the gates were attempted to be forced, under cover of the fhells. More than once the French got into fome parts of the town; but they were received with fo much coolnefs and bravery, that they were never able to preferve what they had with fo much difficulty and lofs acquired. The women vied with their hufbands, fons, and brothers, in the difplay of patriotifm and contempt of danger: regardlefs of the fire of the enemy, they rufhed into the very middle of the battle, adminiftering fupport and refrefhment to the exhaufted and wounded, and animating, by their exhortations and example, all ranks to fuch a difplay of firmnefs and bravery as long fecured this important city. When it is recollected, that the attacks of the French were numerous and varied, that they were conftantly repeated with frefh, and generally with increafing forces, and that the fole defence of the city refted with its fpirited inhabitants and the army of Palafox; fome idea may be formed of the difficulties they muft have undergone and furmounted, and of the glory to which they are fo juftly entitled. The patriots had gained poffeffion of moft of the fea ports in the bay of Bifcay, and headed by the bifhop of St Andero, repulfed the French in feveral attacks. The French force under General Moncey was alfo repulfed before Valencia, and the patriots were equally fuccefsful in feveral other quarters; fo that by the end of July there did not remain above 40,000 French forces within the Spanifh territory.

186 Arrival and flight of Jofeph Bonaparte.

In the meantime preparations were making at Madrid for the reception of the new fovereign Jofeph; and Murat, under pretence of ill health, quitted the capital, to give way to the brother of his mafter. Jofeph Bonaparte arrived at Madrid in the latter end of July, with a guard of 10,000 men; but foon after his arrival the news of the defeat and capitulation of Dupont reached Madrid, and threw the new court into the utmoft confternation. They underftood that the victorious army of Caftanos was on its march towards the capital; and if he did not fpeedily retire from fo dangerous a pofition, King Jofeph dreaded either falling into the hands of the conqueror of Dupont, or of being intercepted in his retreat by the army of General Blake. In this fituation he found himfelf under the neceffity of quitting the capital which he had fo lately entered, and before the end of the month he had reached Burgos in his precipitate flight towards the frontiers. Thus, within the fpace of two months, did the people of Spain behold their country almoft entirely freed from the prefence of the French; and this glorious and happy iffue had been brought about by their own intrepidity. At a time when their fituation was the moft difpiriting and forlorn;

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lorn; when their king had been compelled to forsake them, and to make over his right to the throne to a foreign potentate; when they beheld scarcely any troops surrounding them on all sides, but those of that potentate, they rose in arms, and opposed themselves, unskilled as they were in war, and totally unprepared for it, to a man before whom the mightiest empires in Europe had fallen.

187 Reverses.

The successes of the Spanish arms, though brilliant and important, were but transient. The leaders of the insurrection appear to have been but ill calculated to oppose the system of tactics which had been so often practised with success by the conqueror of Marengo, of Jena, and of Austerlitz. Though the conquests of Austria and Prussia had been effected by the same system which the French were now pursuing in Spain, the military men of this kingdom were incapable of analyzing them, or of adopting effectual measures of opposition or defence. In a series of about 30 bulletins, published from the French army of Spain, comprehending from the beginning of November 1808 to the middle of January 1809, we read of nothing but the rapid movements and successes of the French, and the defeat and annihilation of the best appointed armies of the insurgents. In Gallicia, General Blake, after having withstood the duke of Dantzick (Marshal Ney), in several encounters, was at length defeated, and his army dispersed. A division of the army of Estremadura, under Count Belvider, which had marched from Madrid to support the city of Burgos, was attacked and defeated by a division of the French army under the dukes of Istria and Dalmatia; while the army of General Castanos was in a great measure dispersed, after a severe conflict on the heights of Tudela. According to the French account, the army of Castanos consisted of 45,000 men. It was opposed by the duke of Montebello, and entirely defeated, with the loss of nearly 4000 killed, and 5000 taken prisoners.

In the meantime Bonaparte had entered Spain, and taken the command of the French army. He advanced by rapid marches towards Madrid, and at the end of November his advanced guard reached the important pass of Somosierra. This pass was defended by a body of 13,000 Spaniards, with sixteen pieces of cannon. They were attacked by the French under the duke of Belluno, and after making a considerable stand, were entirely defeated. On the 2d of December Bonaparte arrived in the neighbourhood of Madrid, and on the 5th he was master of that capital.

188 British expeditions in support of the Spanish patriots.

While the Spanish patriots were thus pursuing their plan of opposition to French tyranny with various success, the British cabinet were fitting out formidable expeditions to the coasts of Spain and Portugal. The result of the expedition under Sir Harry Burrard and Sir Arthur Wellesley, the battle of Vimiera, the convention of Cintra, and the consequent evacuation of Portugal by the French, in the month of August 1808, have been already noticed under Portugal, N° 49 and 50. After these transactions, the greater part of the British army under the command of Lieutenant-general Sir John Moore, proceeded on their march to the frontiers of Spain. The progress and operations of this army will be detailed mentioned. About the middle of the same month, a body of 13,000 British troops, under the command of Sir David Baird, arrived at Corunna, and proceeded through the interior of the country, intending to join Sir John Moore in the neighbourhood of Madrid. A brigade of 10,000 men under General Hope, reached that capital, and established themselves at the Escurial; but on the approach of Bonaparte, were under the necessity of retiring.

189 March of Sir John Moore to Sahagun.

Experience has shown that in their military campaigns on the continent, British forces have to contend with numerous difficulties, surmountable only by the utmost prudence and vigilance on the part of the commanding officers, and by a considerable degree of skill and foresight on that of the projectors of such undertakings. Never perhaps were these difficulties more severely felt than in the march of Sir John Moore from Portugal to the centre of the Spanish territory. It was found that in whatever direction he might prosecute his march, he would encounter either bad roads or scanty supplies of provisions. In particular, the difficulty of transporting the artillery over the Portuguese mountains was extreme; and the Portuguese at Lisbon were either egregiously ignorant of the state of the roads which led through their own country to the Spanish frontiers, or were unwilling to communicate the information which they really possessed. Under these circumstances it was found necessary to divide the British army; and it was determined to send forward one division consisting of 6000 men under the command of Lieutenant-General Hope, which was directed to march by Elvas, to enter Spain by Badajos, and to proceed along the Madrid road by way of Espinar. Another division, consisting of two brigades under General Paget, was detached by way of Elvas and Alcantara, where it was to pass the Tagus. Two brigades under General Beresford moved through Portugal by way of Coimbra and Almeyda towards Salamanca, while three brigades under General Fraser marched towards the frontiers of Spain by Abrantes and Almeyda.

Burgos had been recommended by the Spanish government as the point of union for the British troops, and Madrid and Valladolid were appointed for magazines. The British had been led to expect that they would find between 60,000 and 70,000 Spaniards assembled under General Blake and the marquis de la Romana in the provinces of Asturias and Gallicia, and that a much greater number was ready to co-operate with them under the command of Castanos on the front and left of the principal French position. The Spaniards had been represented as unanimous in their enthusiasm for the cause of liberty, and as ready to treat the British troops as the saviours of their country. How far this information was correct, will be seen presently.

In marching through the Portuguese territory, the troops first encountered difficulties which they were not prepared to expect. The contractor at Lisbon, who had agreed to supply the divisions with rations on the march, failed in his contract, and excessive inconvenience was experienced from the want of money. The divisions under Generals Fraser and Beresford were obliged to halt, and it was some time before they could again set forward. The proceedings of the central junta, on which all the movements both of the British and Spanish armies chiefly depended, were languid, tardy, and irresolute; and before the British troops could assemble in any force in Spain, the principal armies of the patriots had been defeated and dispersed in almost every

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every quarter. On the 8th of November Sir John Moore reached Almeyda. The weather was at this time extremely unfavourable, and the troops were expofed to almoft inceffant rain. They entered Spain on the 11th of November, and on the 13th Sir John arrived with his advanced guard at Salamanca, where he halted, intending to affemble there all the troops which were on their march through Portugal. While he remained at Salamanca, he was informed that a confiderable French force had advanced and taken poffeffion of Valladolid, at the diftance of only twenty leagues, by which one of the places that had been intended for magazines was loft. At this time Sir John had with him only three brigades of infantry without artillery, and it would be at leaft ten days before the whole of the divifions could come up. He was thus expofed to almoft an immediate attack by the French without any effectual fupport from the boafted patriotifm of the Spaniards.

The fituation of affairs in Spain had now become extremely critical; and every account fent to Sir John Moore by men of found judgement, was filled with convincing proofs that the Spanifh government had concealed from their ally the very defperate ftate of their affairs. General Hope, by a long and tirefome march, had reached the neighbourhood of Madrid, whence he wrote a letter to Sir John, ftating that every branch was affected by the disjointed and inefficient conftruction of the government. On the 28th of November Sir John was advertifed of the late defeat and difperfion of Caftanos, and of the little probability there was of his being able to march forward, fo as to effect any thing of advantage. He therefore determined to fall back, though this determination was evidently in oppofition to the wifhes and advice of his officers. Frefh difpatches, however, from the feat of government, diminifhing the loffes which had been fuftained by the patriots, and exaggerating the ardour with which the people were actuated, induced him to delay his retreat, efpecially as he had now a complete, though fmall corps, with cavalry and artillery, and could, by a movement to the left, eafily effect a junction with Sir David Baird, while the divifion under General Hope had, by rapid marches, arrived in the neighbourhood of Salamanca.

In addition to the mifreprefentations by which the commanders of the Britifh forces, and the Britifh envoy at Aranjuez, had been deceived, they had now to contend with two defigning men, who, it foon appeared, were in the French intereft. Thefe were Don Morla, the late governor of Cadiz, and a M. Charmilly. By the machinations of thefe men, Mr Frere was led to advife, and Sir John Moore ftrongly incited to undertake, bringing the whole of the Britifh force to the neighbourhood of Madrid, where they would foon have been completely within the power of the enemy. Though by thefe arts Sir John was effectually mifled, he did not fuffer himfelf to be drawn into fo dangerous a fnare. He, however, advanced beyond Salamanca, and fent forward the referve and General Beresford's brigade towards Toro on the Douro, where they were to unite with the cavalry under Lord Paget, who had advanced thither from Aftorga. On December 12th, Lord Paget, with the principal part of the cavalry, marched from Toro to Tordefillas, while the brigade under General Stewart moved from Arivolo. In the vicinity of Tordefillas, near the village of Rueda, the Britifh forces were firft oppofed by the French, a fmall party of whom were attacked and defeated.

Spain.

While Sir John Moore was at Toro, he received intelligence that the duke of Dalmatia was at Saldana with a confiderable body of French troops, that Junot, duke of Abrantes, was marching with another towards Burgos, and that a third under the duke of Trevifo was deftined for Zaragoza. He was very defirous that the firft of thefe generals fhould advance to meet him, and with this view he had come forward to Toro, which he reached on the 16th of December. He had hoped for effectual affiftance from the corps commanded by the marquis de la Romana, but he foon found that this general could render him no fupport. He had now refolved to threaten the communication between France and Madrid; and, if a favourable opportunity offered, to attack the duke of Dalmatia's corps, or any of the covering divifions that fhould prefent themfelves. He forefaw that this would neceffarily draw upon him a large French force, and of courfe would prove an important diverfion in favour of the Spaniards; who would by this means have the opportunity of collecting in the fouth, and reftoring their affairs. The army was now near the French pofition. The cavalry under Lord Paget were pufhed fo forward, that their patrols reached as far as Valladolid, and had frequent fuccefsful fkirmifhes with the enemy. Colonel Otway met a detachment of French cavalry, charged them, and made the whole prifoners.

On the 18th of December, Sir John's head-quarters were at Caftro Nuevo, and Sir David Baird's at Benevente, on the road to join him. On the 20th Sir John reached Majorga, where he was joined by Sir David Baird. The united Britifh army now amounted to rather fewer than 26,000 men, of whom about 2000 were cavalry. The weather was extremely cold, and the ground covered with deep fnow. Still the exertions of the troops were indefatigable, and the cavalry in particular attacked and defeated a confiderable body of French horfe. On the 21ft the army reached Sahagun, where Sir John eftablifhed his head-quarters, and determined to halt for fome time, to refrefh his troops, after the fatigues which they had undergone.

Sir John had now arrived within a very fhort diftance from Saldana, where the duke of Dalmatia was pofted, with the flower of the French army; and preparations were made for an attack, which was waited for with all the ardour and impatience which diftinguifh Britifh troops. In the mean time, however, repeated couriers arrived at head-quarters, the bearers of unpleafant intelligence. Certain information was received, that a ftrong French reinforcement had arrived at Carrion, a little to the right of Sahagun, that the French corps, which was marching to the fouth, had halted at Talavera, and that the enemy were advancing from Madrid in confiderable force. Sir John now faw that his motions had been watched by Bonaparte, and that all the arts of this experienced general had been preparing to entrap him. To advance was madnefs; to retreat, almoft in the face of an enemy, was a meafure of the utmoft danger, but it was the only alternative. 190

His retreat.

On the 24th of December Sir John began filently and fecretly to prepare for his retreat, and to provide, as far as poffible, for the defence of thofe parts of the country

country which were ſtill held by the patriots. With this latter view, he directed Sir David Baird to take the route towards Valencia de Don Juan, while the reſt of the army was to proceed by Caſtro Gonzalo. By this diviſion the magazines and ſtores which had been depoſited at Benevente and Zamora, were alſo effectually ſecured.

According to the arrangement made, General Fraſer, followed by General Hope, marched with their diviſions on the 24th December to Valderos and Majorga, and Sir David Baird proceeded with his to Valencia. To conceal this movement, Lord Paget was ordered to puſh on ſtrong patrols of cavalry cloſe to the advanced poſts of the enemy. The reſerve, with two light corps, did not retire from Sahagun till the morning of the 25th, following General Hope. Lord Paget was ordered to remain with the cavalry until evening, and then follow the reſerve. Theſe laſt were accompanied by Sir John. The retreat commenced in this deliberate manner. On the 26th of December, Sir David Baird reached the Eſlar, and paſſed the ferry with leſs difficulty than was expected. He took poſt, according to his orders, at Valencia, and wrote to the marquis of Romana, urging him to blow up the bridge of Manſilla. The other diviſions of infantry proceeded unmoleſted to Caſtro Gonzalo. On the 24th the advanced guard of Bonaparte's army marched from Tordeſillas, 120 miles from Madrid, aud ſtrong detachments of cavalry had been puſhed forward to Villalpando and Majorga. On the 26th, Lord Paget fell in with one of thoſe detatchments at the latter place. His lordſhip immediately ordered Colonel Leigh, with two ſquadrons of the 10th huſſars, to attack this corps, which had halted on the ſummit of a ſteep hill. One of Colonel Leigh's ſquadrons was kept in reſerve; the other rode briſkly up the hill; on approaching the top, where the ground was rugged, the colonel judiciouſly reined-in to refreſh the horſes, though expoſed to a ſevere fire from the enemy. When he had nearly gained the ſummit, and the horſes had recovered their breath, he charged boldly and overthrew the enemy; many of whom were killed and wounded, and above 100 ſurrendered priſoners. Nothing could exceed the coolneſs and gallantry diſplayed by the Britiſh cavalry on this occaſion. The 18th dragoons had ſignalized themſelves in ſeveral former ſkirmiſhes; they were ſucceſsful in ſix different attacks. Captain Jones, when at Palencia, had even ventured to charge 100 French dragoons with only 30 Britiſh; 14 of the enemy were killed, and ſix taken priſoners. The cavalry, the horſe-artillery, and a light corps, remained on the night of the 26th, at Caſtro Gonzalo; and the diviſions under Generals Hope and Fraſer marched to Benevente. On the 27th, the rear guard croſſed the Eſlar, and followed the ſame route, after completely blowing up the bridge.

We ſhall not attempt any farther detail of this dangerous and calamitous retreat, in which our army ſuffered extremely, from the fatigues of conſtant marching, from the badneſs of the weather, and even from the brutality of the Spaniards, in whoſe cauſe they had embarked. Before they reached Aſtorga, it was found neceſſary to divide the army. A body of 3000 men, under Brigadier-general Crawford, was detached on the road to Orenſe towards Vigo, while the main body, under the command of Sir John Moore, marched by Aſtorga and Lugo, on the road to Corunna. They left Aſtorga on the 30th of December, and on the 11th of January came in ſight of Corunna. The army had now reached the ſea port from which they were to embark, but adverſe winds had detained the tranſports, or the whole of the troops would have been ſpeedily and ſafely on board. Only a few ſhips lay in the harbour, and in theſe ſome ſick men and a few ſtragglers, under pretence of ſickneſs, had immediately embarked.

191 Cloſely followed by the French.

During the whole march from Sahagun to Corunna, the Britiſh army was cloſely followed by the French, under Bonaparte and the duke of Dalmatia; and the two armies were often ſo near each other, that the French patrols fell in, during the night, with the cavalry piquets of the Britiſh. The duke of Dalmatia had joined Bonaparte at Aſtorga, and had increaſed his force to nearly 70,000 men, while the whole force of the Britiſh did not exceed 26,000. When Sir John's army reached Lugo, it was found that three diviſions of the French were arranged in front, and it was thought adviſable, on the 8th of January, to offer the enemy battle. This offer, however, the French thought proper to decline, and the duke of Dalmatia ſtirred not from his poſt. When the army reached Corunna, the French were far in the rear, and it was hoped that the tranſports might arrive before the enemy could come up.

The retreat of the Britiſh, conſidering the circumſtances under which it was effected, was a brilliant and ſucceſsful achievement. Two hundred and fifty miles of country had been traverſed in 11 days, during the worſt ſeaſon of the year, through bad roads, over mountains, defiles, and rivers, and in almoſt daily contact with an enemy nearly three times their numbers. Though often engaged, the rear guard of the Britiſh had never been beaten, nor even thrown into confuſion. Many loſſes had indeed been ſuſtained, in baggage, artillery, and horſes, and many ſtragglers had fallen into the hands of the enemy; but neither Napoleon nor the duke of Dalmatia could boaſt of a ſingle military trophy taken from the retreating army. The greateſt danger was ſtill to be incurred; the poſition of Corunna was found to be extremely unfavourable; the tranſports had not arrived, and the enemy began to appear upon the heights. The ſituation of the army was by moſt of the officers thought ſo deſperate, that they adviſed the general to propoſe terms to the duke of Dalmatia, that they might be ſuffered to embark unmoleſted; but this advice Sir John, without heſitation, rejected.

On the 12th of January, the French were ſeen moving in conſiderable force on the oppoſite ſide of the river Mero. They took up a poſition near the village of Perillo, on the left flank of the Britiſh, and occupied the houſes along the river. In the mean time Sir John was inceſſantly occupied in preparing for the defence of his poſt, and in making every arrangement for the embarkation of the troops.

192 Poſition of the army.

On the 13th, Sir David Baird marched out of Corunna with his diviſion, and took poſt on a riſing ground, where he determined to remain all night. A diviſion under General Hope was ſent to occupy a hill on the left, which commanded the road to Betanzos, forming a ſemicircle with Sir David Baird's diviſion on the right. General Frazer's diviſion was drawn up near the road to Vigo, about half a mile from Corunna, and communicated

Spain. communicated with that under Sir David Baird, by means of the rifle corps attached to the latter, which formed a chain acroſs the valley. The reſerve under Major-general Paget occupied a village on the Betanzos road, about half a mile from the rear of General Hope. The higher grounds on the rear and flanks of the Britiſh were poſſeſſed by the French, a ſituation which gave the latter a conſiderable advantage.

In the evening the tranſports from Vigo hove in ſight; but the enemy was now ſo near, and had, during this day, ſhown ſo much diſpoſition to moleſt the Britiſh, that a general action was become inevitable. On the 15th, the enemy had advanced to a height where, the day before, a magazine, containing nearly 4000 barrels of gun powder, had been blown up, and which was immediately oppoſite to the poſition of the Britiſh. On this day ſome ſkirmiſhes took place.

193 Battle of Corunna.

On the 16th, every thing was prepared for a general action. Moſt of the artillery had been embarked, as it was found that, from the nature of the ground, much artillery could not be employed with advantage. During the 13th and 14th, the ſick, the diſmounted cavalry and horſes, were alſo nearly all embarked. On the morning of the 16th, the French on the hills were apparently quiet, and it was hoped that the embarkation might be effected in the courſe of that night; but about noon the enemy, who had in the morning received reinforcements, and had placed ſome guns in front of the right and left of his line, was obſerved to be getting under arms, to be moving troops towards his left flank, and forming various columns of attack at that extremity of the ſtrong and commanding poſition which he had taken on the 15th, in front of the Britiſh line. This indication of his intention was immediately ſucceeded by a rapid and determined attack on the diviſion under Sir David Baird, which formed the right wing, and was the weakeſt part of the line. The firſt effort of the enemy was met by Sir John Moore and Sir David Baird at the head of the 42d regiment, and the brigade under Lord William Bentinck. The village on the right became an object of obſtinate conteſt. While leading on his diviſion to ſupport this poſition, Sir David had his arm ſhattered with a grape ſhot.

Not long after, while Sir John Moore was riding from poſt to poſt, everywhere encouraging his troops, and pointing out the moſt advantageous opportunities for attack or defence, his conſpicuous ſituation had expoſed him to the fire of the enemy. A cannon-ball ſtruck his left ſhoulder, and beat him to the ground. He raiſed himſelf, and ſat up with an unaltered countenance, looking intently at the Highlanders, who were warmly engaged. Captain Hardinge threw himſelf from his horſe, and took him by the hand; then, obſerving his anxiety, he told him the 42d were advancing, upon which his countenance immediately brightened. His friend Colonel Graham now diſmounted to aſſiſt him; and, from the compoſure of his features, entertained hopes that he was not even wounded: but obſerving the horrid laceration and effuſion of blood, he rode off for ſurgeons. The general was carried from the field on a blanket, by a ſergeant of the 42d, and ſome ſoldiers. On the way he ordered Captain Hardinge to report his wound to General Hope, who aſſumed the command. Many of the ſoldiers knew that their two chiefs were carried off: yet they continued to fight with undiminiſhed courage; and, by the Spain. moſt determined bravery, not only repelled every attempt of the enemy to gain ground, but actually forced him to retire, though he had brought up freſh troops in ſupport of thoſe originally engaged.

The enemy finding himſelf foiled, in every attempt to force the right of the poſition, endeavoured by numbers to turn it. A judicious and well-timed movement, which was made by Major-general Paget, with the reſerve, which corps had moved out of its cantonments to ſupport the right of the army, by a vigorous attack, defeated this intention. The major-general having puſhed forward the 95th (rifle corps) and 1ſt battalion 52d regiment, drove the enemy before him; and, in his rapid and judicious advance, threatened the left of the enemy's poſition. This circumſtance, with the poſition of Lieutenant-general Fraſer's diviſion (calculated to give ſtill farther ſecurity to the right of the line) induced the enemy to relax his efforts in that quarter. They were, however, more forcibly directed towards the centre, where they were again ſucceſsfully reſiſted by the brigade under Major-general Manningham, forming the left of Sir David Baird's diviſion, and a part of that under Major-general Leith, forming the right of the diviſion under General Hope. Upon the left the enemy at firſt contented himſelf with an attack upon our picquets, which, however, in general, maintained their ground. Finding, however, his efforts unavailing on the right and centre, he ſeemed determined to render the attack on the left more ſerious, and had ſucceeded in obtaining poſſeſſion of the village through which the great road to Madrid paſſes, and which was ſituated in front of that part of the line. From this point, however, he was ſoon expelled with conſiderable loſs, by a gallant attack of ſome companies of the 2d battalion of the 14th regiment, under Lieutenant-colonel Nicholls. Before five in the evening, the Britiſh had not only ſucceſsfully repelled every attack made upon the poſition, but had gained ground in almoſt all points, and occupied a more forward line than at the commencement of the action, whilſt the enemy confined his operations to a cannonade, and the fire of his light troops, with a view to draw off his other corps. At ſix the firing ceaſed. The different brigades were reaſſembled on the ground which they occupied in the morning, and the picquets and advanced poſts reſumed their original ſtations.

Notwithſtanding the decided and marked ſuperiority which at this moment the gallantry of the troops had given them over an enemy, who, from his numbers and the commanding advantages of his poſition, no doubt expected an eaſy victory, General Hope did not, on reviewing all circumſtances, conceive that he ſhould be warranted in departing from what he knew was the previous and fixed determination of the late commander of the forces, to withdraw the army on the evening of the 16th, for the purpoſe of embarkation, the previous arrangements for which had already been made by his order, and were in fact far advanced at the commencement of the action. The troops quitted their poſition about 10 at night, with a degree of order that did them credit. The artillery that remained unembarked, having been withdrawn, the troops followed in the order preſcribed, and marched to their reſpective points of embarkation in the town and neighbourhood of Corunna. The picquets remained at their poſts till five in the

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the morning of the 17th, when they were alſo withdrawn with ſimilar order, and without the movement having been diſcovered by the enemy.

By the unremitted exertion of the captains of the royal navy, who had been entruſted with the ſervice of embarking the army, and in conſequence of the arrangements made by the agents for tranſports, the whole of the forces were embarked with an expedition which has been ſeldom equalled. The brigades under Major-generals Hill and Beresford were deſtined to remain till daylight, in order to watch the movements of the enemy. The brigade under General Beresford, which was alternately to form the rear-guard, occupied the land in front of Corunna, while that under General Hill was ſtationed on the promontory in the rear of the town by way of reſerve.

The enemy puſhed his light troops towards the town, ſoon after eight o'clock in the morning of the 17th, and ſhortly after occupied the heights of St Lucia, which commanded the harbour. But notwithſtanding this circumſtance, and the manifold defects of the place, there being no apprehenſion that the rear-guard could be forced, and the diſpoſition of the Spaniards appearing to be good, the embarkation of Major-general Hill's brigade was commenced and completed by three in the afternoon. After having fully explained, to the ſatisfaction of the Spaniſh governor, the nature of the movement, and having made every previous arrangement, General Beresford withdrew his corps from the land in front of the town ſoon after dark, and was, with all the wounded that had not previouſly been removed, ſafely embarked before one o'clock of the morning of the 18th.

In this action the Britiſh troops had come off with glory, and there can be no doubt, from the repulſe of the French forces, and their ſubſequent inactivity, that the honour of the victory belonged to the Britiſh. The victory had indeed coſt them dear. They had loſt one of their beſt generals; and probably nearly 1000 men had been killed or wounded during the action. It had been achieved at the termination of a long and haraſſing ſervice. The ſuperior numbers, and advantageous poſition of the enemy, not leſs than the actual ſituation of the Britiſh army, did not admit of any advantage being reaped from ſucceſs. The luſtre of the Britiſh arms had, however, been maintained under the moſt diſadvantageous circumſtances. The army which had entered Spain amidſt the faireſt proſpects, had no ſooner completed its junction, than owing to the multiplied diſaſters that diſperſed the native armies around it, it was left to its own reſources. The advance of the Britiſh troops from the Douro afforded the beſt hope, that the ſouth of Spain might be relieved; but this generous effort to ſave an unfortunate people, alſo afforded the enemy the opportunity of directing every effort of his numerous troops, and concentrating all his principal reſources for the deſtruction of the only regular force in the north of Spain. Theſe circumſtances had produced the neceſſity of rapid and haraſſing marches, which had diminiſhed the numbers, exhauſted the ſtrength, and impaired the equipment of the army. Notwithſtanding all theſe diſadvantages, and thoſe more immediately attached to a defenſive poſition, which the imperious neceſſity of covering the harbour of Corunna, for a time, had rendered indiſpenſible to aſſume, the native and undaunted valour of Britiſh troops was never more conſpicuous.

At daybreak on the 18th, the Engliſh convoy was under ſail, and on the 19th it had entirely left the Spaniſh coaſts.

194 Second expedition under Sir Arthur Welleſley.

Notwithſtanding the ill ſucceſs which had thus attended the expedition under Sir John Moore, the ſpirit of patriotiſm which appeared ſtill to actuate the ſouthern provinces of Spain, and the hope that the common cauſe might there be ſupported to greater advantage, induced the Britiſh miniſtry to ſend another military force to the weſtern peninſula of Europe, to co-operate with the patriots who ſtill continued in arms. Accordingly, a body of about 15,000 forces, under the command of Sir Arthur Welleſley, whoſe bravery and good conduct in the battle of Vimiera, had recommended him, in a particular manner, both to the miniſtry and the nation, was diſpatched towards the coaſt of Portugal, where Marſhal Beresford ſtill maintained a Britiſh force; while General Hill, with about 5000 infantry, and 400 cavalry, ſailed from Ireland with the ſame deſtination. General Hill arrived at Liſbon on the 4th of April, and ſoon after Sir Arthur landed with the main body. On the 7th of April the army moved forward towards the Douro, and croſſed that river during the night of the 11th, a little above Oporto. Here they fell in with a French detachment from the army of the duke of Dalmatia, which they routed and put to flight, after a ſhort but well-conteſted action.

After this action the duke of Dalmatia found it neceſſary to retreat. He paſſed through the defiles of Salamonde, and thus gained conſiderably on the Britiſh army, though he was obliged to leave behind him part of his artillery. On the 19th of May he was at Allaritz, and on the 20th he continued his retreat acroſs the Minho, which he paſſed at Orenſe, thus leaving Portugal once more in poſſeſſion of the Britiſh forces.

Sir Arthur Welleſley, after having remained for ſome time in the Portugueſe territory, to refreſh his men after the fatigues which they had undergone, advanced into Spain, and effected a junction with General Cueſta, who then commanded a conſiderable part of the remains of the patriotic army. In the latter end of July, the allied army had advanced to Talavera de la Reyna, in the neighbourhood of which they were encountered by a formidable French force, conſiſting of a corps commanded by Marſhal Victor, another under General Sebaſtiani, the guards of Joſeph Bonaparte, amounting to 8000 men, and the garriſon of Madrid. This large force was commanded by Joſeph Bonaparte in perſon, aſſiſted by Marſhals Jourdan and Victor, and General Sebaſtiani.

195 Battle of Talavera.

On the 27th of July, an attack was made by the French army on that of the allies, who had taken up their poſition at Talavera. The attack was vigorous, but was repelled with great ſpirit and ſucceſs, though not without conſiderable loſs on the part of the Britiſh.

The defeat of this attempt was followed about noon of the 28th by a general attack of the enemy's whole force, on the whole of that part of the poſition which was occupied by the Britiſh army. The general attack began by the march of ſeveral columns of infantry into the valley, with a view to attack the height occupied by

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by Major-general Hill. These columns were immediately charged by the 1st German light dragoons, and 23d dragoons, under the command of General Anson, and supported by General Fane's brigade of heavy artillery; and although the 23d dragoons suffered considerable loss, the charge had the effect of preventing the execution of that part of the enemy's plan. At the same time an attack was directed upon Brigadier-general Alexander Campbell's position in the centre of the combined armies, and on the right of the British. This attack was most successfully repulsed by Brigadier-general Campbell, supported by the king's regiment of Spanish cavalry, and two battalions of Spanish infantry; and the allies were left in possession of the enemy's cannon.

An attack was also made at the same time on Lieutenant-general Sherbrooke's division, which was on the left and centre of the first line of the British army. This attack was most gallantly repulsed by a charge with bayonets, by the whole division; but the brigade of guards which were on the right, having advanced too far, were exposed on their left flank to the fire of the enemy's battery, and of their retiring columns; and the division was obliged to retire towards the original position, under cover of the second line of General Cotton's brigade of cavalry, which had moved from the centre, and the 1st battalion 48th regiment. This regiment was removed from its original position on the heights, as soon as the advance of the guards was perceived, and formed in the plain; it advanced upon the enemy, and covered the formation of Lieutenant-general Sherbrooke's division. Shortly after the repulse of this general attack, in which apparently all the enemy's troops were employed, he commenced his retreat across the Alberche, which was conducted in the most regular manner, and effected during the night, leaving in the hands of the British 20 pieces of cannon, ammunition, tumbrils, and some prisoners.

Though the French were defeated in this engagement, and, according to Sir Arthur Wellesley's account, must have lost at least 10,000 men, the loss of the British was very great. By the official returns it is stated to exceed 5000, namely, in killed, 34 officers, 28 serjeants, 2 drummers, and 735 rank and file; in wounded 195 officers, 165 serjeants, 16 drummers, and 3537 rank and file; and in missing 9 officers, 15 serjeants, 9 drummers, and 620 rank and file. The action, though brilliant, does not appear to have been attended with much advantage to the allies, as, from the reinforcements which the French army was daily receiving, Sir Arthur Wellesley (now Lord Wellington) was soon compelled to fall back towards the frontiers of Portugal, leaving behind him much of his baggage, and the whole of his sick and wounded. It must be recorded to the honour of the French commander, into whose hands these unfortunate men had fallen, that, in consequence of a representation in their favour by Lord Wellington, he treated them with the utmost humanity, and afforded them every accommodation which the nature of their situation admitted.

Since the battle of Talavera, nothing of importance has transpired respecting the state of affairs in Spain. It appears that the patriots still continue to make a stand against their invaders; but it cannot be expected that their opposition shall be ultimately attended with success. The resources of the French are so numerous and extensive, and the force which he is able to draw towards the Spanish peninsula, has been so much increased in consequence of the peace lately concluded between France and Austria, that the liberties of Spain must, we fear, fall a sacrifice, and that kingdom must contribute to swell the already exorbitant power of the house of Bonaparte.

196 Summary view of Spanish history.

We shall conclude the historical part of this article with a summary recapitulation of the principal revolutions which have taken place in Spain.

From the year 240 B. C. to the year 206 B. C. Spain was in some degree under the dominion of the Carthaginians. From the year 206 B. C. to the commencement of the fifth century of the Christian era, it continued almost entirely in possession of the Romans. The Goths reigned in Spain from the year 411 to 711; the Moors from the year 711 till 716, in part of the Asturias; till 820 in Catalonia; till 750 in Sobrarba; till 923 in Leon; till 1073 in different parts of the two Castiles; till 1118 in Aragon; till 1236 in Cordova and Jaen; till 1248 in Seville; till 1264 in the kingdom of Valencia; till 1265 in that of Murcia; and even so late as 1492 in Granada. During the wars against the Moors, the Goths reigned in the Asturias, Gallicia, and, finally, in the kingdom of Leon till 1038.

The house of Navarre, descended from the French house of Bigorre, which had previously reigned in Castile for 10 years, united with it the crown of Leon till the year 1126. This was succeeded by the family of Bourbon, descended from the royal family of France, which reigned over these countries till 1555. The house of Charlemagne, a French family descended from that prince, ruled over Catalonia from the year 802 till 1132. The French family of Bigorre first reigned in Sobrarba, and afterwards in Aragon, from the year 750 to 1162; at that period the French family of Barcelona succeeded to the government, and united to the crown of Aragon that of Catalonia, and afterwards the kingdom of Valencia, over which it reigned till the year 1430. These parts of Spain then came into the possession of the princes of the French branch of Navarre, which reigned in Castile, and continued in their descendants to 1515; at which time the different states of the Spanish monarchy were united under the government of Joanna the Foolish, who reigned over them till her death, which happened in 1555. The Austrian family then possessed the throne till 1700, since which time it has been occupied by a branch of the house of Bourbon, till the late revolution, by placing the Spanish monarchs in the power of the French, has given rise to a new dynasty of princes in the person of Joseph Bonaparte.

197 Antiquities.

The earliest Spanish antiquities which can be with certainty ascertained, belong to the Roman period; and of these the examples are extremely numerous. They abound in the provinces of Catalonia, Valencia, and those which border on the Pyrenees. We cannot here enumerate, much less describe, all the remains of Roman antiquity mentioned by Swinburne, Townsend, De Laborde, and other travellers in Spain. The most remarkable are, the aqueduct at Segovia, in Old Castille, consisting of 159 arches, extending about 740 yards, and being at least 94 feet high, where it crosses the valley; the amphitheatre of the ancient *Saguntum*, near the

the modern Morviedro in Valencia, which was hewn out of the ſolid rock, and appears to have been capable of containing 10,000 ſpectators; a ſuperb Roman arch, ſupported by Corinthian pillars, and having a very lofty gateway, not far from Tarragona; a monument near the ſame place, ſuppoſed to be the tomb of the father and uncle of Scipio Africanus; and a conſiderable amphitheatre on an eminence near Seville. It is ſuppoſed that the ancient city of Italica, built by Scipio Africanus for the reception of his wounded ſoldiers, ſtood near this ſpot; but we are aſſured by Mr Swinburne, that no traces of it now remain.

Of the Gothic edifices, no certain remains are to be found; but the Mooriſh antiquities are numerous and ſplendid. Of theſe, the moſt remarkable are the palace of the Alhambra in the city of Granada, and the moſque of Cordova. Of the former we have already given an account under ALHAMBRA. The moſque, now the cathedral of Cordova, was begun by Abdoulrahman I. caliph of Cordova, and is computed to contain not fewer than 800 columns. The architecture of its doors, windows, and arches, eſpecially thoſe of the chapel of the Koran, at leaſt equals that of the Alhambra in grandeur of deſign, and beauty of execution, and exceeds that palace in variety of decoration. This ſuperb edifice has been minutely deſcribed by Mr Swinburne, in his travels into Spain, Letter 35. Not far from Cordova ſtood the magnificent city of Zehra, built by Abdoulrahman III. and which is ſaid to have employed 25 years in building, and to have coſt more than 2,500,000 l. of our preſent ſterling money. In this city was a palace containing 1173 columns, of African, Spaniſh, Italian, and Aſiatic marbles. This ſplendid palace, and the city in which it ſtood, were entirely deſtroyed during the wars by which Spain was deſolated in the middle ages.

198 Population of Spain.

It has been computed, that under the dominion of the Romans, Spain contained a population of nearly 50,000,000 of people; but this calculation is, by De Laborde, diminiſhed to 20,000,000.

At the cloſe of the 14th century, the population is ſtated by moſt Spaniſh writers as follows.

In the ſtates of Caſtile	11,000,000
States of Aragon,	7,700,000
Kingdom of Granada,	3,000,000
	21,700,000

On what De Laborde deems better authority, he reduces this number to 16,000,000.

In the reign of Ferdinand and Iſabella, at the end of the 15th century, the total population of Spain has generally been eſtimated at 20,000,000, but this too is reduced by Laborde to 14,000,000 or 15,000,000.

The population was reduced

in 1688 to	10,000,000
1700	8,000,000
1715	6,000,000
In 1768 it had riſen to	9,307,800
1788	10,143,975

According to the table of the provinces, collected chiefly from De Laborde, it amounted, at the end of the 18th century, to 10,308,505; by the laſt cenſus, taken in the years 1797 and 1798, the ſtatements of which have not been publiſhed, but were lately locked up in the office belonging to the miniſter of finance, it appears that the population, at the end of the 18th century, exceeded 12,000,000.

From theſe ſtatements we obſerve, that the population of Spain had gradually diminiſhed from its conqueſt by the Romans, to the reign of Philip V. in the beginning of the 18th century; but that during the laſt hundred years it has rapidly increaſed.

Various cauſes have been aſſigned for the remarkable depopulation that had taken place in the Spaniſh dominions. Perhaps the following by Dr Playfair are ſufficiently plauſible. "The peſtilential fevers and epidemical diſeaſes, which carried off one-third of the inhabitants in the year 1347, and have produced great mortality during the two laſt centuries; almoſt inceſſant ſtruggles for dominion, from 714 till the conqueſt of Granada, and union of the two crowns of Caſtile and Aragon; the expulſion of about 400,000 Jews by Ferdinand and Iſabella, and of 900,000 Moors, A. D. 1610; the diſcovery of South America in 1493, which has gradually drained the country of its inhabitants and its induſtry; the calamities of war, during two centuries, from the acceſſion of the emperor Charles V.; the form of government, and national prejudices, which diſcourage foreigners from ſettling in the kingdom, and are inimical to manufactures, commerce, and agriculture; the debauchery that prevails among all ranks; the great number of convents; the celibacy of the clergy; religious oppreſſion, and numerous feſtivals, which leſſen the number of working days, and ſo abridge the labour of the people."

Of the number above ſtated, the clergy are reckoned at leaſt 147,722: viz. of ſecular clergy, 60,240; of monks 49,270; of nuns and friars, 22,337, and of ſubaltern miniſters of the church 15,875. The numbers of the clergy have indeed diminiſhed by more than 27,000, during the laſt 30 years of the 18th century, as in the year 1768 they amounted to 176,057.

According to a calculation in the year 1776, the cities, towns, villages, and hamlets, amounted to 84459 (D); and public edifices and temples to 30,496. 199 Number of towns, villages, &c.

It appears that there exiſt in Spain 2,628,557 individuals of both ſexes, who do not contribute, or at leaſt are not ſuppoſed to contribute, to the population. From this view, and the progreſs we have already ſtated, it will be eaſy to diſcover, by comparative calculations with the detailed ſtatements of population in other countries, the proportionate number of births, deaths, marriages, &c. which annually take place in Spain.

The Spaniſh government, which was of a limited nature, during the dynaſties of the kings of Caſtile and Aragon, afterwards became an abſolute monarchy. At that 200 Government.

(D) In the year 1788, the number of villages was eſtimated at 19,219; and that of pariſhes at 20,080.

that period the royal prerogative was confined both by the expreſs tenor of the laws and the forms of their adminiſtration. The peculiar privileges of the two ſtates of Caſtile and Aragon continued to exiſt long after their reunion; but the royal authority was conſtantly taking umbrage at their exerciſe. The princes of the Auſtrian family did not openly attack them, but had recourſe to the more effectual method of ſecretly undermining them; and thus they were ſo far diminiſhed, that at the cloſe of the 17th century they amounted to little more than mere forms. The attachment of Aragon to the cauſe of the archduke Charles, induced the firſt ſovereign of the royal family of France to aboliſh them entirely. Philip V. having ſubdued Aragon, ſuppreſſed the ſtates-general, the laſt meeting having been held at Zaragoza in the year 1720, on which occaſion Queen Iſabella of Savoy preſided in the abſence of her huſband, who was at that time in Italy. Since that period no further power is left the *Cortez* of Caſtile and Aragon, but the privilege of nominating deputies to the ſtates-general of the kingdom, whenever they are ſummoned by the monarch.

The whole authority, previous to the late revolution, centred in the king and his miniſters; the national affairs were conducted by the different councils, appointed by the crown, which deliberated and formed their plans in the capital. Some of theſe poſſeſſed both legiſlative and executive power, and exerciſed the double function of adviſing the king and adminiſtering juſtice. The council of Caſtile, in this diſtribution of power, was paramount; its decrees being deciſive in the courts, but its judgements were under the controul of the king. The reſolutions were tranſmitted to the monarch by a certain number of members, under the title of the *Chamber of Caſtile*, whoſe influence was prodigiouſly great. This council was ſo denominated, becauſe the members choſen by the king formerly co-operated with miniſters in expediting the affairs of ſtate in the royal chamber, and for this purpoſe they attended the court wherever it was held.

Beſides the council of Caſtile, there was the royal and ſupreme council of the Indies, inveſted with the ſame powers, and exerciſing ſimilar functions with reſpect to the American colonies, as the council of Caſtile
201 with reſpect to the European territory.

Revenues. It is not eaſy to aſcertain the amount of the revenues under the late government. They aroſe from a tax on imports and exports; from the chief objects of internal conſumption; from the monopolies of the crown; from landed eſtates; from tythes of church and abbey lands; from the ſale of indulgences; and from the trade with the American colonies. Their total amount has been variouſly ſtated. M. Jordan has computed it to exceed 7,000,000l. ſterling; by M. De Laborde, the revenues for the European continent alone, are calculated to ex-
202 ceed 8,000,000l. ſterling.

Military ſtrength. It would be abſurd to attempt any eſtimate of the military ſtrength of Spain in its preſent ſtate of diſorganization and confuſion. During the latter part of the 18th century, the land forces in time of peace ſeldom exceeded 50,000 ill-diſciplined troops; but in time of war, the army was capable of being augmented to a formidable force. In the year 1798 the ſtanding forces of the Spaniſh monarchy amounted to 100,000 effective men.

Till of late the Spaniſh navy was highly reſpectable, both as to ſtrength and diſcipline. In the year 1778 the Spaniſh fleet conſiſted of 148 veſſels of all deſcriptions; and of theſe more than 60 were ſhips of the line. In 1788, the number of ſhips of the line amounted to 68, and that of large frigates to 47. In the preſent long conteſt among the powers of Europe, the navy of Spain has been greatly diminiſhed; and the only fleet of any importance now exiſting is that in the harbour of Cadiz. 203

There are in Spain ſeveral orders of knighthood, or as they are called, military orders. The principal is that of the *Golden Fleece*, inſtituted in the year 1430, by Duke Philip the Good. The order of St Jago di Compoſtella was inſtituted by Ferdinand II. in the year 1175, and its badge is a red uniform croſs in twelve departments. The order of Calatrava, inſtituted by Sancho III. of Caſtile, has for its badge a red croſs in five departments. The order of Alcantara was inſtituted by Ferdinand II.; and its badge is a lily placed croſsways. The order of Monteſa, inſtituted in the year 1317, by James III. king of Aragon, is compoſed of 19 commanderies. 204 Orders of knighthood.

The money of Spain is either real or imaginary, the former ſerving for the purpoſe of exchange, the latter for keeping accounts and tranſacting buſineſs. Both theſe are common through the whole kingdom; but ſeveral kinds of both are to be found in the different provinces. Coins.

Two kinds of real money, both in gold and ſilver, are diſtinguiſhed in Spain; the old, that is, ſuch as were coined before the year 1772, and thoſe coined ſubſequent to that period. None of the former are uniform, but conſiſt of ſmall pieces of different ſizes unequally cut, and their currency is only by weight. The latter uniformly bear the head of the ſovereign on the obverſe, and on the reverſe ſide the arms of Spain; the ancient gold coins are more intrinſically valuable than the modern. The laſt only will be here deſcribed.

Modern Gold Coins.

Coins.	Value in Sterling money.
Durito Eſcudo chico de oro Veniento de oro	- 4s. 2d. (E)
Eſcudo de oro Doblon ſenzillo	- - 8s. 4d.
Doblon de oro	- - 16s. 8d.
Doblon de quatre Medio doblon de a ocho Media onza de oro	1l. 13s. 4d.
Doblon de ocho Onza de oro	- 3l. 6s. 8d.

Modern

(E) In computing the value of the Spaniſh coins in ſterling money, we have employed M. De Laborde's tables; in which their value is eſtimated in money tournois, computing the livre tournois at 10d. ſterling, and the ſol at ½d. ſterling.

Spain.

Modern Silver Coins.

Coins.	Value in sterling money.
Real Real de vellon Medio real de plata	2½d.
Real de plata Media pecata	5d.
Pecata Real de a dos	10d.
Escudo Medio duro	2s. 1d.
Duro Pezoduro Real de à ocho	4s. 2d.

295 Weights and measures.

The Spanish weights and measures vary considerably in different parts of the kingdom, as almost every province has both peculiar to itself. The pound generally consists of 16 ounces in that part of the kingdom formerly belonging to the crown of Castile, and of 12 ounces in those annexed to the crown of Aragon; viz. in Aragon, in the kingdom of Valencia, and in Catalonia; but the ounce is not the same. We shall here only particularize the weights of Castile.

In the Castiles they reckon by charges, quintals, arobas, arreldes, pounds, ounces, and drams. The following table gives the proportional value of the Castilian weights.

		lb.	*oz.*
The charge contains	3 quintals	300	0
—— quintal	4 arobas	100	0
—— aroba	25 pounds	25	0
—— arrelde	4 pounds	4	0
—— pound	16 ounces	1	0
—— ounce	16 drams		1
—— dram	30 grains		$\frac{1}{16}$
—— grain			$\frac{1}{480}$

The measures are still more complicated than the weights; and especially the measures of capacity, will require to be considered rather more in detail. We shall, as usual, distinguish them into long measure, superficial or land measure, and measures of capacity.

Long measure.—The standard lineal measure in Spain is the royal foot, consisting of $153\frac{41}{100}$ lines; and bearing to the English foot the proportion of about 153 to 144, or of 17 to 16. This foot, however, is not in general use, almost every province having its own foot, which is generally rather less than the royal foot. Thus, the foot in Castile is 8 lines less, and that of Valencia about $9\frac{1}{2}$ lines less than the standard.

Of royal feet 100 are equivalent to 102 feet 7 inches of Catalonia, to 107 feet of Valencia, to 115 feet 10 inches and 4 lines of Castile.

One hundred feet of Catalonia are equal to 92 feet 2 inches 3 lines of the royal foot, to 97 feet $5\frac{1}{2}$ lines of Valencia, and 104 feet 11 inches 11 lines of Castile.

In Valencia 100 feet are equivalent to 93 feet 4 inches 10 lines of the royal foot, to 98 feet 9 inches of Catalonia; and 107 feet 2 inches 6 lines of Castile.

In Castile, 100 feet are equal to 86 feet 1 inch 5 lines of the royal foot; to 93 feet 4 inches $9\frac{1}{2}$ lines of Valencia; and 92 feet 2 inches 3 lines of Catalonia.

Cloths and stuffs in Catalonia are measured by *canas*, in other parts of the kingdom by *varas*; the cana is divided into 8 *pams*, the vara into four. The proportions which these bear to the royal foot will be seen from the following table:

Spain.

	Feet.	Inches	Lines.
Pam of Catalonia, - -	0	7	4
Cana of Catalonia, - -	4	10	8
Six pams make the Paris ell.			
Pam of Castile, -	0	7	8
Vara of Castile, - -	2	6	8
Pam of the kingdom of Valencia,	2	9	4
Five pams and a little more than $\frac{1}{7}$th, or one vara one pam and a little more than $\frac{1}{7}$th, make a Paris ell.			
Pam of Aragon, - - -	0	6	$7\frac{3}{8}$
Vara of the Asturias, - -	2	5	9
Vara of Aragon, - - -	2	2	$5\frac{1}{2}$
A little less than 6 pams, or one vara two pams, make a Paris ell.			
Pam of Galicia for linen drapery,	0	9	2
Vara of Galicia for ditto, -	2	6	8

Land Measure.—Land in the provinces belonging to the crown of Castile is measured by *ungadas*, *fanegas*, *estadales*, *brasses*, *varas*, *pas*, and *aranzadas*. Of these the ungada contains 50 fanegas, about $204\frac{5}{10}$ feet; the fanega 400 estadales = about $4\frac{8}{100}$ feet; the estadale two brasses = about ten feet; the brass two varas, or about 5 feet 1 inch 4 lines; the pas about $1\frac{1}{3}$d of a vara, and the aranzada about 73 varas. This last is only used for measuring vineyards.

In Biscay land is measured by *carros*, *plazas*, and *celemines*; and in Valencia by *yugadas*, *cahizadas*, *fanegas*, *brasses*, and *pams*.

Measures of Capacity.—Corn is measured in the provinces belonging to the crown of Castile by *cahizas*, *fanegas*, *celemines*, and *quartillos*; and in Biscay the same measures are used, with the exception of the cahiza. The cahiza contains 12 fanegas, and is = about $1\frac{1}{2}$ lb. French; the fanega contains 12 celemines = 124 lb.; the celemine 4 quartillos = 10lb. $5\frac{1}{3}$ ounces, and the quartillo = 2 lb. $7\frac{1}{4}$ ounces.

In Catalonia grain is measured by *salmas*, *charges*, *quarteras*, *cortans*, and *picotis*. The salma contains 2 charges or 6 quintals = 546lb.; the charge contains 2 quarteras or 3 quintals = 273lb.; and the quartero 12 cortans or $\frac{1}{2}$ quintal = 136lb. 8 oz.: the cortan contains 4 picotis or 13 lb. of 12 oz. = 11 lb. 6 oz.; and the picoti $3\frac{1}{4}$lb. of 12 oz. = 2lb. $13\frac{1}{2}$ oz.

The measures for liquids vary exceedingly, according to the liquid they are intended to contain. Thus, at Madrid, honey is measured by *arobas* and *quartillos*, the quartillo being about $1\frac{1}{2}$lbs. and the aroba containing 32 *quartillos*. Oil is measured in New Castile also by arobas and quartillos, but the quartillo is $=6\frac{1}{4}$ lbs; and the aroba contains 4 quartillos, or 25 lbs. In Seville, oil is measured by the pipe and aroba, the pipe containing 34 arobas; while in Valencia it is measured by charges, arobas, and cantaros, the charge containing 12 arobas, and the cantaro equal 28 lbs. 1 oz.

Wine in New Castile is measured by moyos, an imaginary measure, cantaras, azumbres, quartillos, and sextarios.

Spain.

tarios. The moyo contains 16 cantaras, the cantara 12 azumbres, the azumbre 4 quartillos, each equal to 1 lb. At Cadiz wine is meaſured by tonneaux, arobas, azumbres, and quartillos. The tonneau contains 30 arobas, the aroba 8 azumbres, the azumbre 4 quartillos, each of which is equal to 1 lb. 1 oz. At Seville the meaſures for wine are cantaras, azumbres, and quartillos. The cantara contains 8 azumbres, the aroba the ſame, the azumbre 4 quartillos, each of which is equal to 17 ounces. In Valencia theſe meaſures are, botas or tonneaux, charges, arobas, or cantaras, and azumbres or cuentas; and in Catalonia, pipes, charges, quintals, arobas, quarteros, and quartos, of which the pipe contains 4 charges, the charge 3 quintals, the quintal 4 arobas, the aroba 22 quarteros, the quartero 4 quartos, and the quarto is equal to nearly 3 ounces of Catalonian meaſure.

206 Laws.

The laws of Spain, which for a long time varied greatly in the different ſtates of the monarchy, are at preſent reduced to a conſiderable degree of uniformity. Navarre and Biſcay have retained their ancient laws and conſtitution; but the revolution which took place in Spain at the beginning of the 18th century, enabled Philip V. to introduce into Catalonia and the kingdoms of Aragon and Valencia the laws of Caſtile; which, excepting a few alterations, rendered neceſſary by local peculiarities, ſtill continue in full effect.

The laws of Caſtile, which are thus become thoſe of almoſt all Spain, are contained in the codes known by the titles of the *Fuero juzgo*, *Ley de las ſiete partidas*, *Ordenamiento real*, *Fuero real*, and *Recepilacion*; of theſe the laſt is a collection of occaſional edicts of the kings of Spain, and enjoys the higheſt authority.

The Roman law has no validity in Spain, and though it may be ſtudied by a few lawyers, as containing firſt principles univerſally applicable; yet it is never quoted in the courts, and is expreſsly excepted againſt by ſome of the old laws of Caſtile.

207 Adminiſtration of juſtice.

The conducting of a law ſuit in Spain is ſubject to very complicated forms; whence neceſſarily reſults a ſlowneſs of progreſs. The whole buſineſs is carried on by writers, a peculiar branch of the legal profeſſion. In the ſuperior tribunals, the management of cauſes is in like manner committed to a kind of ſubaltern magiſtrates, called reporters (*relatores*), who contrive to render their own department a ſituation of much greater emolument than that of the judge.

In all the branches of civil, military, eccleſiaſtical, and judicial adminiſtration, in Spain, is evident a ſpirit of mildneſs and paternal indulgence, which often degenerates into great abuſe. By multiplying courts for the adminiſtration of juſtice, and by eſtabliſhing the long ſeries of appeals from juriſdiction to juriſdiction, in order that each caſe may be heard and re-heard, and receive an equitable ſentence, the ſtill more important advantages of prompt deciſion are ſacrificed, and a door is opened for chicane.

It is univerſally acknowledged that the courts of exception are far too numerous; they enfeeble the authority of the eſtabliſhed judges, and withdraw a number of individuals from the ſuperintendance of magiſtrates who reſide among them, and are readily acceſſible, to conſign them to the care of diſtant and dilatory tribunals.

A conſiderable degree of jealouſy and oppoſition alſo ſubſiſts among many of the tribunals; hence they mutually weaken each other's authority, and the clients are conſigned over from court to court; ſo that lawſuits become intolerably protracted, and a family is held in ſuſpenſe for two or three generations. The conſequence of this is, that the rich wear out thoſe of inferior fortune.

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Even the ordinary and regular forms of civil proceſs are ſlow and complicated. The huſbandman is called from his labour, the merchant from his commercial concerns, the artiſt from his work, and all from their domeſtic affairs. Nearly an equal tardineſs takes place in criminal proceſſes, ſo that witneſſes die, and means of proof are loſt, while the guilty often eſcape unpuniſhed; and thoſe who have been formally acquitted, are ſtill ſubject to a long detention in priſon, whence they are at length diſmiſſed without indemnity, and irretrievably ruined.

In conſequence of the great number of courts, the facility of appeal from one to the other, and the tediouſneſs of law ſuits; the multitude of judges, advocates, writers, and other ſubordinate officers employed in the adminiſtration of juſtice is prodigious. The number of perſons employed in the different law eſtabliſhments has been eſtimated at 100,000, which is nearly an hundredth part of the population of the country; and the very laſt general enumeration of the inhabitants of Spain makes the number of advocates amount to 5675, and of writers to 9351; beſides the judges and their ſecretaries, the attorneys and their clerks, and the innumerable hoſt of alguazils and inferior officers.

Another ſerious inconvenience in the adminiſtration of Spaniſh law, is the neceſſity of repoſing entire and blind confidence in a claſs of ſubaltern officers of the courts, called writers. This appears to be a branch of the profeſſion wholly peculiar to Spain; the writer exerciſing at the ſame time the functions of ſecretary, ſolicitor, notifier, regiſtrar, and being the ſole medium of communication between the client and the judge.

It is not cuſtomary in Spain to allow either of the parties concerned any copy of the documents requiſite for carrying on a ſuit, except by the expreſs order of the judge. All the writings on both ſides are collected together and bound up into a volume, which remains ſtatedly in the poſſeſſion of the writer, who entruſts it for a certain time to the attorneys of the parties for the inſtruction of advocates. The writer, to whoſe care the documents of any ſuit are committed, alſo regiſters the decrees and ſentences of the judges on the caſe, and notifies to the parties concerned, each ſtep of the proceſs, by reading to them the proper inſtrument; without, however, allowing them to have a copy of it.

The union of ſo many important functions in the ſame perſon, neceſſarily affords various opportunities for diſhoneſty; and the chance of being impoſed upon is ſtill further increaſed by an unwiſe regulation which obliges the defendant, in any action, to chooſe the ſame writer as is employed by the plaintiff.

It may be remarked that ſcarcely any other perſons are under equal temptations to diſhoneſty on account of the almoſt total impunity that they enjoy in conſequence of the following regulation. In all thoſe diſtricts where there are either a corregidor and ſuperior alcade, or two ſuperior alcades; each of theſe officers has an independent tribunal for the deciſion of law ſuits; and the right of pronouncing ſentence in any particular caſe belongs to him of the two at whoſe tribunal the firſt applica-

tion

tion was made. Now the eſtabliſhed ſalaries of theſe officers are ſo ſmall, that the largeſt part of their emoluments ariſes from their fees: this portion of their income depends wholly on the writers, who have the power of inſtituting ſuits in which of the two courts they pleaſe. The natural conſequence is, that the judges are induced to overlook and paſs by in ſilence thoſe malpractices of the writers which they cannot prevent without incurring a ſerious perſonal loſs. Finally, the authority of the writers is irrefragably eſtabliſhed by the entire controul that they execute over all cauſes. They alone receive the declarations and perſonal anſwers of the parties concerned; they alone receive the depoſitions of the witneſſes on each ſide; put what queſtions to them they pleaſe; and record the anſwers without the interpoſition, and even in the abſence, of the judges.

Another ſerious defect in the adminiſtration of juſtice in Spain, is, that the party condemned, however clearly unjuſt may have been his demand, or however weak may have been his defence, is ſcarcely ever obliged to pay his adverſary's coſts of ſuit; whence it perpetually happens, that the expences of gaining a juſt cauſe are much greater than the loſs of ſubmitting to an unjuſt demand; hence alſo it is in the power of a rich villain to oppreſs and ruin all thoſe who are unable to ſupport the expences of a law ſuit; which in Spain are enormous, and perhaps the more ſo, becauſe the eſtabliſhed charges are very light.

208 Religion.

The religion of Spain is the Roman Catholic; which, in this country and Portugal, has been carried to a pitch of fanaticiſm unknown to the Italian ſtates, or even in the papal territory. The inquiſition, has in theſe unhappy kingdoms, been inveſted with exorbitant power, and has produced the moſt ruinous effects; having been formerly conducted with a ſpirit totally the reverſe of the mildneſs and charity of Chriſtianity. This evil has been recently ſubdued in a conſiderable degree; but one fanatic reign would ſuffice to revive it. A yet greater evil, which has ſprung from fanaticiſm, is the deſtruction of morals; for the monks being extremely numerous, and human paſſions ever the ſame, thoſe aſcetics atone for the want of marriage by the practice of adultery; and the huſbands, from dread of the inquiſition, are conſtrained to connive at this enormous abuſe. The conſcience is feared by the practice of abſolution, and the mind becomes reconciled to the ſtrangeſt of all phenomena, theoretic piety and practical vice united in bonds almoſt indiſſoluble.

According to the returns made to the government, the Spaniſh clergy then ſtood as follows.

Parochial clergy, called curas - - -	16,689
Aſſiſtants, called tenientes curas - - -	5,771
Sacriſtans or ſextons - - - - -	10,873
Acolitos to aſſiſt at the altar - - -	5,503
Ordinados de patrimonio, having a patrimony of three rials per day	13,244
Ordinados de menores, with inferior eccleſiaſtical orders	10,774
Beneficiados, or canons of cathedrals, and other beneficiaries	23,692
Monks - - - - - - -	61,617
Carry forward	148,163
Brought over	148,163
Nuns - - - - - - - -	32,500
Beatas - - - - - - - -	1,130
Syndics to collect for the mendicants -	4,127
Inquiſitors - - - - - - -	2,705
	188,625

The archbiſhoprics were eight in number; and the biſhoprics 46. The moſt opulent ſee was that of Toledo, ſuppoſed to yield annually about 90,000l. The Mozarabic Miſſal, compoſed by St Iſidora for the Gothic church, after the converſion from Arianiſm to the Catholic faith, continued to be uſed in Spain till the Moors were ſubdued, when the Roman form was introduced.

The Spaniſh clergy, in proportion to the population of the country, is leſs numerous than was the clergy of France prior to the revolution; even their wealth is leſs conſiderable, but better adminiſtered; and their contribution to the public revenue is much greater. As to the general conduct of the Spaniſh church, and its influence on the ſtate, we may remark that after all the perverted and malicious induſtry that has been exerted in the examination of this queſtion, the reſult has turned out highly favourable to the ſuperior orders of the Spaniſh clergy, who are, for the moſt part, free from thoſe irregularities which are charged on the clergy of other countries. The conſpicuous ſituations in the Spaniſh church are by no means conſidered as the patrimony of the rich and noble, but as the well-merited reward of irreproachable conduct. Whatever may be the rank of an eccleſiaſtic in the ſacerdotal hierarchy, he never habitually abſents himſelf from his proper place of reſidence, where he expends the revenue of his benefice in alms or public works. From the period of the reconqueſt of Spain from the Moors, moſt of the public eſtabliſhments owe their foundation to the clergy, by whom alſo whole towns have been rebuilt and raiſed from their ruins. The moſt beautiful aqueducts, fountains, and public walks in the cities, have been conſtructed at the expence of their biſhops; from them alſo the poor have received the moſt effectual relief in times of ſcarcity, epidemic diſeaſe, and war. The biſhop of Orenſe converted his epiſcopal palace into an almshouſe, where were lodged and ſupported 300 French eccleſiaſtics, condemned to tranſportation during the furies of the revolution; the prelate himſelf took his place at their table, and refuſed to partake of any indulgence that he could not alſo procure for his gueſts. Cardinal Orenzana, archbiſhop of Toledo, converted the alcazar of that city into an eſtabliſhment wherein are received 200 children, and 700 poor perſons of all ages. The biſhop of Cordova, during the ſcarcity of 1804, and for a long time afterwards, made a daily diſtribution of 1200 rations of bread to the poor inhabitants of his dioceſe. The aqueduct which conveys water to the city of Tarragona is the work of their archbiſhop, who has thus conferred upon the place the inappreciable benefits of cleanlineſs and health; to both of which it was long a ſtranger. Similar inſtances of public merit may be found in almoſt every dioceſe.

209 Preſent ſtate of the Spaniſh clergy.

With regard to the religious orders, their conduct is certainly leſs exemplary, though by no means meriting the reproaches that have been ſo liberally caſt upon them.

Spain.

them. The reforms that have taken place at various periods have ſtopped the progreſs of the abuſes introduced by length of time; and as the numbers of the monks have diminiſhed, their pernicious influence on public opinion has proportionably declined. Some progreſs has been made in the deſirable policy of uniting the different orders of the ſame rule into a ſingle order; and from the preſent prohibition to receive novices, it is probable that ſeveral orders are about to be totally ſuppreſſed.

210 Language and literature.

The Spaniſh language is one of the great ſouthern dialects which ſpring from the Roman; but many of the words become difficult to the French or Italian ſtudent, bcauſe they are derived from the Arabic uſed by the Moors. The ſpeech is grave, ſonorous, and of exquiſite melody, containing much of the flow and formal manner of the orientals.

The Spaniſh language is, in ſome reſpects, very rich; it abounds in compound words, in ſuperlatives, derivatives, augmentatives, diminutives, and frequentative verbs; it has many quite ſynonymous words, and others which well expreſs the different ſhades of meaning. In the technical terms of arts and ſciences it is, however, extremely poor; a few of theſe it has borrowed from the Latin, and almoſt all the reſt from the French.

On the whole, the Spaniſh is one of the fineſt of the European languages. It is dignified, harmonious, energetic, and expreſſive; and abounds in grand and ſonorous expreſſions, which unite into meaſured periods, whoſe cadence is very agreeable to the ear. It is a language well adapted to poetry; but it alſo inclines to exaggeration, and its vehemence eaſily degenerates into bombaſt. Though naturally grave, it eaſily admits of pleaſantry. In the mouth of well educated men it is noble and expreſſive; lively and pointed in that of the common people; ſweet, ſeductive, and perſuaſive, when uttered by a female. Amongſt the orators it is touching and impoſing, though rather diffuſe; at the bar and in the ſchools it is barbarous, and is ſpoken about the court in a conciſe and agreeable manner.

The literature of Spain is highly reputable, though little known to the other countries of Europe ſince the decline of Spaniſh power. The Bibliotheca Hiſpanica of Antonio will completely ſatisfy the curious reader on this ſubject. Among the fathers of literature in this country muſt be named Iſidore of Seville, many of whoſe works are extant, and inferior in merit to few of that epoch. Lives of ſaints, and chronicles, are alſo found among the earlieſt productions; and ſucceſſive writers may be traced to the 11th century, when they become numerous; but before mentioning ſome Spaniſh authorities poſterior to that period, it will be proper to recollect that Arabian learning flouriſhed under the caliphs of Cordova, and produced many illuſtrious names well known to the oriental ſcholar, as Aben Roe, or Averroes, Aben Zoar, Rhazes, &c. nor muſt it be forgotten that Aben Nazan wrote a book on the learning and authors of Spain. On this ſubject the inquiſitive are referred to the work of Caſiri.

In the 11th century, the Spaniſh authors began to increaſe in number, aud the native language begins to appear. This was the epoch of the famous *Cid*, Roderic Didac de Bivar, whoſe actions againſt the Moors were celebrated in contemporary ſongs, and by a long poem written in the following century. After the 13th century, it would be idle to attempt enumerating all the Spaniſh authors, among whom are Alphonſo the Wiſe, who wrote the Libro del Teroſo, a treatiſe on the Three Parts of Philoſophy; and at whoſe command were compiled the famous Alphonſine Tables of Aſtronomy. Raymond Lully is ſaid to have written not fewer than 319 books, full of metaphyſical froth. In the 15th century appeared Juan de Mena, a poet of ſurpriſing powers, ſince which time a department of literature can ſcarcely be mentioned in which the Spaniards have not excelled. It would be unneceſſary to repeat the well-known names of Cervantes, Quevedo, Lopez de Vega, and others, whoſe works are known to all Europe. The hiſtory of Mexico has been celebrated as a compoſition; but in fact it is defective and erroneous. The name of Bayer in learning, and of Feyjos in general knowledge, have recently attracted deſerved reſpect; nor has the line of royal authors failed, an elegant tranſlation of Salluſt having been publiſhed by the heir apparent to the monarchy, the preſent Ferdinand VII *.

* *Pinkerton's Geography*, vol. i.

211 Education.

As the rudiments of education are in Spain generally imparted by the monks, it can ſcarcely be expected that uſeful knowledge ſhould be common in that country. The accounts given on this ſubject by travellers, have thrown ſo little light on the ſtate of education in Spain, that it can be generally underſtood only by compariſon with other Catholic countries. In this compariſon Spain will be found inferior to France and Italy, but in many reſpects ſuperior to Auſtria and the German ſtates.

212 Univerſities.

The number of univerſities in Spain was formerly 24, but only the following 17 now remain, viz. that of Pampeluna, in Navarre; of Oviedo, in the Aſturias; of San Jago, in Galicia; of Seville, and of Granada, in the provinces of the ſame name; of Hueſca and Zaragoza, in Aragon; of Avila, Oſma, and Valladolid, in Old Caſtile; of Toledo, Siguenza, and Alcala de Hamarez, in New Caſtile; of Cervera, in Catalonia; of Orihuela and Valencia, in Valencia; and of Salamanca, in the province of Leon. Of theſe the moſt celebrated, are the univerſities of Zaragoza, Toledo, Alcala, Cervera, and Salamanca.

The univerſity of Zaragoza has 22 profeſſors, and that of Toledo has 24; about 900 ſtudents attend the claſſes of the former, and nearly 3000 thoſe of the latter; yet neither of theſe eſtabliſhments is known in Europe, or regarded as of high reputation even in Spain.

The univerſity of Alcala, eſtabliſhed at a prodigious expence by Cardinal Ximenes, anſwered for nearly a century the views of its illuſtrious founder. This ſplendid inſtitution conſiſts of 31 general profeſſors, and 13 colleges, each of which has its particular eſtabliſhment of maſters and profeſſors, and of ſtudents, who receive gratuitous ſupport and inſtruction. At preſent, however, this univerſity is gone ſo entirely to decay, that ſcarcely a veſtige of its ancient ſplendour remains, and the whole number of ſtudents ſcarcely amounts to 500.

The univerſity of Cervera, founded at the commencement of the 18th century, with a magnificence truly royal, poſſeſſes 43 profeſſors, five colleges, about 900 ſtudents; but it partakes of the radical fault of all the Spaniſh univerſities; the courſe of ſtudy is incomplete and antiquated, and the very name of the inſtitution is ſcarcely known beyond the boundaries of Catalonia.

The

Spain.

The univerſity of Salamanca, the moſt ancient of any in Spain, has enjoyed a degree of celebrity which entitles it to a particular deſcription.

It was founded by Alphonſo IX. between the years 1230 and 1244, and was conſiderably enlarged by Ferdinand III. his grandſon. But its moſt magnificent patron was Alphonſo X. ſurnamed the Wiſe, ſon and ſucceſſor of the laſt mentioned ſovereign. This prince richly endowed it, and drew up a ſet of ſtatutes for its government. He eſtabliſhed a profeſſorſhip of civil law, with a ſalary of 500 maravedies; a profeſſorſhip of canon law, with a ſalary of 300 maravedies; two profeſſorſhips of decretals with ſalaries of 500 maravedies; two profeſſors of natural philoſophy, and as many of logic, with ſalaries of 200 maravedies each; and two maſters of grammar, with ſalaries of 300 maravedies. It experienced alſo the liberality of many ſucceeding ſovereigns, and received from the popes a vaſt extent of privileges.

For many years this univerſity enjoyed a high reputation; its fame extended over all Europe; it was conſulted by kings and by popes, and its deputies were received into the general councils, where they well ſuſtained the character of the body which they repreſented. Students flocked to it not only from all the provinces of Spain and Portugal, and from the iſlands of Majorca and the Canaries, but alſo from the Weſt Indies and New Spain, and even from France, Flanders, and England. The number of ſtudents who attended the claſſes amounted nearly to 15,000. The whole of this vaſt eſtabliſhment conſiſted of 25 colleges, a library, and an hoſpital, called *Del Eſtudio*, intended for the amelioration of poor ſcholars.

The celebrity of Salamanca continued in full vigour during many ages; but, at length, as rival inſtitutions ſprang up, declined by ſlow degrees, ſo that by the year 1595, the number of ſtudents did not exceed 7000*.

* *De Laborde.*

213
State of the Spaniſh ſtage.

After the evacuation of Spain by the Romans, theatrical repreſentations were diſcontinued till they were reſtored by the Moors, and from them adopted by the Gothic Spaniards, who ſoon became paſſionately fond of the ſtage, a taſte which they have ever ſince preſerved.

They had at firſt neither theatres nor a ſtage, their dramas were acted in a court, a garden, or the open fields; the actors and ſpectators were mingled, and were equally expoſed to the injuries of the weather.

At a ſubſequent period the ſtage was marked out by a kind of boarded platform, and was ſurrounded by old clothes, drawn back, on occaſion, by means of cords, which formed the only decorations, and behind which the actors dreſſed. Their properties conſiſted only of crooks, ſome wigs and falſe beards, and a few white ſkins, trimmed with gold fringe.

Theatrical exhibitions became more regular and decent towards the end of the 16th century, when a new form was given to them by the exertions of Bartholemew Naharro, a middling dramatic poet. Theatres were then erected, but the greateſt part were upon treſſels, and two parallel pieces of canvas formed their ſcenes, which were ſometimes checquered with various colours, ſometimes covered with miſerable paintings, or adorned with foliage, trees, or flowers.

During all theſe periods, the prompter, with a candle in his hand, ſtationed himſelf on the ſtage by the ſide of the performers who were ſpeaking, and jumped from ſide to ſide whenever the actors changed their places. This cuſtom prevailed at the end of the 17th century, and even ſtill prevails among the ſtrolling companies of ſmall towns.

Spain.

Theatres have at length, however, aſſumed a handſomer appearance in this country, and cuſtoms more conformable to the reſt of Europe. Handſome theatres have been multiplied, and their ſtages are now well arranged and decorated; all the great cities are well provided with them, and many of the ſmaller towns may boaſt of elegant and not ill furniſhed playhouſes.

The prompter no longer runs from one ſide of the ſtage to the other; he is placed in the middle before the ſcenes, in a kind of well, where he no longer offends the ſight and taſte of the ſpectator: but an old cuſtom which is ſtill obſerved, greatly injures the intereſt and effect of the repreſentation. The prompter, who has the piece before him, does not wait till the actor is at a loſs to prompt him, but recites the whole drama aloud, ſo that the actor appears to follow him in his declamation. By this means two voices are heard in the theatre pronouncing the ſame words, which are confounded, and often produce a diſcord, and the ſpectator who has firſt heard the piece recited, no longer takes an equal intereſt in the ſame verſes, phraſes, and words, which the actor afterwards declaims.

The Spaniſh theatres are divided into a *patio*, or area, and boxes called *balco* and *apóſentos*. The orcheſtra, where the muſicians are ſtationed, adjoins the ſtage; an incloſure between it and the pit is ſet round with arm chairs, and deſtined for the reception of the higher claſs: the *patio*, or pit, is placed behind, and filled with benches, and the *gradas* conſiſt of two rows of benches diſpoſed amphitheatrically on each ſide below the boxes, and ſometimes alſo acroſs the lower end of the theatre. This laſt diviſion is found only in a few theatres; in the others, the ſpace beneath the boxes is empty, and perſons ſtand in it. The *patio* and the *gradas* contain the common people, the moſt numerous, moſt noiſy, and moſt imperious part of the public.

There are commonly only two tiers of boxes, ſometimes three; they extend on each ſide from the ſtage to the end of the theatre. The form is the uſual one, but they are divided from each other by partitions, which completely ſhut them up on each ſide, a circumſtance which greatly injures the beauty of the general effect.

There is commonly at the end of the theatre fronting the ſtage, a large box with ſeats placed ſemicircularly behind one another, which is called the *cazuela*. No man is allowed to enter it, and only women muffled up in their *mantelas* are admitted.

There are ſeveral things very ſingular and amuſing in this cazuela. Women of every age and condition are there united; the married are confounded with the ſingle; the wives of the common people with thoſe of tradeſmen and the ladies of the court; the poor woman with the rich one who would not be at the trouble of dreſſing to appear in her box. Their appearance is moſt curious; they are all covered with their *mantelas*, a kind of white or black veil, and give the idea of a choir of nuns. It is the place for chattering, and between the acts there proceeds from the cazuela a confuſed noiſe like the hum of bees, which aſtoniſhes and diverts all who hear it for the firſt time. Scarcely is the performance ended, when the door of this box, its galleries, paſſages, and the ſtaircaſe leading to it, are all

all beſieged by a great crowd of men of every condition; ſome attracted by curioſity; others coming to wait upon the women who are in it.

Notwithſtanding all that has been done for its improvement, the Spaniſh ſtage is ſtill far from the celebrity which it once poſſeſſed; and the people do not ſecond the efforts of their beſt writers. The acting is in a ſtill lower ſtate. The performers poſſeſs neither that dignity which characterizes great perſonages, and ennobles a ſubject without injuring its intereſt; nor that ſweet expreſſion of voice and geſture which goes to the heart, and awakens the ſentiments it expreſſes. In their acting every thing is violent or inanimate; every thing departs from nature. Their recitation is a feat of ſtrength, and is performed at the ſole expence of the lungs. Cries and ſhrieks are its moſt impreſſive part, and the moſt applauded by the majority of the audience. They put nothing in its proper place: all their action is exaggerated; when they threaten they roar; when they command they thunder; when they ſigh, it is with an effort which completely exhauſts the breath. They ſubſtitute anger for dignity, violence for ſpirit, inſipidity for gallantry. Their geſtures rarely correſpond with the ſentiments they ought to expreſs; but reſemble their recitation; and are uſually monotonous, capricious, ignoble, and almoſt always violent. The women, in their burſts of paſſion, become furies; warriors become villains; generals robbers; and heroes bravos. Nothing, as they manage it, is pathetic; nothing makes any impreſſion on the audience. The ſpectators, equally unmoved at the end of the piece, as at the beginning, ſee it, without having experienced a ſingle moment of intereſt or emotion *.

* De Laborde.

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Produce and agriculture.

As labour and culture are reckoned derogatory to the Spaniſh character, a ſufficient quantity of grain for the ſupport of the inhabitants is not raiſed, though ſocieties for the encouragement of agriculture have been eſtabliſhed in different parts of the kingdom. The principal products are wine, delicious fruits, oil, ſilk, honey, and wax. A conſiderable proportion of the mountains and valleys is paſtured by immenſe flocks of ſheep, whoſe wool is extremely fine and valuable. Eſtremadura is noted for its excellent paſtures; and the wool in Old Caſtile is reputed the fineſt in the kingdom. In Catalonia the hills are covered with foreſt and fruit trees. Valencia is celebrated for its ſilk, and for the exquiſite flavour of its melons. Murcia abounds in mulberry trees; and the ſouthern provinces yield the moſt delicious wines and fruits. Upon the whole, it has been obſerved of Spain, that few countries owe more to nature, and leſs to induſtry.

The ſoil in general repoſes on beds of gypſum, which is an excellent manure. The common courſe of huſbandry about Barcelona begins with wheat; which being ripe in June, is immediately ſucceeded by Indian corn, hemp, millet, cabbage, kidney beans, or lettuce. The ſecond year theſe ſame crops ſucceed each other as before. The next year they take barley, beans, or vetches; which coming off the ground before midſummer, are followed, as in the former years, by other crops, only changing them according to the ſeaſon, ſo as to have on the ſame ſpot the greateſt poſſible variety. Near Carthagena the courſe is wheat, barley, and fallow. For wheat they plough thrice, and ſow from the middle of November to the beginning of December; in July they reap from 10 to 100 for one, as the ſeaſon happens to be humid. The rich vale of Alicant yields a perpetual ſucceſſion of crops. Barley is ſown in September, reaped in April; ſucceeded by maize, reaped in September; and by a mixed crop of eſculents which follow. Wheat is ſown in November, and reaped in June; flax in September, pulled in May. In the vale of Valencia wheat yields from 20 to 40; barley from 18 to 24; oats from 20 to 30; maize 100; rice 40. The Spaniſh plough is generally light; and is drawn by oxen with the yoke over the horns; the moſt proper and natural mode, as the chief ſtrength of the animal centres in the head. For a very minute account of agriculture in Spain, ſee De Laborde's View, vol iv. chap. 2.

215
State of the arts.

That prejudice which regards the mechanic arts as baſe, is not yet extinguiſhed in Spain; hence it happens that theſe arts are either neglected, or abandoned to ſuch unſkilful hands as in general to render the Spaniards much behind their neighbours, in the uſeful arts of life. The influence of this prejudice is leaſt in the province of Catalonia, where the laws, cuſtoms, and opinions are favourable to artizans; and it is accordingly in this province that the mechanic arts have made the greateſt progreſs. Foreign artiſts experience great difficulties in this country. They are not allowed to practice without gaining admiſſion into ſome incorporation or company, and this has almoſt always been refuſed them.

Some arts have, however, made conſiderable progreſs in Spain, eſpecially thoſe of gilding leather, and printing, which has lately acquired a great degree of perfection.

The fabrication of articles of gold and ſilver might become an important object in a country where theſe metals abound; but it is neglected, and the demand is almoſt entirely ſupplied from foreign markets. What little they perform in this way at home is uſually very ill executed, and exorbitantly dear. Madrid, however, begins to poſſeſs ſome good workmen in this way; encouragement would increaſe their number, and facilitate the means of improvement; but manual labour is there exceſſively dear. Hence the Spaniards prefer foreign articles of this kind, which, notwithſtanding the expence of carriage, the enormous duties which are paid on theſe articles, and the profits of the merchants, are ſtill cheaper than thoſe made at home.

216
Architecture.

The liberal arts are cultivated in this country with more aſſiduity and ſucceſs. The 16th century was the moſt brilliant period of the arts in Spain, as well as of the ſciences, of literature, and of the power and grandeur of the monarchy. A crowd of able architects appeared at once under Charles V. and Philip II. They erected numerous edifices, which will immortalize the reigns of theſe princes and the names of the artiſts. John de Herrera and Cepedes diſplayed the higheſt talents; Pedro de Uria conſtructed the magnificent bridge of Almaraz, in Eſtremadura; John-Baptiſt-Monegro of Toledo, aſſiſted in the building of the Eſcurial, and of the church of St Peter at Rome.

The ſtructures of that age are the fineſt in Spain, and perhaps the only ones in the country which deſerve to fix the attention of the ſkilful ſpectator. There are ſome among them which, in regularity, ſolidity, and magnificence, deſerve to be compared with the fine buildings of the Romans. The bridges of Badajoz over the Guadiana, and of Toledo, over the Manzanares, are of this period; as are alſo the grand houſe or palace, now the council-

Spain. council-houſe at Madrid, and the beautiful edifices which adorn Toledo; the palace of Los Vargas; the hoſpital of St John the Baptiſt, and that of the Holy Croſs. During the ſame time, the *alcazar* of this city, built under Alphonſo X. was reſtored with the grandeur and magnificence which it ſtill diſplays; and the noble palace was erected, known under the name of the Houſe of Pilate, at Madrid.

That magnificent building the Eſcurial, which the Spaniards called the eighth wonder of the world, which uſed to lodge at once the king and his court, and 200 monks; this famous palace, which aſtoniſhes us by its maſs and extent, by the ſtrength of its ſtructure, the regularity of its proportions, and the ſplendour of its decorations, as much as by the repulſive appearance of its ſite and neighbourhood, alſo belongs to the ſame period, having been erected in the reign of Philip II.

The decline of architecture became as complete in the 17th century as its ſtate had been flouriſhing in the preceding age. From this period no architect occurs worthy of remembrance; and the buildings are monſtrous maſſes, deſtitute of order, taſte, and regularity. One only deſerves notice, the priſon of Madrid, called Carcel de Conte, the work of a happy genius, who knew how to profit by the bright examples of the preceding period.

About the middle of the 18th century, however, architecture began again to be cultivated with ſucceſs. The academy of San-Fernando, at Madrid, has already produced ſeveral able men in this branch, who purſue their art with credit. The handſome bridge built over the Xarama, between Aranjuez and Madrid, in the reign of Charles III. diſplays the talents of Mark de Vierna, his architect; the cuſtom-houſe of Valencia, and the temple-church of the ſame city, conſtructed on the plan of Michael Fernandez; the exchange of Barcelona; the triumphal arch which forms the gate of Alcala, at Madrid, and the ſnuff manufactory at Seville, do honour to the Spaniſh architecture of the preſent day.

217 Painting. Spain juſtly boaſts of many eminent ſculptors; but of all the liberal arts, painting is that which has been moſt cultivated in Spain, and in which its natives have beſt ſucceeded. The Spaniſh ſchool is much leſs known than it deſerves: it holds a middle place between the Italian and Flemiſh ſchools; it is more natural than the former, more noble than the latter, and partakes of the beauties of both. It has particularly excelled in ſacred ſubjects; and we recogniſe in the Spaniſh pictures the feelings uſually experienced by the people of the myſteries of religion. By none have devout ecſtaſy, fervour, and genuine piety, been ſo well expreſſed, or the myſtic paſſion given with ſo much truth. It is not in correctneſs of deſign, or nobleneſs of form, that the Spaniſh artiſts uſually excel, but in the pure imitation of nature, in grace, truth, effect, and the expreſſion of feelings.

The Spaniards have at length opened their eyes to the utility of the arts; they acknowledge them to be advantageous and deſerving of reſpect, and have begun to give them ſuch encouragement as is likely to promote a taſte for them, and to inſure their advancement. Government has done ſomething by affording protection and countenance to the new eſtabliſhments; but the ſtrongeſt impulſe has been given by individuals, or private aſſociations.

Spain now poſſeſſes an academy of painting, at Seville, and two academies of the fine arts, one at Madrid, and the other at Valencia. The firſt owes its origin to an aſſociation of the painters of Seville formed by themſelves, about the year 1660; Charles III. revived it, and eſtabliſhed there a ſchool of the fine arts. That of Madrid was founded by Philip V. The laſt was eſtabliſhed by the exertions of ſome private perſons, aſſiſted by the benefaction of Andrew Majoral, archbiſhop of Valencia, and the protection of the municipal body. Charles III. came to its aſſiſtance 26 years after its eſtabliſhment, with an annual gift of nearly 700l. Theſe academies have for their object the ſtudy and improvement of painting, ſculpture, and architecture; they give public leſſons on theſe three arts, and diſtribute annual prizes among their pupils. That of Madrid, or San-Fernando, ſends its pupils to Rome at the expence of government, to complete their ſtudies.

Public and gratuitous ſchools for drawing have been eſtabliſhed within the laſt 20 years in different places; at Madrid, Cordova, Valencia, Seville, Zaragoza, Barcelona, &c. The laſt of theſe is ſupported by the merchants; that of Vergara was founded by the patriotic ſociety of Biſcay; and thoſe of Zaragoza and Cordova owe their birth to the zeal and generoſity of two individuals; the firſt to Don Martin Noy Cochear, the laſt to Don Antonio Cavallero, the preſent biſhop of Cordova. Thoſe of Madrid, Seville, and Valencia, depend on the academies of theſe cities.

The manufactures of Spain were more flouriſhing during the government of the Moors in that country, than they have been at any ſubſequent period. So completely had the kingdom declined in this reſpect at the end of the 16th century, when Philip V. aſcended the throne, that it is ſaid by De Laborde to have been abſolutely deſtitute of trade. The inteſtine wars which ravaged the kingdom during the firſt 14 years of that reign, and the low ſtate to which the national finances were reduced, prevented the government from paying attention to manufactures; and it was not till after tranquillity had been reſtored, and regulations adopted with reſpect to the public revenue, that the natives were induced to wear articles of their own manufacture. Since the reigns of Ferdinand VI. and Charles III. this part of the internal trade of the kingdom has greatly improved, and the manufactures of Spain are now once more on a reſpectable footing. 218 Manufactures.

The Spaniſh manufactures enumerated by De Laborde, in his View of Spain, are thoſe of cloth and other woollen goods; ſilks; brocaded ſtuffs in gold and ſilver; linens and other articles formed from flax or hemp; cottons; leather, and other articles manufactured from ſkins and hides; paper; china and delft ware; brandies; beer; aquafortis; ſalt of lead; ſhears for the woollen trade; copper, iron, and braſs goods; glaſs and mirrors; ſoap; hats; articles for the marine; military implements; arms and ammunition; tobacco and ſnuff. Of theſe, the moſt important are, the woollen and ſilk manufactures; leather; brandy; military weapons; ſoap and tobacco.

The principal places for the woollen manufactures are, Aulot, Arens, Vich, and the convent of Gironne in Catalonia; Jaca, and the diſtrict of Cincavilla in Aragon, and Burgos in Old Caſtile, for woollen ſtockings; Barcelona, Zaragoza, and Burgos, for blankets; Junquera, Segovia, Burgos, and many others for baizes and

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and flannels; Eſtella in Navarre, Eſcoray in Biſcay, Grazolerna in Seville, Toledo, &c. for coarſe cloths, which laſt article is manufactured in large quantities throughout the kingdom. The woollen ſtuffs fabricated in Spain are in general of a very inferior quality, the wool being imperfectly ſcoured, and the dyeing ſo ill executed that the colours are never permanent.

The chief manufactures for ſilken articles are thoſe for blonde lace throughout Catalonia, and at Almagro in La Mancha; for ſilk ſtockings, at Malaga, Zaragoza, Valencia, Talavera, and Barcelona; and for ſilk taffeties, ſerges, damaſks, and velvets, at Jaen, Granada, Murcia, Valencia, Malaga, Zaragoza, Toledo, Talavera, and Barcelona. The articles of this manufacture are in general ſtout and excellent; but they do not poſſeſs that brilliancy of appearance ſo remarkable in the French ſilks.

Tanning, currying, and dreſſing hides, ſkins, and all kinds of leather, are very general throughout Spain; but the ſkins and hides prepared at Arevaca and Pozuelo, are in greateſt repute. The greateſt quantity of ſole leather is manufactured in the provinces of Aragon and Catalonia; and in the latter province are made and exported a prodigious number of ſhoes.

The making of brandy is confined chiefly to the ſtates belonging to the crown of Aragon, eſpecially at Torres in Aragon; at Selva, Mataro, &c. in Catalonia; and in Valencia.

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Spain has long been famous for its manufacture of military weapons; and it is well known that the ſwords, ſabres, hangers, and bayonets, made at Toledo and Barcelona, are of a very ſuperior temper. Large manufactories for fire-arms occur in the diſtrict of Guipuſcoa, and two royal founderies for braſs cannon, are eſtaliſhed at Barcelona and Seville.

There is only one manufactory for tobacco and ſnuff in Spain, viz. at Seville; but this is on a moſt extenſive ſcale, and is ſuppoſed to yield of annual profits about 800,000l. ſterling. Here are employed 202 mills, turned by 300 horſes or mules; and the various operations call for the daily labour of above 1400 perſons.

219 Commerce.

Conſidering the extent of ſea coaſt belonging to the kingdom of Spain, its commerce is but inconſiderable, and principally takes place between the mother-country and the American colonies. Spain, indeed, carries on a foreign trade with every country in Europe; but its principal tranſactions are, with England, Holland, Italy, and France. Its exports to theſe countries conſiſt almoſt entirely of raw produce, as, if we except oil, wine, brandy, ſhoes, ſalt, and a few coarſe cloths and ſilken articles, the trade in manufactured goods is almoſt wholly confined to the interior of the country. Its chief exports, and the amount yielded by each for the ſeveral provinces, as well as the whole amount of the export trade of Spain, to the reſt of Europe, will be ſeen in the following table.

Value of Exports from each Province in pounds ſterling.

Goods exported.	*Catalonia.*	*Valencia.*	*Andaluſia.*	*Murcia.*	*Aragon.*	*Other Provinces.*	*Total.*
Nuts,	L. 26,000	L.	L.	L.	L.	L.8,336	L.34,336
Oil,	26,667	-	208,333	-	-	-	235,000
Cork,	235,990	-	-	-	-	-	235,990
Wine,	2,667	103,333	508,333	31,250	-	-	645,583
Linens and cotton ſtuffs,	295,007	-	-	-	-	-	295,007
Silk handkerchiefs,	51,042	-	-	-	-	-	51,042
Paper,	73,333	-	-	-	-	-	73,333
Brandy,	262,500	125,000	-	-	-	-	387,500
Shoes and ſhoe ſoles,	22,024	-	-	-	-	-	22,024
Raiſins,	-	10,625	625,000	-	-	-	635,625
Dried figs,	-	5,333	34,375	-	-	-	39,708
Almonds,	-	6,563	-	-	-	-	6,563
Dates,	-	6,250	-	-	-	-	6,250
Barylla,	-	15,875	-	108,333	-	-	124,208
Kermes,	-	7,292	-	-	-	-	7,292
Salt,	-	9,250	833,333	-	-	-	842,583
Spart worked,	-	[illegible]	-	4,166	-	-	4,166
Silk,	-	[illegible]	-	229,166	38,333	-	267,499
Cutlery,	-	-	-	5,000	-	-	5,000
Ribbons,	-	-	-	2,083	-	-	2,083
Corn,	-	-	-	78,041	53,437	-	131,478
Saffron,	-	-	-	2,500	-	-	2,500
Wool,	-	-	-	-	48,750	641,682	690,432
Flax,	-	-	-	-	1,458	-	1,458
Coarſe cloths,	-	-	-	-	2,666	-	2,666
Silk and wool mixtures,	-	-	-	-	5,833	-	5,833
Worſted ſtockings,	-	-	-	-	540	-	540
Salt proviſions,	-	-	-	-	-	A large quantity	
Oranges and lemons,	-	-	-	-	-	from Gallicia.	
Hemp,	-	-	-	-	79,063		79,063
Madder,	-	-	-	-	-	From Old Caſtile	66,667
Brooms,	6,875	-	-	-	-	-	6,875
	1,002,105	289,521	2,209,374	460,539	230,080	716,685	4,908,304

The

Spain.

The above table is confined almoſt entirely to the European exports. To theſe muſt be added the amount of Spaniſh exports to the American colonies in order to acquire a juſt view of the total amount of the export commerce. The following table will ſhow the amount of the exports, both of home and foreign produce, from Spain to America in 1784, as eſtimated by Mr Townſend in pounds ſterling.

Ports.	Home produce.	Foreign produce.	Total.
Cadiz	1,438,912	2,182,531	3,621,443
Malaga	196,379	14,301	210,680
Seville	62,713	30,543	93,256
Barcelona	122,631	21,240	143,871
Corunna	64,575	39,962	104,537
Santander	36,715	90,173	126,888
Canaries	24,974		24,974
Tortoſa	7,669	289	7,958
Gijon	4,281	10,190	14471
Total	L.1,958,849	L.2,389,229	L.4,384,878

Of theſe exports we are to regard chiefly thoſe of Spaniſh produce, and theſe Mr Townſend has probably eſtimated too high. M. de Laborde, on whoſe authority we are more diſpoſed to rely, ſtates the value of Spaniſh domeſtic merchandiſe exported to America in the year 1788, as amounting to 1,635,658l. ſterling, while in 1792, it amounted to 2,812,500l; ſterling, and on an average of five years, from 1788 to 1792, it amounted to 1,833,333l. ſterling. The amount of foreign merchandiſe exported in 1788, was 1,484,315l. ſterling. Adding the average to this laſt ſum, we have 3,317,648l. ſterling for the whole export trade to America. This added to 4,908,304l. ſterling, makes a grand total of 8,225,952l. ſterling for the whole export trade of Spain.

The Spaniſh imports are much more conſiderable than the exports. Before the preſent troubles, Spain imported from Holland, tapes, linen drapery, common lace, cutlery goods and paper; from Sileſia linen drapery; from Germany, more particularly from Hamburgh, quantities of haberdaſhery; from England, calicoes, iron and ſteel goods, fine cloth, quantities of cod fiſh and ling; the value of the laſt articles is eſtimated at three millions of duros, five millions livres tournois, (208,333l. 13s. 4d.); from France, calicoes, linen drapery, ſilk ſtockings, ſilks, camlets, and other kinds of worſted ſtuffs, fine cloths, gilded articles, jewellery, iron goods, haberdaſhery, ſteel goods, and perfumery.

We have not ſatisfactory documents ſufficient to aſcertain the amount of theſe imports, but it was certainly much leſs than that of the imports from the American colonies. Theſe latter, according to Mr Townſend's ſtatement, amounted in 1784 to 12,635,173l. ſterling; to which, if we add nearly half a million for duty, we ſhall have a total of above thirteen millions ſterling for American imports alone. De Laborde eſtimates the total amount of American imports for the year 1788 at 8,382,330l. ſterling, of which Cadiz alone imported 6,6[illegible]7,873l. ſterling. If to the above amount we add 577,679l. for the duty at the ſame period, we ſhall have a total of 8,960,009l. ſterling againſt the mother country, deducting from this 3,317,648l. for the average exports, we have 5,642,361l. as the balance of trade in favour of the Spaniſh colonies.

Inland navigation. 220

Though there are in Spain many navigable rivers, few canals of communication have been conſtructed to improve the internal navigation of the country. The canal of Aragon, completed during the reign of Charles IV. muſt be highly beneficial to that province. Two canals, viz. that of Tueuſtre and the imperial canal, both of which begin at Navarre, run in various windings through Aragon, by turns receding from or approaching the river Ebro, where at length they terminate. Beſides the dykes, banks, ſluices, and bridges neceſſary in the courſe of theſe canals, an aqueduct has been conſtructed in the valley of Riozalen, 710 fathoms in length, and 17 feet thick at the baſe, in which the canal runs.

The canal of Caſtile, projected and begun in the laſt reign, has been almoſt abandoned. It was to commence at Segovia, ſixteen leagues north of Madrid, to follow the courſe of the Ereſma, that falls into the Douro, and to be continued as far north as Reynoſa; which is twenty leagues from St Ander, a ſea port. At Reynoſa is the communication with the canal of Aragon, that unites the Mediterranean to the bay of Biſcay. Above Palencia, a branch goes weſtward through Rio-Seco and Benevento to Zamora; making the canal of Caſtile, in its whole extent 140 leagues; where it is completed, viz. between Reynoſa and Rio-Seco, its width at top is 56 feet, at bottom 20, and nine in depth.

In 1784, a canal was planned, which, from the foot of the mountains of Guadarama near the Eſcurial, ſhould proceed ſouthward to the Tagus; afterwards to the Guadiana, and terminate at the Guadalquivir above Andaxar. Some other attempts to improve the inland navigation of the country have been unſucceſsful.

General character of the Spaniards. 221

There is no nation in Europe which diſplays ſuch a variety of national character as Spain. In no two provinces are the manners and character exactly alike. It is therefore difficult to collect traits on which to found the national character of the Spaniards; and this character has been variouſly repreſented by different writers. From the tranſactions which have lately taken place between that people and the Britiſh nation, we confeſs ourſelves prejudiced againſt them; and we ſhall therefore, inſtead of ſketching their character according to our own preconceived notions, endeavour to delineate it as conciſely as poſſible from De Laborde, who is probably a ſufficiently competent judge.

The national pride, ſays this author, is every where the ſame. The Spaniard has the higheſt opinion of his nation and himſelf, and this he expreſſes with energy, in his geſtures, words, and actions. This opinion is diſcovered among all ranks in life, and all claſſes of ſociety. Its reſult is a kind of haughtineſs, ſometimes repulſive to him who is its object, but uſeful in giving to the mind a ſentiment of nobleneſs and ſelf-eſteem which fortifies it againſt all meanneſs.

In later times the Spaniards have not degenerated from the valour of their anceſtors. The Spaniſh ſoldier is ſtill one of the beſt in Europe, when placed under an experienced general, and brave and intelligent officers. He poſſeſſes a cool and ſteady valour; he long endures fatigue and hunger, and eaſily inures himſelf to labour.

The Spaniards are very reſerved, and rather wait for, than

Spain. than court the advances of a ftranger. Yet in fpite of their apparent gravity, they poffefs an inward gaiety, which frequently fhines out when proper occafions call it forth.

The Spaniard is very flow in all his operations; he often deliberates when he ought to act, and fpoils affairs as much by temporifing as the natives of other countries do by precipitation. This tardinefs would be but a flight defect, did it not proceed from a ferious radical want, from the invincible indolence and hatred of labour which prevails among all ranks of fociety.

That jealoufy which was formerly proverbial among the Spaniards, is now greatly diminifhed; hufbands are much lefs fufpicious, and women much more acceffible. Lattices have difappeared; duennas exift only in romances; veils are exchanged for mantelas; houfes are thrown open, and the women have recovered a liberty by which they are lefs tempted to go aftray than when their virtue was entrufted to locks and grates, and to the fuperintendance of guards often faithlefs and eafily corrupted.

In fine, the Spaniards are fober, difcreet, adroit, frank, patient in adverfity, flow in decifion, but wife in deliberation; ardent in enterprife, and conftant in purfuit. They are attached to their religion, faithful to their king, hofpitable, charitable, noble in their dealings, generous, liberal, magnificent; good friends, and full of honour. They are grave in carriage, ferious in difcourfe, gentle and agreeable in converfation, and enemies to falfehood and evil fpeaking.

222 Diverfities of character in the feveral provinces.

Such is the Spanifh character as drawn by De Laborde. Its varieties in the feveral provinces are thus ftated by the fame author. The Old Caftilians are filent, gloomy, and indolent, and are the moft feverely grave of all the Spaniards; but they poffefs a fteady prudence, an admirable conftancy under adverfity, an elevation of foul, and an unalterable probity and uprightnefs. The character of the natives of New Caftile is nearly the fame, but more open, and lefs grave and taciturn. Indocility and conceit make part of the character of the people of Navarre; they are diftinguifhed by lightnefs and adroitnefs. The Bifcayans are proud, impetuous, and irritable; abrupt in difcourfe and in action; haughty and independent, but induftrious, diligent, faithful, hofpitable, and fociable. The Gallicians are gloomy, and live very little in fociety; but they are bold, courageous, laborious, very fober, and diftinguifhed for their fidelity. The Afturians partake of the character of the Gallicians and Bifcayans; but they are lefs induftrious than the former, lefs civilized, lefs fociable, lefs amiable, and more haughty than the latter. The people of Eftremadura are proud, haughty, vain, ferious, indolent; but remarkably fober, honourable, and much attached to their own province, which they feldom quit. The Murcians are lazy, liftlefs, plotting, and fufpicious; attached neither to fciences, arts, commerce, navigation, nor a military life. The Valencians are light, inconftant, and indecifive; gay, fond of pleafure, little attached to each other, and ftill lefs to ftrangers, but affable, agreeable, and diligent. The Calatans are proud, haughty, violent in their paffions, rude in difcourfe and in action, turbulent, untractable, and paffionately fond of independence; they are not particularly liberal, but active, induftrious, and indefatigable; they are failors, hufbandmen, and builders, and refort to all corners of the world to feek their fortunes. They are brave, intrepid, fometimes rafh, obftinate in adhering to their fchemes, and often fuccefsful in vanquifhing, by their fteady perfeverance, obftacles which would appear infurmountable to others. Spain.

223 Manners and cuftoms.

The natives of almoft every province have fome diftinguifhing peculiarity in their drefs, manners, and purfuits. Before the acceffion of the houfe of Bourbon to the throne, the ufual drefs of a Spanifh nobleman confifted of a flouched hat, a long black or brown cloak, fhort jerkin, and ftrait breeches, with a long Toledo fword; but French dreffes are now introduced at court. The higher claffes wear their hats under their arm. The common people wrap themfelves up to the eyes in a brown cloak, called *aleapo*, that reaches to the ground; and conceal their hair beneath a cotton cap, and a broad hat called a *fombrero*. When a lady walks abroad, her head and upper part of her body are covered with a mantela; that is, a white or black veil, fo that it is impoffible fhe fhould be known. At home, the drefs is a jacket and a petticoat of filk or cotton. The hair is generally a fine black; and powder is rare.

In romance, the ladies are celebrated for beauty, and fome of them deferve that character; yet beauty is not their general character. They are of a flender make, but with great art they fupply the defects of nature. By an indifcriminate ufe of paint, they disfigure their complexion and fhrivel their fkin.

Several of the Spanifh cuftoms and habits, which feem ridiculous to foreigners, are gradually wearing out, and in procefs of time will no doubt be corrected. The higher claffes at breakfaft ufe chocolate, and feldom tea. Dinner generally confifts of beef, veal, pork, mutton, and beans, boiled together. They are fond of garlic; and it is proverbial that olives, falad, and radifhes, are food for gentlemen. The men drink little wine, and the women ufe water or chocolate. Both fexes fleep after dinner, and air themfelves in the cool of the evening. Their repafts are compofed of fweatmeats, bifcuit, coffee and fruit, which fervants diftribute to the company; who keep their feats, and have little converfation.

Dancing and cards are favourite amufements. Theatrical exhibitions are generally infipid or ridiculous bombaft, low wit, abfurdity, and buffoonery. The combats of the cavalleros and bull fights, are almoft peculiar to this country. On thefe occafions young gentlemen were ufed to fhow their courage to their miftreffes; and were honoured and rewarded according to their fuccefs. But thefe exhibitions were lately conducted with greater economy and parfimony; and mercenary champions ftudied in the moft fecure and graceful manner to deftroy the devoted animal. See BULL-Fighting.

The chief defect in all ranks is an averfion to labour and induftry. The higher orders beftow no attention on agriculture and commerce; they refide for the moft part at court and in the metropolis, reckoning it beneath their dignity to live in villas on their eftates among their tenants. In their eftimation, a labouring man quits the dignity of the Spanifh character, and renders himfelf an object of contempt. Hence a liftlefs indolence prevails. Thoufands wafte their time in total want of every incitement to action. Their intellectual powers lie dormant, and their views and exertions are confined within the narrow fphere of mere exiftence. The common people have no encouragement to induftry; and muft feel little concern

Spain. concern for the welfare of a country where a few overgrown families engroſs every thing valuable, and never think of the condition of their vaſſals. The indigent Spaniard does not beſtir himſelf unleſs impelled by want, becauſe he perceives no advantage to be derived from induſtry. A ſtranger to intemperance and exceſs, his ſcanty fare is eaſily procured; and under a climate ſo propitious, few clothes are required. The hovel which he occupies, together with all its contents, has a mean, filthy, deſpicable appearance; and all that relates to him bears the impreſſion of wretchedneſs and miſery *.

There are certain cuſtoms which may be regarded as peculiar to the Spaniards, or which at leaſt are ſcarcely found in any other European country. The number of ſervants retained in the families of the higher ranks is prodigious; and even a tradeſman's wife, in narrow circumſtances, will frequently have four maid ſervants, though ſhe cannot, with propriety, employ more than two. The houſes of gentlemen, and eſpecially of grandees, ſwarm with them; and, not unfrequently, all the principal ſervants will have their wives and children lodged with them, and ſupported by their maſter. We have heard of one nobleman who was at the daily expence of 120l. merely for the maintenance of his numerous retainers.

* *Playfair's Geography*, vol. i. p. 68.

The Spaniards are fond of meeting in the evening in parties, which are often very numerous. On theſe occaſions, the ladies as they arrive place themſelves in one room, and the gentlemen in another; or elſe the ladies range themſelves in a line along the ſide of the room, the lady of the houſe always taking the loweſt place next to the door, whilſt the men remain ſtanding, or ſeat themſelves on the oppoſite ſide. They remain ſeparated in this manner till the card parties are introduced. They play at loo, loto, and other games of a ſimilar kind. Thoſe who do not play, either look on, or embrace the opportunity of chatting with the perſon moſt intereſting to them. Others form little circles, where the converſation is uſually very animated. Theſe parties very much reſemble the French evening, and the Engliſh rout.

A *refreſco* ſometimes makes part of theſe entertainments, but only on particular occaſions, when the company is more than uſually numerous. But orgeat, lemonade, orangeade, ices of different kinds, ſweetmeats, and biſcuits, are diſtributed with uncommon profuſion; and chocolate ends the *funcion*, as all theſe entertainments are called.

Many precautions are taken in Spain againſt the heat. The rooms are watered ſeveral times a-day, and the windows are ſhaded on the outſide with awnings of cloth or ticking, or on the inſide by large and full curtains. In ſome places, as at Valencia, the glaſs is taken out of the windows at the approach of ſummer, and the doors of the apartments are all ſet open.

The beds in Spain are hard, being made of mattreſſes, laid on paillaſſes, reſting on a wooden bottom. The furniture of the houſes is uſually very ſimple, and the floors are covered with matting or printed cloth. The chairs have ruſh bottoms, and are uſually of different heights, thoſe for the ladies being one-third lower than thoſe for the gentlemen.

224 Amuſements.

Among the principal amuſements of the Spaniards muſt be reckoned muſic and dancing. Though the Spaniards have a taſte for muſic, they are by no means proficients in that accompliſhment. Their principal inſtrument is the guitar, which is in the hands of every body. Different provinces have alſo their peculiar inſtruments. Thus the Gallicians uſe a dull and heavy bagpipe; the Catalonians a large flageolet, and a little drum or tabor; and the Biſcayans a ſhort flute, with four holes. Caſtanettes are alſo extremely common, and are employed with great dexterity and addreſs in the national dances.

The Spaniards are paſſionately fond of dancing, and they have certain dances which are peculiar to Spain. Of theſe the fandango is the moſt celebrated, and appears to be the moſt ancient. It is a very extraordinary dance, in which the whole body is thrown into a regular and harmonious convulſion, expreſſive of the moſt laſcivious ideas.

The paſſion of the Spaniards for theſe dances is carried to a height which can ſcarcely be imagined. No ſooner are the guitar and the ſinging to which they are danced heard in a ball room or theatre, than a murmur of delight ariſes on all ſides; all faces become animated; the feet, hands, and eyes of all preſent are put in motion: it is impoſſible to deſcribe the effect produced. Mr Townſend, an Engliſh traveller, affirms, that if a perſon were to come ſuddenly into a church or a court of juſtice playing the *fandango*, or the *colero*, prieſts, judges, lawyers, criminals, audience, one and all, grave and gay, young or old, would quit their functions, forget all diſtinctions, and all ſet themſelves a dancing.

The Spaniſh balls are directed by two perſons choſen among the viſitors, who are called *baſteneras*, and with the hat under the arm, and the cane in the hand, perform the office of maſters of the ceremonies. One is for the gentlemen, the other for the ladies. It is their buſineſs to appoint who is to dance, whether minuets or country dances: they are in general very attentive to the obſervance of precedence and etiquette, and have uſually the complaiſance to contrive that thoſe ſhall dance together to whom it is peculiarly agreeable to meet.

A ſingular cuſtom is obſerved at theſe balls, which appears new and ſtrange to a foreigner. The lady choſen to dance riſes, croſſes the room alone, and places herſelf where ſhe is to begin dancing, without waiting for her partner to lead her out; and after the dance is over, her partner makes his bow to her again in the middle of the room without taking any further concern about her, or handing her back to her place. But this cuſtom prevails only in the provinces.

The bull-fights noticed above were once not only a favourite but a faſhionable ſpectacle in Spain. Every city, and almoſt every ſmall town, had a place ſet apart for theſe darling combats; and hither all ranks and ages reſorted with the greateſt avidity, and witneſſed the proweſs of the combatants, and the torture of the wretched animals, whom they were hired to butcher, with the moſt ſavage expreſſions of delight. Theſe fights made a part of every feſtival, and, as ſoon as they were announced, the houſewife left her family, the tradeſman forſook his ſhop, the artiſt his work-room, the labourer his field, and joy and expectation were painted on every countenance. To the honour of the nation, theſe cruel ſports are at length aboliſhed, and Spain has thus ſet an example of humanity, which Britain, with all her civilization and refinement, need not bluſh to copy.

New-SPAIN.

Spalatro || Spallanzani.

New-SPAIN. See MEXICO.

SPALATRO, or SPALATTO, a rich, populous, and ſtrong town of the republic of Venice, capital of Venetian Dalmatia, with a good harbour and an archbiſhop's ſee. Here are the ruins of the palace of Diocleſian, of which the late Mr Robert Adam publiſhed in 1764 a ſplendid account, enriched with 71 folio plates. In 1784, Spalatro was nearly depopulated by the plague. It is ſtrong by ſituation, being built on a peninſula, which is joined to terra firma by a neck of land half a mile over. It is ſeated on the gulf of Venice, 35 miles ſouth-eaſt of Sebenico, and 102 north-weſt of Raguſa. E. Long. 17. 31. N. Lat. 44. 4.

SPALLANZANI, LAZARUS, a celebrated naturaliſt, was born at Scandiano, in the duchy of Modena, in January 1729. He began his ſtudies in his native country, and went to Reggio de Modena at 15 years of age, to proſecute them further. He was inſtructed in the *belles lettres* by the Jeſuits, who contended with the Dominicans in order to ſecure his attachment; but his thirſt for knowledge determined him to go to Bologna, where his relative Laura Baſſi, a woman highly celebrated for her genius, eloquence, and ſkill in natural philoſophy and mathematics, was one of the moſt diſtinguiſhed profeſſors of the Inſtitute and of Italy. Under this enlightened guide, he was taught to prefer the ſtudy of nature to that of her commentators, judging of the real value of the commentary by its reſemblance to the original. He availed himſelf of the wiſdom of that lady's counſels, the happy effects of which he very ſoon experienced. Spallanzani's taſte for philoſophy was not excluſive, for he carefully ſtudied his own language, became a proficient in the Latin tongue, and attached himſelf above every other to the Greek and French. By the advice of a father whom he ardently loved, he applied himſelf to juriſprudence; but being urged by Anthony Valliſnieri to renounce his vocation, by procuring the conſent of his father, he gave himſelf up to the ſtudy of mathematics with more zeal than ever, at the ſame time devoting himſelf to the ſtudy of languages, both living and dead.

It was not long before he was known all over Italy, and what is ſeldom the caſe, his own country firſt put that value on his talents which they juſtly merited. He was choſen profeſſor of logic, metaphyſics and Greek, in the univerſity of Reggio, in the year 1745, where he taught during ten years, devoting every moment of his leiſure time to the ſtudy and contemplation of the works of nature. The attention of Haller and Bonnet was fixed by his obſervations on the animalculæ of infuſions, the latter aſſiſting him in his laudable career, and ever after diſtinguiſhed him as one of the learned interpreters of nature.

Spallanzani was invited to the univerſity of Modena in the year 1760, and ſome years after he declined to accept of the offers made to him by the academy of Peterſburg, as well as ſimilar ones from Coimbra, Parma, and Ceſena, though extremely advantageous. He preferred his native ſpot, and therefore continued at Modena till the year 1768, and ſaw raiſed up by his care a generation of men conſtituting at that time the glory of Italy, among whom we find Venturi, Belloni, Lucchefini, and Angelo Mazzo.

While Spallanzani remained at Modena, he publiſhed his *Saggio di Oſſervazioni Microſcopiche concernente il Syſtema di Needham e Buffon*, in 1765, in which he eſtabliſhes, by a number of the moſt ingenious and ſolid experiments, the *animality of microſcopic animalculæ*. This work was ſent by the author to Bonnet, who drew from it a prediction reſpecting the future celebrity of Spallanzani, which he lived to ſee accompliſhed. This circumſtance gave birth to the moſt intimate friendſhip, which laſted to the cloſe of life, and conſtituted their chief happineſs. During the ſame year he publiſhed a truly original work, entitled *De Lapidibus ab aqua reſilientibus*, in which he proves, in oppoſition to the commonly received opinion, by the moſt ſatisfactory experiments, that what are called *ducks* and *drakes*, are not produced by the elaſticity of the water, but by the effect naturally reſulting from the change of direction experienced by the ſtone in its movement, after it has ſtruck the water, and that it has been carried over the hollow of the cup formed by the concuſſion.

When the univerſity of Padua was re-eſtabliſhed upon a larger ſcale, the Count de Firmian was directed by the empreſs Maria Thereſa, to invite Spallanzani to be profeſſor of natural hiſtory, to which his great reputation made him competent, although it was ſolicited by many celebrated characters; and he merited it by his ſucceſs, as immenſe crowds of ſtudents thronged to his lectures. He had a fine genius, and his knowledge was of vaſt extent; his method was ſimple, but rigorous in its nature, and what he knew he connected with principles firmly eſtabliſhed. He acquired the valuable art of interpreting nature by herſelf, which diffuſed ſuch a light over his lectures, that every thing became perſpicuous, which could be ſaid to afford any inſtruction. His diſcourſes were plain and animated, and the elegance and purity of his ſtyle charmed every hearer. He prepared his lectures a year before hand, and it was his chief aim to render them uſeful in an eminent degree. His new obſervations made them always new and engaging. Many learned perſons who attended his lectures were not above becoming his ſcholars, in order to acquire a more extenſive knowledge of what they knew before, and to learn that which otherwiſe they might probably never have known. The *Contemplation de la Nature* of Bonnet was his text book, the vacancies of which he ably filled up, fully explained the ideas, and eſtabliſhed the theories by his own experiments. This work was tranſlated by him into the Italian language, and he added much to its value by notes of his own, the firſt volume of which he publiſhed in 1769, and the ſecond the following year.

His connection with Bonnet tended, in a great meaſure, to influence his genius, which yielded to the ſevere method of inveſtigation adopted by the philoſopher of Geneva. He was proud of being the pupil of ſuch an illuſtrious character, upon whoſe writings he inceſſantly beſtowed every leiſure moment, and thus became anxious to learn from Nature herſelf the proofs of Bonnet's ſentiments reſpecting the generation of organized bodies, the pleaſing nature of which reſearch captivated his attention for a conſiderable time.

The firſt two volumes of this work entitled *Opuſculi di Fiſica Animale e Vegetabile*, were publiſhed in the year 1776, containing the explanation of part of the microſcopic obſervations which were previouſly given to the world.

If it muſt be admitted that the art of accurate obſervation

Spallanzani.

tion is by far the most difficult, it cannot be denied that it is at the same time the most necessary, and requires the most brilliant talents and abilities, which were possessed by Spallanzani in a remarkable degree, as is fully evinced by all his researches and all his admirable writings.

The polite manner in which he conducted his dispute with Needham respecting the phenomena of generation, secured for him a high degree of applause. On this occasion he treated of the influence of cold upon animals, and proved that the torpidity of some during winter, does not depend on the impression the blood may receive from it, since a frog deprived of blood, becomes torpid when reduced to the same cold state by being immersed in ice, and swims as formerly when restored to a proper degree of warmth.

Spallanzani travelled through Switzerland and the Grisons in the year 1779, after which he went to Geneva, spending a month with his friends, by whom his conversation was as much admired as his masterly writings. From this place he returned to Pavia, and in 1780 published two more volumes of his *Differtazione di Fisica Animale e Vegetabile*, wherein he unfolded the secrets of the interpretation of two very intricate phenomena, concerning the economy of animals and vegetables. He was led to this study from some experiments made by him upon *digestion*, for his lectures; and he repeated the experiments of Reaumur on gallinaceous birds, remarking that the trituration which in this case is favourable to digestion, could not be a very powerful means. He perceived that the gizzard of those birds, by which the stones of fruit are pulverized, did not digest the powder thus formed, it being necessary that it should undergo a new operation in the stomach, previous to its becoming chyle for the production of the blood and other humours.

This subject may be regarded as one of the most difficult in physiology, because the observer is always under the necessity of acting and looking in the midst of darkness; the animal must be managed with care, that the derangement of the operations may be avoided; and when the experiments are completed with great labour, it is requisite that the consequences be well distinguished. Spallanzani in this work is truly enchanting, analysing facts with scrupulosity, in order to ascertain their causes with certainty; comparing Nature with his experiments, in order to form a correct judgement respecting them; laying hold of every thing essential to them in his observations, and measuring their solidity by the increase or diminution of supposed causes.

Mr John Hunter appears to have been greatly hurt by this work, which led him to publish, in the year 1785, *Some Observations upon Digestion*, in which he threw out some bitter sarcasms against the Italian naturalist, who took ample revenge by publishing this work in the Italian language, and addressing to Caldani in 1788, *Una Lettera Apologetica in Risposta alle Osservazione del Signor Giovanni Hunter*. In this he exposed with great moderation, but at the same time with logic which nothing could resist, the mistakes and errors of the British physiologist, leaving the power of a reply altogether hopeless.

The generation of animals and plants is treated of in the second volume of this last-mentioned work, in which he proves the pre-existence of germs to fecundation, by experiments as satisfactory as surprising; shewing also the existence of tadpoles in the females of five different species of frogs, in salamanders, and toads, before their fecundation. He likewise recounts the success of some artificial fecundations upon the tadpoles of those five species, and even upon a quadruped.

In the year 1781, he took the advantage of the academical vacation, for the purpose of making a journey, in order to add to the cabinet of Pavia. He set out for Marseilles in the month of July that year, where he began a new history of the sea, which presented him with many new and curious facts on numerous genera of the natives of the ocean. He went also to Finale, Genoa, Massa, and Carrara, to make observations on the quarries of marble, held by statuaries in such estimation. He then returned to Spezzia, and brought from thence to Pavia a vast number of fishes, which he deposited in the cabinet of that city, wholly collected by himself. With the same view and success he visited the coasts of Istria in 1782, and the Apennine mountains the subsequent year, taking notice of the dreadful hurricanes, and the astonishing vapours by which that year became so noted in meteorology. The emperor Joseph, on examining this cabinet presented Spallanzani with a gold medal. In 1785, he was offered the chair of natural history by the university of Padua, vacant by the death of Anthony Vallisnieri; but in order to prevent his acceptance of it, his salary was doubled by the archduke, and he went to Constantinople with Chevalier Zuliani, who had been appointed ambassador from the Venetian republic. He set out on the 21st of August, and reached the Turkish metropolis on the 11th of October, where he remained during eleven months. His attention was fixed by the physical and moral phenomena of this country, which were new even to Spallanzani. He strayed along the borders of the two seas, and ascended the mountains in the vicinity; he paid a visit to the island of Chalki, discovering to the Turks a copper mine, the existence of which they had never once conjectured. He discovered an iron mine not far from Constantinople, in the island of Principi, of which the Turks were equally ignorant, and prepared to return for Italy on the 16th of August 1786.

A voyage by sea was undoubtedly the safest, but the dangers to which he would be exposed by land were regarded as nothing when contrasted with the idea of being beneficial to science and to man. Having reached Bucharest, Mauroceni the friend of science, received Spallanzani with marks of distinction, presented him with many rarities which the country produced, and gave him horses for travelling, with an escort of 30 troopers, to the utmost confines of his own dominions. Our philosopher passed by Hermanstadt in Transylvania, and reached Vienna on the 7th of December, where he remained during five days, and had two long conferences with the emperor Joseph II. was much esteemed by the nobility of that city, and respectfully visited by many literary characters. When he arrived at Pavia, the students went out of the city gates to meet him, and testified their joy at his return by repeated acclamations. He was almost instantly drawn to the auditory, and compelled to ascend the chair from which he had been accustomed to deliver his fascinating lectures; but their demonstrations of joy and shouts of applause made him request of them to give over, and indulge him with that

that repose in his own house which was now so absolutely necessary. His students this year exceeded 500.

So extensive was the fame of Spallanzani become by this time, that envy was determined, if possible, to wound his reputation. If his discoveries were too new, solid, and original, to be successfully disputed, that vile passion, or rather *fiend*, began to question his integrity and uprightness respecting the administration of the cabinet of Pavia; but this iniquitous attempt to tarnish his honour, only made it shine forth with redoubled splendour. The juridical examination of the tribunals made his integrity appear even purer than before; and it must be mentioned to his honour, that he had the fortitude to forget this event; his enemies in general confessed their mistake, renounced their unprovoked animosity, and still hoped to regain a friendship of which they had proved themselves so unworthy.

In the voyage of Spallanzani we meet with what may be denominated a new volcanology. We are there instructed how to measure the intensity of volcanic fires, and in his analysis of the lava, almost to touch the particular gas which tears those torrents of stone in fusion from the bowels of the earth, and raises them to the top of Mount Etna. This delightful work is closed by some important enquiries into the nature of Swallows, the mildness of their dispositions, the rapidity of their flight, discussing the celebrated problem respecting their remaining torpid during the winter season, proving that artificial cold, much more intense than what is ever naturally experienced in our climates, does not reduce these birds to the torpid state.

Things apparently impossible were often discovered by Spallanzani. In the year 1795 he made one of this description, which he gave to the world in his *Lettere sopra il sopetto d'un nuovo senso nei Pippistrelli*. In that work we are informed that bats, if deprived of sight, act with the same precision in every instance as those which have their eyes; that they shun in the same manner the most trivial obstacles, and also know where to fix themselves when their flight is terminated. Several philosophers confirmed these astonishing experiments, from which a suspicion arose, that these animals must have a new sense, as it appeared to Spallanzani that the other known senses could not compensate for the want of sight; but he was afterwards inclined to think, in consequence of Professor Jurine's experiments on the organ of hearing in bats, that in this particular instance the sense of hearing might possibly supply the want of sight.

The literary career of this celebrated naturalist was terminated by a letter to Giobert, entitled *Sopra la piante chiuse ne vasi dentro l'aqua e l'aria, esposte a l'immediata lume solare e a l'ombra*. These numerous works, which met with the highest approbation, do not comprehend the whole of his multifarious labours; for the phenomena of respiration had occupied his attention a considerable time; their points of resemblance and dissimilitude in many species of animals; and he had nearly finished his voyage to Constantinople, as well as collected many valuable materials for a history of the sea, when his life and labours were unfortunately terminated.

He was seized with a retention of urine on the 4th of February 1799, and next morning was deprived of the regular use of his faculties, only enjoying a sound mind during very short intervals. Tourdes and Professor Scarpa did every thing to save him, which could be produced by the joint exertions of genius, experience, and friendship, but in vain. He died on the 17th; but we know not what credit is due to the assertion, that he edified those around him during his last moments by his *piety*. Be that as it may, while his works exist to speak for themselves, impartial posterity will regard him as a very extraordinary man. These works have been translated into almost every European language, and he was admitted a member of the academies and learned societies of London, Stockholm, Gottingen, Holland, Lyons, Bologna, Turin, Padua, Mantua, and Geneva, and he received from Frederick the Great the diploma of member of the academy of Berlin.

SPAN, a measure taken from the space between the thumb and the tip of the little finger when both are stretched out. The span is estimated at three hand's-breadths or nine inches.

SPANDRELL, the solid work on each haunch of an arch, to keep it from spreading.

SPANHEIM, Ezekiel, a learned writer in the 17th century, was born at Geneva in 1629; and in 1642 went to Leyden to study. Here he distinguished himself to great advantage; and his reputation spreading, Charles Louis elector palatine sent for him to be tutor to his only son. This task our author discharged to the entire satisfaction of the elector; by whom he was also employed in divers negotiations at foreign courts. He afterwards entered into the service of the elector of Brandenburg, who in 1680 sent him envoy extraordinary to the court of France, and soon after made him a minister of state. After the peace of Ryswic, he was again sent on an embassy to France where he continued from the year 1697 to 1702. The elector of Brandenburg having during that interval assumed the title of *King of Prussia*, conferred on him the title and dignity of a baron. In 1702 he left France; and went ambassador to England, where he had been several times. Here he died in 1710, aged 81 years. It is surprising, that in discharging the duties of a public minister with so much exactness, and amidst so many different journeys, he could find time enough to write the several books published by him. It may be said of him, that he acquitted himself in his negotiations like a person who had nothing else in his thoughts; and that he wrote like a man who had spent his whole time in his study. The principal of his works are, 1. *De præstantia et usu numismatum antiquorum;* the best edition of which is in two volumes folio. 2. Several letters or dissertations on scarce and curious medals. 3. A preface and notes to the edition of the emperor Julian's works, printed at Leipsic in 1696, folio.

SPANIEL, in *Zoology*. See Canis, Mammalia, *Index*.

SPAR, in *Mineralogy*, a name given chiefly to some of the crystallized combinations of lime, as the carbonate and the fluate; the former being called simply *lime spar*, the latter fluor spar, or Derbyshire spar, from the name of the place where it is found in greatest abundance. See Mineralogy.

SPARGANIUM, Bur-reed, a genus of plants belonging to the class of monœcia, and to the order of triandria; and in the natural system ranged under the 3d order, *Calamariæ*. See Botany *Index*.

SPARLING, or SPIRLING, a small fish belonging to the genus *Salmo*. See ICHTHYOLOGY, p. 99.

SPARMANNIA, a genus of plants belonging to the class of polyandria, and to the order of monogynia. See BOTANY *Index*.

SPARROW. See FRINGILLA, ORNITHOLOGY *Index*.

SPARROW-Hawk. See FALCO, ORNITHOLOGY *Index*.

SPARROW-Grass. See ASPARAGUS, BOTANY and GARDENING *Index*.

SPARRY-ACID. See *FLUORIC-Acid*, CHEMISTRY *Index*.

SPARTA, or LACEDÆMON, the capital of the country of Laconia in Greece, an ancient and most renowned state, the inhabitants of which have been in all ages celebrated for the singularity of their laws and character.—The history of Sparta for many ages is entirely fabulous; and the authentic accounts commence only with the celebrated lawgiver Lycurgus, who flourished about 870 B. C. See the article LYCURGUS.

1 The history of Sparta mostly fabulous till the time of Lycurgus.

After his death, the first important transaction which we find mentioned in the Spartan history is the Messenian war, which commenced in the year 752 B. C. and ended in the total reduction of the Messenian territory, as related under the article MESSENIA. During this period, according to some authors, a great change took place in the government of Sparta. This was the creation of the ephori, which is ascribed to one of the kings named *Theopompus*. This man perceiving that there was a necessity for leaving magistrates to execute the laws, when the kings were obliged to be in the field, appointed the magistrates above mentioned, who afterwards made so great a figure in the state (see EPHORI). One great privilege of the ephori was, that they did not rise up at the presence of the kings, as all other magistrates did: another was, that if the kings offended against the laws, the ephori took cognizance of the offence, and inflicted a suitable punishment. From the first election of the ephori, the year was denominated, as at Athens, from the first election of the archons.

The conquest of Messenia gave Sparta the superiority over the rest of the states, excepting only that of Athens, which for a long time continued to be a very troublesome rival: but the contests between these two rival states have been so fully related under the article ATTICA, that nothing more is requisite to be added in this place.—In the time of the Persian war, Leonidas the Spartan king, distinguished himself in such a manner, as to become the admiration not only of that but of every succeding age. It being resolved in a general council to defend the straits of Thermopylæ against the Persians, 7000* foot were put under the command of Leonidas; of whom, however, only 300 were Spartans. Leonidas did not think it practicable to defend the pass against such multitudes as the Persian king commanded; and therefore privately told his friends, that his design was to devote himself to death for his country.

2 Leonidas undertakes to defend the straits of Thermopylæ against the Persians.

* See *Anacharsis's Travels*, vol. i. p. 468.

Xerxes advancing near the straits, was strangely surprised to find that the Greeks were resolved to dispute his passage; for he had always flattered himself, that on his approach they would betake themselves to flight, and not attempt to oppose his innumerable forces. However, Xerxes still entertaining some hopes of their flight, waited four days without undertaking any thing, on purpose to give them time to retreat. During this time, he used his utmost endeavours to gain and corrupt Leonidas, promising to make him master of all Greece if he would come over to his interest. His offers being rejected with contempt and indignation, the king ordered him by a herald to deliver up his arms. Leonidas, in a style and with a spirit truly laconical, answered, "Come thyself, and take them." Xerxes, at this reply, transported with rage, commanded the Medes and Cissians to march against them, take them all alive, and bring them to him in fetters. The Medes, not able to stand the shock of the Greeks, soon betook themselves to flight: and in their room Hydarnes was ordered to advance with that body which was called *Immortal*, and consisted of 10,000 chosen men; but when these came to close with the Greeks, they succeeded no better than the Medes and Cissians, being obliged to retire with great slaughter. The next day the Persians, reflecting on the small number of their enemies, and supposing so many of them to be wounded that they could not possibly maintain a second fight, resolved to make another attempt; but could not by any efforts make the Greeks give way: on the contrary, they were themselves put to a shameful flight. The valour of the Greeks exerted itself on this occasion in a manner so extraordinary, that Xerxes is said to have three times leaped from his throne, apprehending the entire destruction of his army.

3 The Persians repulsed with great slaughter.

Xerxes having lost all hopes of forcing his way through troops that were determined to conquer or die, was extremely perplexed and doubtful what measures he should take in this posture of affairs; when one Epialtes, in expectation of a great reward, came to him, and discovered a secret passage to the top of the hill which overlooked and commanded the Spartan forces. The king immediately ordered Hydarnes thither with his select body of 10,000 Persians; who marching all night, arrived at break of day, and possessed themselves of that advantageous post. The Phocæans, who defended this pass, being overpowered by the enemy's numbers, retired with precipitation to the very top of the mountain, prepared to die gallantly. But Hydarnes neglecting to pursue them, marched down the mountain with all possible expedition, in order to attack those who defended the straits in the rear. Leonidas being now apprised that it was impossible to bear up against the enemy, obliged the rest of his allies to retire: but he staid himself, with the Thespians, Thebans, and 300 Lacedemonians, all resolved to die with their leader; who being told by the oracle, that either Sparta should be destroyed or the king lose his life, determined without the least hesitation to sacrifice himself for his country. The Thebans indeed remained against their inclination, being detained by Leonidas as hostages; for they were suspected to favour the Persians. The Thespians, with their leader Demophilus, could not by any means be prevailed upon to abandon Leonidas and the Spartans. The augur Megistias, who had foretold the event of this enterprise, being pressed by Leonidas to retire, sent home his only son; but remained himself, and died by Leonidas. Those who staid did not feed themselves with any hopes of conquering or escaping, but looked upon Thermopylæ as their graves; and when Leonidas, exhorting them to take some nourishment, said, that they should

4 They are shown a way over the hill to surround the Greeks.

Sparta.

should all sup together with Pluto, with one accord they set up a shout of joy, as if they had been invited to a banquet.

5
Leonidas killed with all his men.

Xerxes, after pouring out a libation at the rising of the sun, began to move with the whole body of his army, as he had been advised by Epialtes. Upon their approach, Leonidas advanced to the broadest part of the passage, and fell upon the enemy with such undaunted courage and resolution, that the Persian officers were obliged to stand behind the divisions they commanded, in order to prevent the flight of their men. Great numbers of the enemy falling into the sea, were drowned; others were trampled under foot by their own men, and a great many killed by the Greeks; who knowing they could not avoid death upon the arrival of those who were advancing to fall upon their rear, exerted their utmost efforts. In this action fell the brave Leonidas; which Abrocomes and Hyperanthes, two of the brothers of Xerxes, observing, advanced with great resolution to seize his body, and carry it in triumph to Xerxes. But the Lacedemonians, more eager to defend it than their own lives, repulsed the enemy four times, killed both the brothers of Xerxes, with many other commanders of distinction, and rescued the body of their beloved general out of the enemy's hands. But in the mean time, the army that was led by the treacherous Epialtes, advancing to attack their rear, they retired to the narrowest place of the passage, and drawing all together except the Thebans, posted themselves on a rising ground. In this place they made head against the Persians, who poured in upon them on all sides, till at length, not vanquished, but oppressed and overwhelmed by numbers, they all fell, except one who escaped to Sparta, where he was treated as a coward and traitor to his country; but afterwards made a glorious reparation in the battle of Platæa, where he distinguished himself in an extraordinary manner. Some time after, a magnificent monument was erected at Thermopylæ, in honour of those brave defenders of Greece, with two inscriptions; the one general, and relating to all those who died on this occasion, importing, that the Greeks of Peloponnesus, to the number only of 4000, made head against the Persian army, consisting of 3,000,000. The other related to the Spartans in particular, and was composed by the poet Simonides, to this purport: "Go, passenger, and acquaint the Spartans that we died here in obedience to their just commands." At those tombs a funeral oration was yearly pronounced in honour of the dead heroes, and public games performed with great solemnity, wherein none but the Lacedemonians and Thespians had any share, to show that they alone were concerned in the glorious defence of Thermopylæ.

6
A dreadful earthquake in Sparta.

At the end of the 77th Olympiad, a most dreadful earthquake happened at Sparta, in which, according to Diodorus, 20,000 persons lost their lives; and Plutarch tells us, that only five houses were left standing in the whole city. On this occasion the Helotes or slaves, whom the Spartans had all along treated with the utmost cruelty, attempted to revenge themselves, by taking up arms, and marching directly to the ruins of the city, in hopes of cutting off at once those who had escaped from the earthquake. But in this they were prevented by the prudence of the Spartan king Archidamus; for he, observing that the citizens were more desirous of preserving their effects than taking care of their own lives, caused an alarm to be sounded, as if he had known that an enemy was at hand. On this the citizens armed themselves in haste with such weapons as they could come at; and having marched a little way from the city, met the Helotes, whom they soon compelled to retire. The latter, however, knowing that they had now no mercy to expect from those who had alreaty treated them with such cruelty, resolved to defend themselves to the last. Having therefore seized a sea-port town in Messenia, they from thence made such incursions into the Spartan territories, that they compelled those imperious masters to ask assistance from the Athenians. This was immediately granted; but when the Spartans saw that the skill of the Athenians in besieging towns was much greater than their own, they became jealous, and dismissed their allies, telling them, that they had now no farther occasion for their services. On this the Athenians left them in disgust; and as the Helotes and Messenians did not choose to come to an engagement with a Spartan army in the field, but took shelter in their fortified places, the war was protracted for ten years and upwards. At last the Helotes were reduced to their former misery; and the Messenians were obliged to leave Peloponnesus, on pain of being made slaves also. These poor people were then received by the Athenians, who granted them Naupactus for their residence, and afterwards brought them back to a part of their own country, from whence in the course of the Peloponnesian war they had driven the Spartans.

7
War with the Helotes.

8
With the Athenians and Persians.

In the year 431 B. C. the Peloponnesian war commenced; of which a full account has been given under the article ATTICA, N° 116—165. It ended most unfortunately for the Athenians; their city being taken and dismantled, as related in the article above mentioned. Thus were the Spartans raised to the highest pitch of glory; and, in the reign of Agesilaus, they seemed to be on the point of subverting the Persian empire, as related under the article PERSIA, N° 34. But here their good fortune and their views of empire were suddenly checked. Agesilaus had carried on the war in Asia with the greatest success; and as he would hearken to no terms of accommodation, a Persian governor named *Tithraustes*, having first attempted in vain to bribe the king, dispatched Timocrates the Rhodian with 50 talents into Greece, in order to try whether he could there meet with any persons less incorruptible than the Spartan monarch. This agent found many who inclined to accept his offers; particularly in Thebes, Corinth, and Argos. By distributing the money in a proper manner, he inflamed the inhabitants of these three cities against the Spartans; and of all others the Thebans came into his terms with the greatest readiness. They saw that their antagonists would not of their own accord break with any of the states of Greece, and did not choose to begin the war themselves, because the chiefs of the Persian faction were unwilling to be accountable for the event. For this reason they persuaded the Locrians to invade a small district which lay in dispute betwixt the Phocians and themselves. On this the Phocians invaded Locris; the Locrians applied to the Thebans, and the Phocians to the Spartans. The latter were glad of an opportunity of breaking with the Thebans; but met with a much warmer reception than they expected. Their old general Lysander, who had reduced

9
A general combination against Sparta.

Sparta. reduced Athens, was defeated and killed, with the loss of 1000 men: on which disaster Agesilaus was recalled, and obliged to relinquish all hopes of conquering the Persians. His return changed the fortune of the war so much, that all the states began to grow weary of a
10 contest from which nobody derived any advantage except the king of Persia. In a short time a treaty was concluded, known in history by the name of the *peace of Antalcidas*. The terms of this treaty were highly disadvantageous and dishonourable to the Greeks *; for even the Spartans, though successful in Greece, had lost a great battle at sea with the Persian fleet under Conon the Athenian, which entirely broke their power in Asia.

Peace of Antalcidas.

* See *Persia*, n° 37.

By the peace of Antalcidas, the government of Bœotia was taken from the Thebans, which they had for a long time enjoyed; and by this they were so much provoked, that at first they absolutely refused to accede to the treaty; but as Agesilaus made great preparations
11 to invade them, they thought proper at last to comply. However, it was not long before a new war commenced, which threatened the total subversion of the Spartan state. As, by the peace of Antalcidas, the king of Persia had in a manner guaranteed the sovereignty of Greece to Sparta, this republic very soon began to exercise its power to the utmost extent. The Mantineans were the first who felt the weight of their resentment, although they had been their allies and confederates. In order to have a pretence for making war against them, they commanded them to quit their city, and to retire into five old villages which, they said, had served their forefathers, and where they would live in peace themselves, and give no umbrage to their neighbours. This being refused, an army was sent against them to besiege their city. The siege was continued through the summer with very little success on the part of the Spartans; but having during the winter season dammed up the river on which the city stood, the water rose to such a height, as either to overflow or throw down the houses; which compelled the Mantineans to submit to the terms prescribed to them, and to retire into the old villages. The Spartan vengeance fell next on the Phliasians and Olynthians, whom they forced to come into such measures as they thought proper. After this they fell on the Thebans, and, by attempting to seize on the Piræum, drew the Athenians also into the quarrel. But here their career was stopped: the Thebans had been taught the art of war by Chabrias the Athenian; so that even Agesilaus himself took the command
12 of the Spartan army in vain. At sea they were defeated by Timotheus the son of Conon; and by land the battle of Leuctra put an end to the superiority which Sparta had held over Greece for near 500 years. See LEUCTRA.

Hostilities recommenced.

The power of Sparta entirely broken.

After this dreadful defeat, the Spartans had occasion to exert all their courage and resolution. The women and nearest relations of those who were killed in battle, instead of spending their time in lamentations, shook each other by the hand, while the relations of those who had escaped from the battle hid themselves among the women; or if they were obliged to go abroad, they appeared in tattered clothes, with their arms folded, and their eyes fixed on the ground. It was a law among the Spartans, that such as fled from battle should be degraded from their honours, should be constrained to appear in garments patched with divers colours, to wear their beards half-shaved, and to suffer any to beat them who pleased, without resistance. At present, however, this law was dispensed with; and Agesilaus by his prudent conduct kept up the spirits of the people, at the same time that by his skill in military affairs he checked the progress of the enemy. Yet, during the lifetime of Epaminondas the Theban general, the war went on greatly to the disadvantage of the Spartans; but he being killed at the battle of Mantinea, all parties became quickly desirous of peace. Agesilaus did not long survive; and with him, we may say, perished the glory of Sparta. Soon after this all the states of Greece fell under the power of Alexander the Great; and the Spartans, as well as the rest, having become corrupt, and lost their martial spirit, became a prey to domestic tyrants, and to foreign invaders. They maintained their ground, however, with great resolution against the celebrated Pyrrhus king of Epirus; whom they repulsed for three days successively, though not without assistance from one of the captains of Antigonus. Soon after this, one of the kings of Sparta named *Agis*, perceiving the universal degeneracy that had taken place, made an attempt to restore the laws and discipline of Lycurgus, by which he supposed the state would be restored to its former glory. But though at first he met with some appearance of success, he was in a short time tried and condemned by the ephori as a traitor to his country. Cleomenes, however, who ascended the throne in 216 B. C. accomplished the reformation which Agis had attempted in vain. He suppressed the ephori; cancelled all debts; divided the lands equally, as they had been in the time of Lycurgus; and put an end to the luxury which prevailed among the citizens. But at last he was overborne by the number of enemies which surrounded him; and being defeated in battle by Antigonus, he fled to Egypt, where he put an end to his own life. With him perished every hope of retrieving the affairs of Sparta: the city for the present fell into the hands of Antigonus; after which a succession of tyrants took place; till at last all disturbances were ended by the Romans, who reduced MACEDON and GREECE to provinces of their empire, as has been related under these articles.

13 Agis and Cleomenes attempt in vain to restore it.

It remains now only to say something concerning the character, manners, and customs of the Spartans, which, as they were founded on the laws of Lycurgus, may best be learned from a view of these laws.

14 Institutions of Lycurgus.

The institutions of Lycurgus were divided into 12 tables. The first comprehended such of the Spartan laws as regarded religion. The statues of all the gods and goddesses were represented in armour, even to Venus herself; the reason of which was, that the people might conceive a military life the most noble and honourable, and not attribute, as other nations did, sloth and luxury to the gods. As to sacrifices, they consisted of things of very small value; for which Lycurgus himself gave this reason, That want might never hinder them from worshipping the gods. They were forbidden to make long or rash prayers to the heavenly powers, and were injoined to ask no more than that they might live honestly and discharge their duty. Graves were permitted to be made within the bounds of the city, contrary to the custom of most of the Greek nations; nay, they buried close by their temples, that all degrees of

15 His laws concerning religion.

of people might be made familiar with death, and not conceive it ſuch a dreadful thing as it was generally eſteemed elſewhere: on the ſame account, the touching dead bodies, or aſſiſting at funerals, made none unclean, but were held to be as innocent and honourable duties as any other. There was nothing thrown into the grave with the dead body; magnificent ſepulchres were forbidden; neither was there ſo much as an inſcription, however plain or modeſt, permitted. Tears, ſighs, outcries, were not allowed in public, becauſe they were thought diſhonourable in Spartans, whom their lawgiver would have to bear all things with equanimity. Mourning was limited to 11 days; on the 12th the mourner ſacrificed to Ceres, and threw aſide his weeds. In favour of ſuch as were ſlain in the wars, however, and of women who devoted themſelves to a religious life, there was an exception allowed as to the rules before mentioned; for ſuch had a ſhort and decent inſcription on their tombs. When a number of Spartans fell in battle, at a diſtance from their country, many of them were buried together under one common tomb; but if they fell on the frontiers of their own ſtate, then their bodies were carefully carried back to Sparta, and interred in their family ſepulchres.

16 Concerning the diviſion of land.

II. Lycurgus divided all the country of Laconia into 30,000 equal ſhares: the city of Sparta he divided into 9000, as ſome ſay; into 6000, as others ſay; and as a third party will have it, into 4500. The intent of the legiſlator was, that property ſhould be equally divided among his citizens, ſo that none might be powerful enough to oppreſs his fellows, or any be in ſuch neceſſity, as to be therefrom in danger of corruption. With the ſame view he forbade the buying or ſelling theſe poſſeſſions. If a ſtranger acquired a right to any of theſe ſhares, he might quietly enjoy it, provided he ſubmitted to the laws of the republic. The city of Sparta was unwalled; Lycurgus truſting it rather to the virtue of its citizens than to the art of maſons. As to the houſes, they were very plain; for their ceilings could only be wrought by the axe, and their gates and doors only by the ſaw; and their utenſils were to be of a like ſtamp, that luxury might have no inſtruments among them.

17 Of the citizens, children, &c.

III. The citizens were to be neither more nor leſs than the number of city lots; and if at any time there happened to be more, they were to be led out in colonies. As to children, their laws were equally harſh and unreaſonable; for a father was directed to carry his new-born infant to a certain place, where the graveſt men of his tribe looked upon the infant; and if they perceived its limbs ſtraight, and thought it had a wholeſome look, they then returned it to its parents to be educated; otherwiſe it was thrown into a deep cavern at the foot of the mountain Taygetus. This law ſeems to have had one very good effect, viz. making women very careful, when they were with child, of either eating, drinking, or exerciſing, to exceſs: it made them alſo excellent nurſes; for which they were in mighty requeſt throughout Greece. Strangers were not allowed to reſide long in the city, that they might not corrupt the Spartans by teaching them new cuſtoms. Citizens were alſo forbidden to travel, for the ſame reaſon, unleſs the good of the ſtate required it. Such as were not bred up in their youth according to the law, were not allowed the liberty of the city, becauſe they held it unreaſonable, that one who had not ſubmitted to the laws in his youth ſhould receive the benefit of them when a man. They never preferred any ſtranger to a public office; but if at any time they had occaſion for a perſon not born a Spartan, they firſt made him a citizen, and then preferred him.

18 Of celibacy and marriage.

IV. Celibacy in men was infamous, and puniſhed in a moſt extraordinary manner; for the old bachelor was conſtrained to walk naked, in the depth of winter, through the market-place: while he did this, he was obliged to ſing a ſong in diſparagement of himſelf; and he had none of the honours paid him which otherwiſe belonged to old age, it being held unreaſonable, that the youth ſhould venerate him who was reſolved to leave none of his progeny behind him, to revere them when they grew old in their turn. The time of marriage was alſo fixed; and if a man did not marry when he was of full age, he was liable to an action; as were ſuch alſo as married above or below themſelves. Such as had three children had great immunities; ſuch as had four were free from all taxes whatſoever. Virgins were married without portions; becauſe neither want ſhould hinder a man, nor riches induce him, to marry contrary to his inclinations. When a marriage was agreed on, the huſband committed a kind of rape upon his bride. Huſbands went for a long time, ſecretly and by ſtealth, to the beds of their wives, that their love might not be quickly and eaſily extinguiſhed. Huſbands were allowed to lend their wives; but the kings were forbidden to take this liberty. Some other laws of the like nature there were, which as they were evidently againſt modeſty, ſo they were far from producing the end for which Lycurgus deſigned them; ſince, though the men of Sparta were generally remarkable for their virtue, the Spartan women were as generally decried for their boldneſs and contempt of decency.

19 Education of their children.

V. It was the care of Lycurgus, that, from their very birth, the Lacedemonians ſhould be inured to conquer their appetites: for this reaſon he directed, that nurſes ſhould accuſtom their children to ſpare meals, and now and then to faſting; that they ſhould carry them, when 12 or 13 years old, to thoſe who ſhould examine their education, and who ſhould carefully obſerve whether they were able to be in the dark alone, and whether they had got over all other follies and weakneſſes incident to children. He directed, that children of all ranks ſhould be brought up in the ſame way; and that none ſhould be more favoured in food than another, that they might not, even in their infancy, perceive any difference between poverty and riches, but conſider each other as equals, and even as brethren, to whom the ſame portions were aſſigned, and who, through the courſe of their lives, were to fare alike: the youths alone were allowed to eat fleſh: older men ate their black broth and pulſe; the lads ſlept together in chambers, and after a manner ſomewhat reſembling that ſtill in uſe in Turkey for the Janizaries: their beds, in the ſummer, were very hard, being compoſed of the reeds plucked by the hand from the banks of the Eurotas: in winter their beds were ſofter, but by no means downy, or fit to indulge immoderate ſleep. They ate altogether in public; and in caſe any abſtained from coming to the tables, they were fined. It was likewiſe ſtrictly forbidden for any to eat or drink at home before they came to the common meal; even then each had his proper portion, that every thing might be done there with gravity and decency. The black broth was the great rarity of the Spartans, which was compoſed of ſalt, vinegar, blood, &c. ſo that, in our times, it would be eſteemed a very unſavoury ſoup. If they were moderate in their eating, they were ſo in their drinking alſo; thirſt was the ſole meaſure thereof; and never any Lacedemonian thought of drinking for pleaſure: as for drunkenneſs, it was both infamous and ſeverely puniſhed; and, that young men might perceive the reaſon, ſlaves were compelled to drink to exceſs, that the beaſtlineſs of the vice might appear. When they retired from the public meal, they were not allowed any torches or lights, becauſe it was expected, that men who were perfectly ſober ſhould be able to find their way in the dark: and, beſides, it gave them a facility of marching without light; a thing wonderfully uſeful to them in time of war.

20 Of their diet, clothing, &c.

VI. As the poor ate as well as the rich, ſo the rich could wear nothing better than the poor: they neither changed their faſhion nor the materials of their garments; they were made for warmth and ſtrength, not for gallantry and ſhow: and to this cuſtom even their kings conformed, who wore nothing gaudy in right of their dignity, but were contented that their virtue ſhould diſtinguiſh them rather than their clothes. The youths wore a tunic till they were twelve years old; afterwards they had a cloak given them, which was to ſerve them a year: and their clothing was, in general, ſo thin, that a Lacedemonian veſt became proverbial. Boys were always uſed to go without ſhoes; but when they grew up, they were indulged with them, if the manner of life they led required it; but they were always inured to run without them, as alſo to climb up and ſlip down ſteep places with bare feet: nay, the very ſhoe they uſed was of a particular form, plain and ſtrong. Boys were not permitted to wear their hair; but when they arrived at the age of twenty, they ſuffered their hair and beard to grow. Baths and anointing were not much in uſe among the Lacedemonians; the river Eurotas ſupplied the former, and exerciſe the latter. In the field, however, their ſumptuary laws did not take place ſo ſtrictly as in the city; for when they went to war, they wore purple habits; they put on crowns when they were about to engage the enemy; they had alſo rings, but they were of iron; which metal was moſt eſteemed by this nation. Young women wore their veſts or jerkins only to their knees, or, as ſome think, not quite ſo low; a cuſtom which both Greek and Roman authors cenſure as indecent. Gold, precious ſtones, and other coſtly ornaments, were permitted only to common women; which permiſſion was the ſtrongeſt prohibition to women of virtue, or who affected to be thought virtuous. Virgins went abroad without veils, with which married women, on the contrary were always covered. In certain public exerciſes, in which girls were admitted as well as boys, they were both obliged to perform naked. Plutarch apologiſes for this cuſtom, urging, that there could be no danger from nakedneſs to the morals of youth whoſe minds were fortified and habituated to virtue. One of Lycurgus's principal views in his inſtitutions, was to eradicate the very ſeeds of civil diſſenſion in his republic. Hence proceeded the equal diviſion of eſtates injoined by him; hence the contempt of wealth, and the neglect of other diſtinctions, as particularly birth, he conſidering the people of his whole ſtate as one great family; diſtinctions which, in other commonwealths, frequently produce tumults and confuſions that ſhake their very foundation.

21 Obedience to their ſuperiors.

VII. Though the Spartans were always free, yet it was with this reſtriction, that they were ſubſervient to their own laws, which bound them as ſtrictly in the city as ſoldiers, in other ſtates, were bound by the rules of war in the camp. In the firſt place, ſtrict obedience to their ſuperiors was the great thing required in Sparta. This they looked upon as the very baſis of government; without which neither laws nor magiſtrates availed much. Old age was an indubitable title to honour in Sparta: to the old men the youth roſe up whenever they came into any public place; they gave way to them when they met them in the ſtreets, and were ſilent whenever their elders ſpoke. As all children were looked upon as the children of the ſtate, ſo all the old men had the authority of parents: they reprehended whatever they ſaw amiſs, not only in their own, but in other people's children: and by this method Lycurgus provided, that as youth are everywhere apt to offend, they might be nowhere without a monitor. The laws went ſtill further: if an old man was preſent where a young one committed a fault, and did not reprove him, he was puniſhed equally with the delinquent. Amongſt the youths there was one of their own body, or at moſt two years older than the reſt, who was ſtyled *iren*: he had authority to queſtion all their actions, to look ſtrictly to their behaviour, and to puniſh them if they did amiſs; neither were their puniſhments light, but, on the contrary, very ſevere; whereby the youth were made hardy, and accuſtomed to bear ſtripes and rough uſage. Silence was a thing highly commended at Sparta, where modeſty was held to be a moſt becoming virtue in young people; nor was it reſtrained only to their words and actions, but to their very looks and geſtures; Lycurgus having particularly directed, that they ſhould look forward, or on the ground, and that they ſhould always keep their hands within their robes. A ſtupid inconſiderate perſon, one who would not liſten to inſtruction, but was careleſs of whatever the world might ſay of him, the Lacedemonians treated as a ſcandal to human nature; with ſuch a one they would not converſe, but threw him off as a rotten-branch and worthleſs member of ſociety.

22 Learning.

VIII. The plainneſs of their manners, and their being ſo very much addicted to war, made the Lacedemonians leſs fond of the ſciences than the reſt of the Greeks. A ſoldier was the only reputable profeſſion in Sparta; a mechanic or huſbandman was thought a low fellow. The reaſon of this was, that they imagined profeſſions which required much labour, ſome conſtant poſture, being continually in the houſe, or always about a fire, weakened the body and depreſſed the mind: whereas a man brought up hardily, was equally fit to attend the ſervice of the republic in time of peace, and to fight its battles when engaged in war. Such occupations as were neceſſary to be followed for the benefit of the whole, as huſbandry, agriculture, and the like, were left to their ſlaves the Helotes; but for curious arts, and ſuch as ſerved only to luxury, they would not ſo much as ſuffer them to be introduced in their city; in conſequence of which, rhetoricians, au-

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gurs, bankers, and dealers in money, were ſhut out. The Spartans admitted not any of the theatrical diverſions among them; they would not bear the repreſentation of evil even to produce good; but other kinds of poetry were admitted, provided the magiſtrates had the peruſal of pieces before they were handed to the public.

Above all things, they affected brevity of ſpeech, and accuſtomed their children, from their very infancy, never to expreſs themſelves in more words than were ſtrictly neceſſary; whence a conciſe and ſententious oratory is to this day ſtyled *Laconic*. In writing they uſed the ſame conciſeneſs; of which we have a ſignal inſtance in a letter of Archidamus to the Eleans, when he underſtood that they had ſome thoughts of aſſiſting the Arcadians. It ran thus: "Archidamus to the Eleans: It is good to be quiet." And therefore Epaminondas thought that he had reaſon to glory in having forced the Spartans to abandon their monoſyllables, and to lengthen their diſcourſes.

The greateſt part of their education conſiſted in giving their youth right ideas of men and things: the iren or maſter propoſed queſtions, and either commended the anſwers that were made him, or reproved ſuch as anſwered weakly. In theſe queſtions, all matters, either of a trivial or abſtruſe nature, were equally avoided; and they were confined to ſuch points as were of the higheſt importance in civil life; ſuch as, Who was the beſt man in the city? wherein lay the merit of ſuch an action? and, Whether this or that hero's fame was well-founded? Harmleſs raillery was greatly encouraged; and this, joined to their ſhort manner of ſpeaking, rendered laconic replies univerſally admired.

Muſic was much encouraged; but in this, as in other things, they adhered to that which had been in favour with their anceſtors; nay, they were ſo ſtrict therein, that they would not permit their ſlaves to learn either the tune or the words of their moſt admired odes; or, which is all one, they would not permit them to ſing them if they had learned them. Though the youth of the male ſex were much cheriſhed and beloved, as thoſe that were to build up and continue the future glory of the ſtate, yet in Sparta it was a virtuous and modeſt affection, untinged with that ſenſuality which was ſo ſcandalous at Athens. The good effects of this part of Lycurgus's inſtitutions were ſeen in the union that reigned among his citizens; and which was ſo extraordinary, that even in caſes of competition, it was hardly known that rivals bore ill-will to each other; but, on the contrary, their love to the ſame perſon begat a ſecondary friendſhip among themſelves, and united them in all things which might be for the benefit of the perſon beloved.

Some authors have accuſed this great lawgiver of encouraging theft in his inſtitutions; which, they ſay, was not held ſcandalous among the Spartans, if it were ſo dexterouſly managed as that the perſon was not detected in it. But this is certain, and ſeems to be a ſtrong contradiction of the heinous charge, that when a theft was diſcovered, it was puniſhed with the utmoſt ſeverity: a perſon even ſuſpected of it would endure the heavieſt puniſhments rather than acknowledge it, and be branded with ſo baſe a crime.

23 Exerciſes.

IX. The exerciſes inſtituted by law fall under the ninth table. In theſe all the Greeks were extremely careful, but the Lacedemonians in a degree beyond the reſt; for if a youth, by his corpulence, or any other means, became unfit for theſe exerciſes, he underwent public contempt at leaſt, if not baniſhment.— Hunting was the uſual diverſion of their children; nay, it was made a part of their education, becauſe it had a tendency to ſtrengthen their limbs, and to render thoſe who practiſed it ſupple and fleet: they likewiſe bred up dogs for hunting with great care. They had a kind of public dances, in which they exceedingly delighted, and which were common alike to virgins and young men: indeed, in all their ſports, girls were allowed to divert themſelves with the youths: inſomuch, that, at darting, throwing the quoit, pitching the bar, and ſuch like robuſt diverſions, the women were as dexterous as the men. For the manifeſt oddity of this proceeding, Lycurgus aſſigned no other reaſon, than that he ſought to render women, as well as men, ſtrong and healthy, that the children they brought forth might be ſo too. Violent exerciſes, and a laborious kind of life, were only enjoined the youth; for when they were grown up to men's eſtate, that is, were upwards of 30 years old, they were exempted from all kinds of labour, and employed themſelves wholly either in affairs of ſtate or in war. They had a method of whipping, at a certain time, young men in the temple of Diana, and about her altar; which, however palliated, was certainly unnatural and cruel. It was eſteemed a great honour to ſuſtain theſe flagellations without weeping, groaning, or ſhowing any ſenſe of pain; and the thirſt of glory was ſo ſtrong in theſe young minds, that they very frequently ſuffered death without ſhedding a tear or breathing a ſigh. A deſire of overcoming all the weakneſſes of human nature, and thereby rendering his Spartans not only ſuperior to their neighbours, but to their ſpecies, runs through many of the inſtitutions of Lycurgus; which principle, if well attended to, thoroughly explains them, and without attending to which it is impoſſible to give any account of them at all. 24

X. Gold and ſilver were, by the conſtitutions of Lycurgus, made of no value in Sparta. He was ſo well apprized of the danger of riches, that he made the very poſſeſſion of them venal; but as there was no living without ſome ſort of money, that is, ſome common meaſure or ſtandard of the worth of things, he directed an iron coinage, whereby the Spartans were ſupplied with the uſeful money, and at the ſame time had no temptation to covetouſneſs afforded them; for a very ſmall ſum was ſufficient to load a couple of horſes, and a great one muſt have been kept in a barn or warehouſe. The introduction of all foreign money was alſo prohibited, that corruption might not enter under the name of commerce. The moſt ancient method of dealing, viz. by barter, or exchange of one commodity for another, was preſerved by law in Sparta long after it had gone into diſuſe everywhere elſe. Intereſt was a thing forbidden in the Spartan commonwealth; where they had alſo a law againſt alienation of lands, accepting preſents from foreigners, even without the limits of their own country, and when their authority and character might well ſeem to excuſe them. 25

Money, &c.

XI. Such of the laws of Sparta as related to courts of juſtice may be brought under the 11th table. Thirty years muſt have paſſed over the head of him who had a right to concern himſelf in juridical proceedings. Young

Courts of juſtice.

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Young men were thought unfit for them; and it was even held indecent, and of ill report, for a man to have any fondneſs for law-ſuits, or to be buſying himſelf at the tribunals, when he had no affairs there of his own. By theſe rules Lycurgus thought to ſhut out litigiouſneſs, and to prevent that multiplicity of ſuits which is always ſcandalous in a ſtate. As young people were not permitted to inquire about the laws of other countries, and as they were hindered from hearing judicial proceedings in their courts, ſo they were likewiſe forbidden to aſk any queſtions about, or to endeavour to diſcover, the reaſons of the laws by which themſelves were governed. Obedience was their duty; and to that alone they would have them kept. Men of abandoned characters, or who were notoriouſly of ill fame, loſt all right of giving their votes in reſpect of public affairs, or of ſpeaking in public aſſemblies; for they would not believe that an ill man in private life could mean his country better than he did his neighbour.

26 Military ſervice.

XII. Till a man was 30 years old, he was not capable of ſerving in the army, as the beſt authors agree; though ſome think that the military age is not well aſcertained by ancient writers. They were forbidden to march at any time before the full-moon; the reaſon of which law is very hard to be diſcovered, if indeed it had any reaſon at all, or was not rather founded on ſome ſuperſtitious opinion, that this was a more lucky conjuncture than any other. They were likewiſe forbidden to fight often againſt the ſame enemy; which was one of the wiſeſt maxims in the political ſyſtem of Lycurgus: and Ageſilaus, by offending againſt it, deſtroyed the power of his country, and loſt her that authority which for many ages ſhe maintained over the reſt of Greece; for, by continually warring againſt the Thebans, to whom he had an inveterate hatred, he at laſt beat them into the knowledge of the art of war, and enabled them, under the command of Epaminondas, to maintain for a time the principality of Greece. Maritime affairs they were forbidden to meddle with, though the neceſſity of things compelled them, in proceſs of time, to tranſgreſs this inſtitution, and by degrees to transfer to themſelves the dominion of the ſea as well as of the land: but, after the Peloponneſian war, they again neglected naval affairs from a perſuaſion that ſailors and ſtrangers corrupted thoſe with whom they converſed. As they never fortified Sparta, they were not ready to undertake ſieges: fighting in the field was their proper province, and, while they could overcome their enemies there, they rightly conceived that nothing could hurt them at home. In time of war they relaxed ſomewhat of their ſtrict manner of living, in which they were ſingular. The true reaſon for this was, in all probability, that war might be leſs burdenſome to them; for, as we have more than once obſerved, a ſtrong deſire to render them bold and warlike was the reigning paſſion of their legiſlator. They were forbidden to remain long encamped in the ſame place, as well to hinder their being ſurpriſed, as that they might be more troubleſome to their enemies, by waſting every corner of their country. They ſlept all night in their armour; but their outguards were not allowed their ſhields, that, being unprovided of defence, they might not dare to ſleep. In all expeditions they were careful in the performance of religious rites; and, after their evening meal was over, the ſoldiers ſung together hymns to their gods. When they were about to engage, the king ſacrificed to the muſes, that, by their aſſiſtance, they might be enabled to perform deeds worthy of being recorded to lateſt times. Then the army advanced in order to the ſound of flutes, which played the hymn of Caſtor. The king himſelf ſung the pæan, which was the ſignal to charge. This was done with all the ſolemnity imaginable; and the ſoldiers were ſure either to conquer or die: indeed they had no other choice; for if they fled they were infamous, and in danger of being ſlain, even by their own mothers, for diſgracing their families. In this conſiſted all the excellency of the Spartan women, who, if poſſible, exceeded in bravery the men, never lamenting over huſbands or ſons, if they died honourably in the field; but deploring the ſhame brought on their houſe, if either the one or the other eſcaped by flight. The throwing away a ſhield alſo induced infamy; and, with reſpect to this, mothers, when they embraced their departing ſons, were wont to caution them, that they ſhould either return armed as they were, or be brought back ſo when they were dead; for, as we have obſerved, ſuch as were ſlain in battle were nevertheleſs buried in their own country. When they made their enemies fly, they purſued no longer than till victory was certain; becauſe they would ſeem to fight rather for the honour of conquering, than of putting their enemies to death. According to their excellent rules of war, they were bound not to ſpoil the dead bodies of their enemies; but in proceſs of time, this, and indeed many other of their moſt excellent regulations, fell into deſuetude. He who overcame by ſtratagem, offered up an ox to Mars; whereas he who conquered by force, offered up only a cock; the former being eſteemed more manly than the latter. After 40 years ſervice, a man was, by law, no longer required to go into the field; and conſequently, if the military age was 30, the Spartans were not held invalids till they were 70.

Sparta || Spartium.

SPARTIANUS, Ælius, a Latin hiſtorian, who wrote the lives of Adrian, Caracalla, and four other Roman emperors. He lived under the reign of Diocleſian, about the year 290.

SPARTIUM, Broom, a genus of plants belonging to the claſs of diadelphia, and order of decandria; and in the natural ſyſtem arranged under the 32d order, *Papilionaceæ*. See Botany *Index*.

The flower buds are in ſome countries pickled, and eaten as capers; and the ſeeds have been uſed as a bad ſubſtitute for coffee. The branches are uſed for making beſoms, and tanning leather. They are alſo uſed inſtead of thatch to cover houſes. The old wood furniſhes the cabinet-maker with beautiful materials for vaneering. The tender branches are in ſome places mixed with hops for brewing, and the macerated bark may be manufactured into cloth.

The *junceum*, or Spaniſh broom, grows naturally in the ſouthern provinces of France, as well as in other parts of the ſouth of Europe. It grows in the pooreſt ſoils, on the ſteepeſt declivities of the hills, in a ſtony ſoil, where hardly any other plant could vegetate. In a few years it makes a vigorous ſhrub; inſinuating its roots between the interſtices of the ſtones, it binds the ſoil, and retains the ſmall portion of vegetable earth ſcattered over theſe hills, which the autumnal rains would otherwiſe

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wiſe waſh away. It is moſt eaſily raiſed from ſeed, which is uſually ſown in January, after the ground has received a ſlight dreſſing.

The ſhrub ſerves two uſeful purpoſes. Its branches yield a thread of which linen is made, and in winter ſupport ſheep and goats.

In manufacturing thread from broom, the youngeſt plants are cut in the month of Auguſt, or after harveſt, and gathered together in bundles, which at firſt are laid in the ſun to dry: they are then beaten with a piece of wood, waſhed in a river or pond, and left to ſteep in the water for about four hours. The bundles thus prepared are taken to a little diſtance from the water, and laid in a hollow place made for them, where they are covered with fern or ſtraw, and remain thus to ſteep for eight or nine days; during which time, all that is neceſſary, is to throw a little water once a-day on the heap, without uncovering the broom. After this, the bundles are well waſhed, the green rind of the plant or epidermis comes off, and the fibrous part remains; each bundle is then beaten with a wooden hammer upon a ſtone, to detach all the threads, which are at the ſame time carefully drawn to the extremity of the branches. After this operation, the faggots are untied, and ſpread upon ſtones or rocks till they are dry. The twigs muſt not be peeled till they are perfectly dry; they are then dreſſed with the comb, and the threads are ſeparated according to the fineneſs, and ſpun upon a wheel.

The linen made of this thread ſerves various purpoſes in rural economy. The coarſeſt is employed in making ſacks and other ſtrong cloths for carrying grain or ſeeds. Of the fineſt is made bed, table, and body linen. The peaſants in ſeveral places uſe no other, for they are unacquainted with the culture of hemp or flax, their ſoil being too dry and too barren for raiſing them. The cloth made with the thread of the broom is very uſeful; it is as ſoft as that made of hemp; and it would perhaps look as well as that made of flax if it was more carefully ſpun. It becomes white in proportion as it is ſteeped. The price of the fineſt thread, when it is ſold, which ſeldom happens, is generally about a ſhilling a pound.

The other uſe to which this broom is applied, is to maintain ſheep and goats during winter. In the mountains of Lower Languedoc theſe animals have no other food from November to April, except the leaves of trees preſerved. The branches of this broom therefore are a reſource the more precious, that it is the only freſh nouriſhment which at that ſeaſon the flocks can procure, and they prefer it at all times to every other plant. In fine weather the ſheep are led out to feed on the broom where it grows; but in bad weather the ſhepherds cut the branches, and bring them to the ſheep folds. There is, however, an inconvenience attending the continued uſe of this food. It generally produces inflammation in the urinary paſſages. But this inconvenience is eaſily removed by cooling drink, or a change of food, or by mixing the broom with ſomething elſe.

It is perhaps needleſs to add, that it differs much from the broom that is common everywhere in the north of Europe, though this too, in many places, is uſed for food to cattle. Both of them produce flowers that are very much reſorted to by bees, as they contain a great quantity of honey juice. And this ſhould be another inducement to the cultivation of the Spaniſh broom.

SPARUS, GILTHEAD, a genus of fiſhes belonging to the order of *thoracici*. See ICHTHYOLOGY *Index*. The ſarus auratus, or gilthead, was well known to the Romans, who did not eſteem them unleſs they were fed with Lucrine oyſters, as Martial informs us,

Non omnis laudem pretiumque AURATA *meretur,*
Sed qui ſolus erit concha Lucrina cibus.
Lib. xiii. Ep. 90.

SPASM, a convulſion. See MEDICINE, n° 278.

SPATHA, in *Botany*, a ſheath; a ſpecies o calyx which burſts lengthwiſe, and protrudes a ſtalk ſupporting one or more flowers, which commonly have no perianthium or flower-cup.

SPATHACEÆ (from *ſpatha*, "a ſheath"), the name of the ninth order in Linnæus's Fragments of a Natural Method, conſiſting of plants whoſe flowers are protruded from a ſpatha or ſheath. See BOTANY *Index*.

SPATHELIA, a genus of plants belonging to the claſs of pentandria, and to the order of trigynia. See BOTANY *Index*.

SPAW. See SPA.

SPAWN, in *Natural Hiſtory*, the eggs of fiſhes or frogs.

SPAVENTO. See SCANTO.

SPAVIN, in the manege, a diſeaſe in horſes, being a ſwelling or ſtiffneſs, uſually in the ham, occaſioning a lameneſs. See FARRIERY *Index*.

SPAYING, or SPADING, the operation of caſtrating the females of ſeveral kinds of animals, as ſows, bitches, &c. to prevent any further conception, and promote their fattening. It is performed by cutting them in the mid flank, on the left ſide, with a ſharp knife or lancet, taking out the uterus, and cutting it off, and ſo ſtitching up the wound, anointing the part with tar, and keeping the animal warm for two or three days. The uſual way is to make the inciſion aſlope, two inches and a half long; that the fore-finger may be put in towards the back, to feel for the ovaries, which are two kernels as big as acorns on both ſides of the uterus, one of which is drawn to the wound, and thus both taken out.

SPEAKER *of the Houſe of Commons*, a member of the houſe elected by a majority of notes thereof to act as chairman or preſident in putting queſtions, reading briefs, or bills, keeping order, reprimanding the refractory, adjourning the houſe, &c. See PARLIAMENT.

SPEAKING, the art or act of expreſſing one's thoughts in articulate ſounds or words. See GRAMMAR, LANGUAGE, READING, and ORATORY, Part iv.

SPEAKING-Trumpet. See TRUMPET.

SPEAR-MINT. See MENTHA, BOTANY *Index*.

SPEAR-Wort. See RANUNCULUS, BOTANY *Index*.

SPECIAL, ſomething that is particular, or has a particular deſignation; from the Latin *ſpecies*, in oppoſition to the *general*, from *genus*.

SPECIES, in *Logic*, a relative term, expreſſing an idea which is compriſed under ſome general one called a *genus*. See LOGIC, N° 68.

SPECIES, in *Commerce*, the ſeveral pieces of gold, ſilver, copper, &c. which having paſſed their full

 preparation

preparation and coinage, are current in public. See MONEY.

SPECIES, in *Algebra*, are the letters, ſymbols, marks, or characters, which repreſent the quantities in any operation or equation. This ſhort and advantageous way of notation was chiefly introduced by Vieta, about the year 1590; and by means of it he made many diſcoveries in algebra, not before taken notice of.

SPECIES, in *Optics*, the image painted on the retina by the rays of light reflected from the ſeveral points of the ſurface of an object, received by the pupil, and collected in their paſſage through the cryſtalline, &c.

It has been a matter of diſpute among philoſophers, whether the ſpecies of objects which give the ſoul an occaſion of ſeeing, be an effuſion of the ſubſtance of the body; a mere impreſſion which they make on all bodies under certain circumſtances; or whether they are not ſome more ſubtile body, ſuch as light. The moderns have decided this point by the invention of artificial eyes, in which the ſpecies of objects are received on paper, in the ſame manner as in the natural eye.

SPECIFIC, in *Philoſophy*, that which is peculiar to any thing, and diſtinguiſhes it from all others.

SPECIFICS, in *Medicine*. By ſpecifics is not meant ſuch as infallibly and in all patients produce ſalutary effects. Such medicines are not to be expected, becauſe the operations and effects of remedies are not formally inherent in them, but depend upon the mutual action and reaction of the body and medicine upon each other; hence the various effects of the ſame medicine in the ſame kind of diſorders in different patients, and in the ſame patient at different times. By ſpecific medicines we underſtand ſuch medicines as are found to be more uniform in their effects than others in any particular diſorder.

SPECIFIC Gravity, is a term much employed in the diſcuſſions of modern phyſics. It expreſſes the weight of any particular kind of matter, as compared with the weight of the ſame bulk of ſome other body of which the weight is ſuppoſed to be familiarly known, and is therefore taken for the ſtandard of compariſon. The body generally made uſe of for this purpoſe is pure water.

The ſpecific gravity of bodies is a very intereſting queſtion both to the philoſopher and to the man of buſineſs. The philoſopher conſiders the weights of bodies as meaſures of the number of material atoms, or the quantity of matter which they contain. This he does on the ſuppoſition that every atom of matter is of the ſame weight, whatever may be its ſenſible form. This ſuppoſition, however, is made by him with caution, and he has recourſe to ſpecific gravity for aſcertaining its truth in various ways. This ſhall be conſidered by and by. The man of buſineſs entertains no doubt of the matter, and proceeds on it as a ſure guide in his moſt intereſting tranſactions. We meaſure commodities of various kinds by tons, pounds, and ounces, in the ſame manner as we meaſure them by yards, feet, and inches, or by buſhels, gallons, and pints; nay, we do this with much greater confidence, and prefer this meaſurement to all others, whenever we are much intereſted to know the exact proportions of matter that bodies contain. The weight of a quantity of grain is allowed to inform us much more exactly of its real quantity of uſeful matter than the moſt accurate meaſure of its bulk. We ſee many circumſtances which can vary the bulk of a quantity of matter, and theſe are frequently ſuch as we cannot regulate or prevent; but we know very few indeed that can make any ſenſible change in this weight without the addition or abſtraction of other matter. Even taking it to the ſummit of a high mountain, or from the equator to the polar region, will make no change in its weight as it is aſcertained by the balance, becauſe there is the ſame real diminution of weight in the pounds and ounces uſed in the examination.

Notwithſtanding the unavoidable change which heat and cold make in the bulk of bodies, and the permanent varieties of the ſame kind of matter which are cauſed by different circumſtances of growth, texture, &c. moſt kinds of matter have a certain conſtancy in the denſity of their particles, and therefore in the weight of a given bulk. Thus the purity of gold, and its degree of adulteration, may be inferred from its weight, it being purer in proportion as it is more denſe. The denſity, therefore, of different kinds of tangible matter becomes characteriſtic of the kind, and a teſt of its purity; it marks a particular appearance in which matter exiſts, and may therefore be called, with propriety, SPECIFIC.

But this denſity cannot be directly obſerved. It is not by comparing the diſtances between the atoms of matter in gold and in water that we ſay the firſt is 19 times denſer than the laſt, and that an inch of gold contains 19 times as many material atoms as an inch of water; we reckon on the equal gravitation of every atom of matter whether of gold or of water; therefore the weight of any body becomes the indication of its material denſity, and the weight of a given bulk becomes ſpecific of that kind of matter, marking its kind, and even aſcertaining its purity in this form.

It is evident that, in order to make this compariſon of general uſe, the ſtandard muſt be familiarly known, and muſt be very uniform in its denſity, and the compariſon of bulk and denſity muſt be eaſy and accurate. The moſt obvious method would be to form, with all nicety, a piece of the ſtandard matter of ſome convenient bulk, and to weigh it very exactly, and keep a note of its weight: then, to make the compariſon of any other ſubſtance, it muſt be made into a maſs of the ſame preciſe bulk, and weighed with equal care; and the moſt convenient way of expreſſing the ſpecific gravity would be to conſider the weight of the ſtandard as unity, and then the number expreſſing the ſpecific gravity is the number of times that the weight of the ſtandard is contained in that of the other ſubſtance. This compariſon is moſt eaſily and accurately made in fluids. We have only to make a veſſel of known dimenſions equal to that of the ſtandard which we employ, and to weigh it when empty, and then when filled with the fluid. Nay, the moſt difficult part of the proceſs, the making a veſſel of the preciſe dimenſions of the ſtandard, may be avoided, by uſing ſome fluid ſubſtance for a ſtandard. Any veſſel will then do; and we may enſure very great accuracy by uſing a veſſel with a ſlender neck, ſuch as a phial or matraſs; for when this is filled to a certain mark in the neck, any error in the eſtimation by the eye will bear a very ſmall proportion to the whole. The weight of the ſtandard fluid which fills it to this mark being carefully aſcertained, is kept in remembrance. The ſpecific gravity of any other fluid is had by weighing the contents of this veſſel when filled with it, and dividing

dividing the weight by the weight of the ſtandard. The quotient is the ſpecific gravity of the fluid. But in all other caſes this is a very difficult problem: it requires very nice hands, and an accurate eye, to make two bodies of the ſame bulk. An error of one hundredth part in the linear dimenſions of a ſolid body makes an error of a 30th part in its bulk; and bodies of irregular ſhapes and friable ſubſtance, ſuch as the ores of metals, cannot be brought into convenient and exact dimenſions for meaſurement.

From all theſe inconveniences and difficulties we are freed by the celebrated Archimedes, who, from the principles of hydroſtatics diſcovered or eſtabliſhed by him, deduced the accurate and eaſy method which is now univerſally practiſed for diſcovering the ſpecific gravity and denſity of bodies. (See ARCHIMEDES and HYDRODYNAMICS). Inſtead of meaſuring the bulk of the body by that of the diſplaced fluid (which would have been impoſſible for Archimedes to do with any thing like the neceſſary preciſion), we have only to obſerve the loſs of weight ſuſtained by the ſolid. This can be done with great eaſe and exactneſs. Whatever may be the bulk of the body, this loſs of weight is the weight of an equal bulk of the fluid; and we obtain the ſpecific gravity of the body by ſimply dividing its whole weight by the weight loſt: the quotient is the ſpecific gravity when this fluid is taken for the ſtandard, even though we ſhould not know the abſolute weight of any given bulk of this ſtandard. It alſo gives us an eaſy and accurate method of aſcertaining even this fundamental point. We have only to form any ſolid body into an exact cube, ſphere, or priſm, of known dimenſions, and obſerve what weight it loſes when immerſed in this ſtandard fluid. This is the weight of the ſame bulk of the ſtandard to be kept in remembrance; and thus we obtain, by the bye, a moſt eaſy and accurate method for meaſuring the bulk or ſolid contents of any body, however irregular its ſhape may be. We have only to ſee how much weight it loſes in the ſtandard fluid; we can compute what quantity of the ſtandard fluid will have this weight. Thus ſhould we find that a quantity of ſand, or a furze buſh, loſes 250 ounces when immerſed in pure water, we learn by this that the ſolid meaſure of every grain of the ſand, or of every twig and prickle of the furze, when added into one ſum, amounts to the fourth part of a cubic foot, or to 432 cubic inches.

To all theſe advantages of the Archimedean method of aſcertaining the ſpecific gravity of bodies, derived from his hydroſtatical doctrines and diſcoveries, we may add, that the immediate ſtandard of compariſon, namely, water, is, of all the ſubſtances that we know, the fitteſt for the purpoſe of an univerſal ſtandard of reference. In its ordinary natural ſtate it is ſufficiently conſtant and uniform in its weight for every examination where the utmoſt mathematical accuracy is not wanted; all its variations ariſe from impurities, from which it may at all times be ſeparated by the ſimple proceſs of diſtillation: and we have every reaſon to think that when pure, its denſity, when of the ſame temperature, is invariable.

Water is therefore univerſally taken for the unit of that ſcale on which we meaſure the ſpecific gravity of bodies, and its weight is called 1. The ſpecific gravity of any other body is the real weight in pounds and ounces, when of the bulk of one pound or one ounce of water. It is therefore of the firſt importance, in all diſcuſſions reſpecting the ſpecific gravity of bodies, to have the preciſe weight of ſome known bulk of pure water. We have taken ſome pains to examine and compare the experiments on this ſubject, and ſhall endeavour to aſcertain this point with the preciſion which it deſerves. We ſhall reduce all to the Engliſh cubic foot and avoirdupois ounce of the Exchequer ſtandard, on account of a very convenient circumſtance peculiar to this unit, viz. that a cubic foot contains almoſt preciſely a thouſand ounces of pure water, ſo that the ſpecific gravity of bodies expreſſes the number of ſuch ounces contained in a cubic foot.

We begin with a trial made before the houſe of commons in 1696 by Mr Everard. He weighed 2145.6 cubic inches of water by a balance, which turned ſenſibly with 6 grains, when there were 30 pounds in each ſcale. The weights employed were the troy weights, in the depoſit of the Court of Exchequer, which are ſtill preſerved, and have been moſt ſcrupulouſly examined and compared with each other. The weight was 1131 ounces 14 pennyweights. This wants juſt 11 grains of a thouſand avoirdupois ounces for 1728 cubic inches, or a cubic foot; and it would have amounted to that weight had it been a degree or two colder. The temperature indeed is not mentioned; but as the trial was made in a comfortable room, we may preſume the temperature to have been about 55° of Fahrenheit's thermometer. The dimenſions of the veſſel were as accurate as the nice hand of Mr Abraham Sharp, Mr Flamſtead's aſſiſtant at Greenwich, could execute, and it was made by the Exchequer ſtandard of length.

This is confided in by the naturaliſts of Europe as a very accurate ſtandard experiment, and it is confirmed by many others both private and public. The ſtandards of weight and capacity employed in the experiment are ſtill in exiſtence, and publicly known, by the report of the Royal Society to parliament in 1742, and by the report of a committee of the houſe of commons in 1758. This gives it a ſuperiority over all the meaſures which have come to our knowledge.

The firſt experiment, made with proper attention, that we meet with, is by the celebrated Snellius, about the year 1615, and related in his *Eratoſthenes Batavus*. He weighed a Rhinland cubic foot of diſtilled water, and found it 62.79 Amſterdam pounds. If this was the ordinary weight of the ſhops, containing 7626 Engliſh troy grains, the Engliſh cubic foot muſt be 62 pounds 9 ounces, only one ounce more than by Everard's experiment. If it was the Mint pound, the weight was 62 pounds 6 ounces. The only other trials which can come into competition with Mr Everard's are ſome made by the Academy of Sciences at Paris. Picart, in 1691, found the Paris cubic foot of the water of the fountain d'Arcueil to weigh 69.588 pounds, *poids de Paris*. Du Hamel obtained the very ſame reſult; but Mr Monge, in 1783, ſays that filtered rain-water of the temperature 12° (Reaumur) weighs 69.3792. Both theſe meaſures are conſiderably below Mr Everard's, which is 62.5, the former giving 62.053, and the latter 61.868. M. Lavoiſier ſtates the Paris cubic foot at 70 pounds, which makes the Engliſh foot 62.47. But there is an inconſiſtency

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fistency among them which makes the comparison impossible. Some changes were made in 1688, by royal authority, in the national standards, both of weight and length; and the academicians are exceedingly puzzled to this day in reconciling the differences, and cannot even ascertain with perfect assurance the lineal measures which were employed in their most boasted geodetical operations.

Such variations in the measurements made by persons of reputation for judgement and accuracy engaged the writer of this article some years ago to attempt another. A vessel was made of a cylindrical form, as being more easily executed with accuracy, whose height and diameter were 6 inches, taken from a most accurate copy of the Exchequer standard. It was weighed in distilled water of the temperature 55° several times without varying 2 grains, and it lost 42895 grains. This gives for the cubic foot 998.74 ounces, deficient from Mr Everard's an ounce and a quarter; a difference which may be expected, since Mr Everard used the New River water without distillation.

We hope that these observations will not be thought superfluous in a matter of such continual reference, in the most interesting questions both to the philosopher and the man of business; and that the determination which we have given will be considered as sufficiently authenticated.

Let us, therefore, for the future take water for the standard, and suppose that, when of the ordinary temperature of summer, and in its state of greatest natural purity, viz. in clean rain or snow, an English cubic foot of it weighs a thousand avoirdupois ounces of 437.5 troy grains each. Divide the weight of any body by the weight of an equal bulk of water, the quotient is the specific gravity of that body; and if the three first figures of the decimal be accounted integers, the quotient is the number of avoirdupois ounces in a cubic foot of the body. Thus the specific gravity of the very finest gold which the refiner can produce is 19.365, and a cubic foot of it weighs 19365 ounces.

But an important remark must be made here. All bodies of homogeneous or unorganised texture expand by heat, and contract by cooling. The expansion and contraction by the same change of temperature is very different in different bodies. Thus water, when heated from 60° to 100°, increases its volume nearly $\frac{1}{107}$ of its bulk, and mercury only $\frac{1}{143}$, and many substances much less. Hence it follows, that an experiment determines the specific gravity only in that very temperature in which the bodies are examined. It will therefore be proper always to note this temperature; and it will be convenient to adopt some very useful temperature for such trials in general: perhaps about 60° of Fahrenheit's thermometer is as convenient as any. It may always be procured in these climates without inconvenience. A temperature near to freezing would have some advantages, because water changes its bulk very little between the temperature 32° and 45°. But this temperature cannot always be obtained. It will much conduce to the facility of the comparison to know the variation which heat produces on pure water. The following table, taken from the observations of Dr Blagden and Mr Gilpin (Phil. Trans. 1792) will answer this purpose.

Temperature of Water.	Bulk of Water.	Specific Gravity.
30		
35	99910	1.00090
40	99070	1.00094
45	99914	1.00086
50	99932	1.00068
55	99962	1.00038
60	100000	1.00000
65	100050	0.99950
70	100106	0.99894
75	100171	0.99830
80	100242	0.99759
85	100320	0.99681
90	100404	0.99598
95	100501	0.99502
100	100602	0.99402

Those gentlemen observed the expansion of water to be very anomalous between 32° and 45°. This is distinctly seen during the gradual cooling of water to the point of freezing. It contracts for a while, and then suddenly expands. But we seldom have occasion to measure specific gravities in such temperature.

The reader is now sufficiently acquainted with the principles of this hydrostatical method of determining the specific gravity of bodies, and can judge of the propriety of the forms which may be proposed for the experiment.

The specific gravity of a fluid may be determined either by filling with it a vessel with a narrow neck, or by weighing a solid body that is immersed in it. It is hard to say which is the best way. The last is not subject to any error in filling, because we may suspend the solid by a fine wire, which will not displace any sensible quantity of the fluid; and if the solid is but a little heavier than the fluid, the balance being loaded only with the excess, will be very sensible to the smallest want of equilibrium. But this advantage is perhaps compensated by an obstruction to the motion of the solid up or down in the fluid, arising from viscidity. When the weight in the opposite scale is yet too small, we slowly add more, and at last grain by grain, which gradually brings the beam to the level. When it is exactly level, the weight in the scale is somewhat too great; for it not only balances the preponderance of the solid, but also this viscidity of the fluid. But we may get rid of this error. Add a small quantity more; this will bring the beam over to the other side. Now put as much into the scale on the same side with the solid; this will not restore the beam to its level. We must add more till this be accomplished; and this addition is the measure of the viscidity of the fluid, and must be subtracted from the weight that was in the other scale when the beam came *first* to a level. This effect of viscidity is not insensible, with nice apparatus, even in the purest water, and in many fluids it is very considerable—and, what is worse, it is very changeable. It is greatly diminished by heat; and this is an additional reason for making

making thofe trials in pretty warm temperatures. But for fluids of which the vifcidity is confiderable, this method is by no means proper; and we muft take the other, and weigh them in a veffel with a narrow neck. Mercury muft alfo be treated in this way, becaufe we have no folid that will fink in it but gold and platina.

It is not fo eafy as one would imagine to fill a veffel precifely to the fame degree upon every trial. But if we do not operate on too fmall quantities, the unavoidable error may be made altogether infignificant, by having the neck of the veffel very fmall. If the veffel hold a pound of water, and the neck do not exceed a quarter of an inch (and it will not greatly retard the operation to have it half this fize), the examinator muft be very carelefs indeed to err one part in two thoufand; and this is perhaps as near as we can come with a balance. We muft always recollect that the capacity of the veffel changes by heat, and we muft know this variation, and take it into the account. But it is affectation to regard (as Mr Homberg would make us believe that he did) the diftenfion of the veffel by the preffure of the fluid. His experiments of this kind have by no means the confiftency with each other that fhould convince us that he did not commit much greater errors than what arofe from diftenfion.

In examining either folids or fluids, we muft be careful to free their furface, or that of the veffel in which the fluid is to be weighed, from air, which frequently adheres to it in a peculiar manner, and, by forming a bubble, increafes the apparent bulk of the folid, or diminifhes the capacity of the veffel. The greateft part of what appears on thofe occafions feems to have exifted in the fluid in a ftate of chemical union, and to be fet at liberty by the fuperior attraction of the fluid for the contiguous folid body. Thefe air bubbles muft be carefully brufhed off by hand. All greafy matters muft be cleared off for the fame reafon: they prevent the fluid from coming into contact.

We muft be no lefs careful that no water is imbibed by the folid, which would increafe its weight without increafing its bulk. In fome cafes, however, a very long maceration and imbibition is neceffary. Thus, in examining the fpecific gravity of the fibrous part of vegetables, we fhould err exceedingly if we imagined it as fmall as appears at firft. We believe that in moft plants it is at leaft as great as water, for after long maceration they fink in it.

It is almoft needlefs to fay that the niceft and moft fenfible balances are neceffary for this examination. Balances are even conftructed on purpofe, and fitted with feveral pieces of apparatus, which make the examination eafy and neat. We have defcribed (fee BALANCE) Mr Gravefande's as one of the moft convenient of any. His contrivance for obferving the fractions of a grain is extremely ingenious and expeditious, efpecially for detecting the effect of vifcidity.

The hydrometer, or areometer, is another inftrument for afcertaining the fpecific gravity of fluids. This very pretty inftrument is the invention of a lady, as eminent for intellectual accomplifhments as fhe was admired for her beauty. Hypatia, the learned daughter of the celebrated mathematician Theon of Alexandria, became fo eminent for her mathematical knowledge, that fhe was made public profeffor of the fcience in the firft fchool in the world. She wrote a commentary on the works of Apollonius and of Diophantus, and compofed Aftronomical Tables; all of which are loft. Thefe rare accomplifhments, however, could not fave her from the fury of the fanatics of Alexandria, who cut her in pieces for having taken an offenfive part in a difpute between the governor and patriarch.—We have defcribed fome of the moft approved of thefe inftruments in the article HYDROMETER, and fhall in this place make a few obfervations on the principles of their conftruction, not as they are ufually made, accommodated to the examination of particular liquors, but as indicators of pure fpecific gravity. And we muft premife, that this would, for many reafons, be the beft way of conftructing them. The very ingenious contrivances for accommodating them to particular purpofes are unavoidably attended with many fources of error, both in their adjuftment by the maker and in their ufe; and all that is gained by a very expenfive inftrument is the faving the trouble of infpecting a table. A fimple fcale of fpecific gravity would expofe to no error in conftruction, becaufe all the weights but one, or all the points of the fcale but one, are to be obtained by calculation, which is incomparably more exact than any manual operation, and the table can always be more exact than any complex obfervation. But a ftill greater advantage is, that the inftruments would by this means be fitted for examining all liquors whatever, whereas at prefent they are almoft ufelefs for any but the one for which they are conftructed.

Hydrometers are of two kinds. The moft fimple and the moft delicate are juft a fubftitute for the hydroftatical balance. They confift of a ball (or rather an egg or pear-fhaped veffel, which moves more eafily through the fluid) A (fig. 1.) having a foot projecting down from it, terminated by another ball B, and a flender ftalk or wire above, carrying a little difh C. The whole is made fo light as to float in the lighteft fluid we are acquainted with; fuch as vitriolic or muriatic ether, whofe fpecific gravity is only 0.73. This number fhould be marked on the difh, indicating that this is the fpecific gravity of the fluid in which the inftrument floats, finking to the point D of the ftem. The ball B is made heavy, and the foot is of fome length, that the inftrument may have ftability, and fwim erect, even if confiderably loaded above; and, for the fame reafon, it muft be made very round, otherwife it will lean to a fide. When put into a heavier liquor, its buoyancy will caufe it to float with a part of the ball above the furface. Weights are now put into the fcale C, till the inftrument fink to D. The weight put into the fcale, added to the weight of the inftrument, is the weight of the difplaced fluid. This, compared with the weight of the whole when the inftrument is fwimming in pure water, gives the fpecific gravity of the fluid. All trouble of calculation may be avoided by marking the weights with fuch numbers as fhall indicate the fpecific gravity at once. Thus having loaded the inftrument fo as to fink it to D in pure water, call the whole weight 1000; then weigh the inftrument itfelf, and fay, "as the weight when fwimming in water is to its prefent weight, fo is 1000 to a 4th proportional." This is the fpecific gravity of the liquor which would float the unloaded inftrument. Suppofe this to be 730. The hydrometer would juft float in muriatic ether, and this fhould be marked on the fide. Now make a fet of fmall weights,

Plate CCCCXCIX.

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weights, and mark them, not by their weights in grains, but in ſuch units that 270 of them ſhall be equal to the weight which fits the inſtrument for pure water.

Suppoſe that, in order to float this inſtrument in a certain brandy, there are required 186 in theſe ſmall weights. This added to 730 gives 916 for the ſpecific gravity, and ſhows it to be preciſely exciſe proof ſpirit. Nine weights, viz. 256, 128, 64, 32, 16, 8, 4, 2, 1, will ſuffice for all liquors from ether to the ſtrongeſt worts. And that the trouble in changing the weights may be greatly leſſened, let a few circles *a*, *b*, *c*, *d*, *e*, be marked on the top of the ball. When we ſee it float unloaded at the circle C for inſtance, we know it will require at leaſt 128 to ſink it to D on the ſtem.

If the weights to be added above are conſiderable, it raiſes the centre of gravity ſo much, that a ſmall want of equilibrium, by laying the weights on one ſide, will produce a great inclination of the inſtrument, which is unſightly. Inſtead therefore of making them looſe weights, it is proper to make them round plates, with a ſmall hole in the middle, to go on a pin in the middle of the ſcale. This will keep the inſtrument always upright. But unleſs the hydrometer is of a conſiderable ſize, it can hardly be made ſo as to extend from the lighteſt to the heavieſt fluid which we may have occaſion to examine, even though we except mercury. Some of the mineral acids are conſiderably more than twice the weight of ether. When there is ſuch a load at top, the hydrometer is very apt to overſet, and inclines with the ſmalleſt want of equilibrium. Great ſize is inconvenient even to the philoſopher, becauſe it is not always in his power to operate on a quantity of fluid ſufficient to float the inſtrument. Therefore two, or perhaps three, are neceſſary for general examination. One may reach from ether to water; another may ſerve for all liquors of a ſpecific gravity between one and one and a half; and the third, for the mineral acids, may reach from this to two. If each of theſe be about two ſolid inches in capacity, we may eaſily and expeditiouſly determine the ſpecific gravity within one ten thouſandth part of the truth: and this is preciſion enough for moſt purpoſes of ſcience or buſineſs.

The chief queſtions are, 1. To aſcertain the ſpecific gravity of an unknown fluid. This needs no farther explanation. 2. To aſcertain the proportion of two fluids which are known to be in a mixture. This is done by diſcovering the ſpecific gravity of the mixture by means of the hydrometer, and then deducing the proportion from a compariſon of this with the ſpecific gravities of the ingredients.

In this mode of examination the bulk is always the ſame; for the hydrometer is immerged in the different fluids to the ſame depth. Now if an inch, for example, of this bulk is made up of the heavieſt fluid, there is an inch wanting of the lighteſt; and the change made in the weight of the mixture is the difference between the weight of an inch of the heavieſt, and of an inch of the lighteſt ingredients. The number of inches therefore of the heavieſt fluid is proportional to the addition made to the weight of the mixture. Therefore let B and b be the bulks of the heavieſt and lighteſt fluids in the bulk β of the mixture; and let D, d, and δ be the denſities, or the weights, or the ſpecific gravities (for they are in one ratio) of the heavy fluid, the light fluid, and the mixture (their bulk being that of the hydrometer). We have $\beta = B + b$. The addition which would have been made to the bulk β, if the lighteſt fluid were changed entirely for the heavieſt, would be $D - d$; and the change which is really made is $\delta - d$. Therefore $\beta : b = D - d : \delta - d$. For ſimilar reaſons we ſhould have $\beta : B = D - d : D - \delta$; or, in words, "*the difference between the ſpecific gravities of the two fluids, is to the difference between the ſpecific gravities of the mixture and of the lighteſt fluid, as the bulk of the whole to the bulk of the heavieſt contained in the mixture*;" and "*the difference of the ſpecific gravities of the two fluids, is to the difference of the ſpecific gravities of the mixture and of the heavieſt fluids, as the bulk of the whole to that of the lighteſt contained in the mixture.*" This is the form in which the ordinary buſineſs of life requires the anſwer to be expreſſed, becauſe we generally reckon the quantity of liquors by bulk, in gallons, pints, quarts. But it would have been equally eaſy to have obtained the anſwer in pounds and ounces; or it may be had from their bulk, ſince we know their ſpecific gravities.

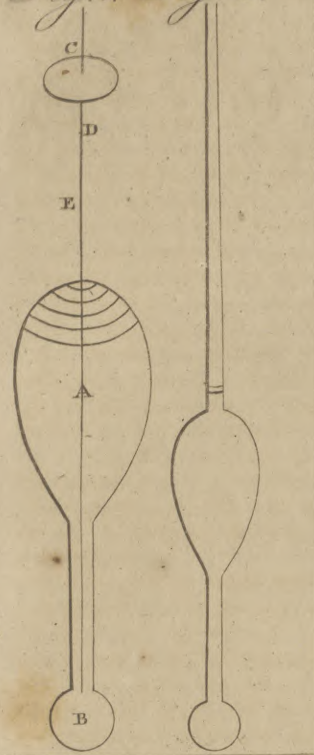
The hydrometer more commonly uſed is the ancient one of Hypatia, conſiſting of a ball A (fig. 2.) made ſteady by an addition B, below it like the former, but having a long ſtem CF above. It is ſo loaded that it ſinks to the top F of the ſtem in the lighteſt of all the fluids which we propoſe to meaſure with it, and to ſink only to C in the heavieſt. In a fluid of intermediate ſpecific gravity it will ſink to ſome point between C and F.

In this form of the hydrometer the weight is always the ſame, and the immediate information given by the inſtrument is that of different bulks with equal weight. Becauſe the inſtrument ſinks till the bulk of the diſplaced fluid equals it in weight, and the additions to the diſplaced fluid are all made by the ſtem, it is evident that equal bulks of the ſtem indicate equal additions of volume. Thus the ſtem becomes a ſcale of bulks to the ſame weight.

The only form in which the ſtem can be made with ſufficient accuracy is cylindrical or priſmatical. Such a ſtem may be made in the moſt accurate manner by wire-drawing, that is, paſſing it through a hole made in a hardened ſteel plate. If ſuch a ſtem be divided into equal parts, it becomes a ſcale of bulks in arithmetical progreſſion. This is the eaſieſt and moſt natural diviſion of the ſcale; but it will not indicate denſities, ſpecific gravities, or weights of the ſame bulk in arithmetical progreſſion. The ſpecific gravity is as the weight divided by the bulk. Now a ſeries of diviſors (the bulks), in arithmetical progreſſion, applied to the ſame dividend (the bulk and weight of the hydrometer as it floats in water), will not give a ſeries of quotients (the ſpecific gravities) in arithmetical progreſſion: they will be in what is called *harmonic progreſſion*, their differences continually diminiſhing. This will appear even when phyſically conſidered. When the hydrometer ſinks a tenth of an inch near the top of the ſtem, it diſplaces one tenth of an inch of a light fluid, compared with that diſplaced by it when it is floating with all the ſtem above the ſurface. In order therefore that the diviſions of the ſtem may indicate equal changes of ſpecific gravity, they muſt be in a ſeries of harmonic progreſſionals increaſing. The point at which the inſtrument floats in pure water ſhould be marked 1000, and thoſe above it 999, 998, 997, &c.; and thoſe

SPECIFIC Gravity.

Fig. 1. Fig. 2.



SPINNING Machinery.

Fig. 1.

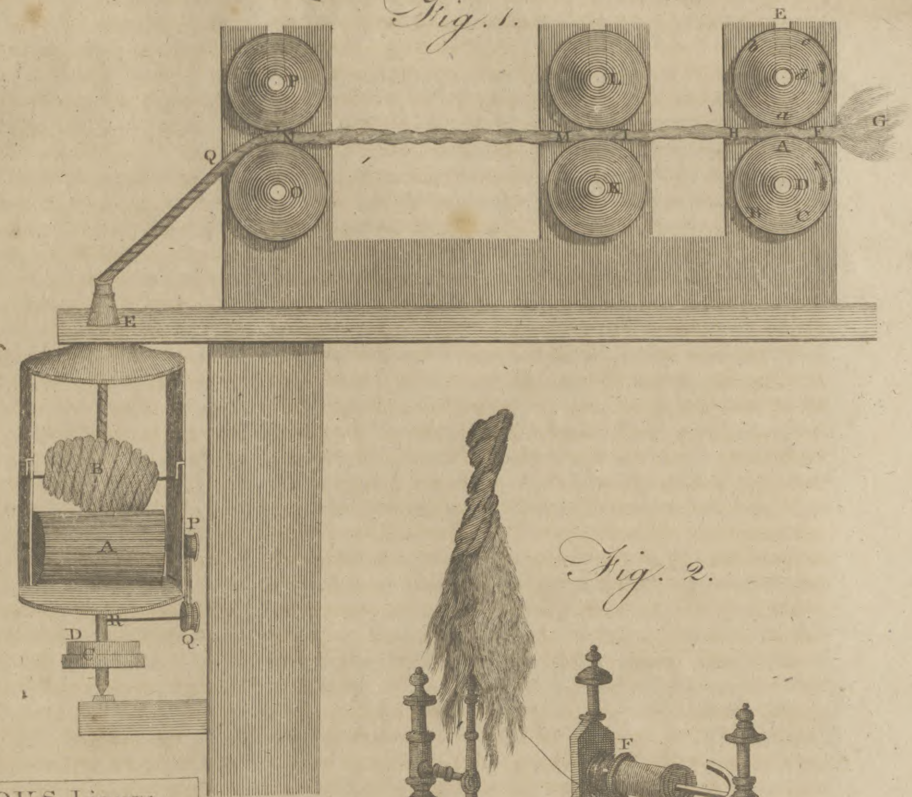
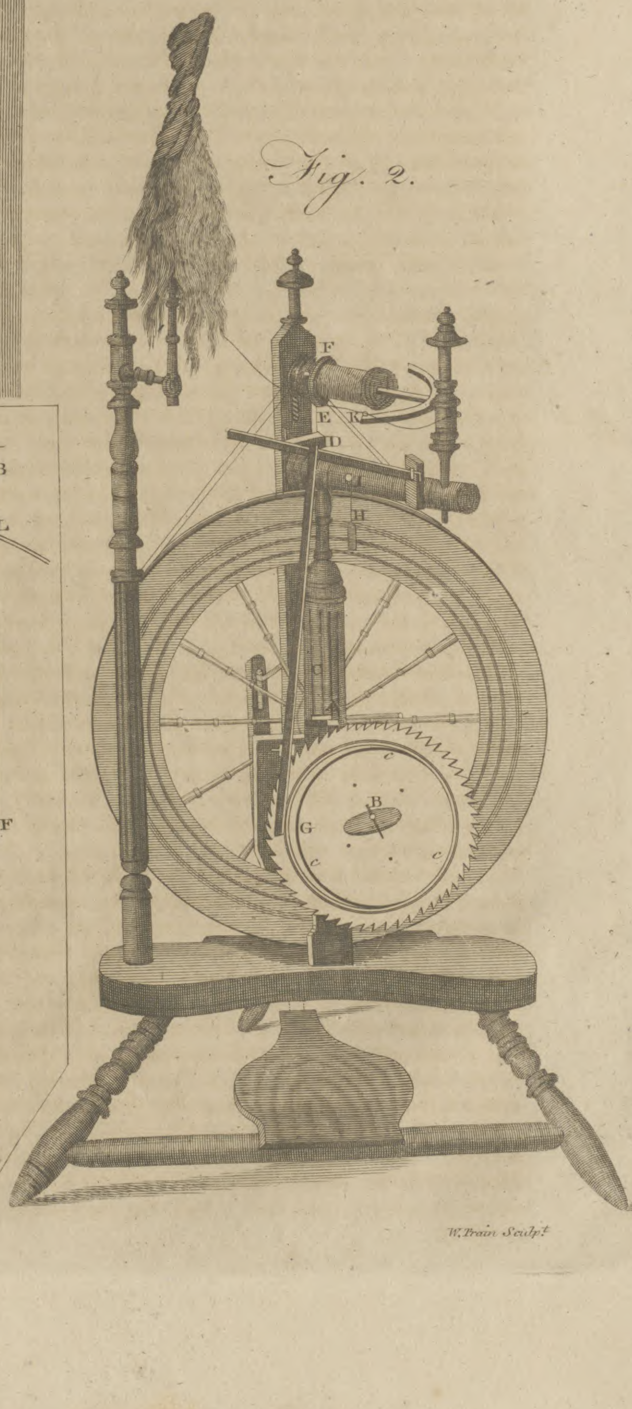


Fig. 2.



SPIRITUOUS Liquors.

Fig. 1.

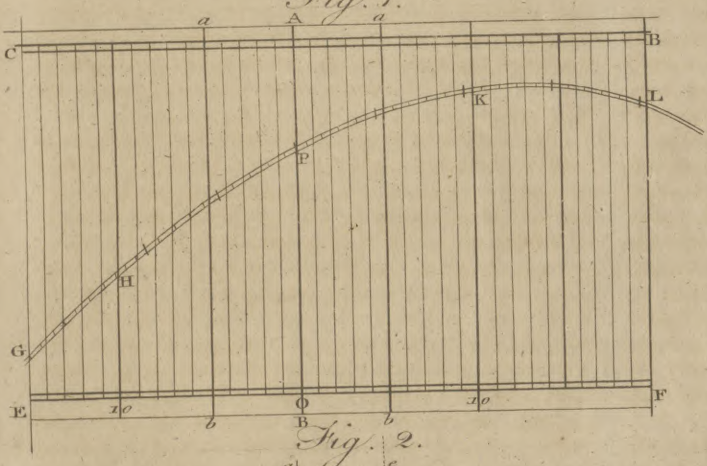
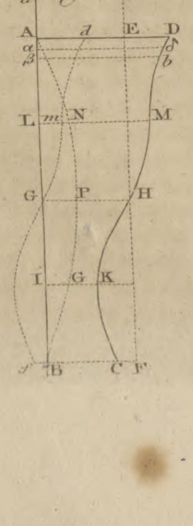


Fig. 2.



W. Prain Sculp^t.

those below the water mark must be numbered 1001, 1002, 1003, &c. Such a scale will be a very apposite picture of the densities of fluids, for the density or vicinity of the divisions will be precisely similar to the density of the fluids. Each interval is a bulk of fluid of the same weight. If the whole instrument were drawn out into wire of the size of the stem, the length from the water mark would be 1000.

Such are the rules by which the scale must be divided. But there must be some points of it determined by experiment, and it will be proper to take them as remote from each other as possible. For this purpose let the instrument be accurately marked at the point where it stands, in two fluids, differing as much in specific gravity as the instrument will admit. Let it also be marked where it stands in water. Then determine with the utmost precision the specific gravities of these fluids, and put their values at the corresponding points of the scale. Then the intermediate points of the scale must be computed for the different intervening specific gravities, or it must be divided from a pattern scale of harmonic progressionals in a way well known to the mathematical instrument-makers. If the specific gravities have been accurately determined, the value 1000 will be found to fall precisely in the water mark. If we attempt the division entirely by experiment, by making a number of fluids of different specific gravities, and marking the stem as it stands in them, we shall find the divisions turn out very anomalous. This is however the way usually practised; and there are few hydrometers, even from the best maker, that hold true to a single division or two. Yet the method by computation is not more troublesome; and one scale of harmonic progressionals will serve to divide every stem that offers. We may make use of a scale of equal parts for the stem, with the assistance of two little tables. One of these contains the specific gravities in harmonic progression, corresponding to the arithmetical scale of bulks on the stem of the hydrometer; the other contains the divisions and fractions of a division of the scale of bulks, which correspond to an arithmetical scale of specific gravities. We believe this to be the best method of all. The scale of equal parts on the stem is so easily made, and the little table is so easily inspected, that it has every advantage of accuracy and dispatch, and it gives, by the way, an amusing view of the relation of the bulks and densities.

We have hitherto supposed a scale extending from the lightest to the heaviest fluid. But unless it be of a very inconvenient length, the divisions must be very minute. Moreover, when the bulk of the stem bears a great proportion to that of the body, the instrument does not swim steady; it is therefore proper to limit the range of the instrument in the same manner as those of the first kind. A range from the density of ether to that of water may be very well executed in an instrument of very moderate size, and two others will do for all the heavier liquors; or an equal range in any other densities as may suit the usual occupations of the experimenter.

To avoid the inconveniences of a hydrometer with a very long and slender stem, or the necessity of having a series of them, a third sort has been contrived, in which the principles of both are combined. Suppose a hydrometer with a stem, whose bulk is $\frac{1}{10}$th of that of the ball, and that it sinks in ether to the top of the stem; it is evident that in a fluid which is $\frac{1}{10}$th heavier, the whole stem will emerge; for the bulk of the displaced fluid is now $\frac{1}{10}$th of the whole less, and the weight is the same as before, and therefore the specific gravity is $\frac{1}{10}$th greater.

Thus we have obtained a hydrometer which will indicate, by means of divisions marked on the stem, all specific gravities from 0.73 to 0.803; for 0.803 is $\frac{1}{10}$th greater than 0.73. These divisions must be made in harmonic progression, as before directed for an entire scale, placing 0.73 at the top of the stem and 0.803 at the bottom.

When it floats at the lowest division, a weight may be put on the top of the stem, which will again sink it to the top. This weight must evidently be 0.073, or $\frac{1}{10}$th of the weight of the fluid displaced by the unloaded instrument. The hydrometer, thus loaded, indicates the same specific gravity, by the top of the stem, that the unloaded instrument indicates by the lowest division. Therefore, when loaded, it will indicate another series of specific gravities, from 0.803 to 0.8833 (=0.803 + 0.0803), and will float in a liquor of the specific gravity 0.8833 with the whole stem above the surface.

In like manner, if we take off this weight, and put on 1 = 0.080.3, it will sink the hydrometer to the top of the stem; and with this new weight it will indicate another series of specific gravities from 0.8833 to 0.97163 (= 0.8833 + 0.08833). And, in the same manner, a third weight = 08833 will again sink it to the top of the stem, and fit it for another series of specific gravities up to 1.068793. And thus, with three weights, we have procured a hydrometer fitted for all liquors from ether to a wort for a malt liquor of two barrels per quarter. Another weight, in the same progression, will extend the instrument to the strongest wort that is brewed.

This is a very commodious form of the instrument, and is now in very general use for examining spirituous liquors, worts, ales, brines, and many such articles of commerce. But the divisions of the scale are generally adapted to the questions which naturally occur in the business. Thus, in the commerce of strong liquors, it is usual to estimate the article by the quantity of spirit of a certain strength which the liquor contains.— This we have been accustomed to call proof spirit, and it is such that a wine gallon weighs 7 pounds 12 ounces; and it is by this strength that the excise duties are levied. Therefore the divisions on the scale, and the weights which connect the successive repetitions of the scale, are made to express at once the number of gallons or parts of a gallon of proof spirits contained in a gallon of the liquor. Such instruments save all trouble of calculation to the exciseman or dealer; but they limit the use of a very delicate and expensive instrument to a very narrow employment. It would be much better to adhere to the expression either of specific gravity or of bulk; and then a very small table, which could be comprised in the smallest case for the instrument, might render it applicable to every kind of fluid.

The reader cannot but have observed that the successive weights, by which the short scale of the instrument is extended to a great range of specific gravities, do not increase by equal quantities. Each difference is the weight of the liquor displaced by the graduated stem of the instrument when it is sunk to the top of the

the

the fcale. It is a determined aliquot part of the whole weight of the inftrument fo loaded, (in our example it is always $\frac{1}{11}$th of it). It increafes therefore in the fame proportion with the preceding weight of the loaded inftrument. In fhort, both the fucceffive additions, and the whole weights of the loaded inftrument, are quantities in geometrical progreffion; and, in like manner, the divifions on the fcale, if they correfpond to equal differences of fpecific gravity, muft alfo be unequal—This is not fufficiently attended to by the makers; and they commit an error here, which is very confiderable when the whole range of the inftrument is great. For the value of one divifion of the fcale, when the largeft weight is on, is as much greater than its value, when the inftrument is not loaded at all, as the full loaded inftrument is heavier than the inftrument unloaded. No manner whatever of dividing the fcale will correfpond to equal differences of fpecific gravity through the whole range with different weights; but if the divifions are made to indicate equal *proportions* of gravity when the inftrument is ufed without a weight, they will indicate equal *proportions* throughout. This is evident from what we have been juft now faying; for the proportion of the fpecific gravities correfponding to any two immediately fucceeding weights is always the fame.

The beft way, therefore, of conftructing the inftrument, fo that the fame divifions of the fcale may be accurate in all its fucceffive repetitions with the different weights, is to make thefe divifions in geometrical progreffion. The correfponding fpecific gravities will alfo be in geometric proportion. Thefe being all inferted in a table, we obtain them with no more trouble than by infpecting the fcale which ufually accompanies the hydrometer. This table is of the moft eafy conftruction; for the ratio of the fucceffive bulks and fpecific gravities being all equal, the differences of the logarithms are equal.

This will be illuftrated by applying it to the example already given of a hydrometer extending from 0.73 to 1.068793 with three weights. This gives four repetitions of the fcale on the ftem. Suppofe this fcale divided into 10 parts, we have 40 fpecific gravities.—Let thefe be indicated by the numbers 0, 1. 2, 3, &c. to 40. The mark 0 is affixed to the top of the ftem, and the divifions downwards are marked 1, 2, 3, &c. the loweft being 10. Thefe divifions are eafily determined. The ftem, which we may fuppofe 5 inches long, was fuppofed to be $\frac{1}{10}$th of the capacity of the ball. It may therefore be confidered as the extremity of a rod of 11 times its length, or 55 inches; and we muft find nine mean proportionals between 50 and 55 inches. Subtract each of thefe from 55 inches, and the remainders are the diftances of the points of divifion from 0, the top of the fcale. The fmalleft weight is marked 10, the next 20, and the third 30. If the inftrument loaded with the weight 20 finks in fome liquor to the mark 7, it indicates the fpecific gravity 27, that is, the 27th of 40 mean proportionals between 0.73 and 1.068793, or 0.944242. To obtain all thefe intermediate fpecific gravities, we have only to fubtract 9 8633229, the logarithm of 0.73, from that of 1.068793, viz. 0.0288937, and take 0.0041393, the 40th part of the difference. Multiply this by 1, 2, 3, &c. and add the logarithm of 0.73 to each of the products. The fums are the logarithms of the fpecific gravities required. Thefe will be found to proceed fo equably, that they may be interpolated ten times by a fimple table of proportional parts without the fmalleft fenfible error. Therefore the ftem may be divided into a hundred parts very fenfible to the eye (each being nearly the 20th of an inch), and 406 degrees of fpecific gravity obtained within the range, which is as near as we can examine this matter by any hydrometer. Thus the fpecific gravities correfponding to N° 26, 27, 28, 29, are as follow:

		1ft Diff.	2d Diff.
26	0.93529		
27	0.94424	895	
28	0.95328	904	9
29	0.96241	913	9

Nay, the trouble of infpecting a table may be avoided, by forming on a fcale the logarithms of the numbers between 7300 and 1068.793, and placing along fide of it a fcale of the fame length divided into 400 equal parts, numbered from 0 to 400. Then, looking for the mark fhown by the hydrometer on this fcale of equal parts, we fee oppofite to it the fpecific gravity.

We have been thus particular in the illuftration of this mode of conftruction, becaufe it is really a beautiful and commodious inftrument, which may be of great ufe both to the naturalift and to the man of bufinefs.—A table may be comprifed in 20 octavo pages, which will contain the fpecific gravities of every fluid which can intereft either, and anfwer every queftion relative to their admixture with as much precifion as the obfervations can be made. We therefore recommend it to our readers, and we recommend the very example which we have given as one of the moft convenient. The inftrument need not exceed eight inches in length, and may be contained in a pocket cafe of two inches broad and as many deep, which will alfo contain the fcale, a thermometer, and even the table for applying it to all fluids which have been examined.

It is unfortunate that no graduated hydrometer can be made fo eafily for the examination of the corrofive mineral acids (A). Thefe muft be made of glafs, and we cannot depend on the accurate cylindric form of any glafs ftem. But if any fuch can be procured, the conftruction is the fame. The divided fcale may either be on thin paper pafted on the infide of the ftem, or it may be printed on the ftem itfelf from a plate, with ink made of a metallic calx, which will attach itfelf to the glafs with a very moderate heat. We would recommend common white enamel, or arfenical glafs, as the fitteft material for the whole inftrument; and the ink ufed, in taking the impreffion of the fcale, may be the fame that is ufed for the low-priced printing on Delft ware pottery.—Firft form the fcale on the ftem. Then, having meafured the folid contents of the graduated part as exactly as poffible, and determined on the general fhape of

(A) It would be worth while to try copper enamelled.

Specific Gravity.

of the ball and counterpoiſe below, calculate its ſize, ſo that it may be a little leſs than ten times that of the ſtem. The glaſs-blower can copy this very nearly, and join it to the ſtem. Then make two brines or other liquors, which ſhall have ſpecific gravities in the ratio of 10 to 11. Load the inſtrument ſo that it may ſink to 0 in the lighteſt. When put into the heavieſt, it ſhould riſe to 10. If it does not riſe ſo high, the immerſed part is too ſmall. Let the glaſs-blower enlarge the ball of the counterpoiſe a little. Repeat this trial till it be exact. Nothing now remains but to form the weights: And here we obſerve, that when the inſtrument is to have a very great range, as for examining all ſtates of the vitriolic acid, it has a chance of being very tottering when loaded with the greateſt weight on the top of ſo long a ſcale. To avoid this, Mr Quin and others have added ſome of their weights below.—But this will not ſuit the preſent conſtruction, becauſe it will alter the proportion between the bulks of the ſtem and immerſed part. Therefore let theſe weights conſiſt of cylinders of metal ſmall enough to go into the ſtem, and let them be ſoldered to the end of long wires, which will let them go to the bottom, and leave a ſmall hook or ring at top. Theſe can lie alongſide of the inſtrument in its caſe. This is indeed the beſt conſtruction for every hydrometer, becauſe it makes it incomparably more ſteady. The inſtrument is poiſed by ſmall ſhot or mercury. But it will be much better to do it with Newton's fuſible metal (three parts of tin, five parts of lead, and eight parts of biſmuth) in coarſe filings. When the exact quantity has been put in, the inſtrument may be ſet in a veſſel of oil, and this kept on the fire till all is completely melted. It ſoon freezes again, and remains faſt. If this metal is not to be had, let a few bits of ſealing-wax be added to the mercury or ſhot, to make up the counterpoiſe. When heated, it will float a-top, and when it freezes again it will keep all faſt. Thus we ſhall make a very complete and cheap inſtrument.

There is yet another method of examining the ſpecific gravities of fluids, firſt propoſed by Dr Wilſon, late profeſſor of aſtronomy in the univerſity of Glaſgow. This is by a ſeries of ſmall glaſs bubbles, differing equally, or according to ſome rule, from each other in ſpecific gravity, and each marked with its proper number. When theſe are thrown into a fluid which is to be examined, all thoſe which are heavier than the fluid will fall to the bottom. Then holding the veſſel in the hand, or near a fire or candle, the fluid expands, and one of the floating bubbles begins to ſink. Its ſpecific gravity, therefore was either equal to, or a little leſs than, that of the fluid; and the degree of the thermometer, when it began to ſink, will inform us how much it was deficient, if we know the law of expanſion of the liquor. Sets of theſe bubbles fitted for the examination of ſpirituous liquors, with a little treatiſe ſhowing the manner of uſing them, and calculating by the thermometer, are made by Mr Brown, an ingenious artiſt of Glaſgow, and are often uſed by the dealers in ſpirits, being found both accurate and expeditious.

Alſo, though a bubble or two ſhould be broken, the ſtrength of ſpirits may eaſily be had by means of the remainder, unleſs two or three in immediate ſucceſſion be wanting: for a liquor which anſwers to N° 4. will ſink N° 2. by heating it a few degrees, and therefore N° 3. may be ſpared. This is a great advantage in ordinary buſineſs. A nice hydrometer is not only an expenſive inſtrument, but exceedingly delicate, being ſo very thin. If broken or even bruiſed, it is uſeleſs, and can hardly be repaired except by the very maker.

As the only queſtion here is, to determine how many gallons of exciſe proof ſpirits is contained in a quantity of liquor, the artiſt has conſtructed this ſeries of bubbles in the ſimpleſt manner poſſible, by previouſly making 40 or 50 mixtures of ſpirits and water, and then adjuſting the bubbles to theſe mixtures. In ſome ſets the number on each bubble is the number of gallons of proof ſpirits contained in 100 gallons of the liquor. In other ſets the number on each bubble expreſſes the gallons of water which will make a liquor of this ſtrength, if added to 14 gallons of alcohol. Thus, if a liquor anſwers to N° 4, then 4 gallons of water added to 14 gallons of alcohol will make a liquor of this ſtrength. The firſt is the beſt method; for we ſhould be miſtaken in ſuppoſing that 18 gallons, which anſwer to N° 4, contains exactly 14 gallons of alcohol: it contains more than 14, for a reaſon to be given by and by.

By examining the ſpecific gravity of bodies, the philoſopher has made ſome very curious diſcoveries. The moſt remarkable of theſe is the change which the denſity of bodies ſuffers by mixture. It is a moſt reaſonable expectation, that when a cubic foot of one ſubſtance is mixed *any how* with a cubic foot of another, the bulk of the mixture will be two cubic feet; and that 18 gallons of water joined to 18 gallons of oil will fill a veſſel of 36 gallons. Accordingly this was never doubted; and even Archimedes, the moſt ſcrupulous of mathematicians, proceeded on this ſuppoſition in the ſolution of his famous problem, the diſcovery of the proportion of ſilver and gold in a mixture of both. He does not even mention it as a poſtulate that *may* be granted him, ſo much did he conceive it to be an axiom. Yet a little reflection ſeems ſufficient to make it doubtful and to require examination. A box filled with muſket-balls will receive a conſiderable quantity of ſmall ſhot, and after this a conſiderable quantity of fine ſand, and after this a conſiderable quantity of water. Something like this might happen in the admixture of bodies of porous texture. But ſuch ſubſtances as metals, glaſs, and fluids, where no diſcontinuity of parts can be perceived, or was ſuſpected, ſeem free from every chance of this kind of introſuſception. Lord Bacon, however, without being a naturaliſt or mathematician *ex profeſſo*, inferred from the mobility of fluids that they conſiſted of diſcrete particles, which muſt have pores interpoſed, whatever be their figure. And if we aſcribe the different denſities, or other ſenſible qualities, to difference in ſize or figure of thoſe particles, it muſt frequently happen that the ſmaller particles will be lodged in the interſtices between the larger, and thus contribute to the weight of the ſenſible maſs without increaſing its bulk. He therefore ſuſpects that mixtures will be in general leſs bulky than the ſum of their ingredients.

Accordingly, the examination of this queſtion was one of the firſt employments of the Royal Society of London, and long before its inſtitution had occupied the attention of the gentlemen who afterwards compoſed it. The regiſter of the Society's early meetings contains many experiments on this ſubject, with mixtures of gold and ſilver, of other metals, and of various fluids,

fluids, examined by the hydroſtatical balance of Mr Boyle. Dr Hooke made a prodigious number, chiefly on articles of commerce, which were unfortunately loſt in the fire of London.

It was ſoon found, however, that Lord Bacon's conjecture had been well founded, and that bodies changed their denſity very ſenſibly in many caſes. In general, it was found that bodies which had a ſtrong chemical affinity increaſed in denſity, and that their admixture was accompanied with heat.

By this diſcovery it is manifeſt that Archimedes had not ſolved the problem of detecting the quantity of ſilver mixed with the gold in King Hiero's crown, and that the phyſical ſolution of it requires experiments made on all the kinds of matter that are mixed together. We do not find that this has been done to this day, although we may affirm that there are few queſtions of more importance. It is a very curious fact in chemiſtry, and it would be moſt deſirable to be able to reduce it to ſome general laws: For inſtance, to aſcertain what is the proportion of two ingredients which produces the greateſt change of denſity. This is important in the ſcience of phyſics, becauſe it give us conſiderable information as to the mode of action of thoſe natural powers or forces by which the particles of tangible matter are united. If this introſuſception, concentration, compenetration, or by whatever name it be called, were a mere reception of the particles of one ſubſtance into the interſtices of thoſe of another, it is evident that the greateſt concentration would be obſerved when a ſmall quantity of the recipiend is mixed with, or diſſeminated through, a great quantity of the other. It is thus that a ſmall quantity of fine ſand will be received into the interſtices of a quantity of ſmall ſhot, and will increaſe the weight of the bagful without increaſing its bulk. The caſe is nowiſe different when a piece of freeſtone has grown heavier by imbibing or abſorbing a quantity of water. If more than a certain quantity of ſand has been added to the ſmall ſhot, it is no longer concealed. In like manner, various quantities of water may combine with a maſs of clay, and increaſe its ſize and weight alike. All this is very conceivable, occaſioning no difficulty.

But this is not the caſe in any of the mixtures we are now conſidering. In all theſe, the firſt additions of either of the two ſubſtances produce but an inconſiderable change of general denſity; and it is in general moſt remarkable, whether it be condenſation or rarefaction, when the two ingredients are nearly of equal bulks. We can illuſtrate even this difference, by reflecting on the imbibition of water by vegetable ſolids, ſuch as timber. Some kinds of wood have their weight much more increaſed than their bulks; other kinds of wood are more enlarged in bulk than in weight. The like happens in grains. This is curious, and ſhows in the moſt unqueſtionable manner that the particles of bodies are not in contact, but are kept together by forces which act at a diſtance. For this diſtance between the centres of the particles is moſt evidently ſuſceptible of variation; and this variation is occaſioned by the introduction of another ſubſtance, which, by acting on the particles by attraction or repulſion, diminiſhes or increaſes their mutual actions, and makes new diſtances neceſſary for bringing all things again into equilibrium. We refer the curious reader to the ingenious theory of the abbé Boſcovich for an excellent illuſtration of this ſubject (*Theor. Phil. Nat.* § de Solutione Chemica).

This queſtion is no leſs important to the man of buſineſs. Till we know the condenſation of thoſe metals by mixture, we cannot tell the quantity of alloy in gold and ſilver by means of their ſpecific gravity; nor can we tell the quantity of pure alcohol in any ſpirituous liquor, or that of the valuable ſalt in any ſolution of it. For want of this knowledge, the dealers in gold and ſilver are obliged to have recourſe to the tedious and difficult teſt of the aſſay, which cannot be made in all places or by all men. It is therefore much to be wiſhed, that ſome perſons would inſtitute a ſeries of experiments in the moſt intereſting caſes: for it muſt be obſerved, that this change of denſity is not always a ſmall matter; it is ſometimes very conſiderable and paradoxical. A remarkable inſtance may be given of it in the mixture of braſs and tin for bells, great guns, optical ſpeculums, &c. The ſpecific gravity of caſt braſs is nearly 8.006, and that of tin is nearly 7.363. If two parts of braſs be mixed with one of tin, the ſpecific gravity is 8.917; whereas, if each had retained its former bulk, the ſp. grav. would have been only $7.793\left(=\frac{2\times 8.006+7.363}{3}\right)$. A mixture of equal parts ſhould have the ſpecific gravity 7.684; but it is 8.441. A mixture of two parts tin with one part braſs, inſtead of being 7.577, is 8.027.

In all theſe caſes there is a great increaſe of ſpecific gravity, and conſequently a great condenſation of parts or contraction of bulk. The firſt mixture of eight cubic inches of braſs, for inſtance, with four cubic inches of tin, does not produce 12 cubic inches of bell-metal, but only $10\frac{1}{2}$ nearly, having ſhrunk $\frac{1}{8}$. It would appear that the diſtances of the braſs particles are moſt affected, or perhaps it is the braſs that receives the tin into its pores; for we find that the condenſations in theſe mixtures are nearly proportional to the quantities of the braſs in the mixtures. It is remarkable that this mixture with the lighteſt of all metals has made a compoſition more heavy and denſe than braſs can be made by any hammering.

The moſt remarkable inſtance occurs in mixing iron with platina. If 10 cubic inches of iron are mixed with $1\frac{1}{4}$ of platina, the bulk of the compound is only $9\frac{3}{4}$ inches. The iron therefore has not ſimply received the platina into its pores: its own particles are brought nearer together. There are ſimilar reſults in the ſolution of turbith mineral, and of ſome other ſalts, in water. The water, inſtead of riſing in the neck of the veſſel, when a ſmall quantity of the ſalt has been added to it, ſinks conſiderably, and the two ingredients occupy leſs room than the water did alone.

The ſame thing happens in the mixture of water with other fluids and different fluids with each other: But we are not able to trace any general rule that is obſerved with abſolute preciſion. In moſt caſes of fluids the greateſt condenſation happens when the bulks of the ingredients are nearly equal. Thus, in the mixture of alcohol and water, we have the greateſt condenſation when $16\frac{1}{2}$ ounces of alcohol are mixed with 20 ounces of water, and the condenſation is about $\frac{1}{36}$ of the whole bulk of the ingredients. It is extremely various in different ſubſtances, and no claſſification of them can be made in this reſpect.

A diſſertation has been publiſhed on this ſubject by Dr

Dr Hahn of Vienna, intitled *De Efficacia Mixtionis in mutandis Corporum Voluminibus*, in which all the remarkable inftances of the variation of denfity have been collected. All that we can do (as we have no directing principle) is to record fuch inftances as are of chief importance, being articles of commerce.

The firft that occurs to us is the mixtures of alcohol and water in the compofition of fpirituous liquors. This has been confidered by many with great care. The moft fcrupulous examination of this, or perhaps of any mixture, has been lately made by Dr Blagden (now Sir Charles Blagden) of the Royal Society, on the requifition of the Board of Excife. He has publifhed an account of the examination in the Philofophical Tranfactions of London in 1791 and 1792. We fhall give an account of it under the article SPIRITUOUS *Liquors*; and at prefent only felect one column, in order to fhow the condenfation. The alcohol was almoft the ftrongeft that can be produced, and its fpecific gravity, when of the temperature 60°, was 0.825. The whole mixtures were of the fame temperature.

Column 1. contains the pounds, ounces, or other meafures by weight, of alcohol in the mixture. Column 2. contains the pounds or ounces of water. Column 3. is the fum of the bulks of the ingredients, the bulk of a pound or ounce of water being accounted 1. Column 4. is the obferved fpecific gravity of the mixture, taken from Dr Blagden's differtation. Column 5. is the fpecific gravity which would have been obferved if the ingredients had each retained its own fpecific gravity. This we calculated by dividing the fum of the two numbers of the firft and fecond columns by the correfponding number of the third. Column 6. is the difference of column 4. and column 5. and exhibits the condenfation.

TABLE.

A.	W.	Volume.	Sp. Grav. obferved.	Sp. Grav. calculated.	Condenfation.
20	0	24.2424	0.8250	0.8250	00
20	1	25.2424	0.8360	0.8320	40
20	2	26.2424	0.8457	0.8383	74
20	3	27.2424	0.8543	0.8443	100
20	4	28.2424	0.8621	0.8498	123
20	5	29.2424	0.8692	0.8549	143
20	6	30.2424	0.8757	0.8597	160
20	7	31.2424	0.8817	0.8642	175
20	8	32.2424	0.8872	0.8684	188
20	9	33.2424	0.8923	0.8724	199
20	10	34.2424	0.8971	0.8761	216
20	11	35.2424	0.9014	0.8796	218
20	12	36.2424	0.9055	0.8829	226
20	13	37.2424	0.9093	0.8860	233
20	14	38.2424	0.9129	0.8891	238
20	15	39.2424	0.9162	0.8919	243
20	16	40.2424	0.9193	0.8946	247
20	17	41.2424	0.9223	0.8971	252
20	18	42.2424	0.9250	0.8996	254
20	19	43.2424	0.9276	0.9019	257
20	20	44.2424	0.9300	0.9041	259
19	20	43.0303	0.9325	0.9063	262
18	20	48.1182	0.9349	0.9087	262
17	20	40.6061	0.9375	0.9112	263
16	20	39.3939	0.9402	0.9139	263
15	20	38.1818	0.9430	0.9167	263
14	20	36.9697	0.9458	0.9197	261
13	20	35.7576	0.9488	0.9229	259
12	20	34.5455	0.9518	0.9263	255
11	20	33.3333	0.9549	0.9300	249
10	20	32.1212	0.9580	0.9340	240
9	20	30.9091	0.9612	0.9382	230
8	20	29.6970	0.9644	0.9429	215
7	20	28.4849	0.9675	0.9479	196
6	20	27.2727	0.9707	0.9533	174
5	20	26.0606	0.9741	0.9593	148
4	20	24.8485	0.9777	0.9659	118
3	20	23.6364	0.9818	0.9731	87
2	20	22.4242	0.9865	0.9811	54
1	20	21.2121	0.9924	0.9900	24
0	20	20.0000	1.0000	1.0000	

It is to be remarked, that the condenfation is greateft when $16\frac{1}{2}$ ounces of alcohol have been added to 20 of water, and the condenfation is $\frac{2633}{91835}$, or nearly $\frac{1}{36}$th of the computed denfity. Since the fpecific gravity of alcohol is 0.825, it is evident that $16\frac{1}{2}$ ounces of alcohol and 20 ounces of water have equal bulks. So that the condenfation is greateft when the fubftances are mixed in equal volumes; and 18 gallons of alcohol mixed with 18 gallons of water will produce not 36 gallons of fpirits, but 35 only.

We may alfo obferve, that this is the mixture to which our revenue laws refer, declaring it to be *one to fix* or *one in feven* under proof, and to weigh 7 pounds 13 ounce per gallon. This proportion was probably felected as the moft eafily compofed, viz. by mixing equal meafures of water and of the ftrongeft fpirit which the known proceffes of diftillation could produce. Its fpecific gravity is 0.939 very nearly.

We muft confider this elaborate examination of the mixture of water and alcohol as a ftandard feries of experiments, to which appeal may always be made, whether for the purpofes of fcience or of trade. The regularity of the progreffion is fo great, that in the column which we have examined, viz. that for temperature 60°, the greateft anomaly does not amount to one part in fix thoufand. The form of the feries is alfo very judicioufly chofen for the purpofes of fcience. It would perhaps have been more directly ftereometrical had the proportions of the ingredients been ftated in bulks, which are more immediately connected with denfity. But the author has affigned a very cogent reafon for his choice, viz. that the proportion of bulks varies by a change of temperature, becaufe the water and fpirits follow different laws in their expanfion by heat.

This is a proper opportunity for taking notice of a miftake which is very generally made in the conclufions drawn from experiments of this kind. Equal additions of the fpirit or water produce a feries of fpecific gravities, which decreafe or increafe by differences continually diminifhing. Hence it is inferred that there is a contraction of bulk. Even Dr Lewis, one of our moft accomplifhed

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compliſhed naturaliſts, advances this poſition, in a diſſertation on the potaſh of America; and it conſiderably affects his method for eſtimating the ſtrength of the potaſh leys. But that it is a miſtake, appears plainly from this, that although we add for ever equal quantities of the ſpirits, we ſhall never produce a *mixture* which has as ſmall a ſpecific gravity as alcohol. Therefore the ſeries of ſucceſſive gravities muſt approximate to this without end, like the ordinates of a hyperbolic curve referred to its aſſymptote.

That this may appear in the moſt general terms, let w repreſent the weight of the conſtant quantity of water in the mixture, and let a be the weight of the ſmall addition of ſpirits. Alſo let w repreſent the bulk of this quantity of water, and b the bulk of the ſmall addition of alcohol. The weight of the mixture is $w+a$, and its bulk is $w+b$, and its ſpecific gravity is $\frac{w+a}{w+b}$. If we now add a ſecond equal quantity of ſpirits, the weight will be $w+2a$, and if the ſpirit retains its denſity unchanged, the bulk will be $w+2b$, and the ſpecific gravity is $\frac{w+2a}{w+2b}$: and after any number m of ſuch equal additions of ſpirits, the ſpecific gravity will be $\frac{w+ma}{w+mb}$. Divide the numerator of this fraction by its denominator, and the quotient or ſpecific gravity will be $1+\frac{m\times\overline{a-b}}{w+mb}$. This conſiſts of the conſtant part 1, and the variable part $\frac{m(a-b)}{w+mb}$. We need attend only to this part. If its denominator were conſtant, it is plain that the ſucceſſive ſpecific gravities would have equal differences, each being $=\frac{a-b}{w+mb}$, becauſe m increaſes by the continual addition of an unit, and $a-b$ is a conſtant quantity. But the denominator $w+mb$ continually increaſes, and therefore the value of the fraction $\frac{a-b}{w+mb}$ continually diminiſhes.

Therefore the gradual diminution of the increments or decrements of ſpecific gravity, by equal additions of one ingredient to a conſtant meaſure of the other, is not of itſelf an indication of a change of denſity of either of the ingredients; nor proves that in very diluted mixtures a greater proportion of one ingredient is abſorbed or lodged in the interſtices of the other, as is generally imagined. This muſt be aſcertained by comparing each ſpecific gravity with the gravity expreſſed by $1+\frac{w+m(a-b)}{w+mb}$.

This ſeries of ſpecific gravities reſembles ſuch a numerical ſeries as the following, 1; ....; 1.56; 1.163; 1.+69; &c. the terms of which alſo conſiſt of the conſtant integer 1, and the decimal fractions 0.156; 0.163; 0.169; &c. The fraction $\frac{m(a-b)}{w+mb}$ expreſſes this decimal part. Call this d, or make $d=\frac{m(a-b)}{w+mb}$. This will give us $b=\frac{ma-wd}{m(1+d)}$. Now a is the weight of the added ingredient, and d is the variable part of the ſpecific gravity obſerved; and thus we learn whether b, the bulk of the added ingredient, ſuffers any change. We ſhall have occaſion by and by to reſume the conſideration of this queſtion, which is of the firſt moment in the theory of ſpecific gravities, and has great influence in many tranſactions of commerce.

This ſeries of ſpecific gravities is not ſo well fitted for commercial tranſactions. In theſe the uſual queſtion is, how many gallons of alcohol is there in a caſk, or ſome number of gallons of ſpirit? and it is more directly anſwered by means of a table, formed by mixing the ingredients in aliquant parts of one conſtant bulk. The following table, conſtructed from the experiments of Mr Briſſon of the academy of Paris, and publiſhed in the Memoirs for 1769, is therefore inſerted.

W.	A.	Denſity obſerved.	Denſity computed.	Condenſation.	Bulk of 10.000 grains..
0	16	0.8371	0.8371		1.0000
1	15	0.8527	0.8473	63	0.9937
2	14	0.8674	0.8575	115	0.9885
3	13	0.8815	0.8677	157	0.9844
4	12	0.8947	0.8778	189	0.9811
5	11	0.9075	0.8880	214	0.9786
6	10	0.9199	0.8982	235	0.9765
7	9	0.9317	0.9084	251	0.9749
8	8	0.9427	0.9186	256	0.9744
9	7	0.9519	0.9287	243	0.9757
10	6	0.9598	0.9389	217	0.9783
11	5	0.9674	0.9491	189	0.9811
12	4	0.9733	0.9593	144	0.9856
13	3	0.9791	0.9695	99	0.9901
14	2	0.9852	0.9796	57	0,9943
15	1	0.9919	0.9898	21	0.9979
16	0	1.0000	1.0000		1.0000

In this table the whole quantity of ſpirituous liquor is always the ſame. The firſt column is the number of meaſures (gallons, pints, inches, &c.) of water in the mixture: and column 2d gives the meaſures of alcohol. Column 3d is the ſpecific gravity which was obſerved by Mr Briſſon. Column 4th is the ſpecific gravity which would have been obſerved if the ſpirits, or water, or both, had retained their ſpecific denſity unchanged. And the 5th column marks the augmentation of ſpecific gravity or denſity in parts of 10.000. A 6th column is added, ſhowing the bulk of the 16 cubic meaſures of the two ingredients. Each meaſure may be conceived as the 16th part of 10.000, or 625; and we may ſuppoſe them cubic inches, pints, gallons, or any ſolid meaſure.

This table ſcarcely differs from Sir Charles Blagden's; and the very ſmall difference that may be obſerved, ariſes from Mr Briſſon's having uſed an alcohol not ſo completely rectified. Its ſpecific gravity is 9,8371, whereas the other was only 0.8250.

Here it appears more diſtinctly that the condenſation is greateſt when the two ingredients are of equal bulk.

Perhaps this ſeries of ſpecific gravities is as declarative as the other, whether or not there is a change of denſity induced in either of the ingredients. The whole

whole bulk being always the same, it is plain that the successive equal additions to one of the ingredients is a successive equal abstraction of the other. The change produced, therefore, in the weight of the whole, is the difference between the weight of the ingredient which is taken out and the weight of the equal measure of the other which supplies its place. Therefore, if neither ingredient changes its density by mixture, the weights of the mixtures will be in arithmetical progression. If they are not, there is a variation of density in one or both the ingredients.

We see this very clearly in the mixtures of water and alcohol. The first specific gravity differs from the second by 156, and the last differs from the preceding by no more than 81. Had neither of the densities changed, the common difference would have been 102. We observe also, that the augmentation of specific gravity, by the successive addition of a measure of water, grows less and less till 12 measures of water is mixed with 4 of alcohol, when the augmentation is only 58, and then it increases again to 81.

It also appears, that the addition of one measure of water to a quantity of alcohol produces a greater change of density than the mixture of one measure of alcohol to a quantity of water. Hence some conclude, that the water disappears by being lodged in the interstices of the spirit. But it is more agreeable to the justest notions which we can form of the internal constitution of tangible bodies to suppose that the particles of water diminish the distances between the particles of alcohol by their strong attractions, and that this diminution (exceedingly minute in itself) becomes sensible on account of the great number of particles whose distances are thus diminished. This is merely a probability founded on this, that it would require a much greater diminution of distances if it was the particles of water which had their distances thus diminished. But the greater probability is, that the condensation takes place in both.

We have been so particular in our consideration of this mixture, because the law of variation of density has, in this instance, been ascertained with such precision by the elaborate examination of Sir Charles Blagden, so that it may serve as an example of what happens in almost every mixture of bodies. It merits a still farther discussion, because it is intimately connected with the action of the corpuscular forces; and an exact knowledge of the variations of distance between the particles will go far to ascertain the law of action of these forces. But the limits of a work like this will not permit us to dwell longer on this subject. We proceed therefore to give another useful table.

The vitriolic or sulphuric acid is of extensive use in manufactures under the name of oil of vitriol. Its value depends entirely on the saline ingredient, and the water is merely a vehicle for the acid. This, being much denser than water, affects its specific gravity, and thus gives us a method of ascertaining its strength.

The strongest oil of vitriol that can be easily manufactured contains $612\frac{1}{10}$ grains of dry acid, united with $387\frac{1}{10}$ grains of water, which cannot be separated from it by distillation, making 1000 grains of OIL OF VITRIOL. Its specific gravity in this state is 1.877.

The following table shows its specific gravity at the temperature of 55° when diluted by the successive addition of parts of water by weight.

			Specific Gravity.		
Ol. Vit.		Water.	Observed.	Calculated.	Cond.
10	×	0	1.877	1.877	.00
		4	1.644	1.501	.143
		8	1.474	1.350	.124
		12	1.381	1.269	.112
		16	1.320	1.219	.101
		20	1.274	1.184	.090
		24	1.243	1.159	.084
		28	1.211	1.140	.071
		32	1.195	1.125	.070
		36	1.183	1.113	.070
		40	1.172	1.103	.070
		50	1.148	1.084	.064
		60	1.128	1.069	.059

Here is observed a much greater condensation than in the mixture of alcohol and water. But we cannot assign the proportion of ingredients which produces the greatest condensation; because we cannot, in any case, say what is the proportion of the saline and watery ingredients. The strongest oil of vitriol is already a watery solution; and it is by a considerable and uncertain detour that Mr Kirwan has assigned the proportion of 612 and 388 nearly. If this be the true ratio, it is unlike every other solution that we are acquainted with; for in all solutions of salts, the salt occupies less room in its liquid form than it did when solid; and here it would be greatly the reverse.

This solution is remarkable also for the copious emergence of heat in its dilutions with more water. This has been ascribed to the great superiority of water in its capacity for heat; but there are facts which render this very doubtful. A vessel of water, and another of oil of vitriol, being brought from a cold room into a warm one, they both imbibe heat, and rise in their temperature; and the water employs nearly the same time to attain the temperature of the room.

Aquafortis or nitrous acid is another fluid very much employed in commerce; so that it is of importance to ascertain the relation between its saline strength and its specific gravity. We owe also to Mr Kirwan a table for this purpose.

The most concentrated state into which it can easily be brought is such, that 1000 grains of it consists of 563 grains of water and 437 of dry acid. In this state its specific gravity is 1.557. Let this be called *nitrous acid.*

Nitr. Ac.		Water.			
10	×	0	1.557	1.557	
		1	1.474	1.474	
		6	1.350	1.273	0.077
		11	1.269	1.191	0.078
		16	1.214	1.147	0.067
		21	1.175	1.120	0.055
		26	1.151	1.101	0.050
		31	1.127	1.087	0.040
		36	1.106	1.077	0.029
		41	1.086	1.068	0.018

There is not the same uniformity in the densities of this acid in its different states of dilution. This seems owing

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owing to the variable proportion of the deleterious and vital air which compofe this acid. It is more denfe in proportion as it contains more of the latter ingredient.

The proportions of the aeriform ingredients of the muriatic acid are fo very variable, and fo little under our command, that we cannot frame tables of its fpecific gravity which would enable us to judge of its ftrength.

It is a general property of thefe acids, that they are more expanfible by heat as they are more concentrated.

There is another clafs of fluids which it would be of great confequence to reduce to fome rules with refpect to fpecific gravity, namely, the folutions of falts, gums, and refins. It is interefting to the philofopher to know in what manner falts are contained in thefe watery folutions, and to difcover the relation between their ftrength and denfity; and to the man of bufinefs it would be a moft defirable thing to have a criterion of the quantity of falt in any brine, or of extractable matter in a decoction. It would be equally defirable to thofe who are to purchafe them as to thofe who manufacture or employ them. Perhaps we might afcertain in this way the value of fugar, depending on the quantity of fweetening matter which it contains; a thing which at prefent refts on the vague determination of the eye or palate. It would therefore be doing a great fervice to the public, if fome intelligent perfon would undertake a train of experiments with this view. Accuracy alone is required; and it may be left to the philofophers to compare the facts, and draw the confequences refpecting the internal arrangement of the particles.

One circumftance in the folution of falts is very general; and we are inclined, for ferious reafons, to think it univerfal: this is a diminution of bulk. This indeed in fome falts is inconfiderable. Sedative falt, for inftance, hardly fhows any diminution, and might be confidered as an exception, were it not the fingle inftance. This circumftance, and fome confiderations connected with our notions of this kind of folution, difpofe us to think that this falt differs in contraction from others only in degree, and that there is fome, though it was not fenfible, in the experiments hitherto made.

Thefe experiments, indeed, have not been numerous. Thofe of Mr Achard of Berlin, and of Dr Richard Watfon of Cambridge, are perhaps the only ones of which we have a defcriptive narration, by which we can judge of the validity of the inferences drawn from them. The fubject is not fufceptible of much accuracy; for falts in their folid form are feldom free from cavities and fhivery interftices, which do not admit the water on their firft immerfion, and thereby appear of greater bulk when we attempt to meafure their fpecific gravity by weighing them in fluids which do not diffolve them, fuch as fpirits of turpentine. They alfo attach to themfelves, with confiderable tenacity, a quantity of atmofpheric air, which merely adheres, but makes no part of their compofition. This efcapes in the act of folution, being fet at liberty by the ftronger affinity of the water. Sal gem, however, and a few others, may be very accurately meafured; and in thefe inftances the degree of contraction is very conftant.

The following experiments of Dr Watfon appear to us the moft inftructive as to this circumftance. A glafs veffel was ufed, having a flender cylindrical neck, and holding 67 ounces of pure water when filled to a certain mark. The neck above this mark had a fcale of equal parts pafted on it. It was filled to the mark with water. Twenty-four pennyweights of falt were thrown into it as fpeedily as poffible, and the bulk of the falt was meafured by the elevation of the water. Every thing was attended to which could retard the immediate folution, that the error arifing from the folution of the firft particles, before the reft could be put in, might be as fmall as poffible; and in order that both the abfolute bulk and its variations might be obtained by fome known fcale, 24 pennyweights of water were put in. This raifed the furface 58 parts of the fcale. Now we know exactly the bulk of 24 pennyweights of pure water. It is 2.275 cubic inches; and thus we obtain every thing in abfolute meafures: And by comparing the bulk of each falt, both at its firft immerfion and after its complete folution, we obtain its fpecific gravity, and the change made on it in paffing from a folid to a fluid form. The following table is an abftract of thefe experiments. The firft column of numbers is the elevation of the furface immediately after immerfion; the fecond gives the elevation when the falt is completely diffolved; and the third and fourth columns are the fpecific gravities of the falts in thefe two ftates.

Twenty-four Pennyweights.	I.	II.	III.	IV.
Water -	58			
Glauber's falt -	42	36	1.380	1.611
Mild volatile alkali -	40	33	1.450	1.787
Sal ammoniac -	40	39	1.450	1.487
Refined white fugar -	39	36	1.487	1.611
Coarfe brown fugar -	39	36	1.487	1.611
White fugar candy -	37	36	1.567	1.611
Lymington Glauber's falt	35	29	1.657	2.000
Terra foliata tartari -	37	30	1.567	1.933
Rochelle falt -	33	28	1.757	2.071
Alum not quite diffolved	33	28	1.757	2.061
Borax not one-half diffolved in two days -	33	31	1.757	
Green vitriol -	32	26	1.812	2.230
White vitriol -	30	24	1.933	2.416
Nitre - -	30	21	1.933	2.766
Sal gem from Northwich	27	17	2.143	3.411
Blue vitriol -	26	20	2.230	2.900
Pearl afhes -	25	10	2.320	5.800
Tart. vitriolatus -	22	11	2.636	5.272
Green vitriol calcined to white -	22	11	2.636	5.272
Dry falt of tartar -	21	13	2.761	4.461
Bafket fea-falt -	19	15	3.052	3.866
Corrofive fublimate -	14	10	4.142	3.800
Turbith mineral -	9	0	6.444	

The infpection of this lift naturally fuggefts two ftates of the cafe as particularly interefting to the philofopher ftudying the theory of folution. The firft ftate is when the lixivium approaches to faturation. In the very point of faturation any addition of falt retains its bulk unchanged. In diluted brines, we fhall fee that the denfity

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fity of the fluid falt is greater, and gradually diminifhes as we add more falt. It is an important queftion, Whether this diminution goes on continually, till the fluid denfity of the falt is the fame with its folid denfity? or, Whether there is an abrupt paffage from fome degree of the one to the fixed degree of the other, as we obferve in the freezing of iron, the fetting of ftucco, and fome other inftances?

The other interefting ftate is that of extreme dilution, when the differences between the fucceffive denfities bear a great proportion to the denfities themfelves, and thus enable the mathematician to afcertain with fome precifion the variations of corpufcular force, in confequence of a variation of diftance between the particles. The fketch of an inveftigation of this important queftion given by Bofcovich, in his Theory of Natural Philofophy, is very promifing, and fhould incite the philofophical chemift to the ftudy. The firft thing to be done is to compare the law of fpecific gravity; that is, the relation between the fpecific gravity and quantity of falt held in folution.

Wifhing to make this work as ufeful as poffible, we have fearched for experiments, and trains of experiments, on the denfity of the many brines which make important articles of commerce; but we were mortified by the fcantinefs of the information, and difappointed in our hopes of being able to combine the detached obfervations, fuited to the immediate views of their authors, in fuch a manner as to deduce from them fcales (as they may be called) of their ftrength. We rarely found thefe detached obfervations attended with circumftances which would connect them with others; and there was frequently fuch a difcrepancy, nay oppofition, in feriefes of experiments made for afcertaining the relation between the denfity and the ftrength, that we could not obtain general principles which enable us to conftruct tables of ftrength *à priori*.

Mr Lambert, one of the firft mathematicians and philofophers of Europe, in a differtation in the Berlin Memoirs (1762), gives a narration of experiments on the brines of common falt, from which he deduces a very great condenfation, which he attributes to an abforption in the weak brines of the falt, or a lodgement of its particles in the interftices of the particles of water. Mr Achard of the fame academy, in 1785, gives a very great lift of experiments on the bulks of various brines, made in a different way, which fhow no fuch introfufception; and Dr Watfon thinks this confirmed by experiments which he narrates in his Chemical Effays. We fee great reafon for hefitating our affent to either fide, and do not think the experiments decifive. We incline to Mr Lambert's opinion; for this reafon, that in the fucceffive dilutions of oil of vitriol and aquafortis there is a moft evident and remarkable condenfation. Now what are thefe but brines, of which we have not been able to get the faline ingredient in a feparate form? The experiments of Mr Achard and Dr Watfon were made in fuch a way that a fingle grain in the meafurement bore too great a proportion to the whole change of fpecific gravity. At the fame time, fome of Dr Watfon's are fo fimple in their nature that it is very difficult to with-hold the affent.

In this ftate of uncertainty, in a fubject which feems to us to be of public importance, we thought it our duty to undertake a train of experiments to which recourfe may always be had. Works like this are feldom confidered as fources of original information; and it is thought fufficient when the knowledge already diffufed is judicioufly compiled. But a due refpect for the public, and gratitude for the very honourable reception hitherto given to our labours, induce us to exert ourfelves with honeft zeal to merit the continuance of public favour. We affure our readers that the experiments were made with care, and on quantities fufficiently large to make the unavoidable irregularities in fuch cafes quite infignificant. The law of denfity was afcertained in each fubftance in two ways. We diffolved different portions of falt in the fame quantity of water, and examined the fpecific gravity of the brine by weighing it in a veffel with a narrow neck. The portions of falt were each of them one-eighth of what would make a nearly faturated folution of the temperature 55. We did not make the brine ftronger, that there might be no rifk of a precipitation in form of cryftals. We confidered the fpecific gravities as the ordinates of a curve, of which the abfciffæ were the numbers of ounces of dry falt contained in a cubic foot of the brine. Having thus obtained eight ordinates correfponding to 1, 2, 3, 4, 5, 6, 7, and 8 portions of falt, the ordinates or fpecific gravities for every other proportion of falt were had by the ufual methods of interpofition.

The other method was, by firft making a brine nearly faturated, in which the proportion of falt and water was exactly determined. We then took out one-eighth of the brine, and filled up the veffel with water, taking care that the mixture fhould be complete; for which purpofe, befides agitation, the diluted brine was allowed to remain 24 hours before weighing. Taking out one-eighth of the brine alfo takes out one eighth of the falt; fo that the proportion of falt and water in the diluted brine was known. It was now weighed, and thus we determined the fpecific gravity for a new proportion of falt and water.

We then took out one-feventh of the brine. It is evident that this takes out one-eighth of the original quantity of falt; an abftraction equal to the former. We filled the veffel with water with the fame precautions; and in the fame manner we proceeded till there remained only one-eighth of the original quantity of falt.

The fpecific gravities by thefe two methods agreed extremely well. In the very deliquefcent falts the firft method exhibited fome fmall irregularities, arifing from the unequal quantities of water which they had imbibed from the atmofphere. We therefore confided moft in the experiments made with diluted brines.

That the reader may judge of the authority of the tables which we fhall infert, we fubmit to his infpection one feries of experiments.

Two thoufand one hundred and eighty-eight grains of very pure and dry (but not decrepitated) common falt, prepared in large cryftals, were diffolved in 6562 grains of diftilled water of the temperature 55°. A fmall matrafs with a narrow neck, which held 4200 grains of diftilled water, was filled with this brine. Its contents weighed 5027 grains. Now $6562 + 2188 : 2188 = 5027 : 1256.75$. Therefore the bottle of brine contained 1256.75 grains of falt diffolved in 3770.25 grains of water. Its fpecific gravity is $= \frac{5027}{4200}$, or 1.196905; and a cubic foot of brine weighs

1196.9

1196.9 ounces avoirdupois. Also 5027 : 1256.75 = 1196.9 : 299.28. Therefore a cubic foot of this brine contains 299.28 ounces of perfectly dry salt.

The subsequent steps of the process are represented as follows.

Salt.	Brine.	Water.	Wt. of Cub. Ft.	Salt in Cub. Ft.
8)1256.75	8)5027	3770.25	1196.9	299.28
157.1	628.4	$=\frac{1}{8}$ of brine.		$37.41\frac{1}{8}$
	4398.6	Remains.		
	527.4	Water to fill it again.		
7)1099.6	7)4926.0	2d Brine.	1172.7	261.87
157.1	703.7	$\frac{1}{7}$ taken out.		37.41
	4222.3			
	604.7	Water added.		
942.5	6)4827.0	3d Brine.	1149.3	224.46
157.1	804.5	Taken out.		
	4022.5	Remains.		
	706.5	Water added.		
785.4	5)4729.0	4th Brine.	1125.9	187.05
157.1	946	Taken out.		
	3783	Remains.		
	847	Water added.		
628.3	4)4630	5th Brine.	1102.3	149.64
157.1	1157.5	Taken out.		
	3472.5	Remains.		
	1054.5	Water added.		
471.2	3)4527	6th Brine.	1077.9	112.23
157.1	1509	Taken out.		
	3018	Remains.		
	1405	Water added.		
314.1	2)4423	7th Brine.	1053.3	74.82
157.1	2212	Taken out.		
	2211	Remains.		
	2102	Water added.		
157.0	4313	8th Brine.	1027.9	37.41

Thus, by repeated abstraction of brine, so as always to take out $\frac{1}{8}$th of the salt contained in one constant bulk, we have obtained a brine consisting of 157 grains of salt united with 4313—157, or 4156 grains of water. Its specific gravity is $\frac{4313}{4200}$,=1,0279, and a cubic foot of it weighs 1028 ounces, and contains $37\frac{4}{10}$ ounces of dry salt. In like manner may the specific gravity, the weight of a cubic foot, and the salt it contains, be estimated for the intermediate brines.

When these eight quantities of salt contained in a cubic foot are made the abscissæ, and the weights of the cubic foot of brine are the corresponding ordinates, the curve will be found to be extremely regular, resembling a hyperbolic arch whose assymptote makes an angle of 30° with the axis. Ordinates were then interpolated analytically for every 10 ounces of contained salt, and thus the table was constructed. We did not, however, rest it on one series alone; but made others, in which one-fourth of the salt was repeatedly abstracted. They agreed, in the case of common salt, with great exactness, and in some others there were some very inconsiderable irregularities.

To show the authority of the tables of strength was by no means our only motive for giving an example of the process. It may be of use as a pattern for similar experiments. But, besides, it is very instructive. We see, in the first place, that there is a very sensible change of density in one or both of the ingredients. For the series is of that nature (as we have formerly explained), that if the ingredients retained their densities in every proportion of commixture, the specific gravities would have been in arithmetical progression; whereas we see that their differences continually diminish as the brines grow more dense. We can form some notion of this by comparing the different brines. Thus in the first brine, weighing 5027 grains, there are 3770 grains of water in a vessel holding 4200. If the density of the water remains the same, there is left for the salt only as much space as would hold 430 grains of water. In this space are lodged 1257 grains of salt, and its specific gravity, in its liquid form, is $\frac{1257}{430}$, = 2.8907 very nearly. But in the 8th brine the quantity of water is 4156, the space left for 157 grains of salt is only the bulk of 44 grains of water, and the density of the salt is $\frac{157}{44}$=3.568, considerably greater than before. This induced us to continue the dilution of the brine as follows, beginning with the 8th brine.

157	2)4313	8th brine
78.5	2156.5	
	2156.5	
	2105.5	
78.5	2)4262.0	9th brine
39.7	2131	
	2102	
39.7	2)4233	10th brine
	2116.5	
	2116.5	
	2102	
19.8	4218	11th brine.

This last brine contains 4198.2 grains of water, leaving only the bulk of 1.8 grains of water to contain 19.8 of salt, so that the salt is ten times denser than water. This will make the strength 243 instead of 210 indicated by the specific gravity. But we do not pretend to measure the densities with accuracy in these diluted brines. It is evident from the process that a single

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single grain of excess or defect in taking out the brine and replacing it with water has a sensible proportion to the whole variation. But we see with sufficient evidence, that from the strong to the weak brines the space left for the portion of salt is continually diminishing. In the first dilution $527\frac{1}{2}$ grains of water were added to fill up the vessel; but one-eighth of its contents of pure water is only 525: so that here is a diminution of two grains and a half in the space occupied by the remaining salt. The subsequent additions are 604.7; 706.5; 847; 1054.5; 1405; 2102; 2105.5; 2102; 2102; instead of 600; 700; 840; 1050; 1400; 2100; 2100; 2100; 2100. Nothing can more plainly show the condensation in general, though we do not learn whether it happens in one or both of the ingredients; nor do the experiments show with sufficient accuracy the progression of this diminution. The excesses of the added water being only six or seven grains, we cannot expect a nice repartition. When the brine is taken out, the upper part of the vessel remains lined with a briny film containing a portion of salt and water, perhaps equal or superior to the differences. Had our time permitted, we should have examined this matter with scrupulous attention, using a vessel with a still narrower neck, and in each dilution abstracting one half of the brine. The curve, whose abscissæ and ordinates represent the weight of the contained salt and the weight of a constant bulk of the brine, exhibits the best and most synoptical view of the law of condensation, because the position of the tangent in any point, or the value of the symbol $\frac{\dot{x}}{\dot{y}}$, always shows the rate at which the specific gravity increases or diminishes. We are inclined to think that the curve in all cases is of the hyperbolic kind, and complete; that is, having the tangent perpendicular to the axis at the beginning of the curve. The mathematical reader will easily guess the physical notions which incline us to this opinion; and will also see that it is hardly possible to discover this experimentally, because the mistake of a single grain in the very small ordinates will change the position of the tangent many degrees. It was for this reason that we thought it useless to prosecute the dilution any farther. But we think that it may be prosecuted much farther in Dr Watson's or Mr Achard's method, viz. by dissolving equal weights of salt in two vessels, of very different capacities, having tubular necks, in which the change of bulk may be very accurately observed. We can only conclude, that the condensation is greatest in the strongest brines, and probably attains its maximum when the quantities of true saline matter and water are nearly equal, as in the case of vitriolic acid, &c.

We consider these experiments as abundantly sufficient for deciding the question "Whether the salt can be received into the pores of the water, or the water into the pores of the salt, so as to increase its weight without increasing its bulk? and we must grant that it may. We do not mean that it is simply lodged in the pores as sand is lodged in the interstices of small shot; but the two together occupy less room than when separate. The experiments of Mr Achard were insufficient for a decision, because made on so small a quantity as 600 grains of water. Dr Watson's experiments have, for the most part, the same defect. Some of them, however, are of great value in this question, and are very fit for ascertaining the specific gravity of dissolved salts. In one of them (not particularly narrated) he found that a quantity of dissolved salt occupied the same bulk in two very different states of dilution. We cannot pretend to reconcile this with our experiments. We have given these as they stood; and we think them conclusive, because they were so numerous and so perfectly consistent with each other; and their result is so general, that we have not found an exception. Common salt is by no means the most remarkable instance of condensation. Vegetable alkali, sal ammoniac, and some others, exhibit much condensation.

We thought this a proper opportunity of considering this question, which is intimately connected with the principles of chemical solution, and was not perhaps considered in sufficient detail under the article CHEMISTRY. We learn from it in general, that the quantities of salt in brines increase at somewhat a greater rate than their specific gravities. This difference is in many cases of sensible importance in a commercial view. Thus an alkaline lixivium for the purposes of bleaching or soap-making, whose specific gravity is 1.234, or exceeds that of water by 234, contains 361 ounces of salt in a cubic foot; a ley, which exceeds the weight of water twice as much, or 468 ounces per cubic foot, contains 777 ounces of salt, which exceeds the double of 361 by 55 ounces more that seven per cent. Hence we learn, that hydrometers for discovering the strength of brines, having equal divisions on a cylindrical stem, are very erroneous; for even if the increments of specific gravity were proportional to the quantities of salt in a gallon of brine, the divisions at the bottom of the stem ought to be smaller than those above.

The construction of the following table of strengths from the above narrated series of brines is sufficiently obvious. Column 1st is the specific gravity as discovered by the balance or hydrometer, and also is the number of ounces in a cubic foot of the brine. Col. 2d is the ounces of the dry salt contained in it.

TABLE of Brines of Common Salt.

Weight Cub Ft. Brine.	Salt in Cub.Ft.	Weight Cub. Ft. Brine.	Salt in Cub.Ft.
1.000	0	1.115	170
1.008	10	1.122	180
1.015	20	1.128	190
1.022	30	1.134	200
1.029	40	1.140	210
1.036	50	1.147	220
1.043	60	1.153	230
1.050	70	1.159	240
1.057	80	1.165	250
1.064	90	1.172	260
1.070	100	1.178	270
1.077	110	1.184	280
1.083	120	1.190	290
1.090	130	1.197	300
1.096	140	1.203	310
1.103	150	1.206	316
1.109	160	1.208	320

The

The table differs conſiderably from Mr Lambert's. The quantities of ſalt correſponding to any ſpecific gravity are about $\frac{1}{18}$th leſs than in his table. But the reader will ſee that they correſpond with the ſeries of experiments above narrated; and theſe were but a few of many which all correſponded within an hundredth part. The cauſe of the difference ſeems to be, that moſt kinds of common ſalt contain magneſian ſalts, which contain a very great proportion of water neceſſary for their cryſtallization. The ſalt which we uſed was of the pureſt kind, but ſuch as may be had from every ſalt work, by Lord Dundonald's very eaſy proceſs, viz. by paſſing through it a ſaturated ſolution boiling hot, which carries off with it about four-fifths of all the bitter ſalts. Our aim being to aſcertain the quantities of pure ſea-ſalt, and to learn by the bye its relation to water in reſpect of denſity, we thought it neceſſary to uſe the pureſt ſalt. We alſo dried it for ſeveral days in a ſtove, ſo that it contained no water not abſolutely neceſſary for its cryſtallization. An ounce of ſuch ſalt will communicate a greater ſpecific gravity to water than an ounce of a ſalt that is leſs pure, or that contains extraneous water.

The ſpecific gravity 1.090 is that of ordinary pickles, which are eſtimated as to ſtrength by floating an egg.

We cannot raiſe the ſpecific gravity higher than 1.206 by ſimply diſſolving ſalt in cold water. But it will become much denſer, and will even attain the ſpecific gravity 1.240 by boiling, then holding about 366 ounces in the cubic foot of hot brine. But it will depoſit by cooling, and when of the temperature 55° or 60°, hardly exceeds 1,206. We obtained a brine by boiling till the ſalt grained very rapidly. When it cooled to 60°, its ſpecific gravity was 1.2063; for a veſſel which held 3506 grains of diſtilled water held 4229 of this brine. This was evaporated to dryneſs, and there were obtained 1344 grains of ſalt. By this was computed the number interpoſed between 310 and 320 in the table. We have, however, raiſed the ſpecific gravity to 1.217, by putting in no more ſalt than was neceſſary for this denſity, and uſing heat. It then cooled down to 60° without quitting any ſalt; but if a few grains of ſalt be thrown into this brine, it will quickly depoſit a great deal more, and its denſity will decreaſe to 1.206. We find this to hold in all ſalts; and it is a very inſtructive fact in the theory of cryſtallization; it reſembles the effect which a magnet produces upon iron filings in its neighbourhood. It makes them temporary magnets, and cauſes them to arrange themſelves as if they had been really made permanent magnets. Juſt ſo a cryſtal already formed diſpoſes the reſt to cryſtallize. We imagine that this analogy is complete, and that the forces are ſimilar in both caſes.

The above table is computed for the temperature 55°; but in other temperatures the ſtrength will be different on two accounts, viz. the expanſion of the brine and the diſſolving power of the water. Water expands about 40 parts in 1000 when heated from 60° to 212°. Saturated brine expands about 48 parts, or one-fifth more than water; and this exceſs of expanſion is nearly proportional to the quantity of ſalt in the brine. If therefore any circumſtance ſhould oblige us to examine a brine in a temperature much above 60°, allowance ſhould be made for this. Thus, ſhould the ſpecific gravity of brine of the temperature 130 (which is nearly half way between 60 and 212) be 1.140, we muſt increaſe it by 20 (half of 40); and having found the ſtrength 240 correſponding to this corrected ſpecific gravity, we muſt correct it again by adding 1 to the ſpecific gravity for every 45 ounces of ſalt.

But a much greater and more uncertain correction is neceſſary on account of the variation of the diſſolving power of water by heat. This indeed is very ſmall in the caſe of ſea-ſalt in compariſon with other ſalts. We preſume that our readers are appriſed of this peculiarity of ſea-ſalt, that it diſſolves nearly in equal quantities in hot or in cold water. But although water of the temperature 60 will not diſſolve more than 320 or 325 ounces of the pureſt and dryeſt ſea-ſalt, it will take up above 20 ounces more by boiling on it. When thus ſaturated to the utmoſt, and allowed to cool, it does not quit any of it till it is far cooled, viz. near to 60°. It then depoſits this redundant ſalt, and holds the reſt till it is juſt going to freeze, when it lets it go in the inſtant of freezing. If evaporated in the ſtate in which it continues to hold the ſalt, it will yield above 400 ounces per cubic foot of brine, in good cryſtals, but rather overcharged with water. And ſince in this ſtate the cubic foot of brine weighs about 1220 ounces, it follows, that 820 ounces of water will, by boiling, diſſolve 400 of cryſtallized ſalt.

The table ſhows how much any brine muſt be boiled down in order to grain. Having obſerved its ſpecific gravity, find in the table the quantity of ſalt correſponding. Call this x. Then, ſince a boiling hot graining or ſaturated ſolution contains 340 ounces in the cubic foot of brine, ſay $340 : 1000 = x : \frac{1000}{340} x$. This is the bulk to which every cubic foot (valued at 1000) muſt be boiled down. Thus ſuppoſe the brine has the ſpecific gravity 1109. It holds 160 ounces per foot, and we muſt boil it down to $\frac{1000 \times 160}{340}$ or 471; that is, we muſt boil off $\frac{529}{1000}$ of every cubit foot or gallon.

Theſe remarks are of importance in the manufacture of common ſalt; they enable us to appretiate the value of ſalt ſprings, and to know how far it may be prudent to engage in the manufacture. For the doctrine of latent heat aſſures us, that in order to boil off a certain quantity of water, a certain quantity of heat is indiſpenſably neceſſary. After the moſt judicious application of this heat, the conſumption of fuel may be too expenſive.

The ſpecific gravity of ſea water in theſe climates does not exceed 1.03, or the cubic foot weighs 1030 ounces, and it contains about 41 ounces of ſalt. The brine-pits in England are vaſtly richer; but in many parts of the world brines are boiled for ſalt which do not contain above 10 or 20 ounces in the cubic foot.

In buying ſalt by weight, it is of importance to know the degree of humidity. A ſalt will appear pretty dry (if free from magneſian ſalts) though moiſtened with one per cent. of water; and it is found that incipient humidity expoſes it much to farther deliqueſcence. A much ſmaller degree of humidity may be diſcovered by the ſpecific gravity of a brine made with a few ounces of the ſalt. And the inſpection of the table informs us, that

that the brine ſhould be weak; for the differences of ſpecific gravity go on diminiſhing in the ſtronger brines: 300 ounces of dry ſalt diſſolved in 897 ounces of water ſhould give the ſpecific gravity 1197. Suppoſe it be but 1190, the quantity of ſalt correſponding is only 290; but when mixed with 897 ounces of water, the weight is 1197, although the weight of the cubic foot is only 1190. There is therefore more than a cubic foot of the brine, and there is as much ſalt as will make more than a cubic foot of the weight 1190. There is $290 \times \frac{1197}{1190}$, or 291$\frac{2}{3}$ ounces, and there is 8$\frac{1}{3}$ ounces of water attached to the ſalt.

The various informations which we have pointed out as deducible from a knowledge of the ſpecific gravity of the brines of common ſalt, will ſerve to ſuggeſt ſeveral advantages of the knowledge of this circumſtance in other lixivia. We ſhall not therefore reſume them, but ſimply give another table or two of ſuch as are moſt intereſting. Of thoſe, alkaline leys are the chief, being of extenſive uſe in bleaching, ſoap-making, glaſs-making, &c.

We therefore made a very ſtrong ley of the pureſt vegetable alkali that is ever uſed in the manufactories, not thinking it neceſſary, or even proper, to take it in its ſtate of utmoſt purity, as obtained from cubic nitre and the like. We took ſalt of tartar from the apothecary, perfectly dry, of which 3983 grains were diſſolved in 3540 grains of diſtilled water; and after agitation for ſeveral days, and then ſtanding to depoſit ſediment, the clear ley was decanted. It was again agitated; becauſe, when of this ſtrength, it becomes, in a very ſhort time, rarer above and denſer at the bottom. A flaſk containing 4200 grains of water held 6165 of this ley when of the temperature 55°. Its ſpecific gravity was therefore 1.4678, and the 6165 grains of ley contained 3264 grains of ſalt. We examined its ſpecific gravity in different ſtates of dilution, till we came to a brine containing 51 grains of ſalt, and 4189 grains of water, and the contents of the flaſk weighed 4240 grains: its ſpecific gravity was therefore 1.0095. In this train of experiments the progreſſion was moſt regular and ſatiſfactory; ſo that when we conſtructed the curve of ſpecific gravities geometrically, none of the points deviated from a moſt regular curve. It was conſiderably more incurvated near its commencement than the curve for ſea-ſalt, indicating a much greater condenſation in the diluted brines. We think that the following table, conſtructed in the ſame manner as that for common ſalt, may be depended on as very exact.

Weight of Cub. Foot. oz.	Salt cont. oz.	Weight of Cub. Foot oz.	Salt cont oz.	Weight of Cub. Foot oz.	Salt cont. oz.	Weight of Cub. Foot oz.	Salt cont. oz.
1000	0	1174	260	1329	520	1471	780
1016	20	1187	280	1340	540	1482	800
1031	40	1200	300	1351	560	1493	820
1045	60	1212	320	1362	580	1504	840
1085	80	1224	340	1372	600	1515	860
1071	100	1236	360	1384	620	1526	880
1084	120	1248	380	1395	640	1537	900
1098	140	1259	400	1406	660	1547	920
1112	160	1270	420	1417	680	1557	940
1125	180	1281	440	1428	700	1567	960
1138	200	1293	460	1438	720	1577	980
1150	220	1305	480	1449	740	1586	1000
1162	240	1317	500	1460	760		

We ſee the ſame augmentation of the denſity of the ſalt in the diluted brines here as in the caſe of common ſalt. Thus a brine, of which the cubit foot weighs 1482 ounces, or which has the ſpecific gravity 1.482, contains 800 ounces of dry alkali and 682 of water. Therefore, if we ſuppoſe the denſity of the water unchanged, there remains the bulk of 318 ounces of water to receive 840 ounces of ſalt: its denſity is therefore $\frac{800}{318}$, $= 2.512$ nearly. But in the brine whoſe weight per foot is only 1016 there are 20 ounces of ſalt, and therefore 996 of water; and there is only four ounce-meaſures of water, that is, the bulk of four ounces of water, to receive 20 ounces of ſalt. Its ſpecific gravity therefore is $\frac{20}{4}$, $= 5$, almoſt twice as great as in the ſtrong brine. Accordingly Mr Achard is diſpoſed to admit the abſorption (as it is careleſsly termed) in the caſe of ſal tart. But it is a general (we think an univerſal) fact in the ſolution of ſalts. It muſt be carefully diſtinguiſhed from the firſt contraction of bulk which ſalts undergo in paſſing from a ſolid to a fluid form. The contraction now under conſideration is analogous to the contraction of oil of vitriol when diluted with water; for oil of vitriol muſt be conſidered as a very ſtrong brine which we cannot dephlegmate by diſtillation, and therefore cannot obtain the dry ſaline ingredient in a ſeparate form, ſo as to obſerve its ſolid denſity, and ſay how much it contracts in firſt becoming fluid. The way of conceiving the firſt contraction in the act of ſolution as a lodging of the particles of the one ingredient on the interſtices of theo ther, "*qu' ils ſe nichent, en augmentant le poids ſans affecter le volume de la ſaumure*," as Euler and Lambert expreſs themſelves, is impoſſible here, when both are fluids. Indeed it is but a ſlovenly way of thinking

Specific Gravity.

thinking in either cafe, and fhould be avoided, becaufe inadvertent perfons are apt to ufe as a phyfical principle what is merely a mode of fpeech.

We learn from the table, that a hydrometer with equi-diftant divifions on a cylindrical or prifmatical ftem is ftill more erroneous than in the brines of common falt.

We learn from the experiments of Kirwan, Lavoifier, and others, that dry falt of tartar contains about one-fourth of its weight of fixed air. In many applications of this falt to the purpofes of manufacture, this ingredient is of no ufe. In fome it is hurtful, and muft be abftracted by lime. Soap-maker's ley confifts of the pure alkaline falt diffolved in water. It is therefore of importance to afcertain its quantity by means of the fpecific gravity of the brine. For this purpofe we took a ley of fal tart. whofe fpecific gravity was 1.20417, containing 314 ounces of mild alkali in a cubic foot of ley, and we rendered it nearly cauftic by lime. The fpecific gravity was then 1.1897. This is a very unexpected refult. Nothing is employed with more fuccefs than quicklime for dephlegmating any watery fluid. We fhould rather have expected an increafe of fpecific gravity by the abftraction of fome of the water of the menftruum, and perhaps the water of the cryftallization, and the aerial part of the falt. But we muft afcribe this to the great denfity in which the fixed air exifts in the mild alkali.

It is unneceffary to give fimilar tables for all the falts, unlefs we were writing a differtation on the theory of their folution. We fhall only obferve, that we examined with particular attention fal ammoniac, becaufe Mr Achard, who denies what is called the abforption of falts, finds himfelf obliged to allow fomething like it in this falt. It does not, however, differ from thofe of which we have given an account in detail in any other refpect than this, that the changes of fluid denfity are much lefs than in others (inftead of being greater, as Achard's experiments feem to indicate) in all brines of moderate ftrength. But in the very weak brines there is indeed a remarkable difference; and if we have not committed an error in our examination, the addition of one part of fal ammoniac to 64 of water occupies lefs room than the water alone. We think that we have met with this as an accidental remark by fome author, whofe work we do not recollect. But we do not choofe to reft fo much on our form of the experiment in fuch weak brines. The following mixtures will abundantly ferve for conftructing the table of its ftrength: Sal ammoniac $=960$ grains was diffolved in 3506 grains of water, making a brine of 4466 grains. A phial which held 1600 grains water held 1698 of this brine. It contained $\frac{1698 \times 960}{4466}$, or 365 grains of falt. The fpecific gravity was $\frac{1698}{1600}$, $=1.061$, and the cubic foot weighed 1061 ounces. It alfo contained $\frac{1061 \times 365}{1698}$, or 288 ounces of falt. By repeated abftraction of brine, and replacing with water, we had the following feries:

Specific Gravity, Spectacles.

Series.		Brine.	Sp. Gr.	Oz. Salt in Cub. Ft.
Weight of brine,		1*ft*, 1698	1.061	228
After taking out $\frac{1}{2}$,		2*d*, 1676	1.048	171
After taking out $\frac{1}{2}$,		3*d*, 1653	1.033	114
After taking out $\frac{1}{2}$,		4*th*, 1630	1.019	57
After taking out $\frac{1}{2}$,		5*th*, 1616	1.010	$28\frac{1}{2}$
	$\frac{1}{2}$,	6*th*, 1610	1.0063	$14\frac{1}{4}$
	$\frac{1}{2}$,	7*th*, 1605	1.0038	$7\frac{1}{8}$

This feries is extremely regular, and the progrefs of denfity may be confidently deduced from it.

From the whole of this difquifition on the relation between the fpecific gravities of brines and the quantities of falt contained, we fee in general that it may be gueffed at, with a ufeful degree of precifion, from the denfity or fpecific gravity of faturated folutions. We therefore conclude with a lift of the fpecific gravities of feveral faturated folutions, made with great care by the bifhop of Landaff.—The temperature was 42°. The firft numerical column is the denfity of faturated brine, and the next is the denfity of a brine confifting of 12 parts (by weight) of water and one of falt. From this may be inferred the quantity in the faturated folution, and from this again may be inferred the quantity correfponding to inferior denfities.

Borax,	1.910	
Cor. Sublim.	1.037	
Alum,	1.033	
Glaub. falt,	1.054	1.029
Common falt,	1.198	1.059
Sal. cath. amar.	1.232	1.039
Sal ammon.	1.072	1.026
Vol. alk. mite,	1.087	
Nitre,	1.095	1.050
Rochelle falt,	1.114	
Blue vitriol,	1.150	1.052
Green vitriol,	1.157	1.043
White vitriol,	1.386	1.045
Pearl afh,	1.534	

SPECTACLES, in *Dioptrics*, a machine confifting of two lenfes fet in filver, horn, &c. to affift the defects of the organ of fight. Old people, and others who have flat eyes, ufe convex fpectacles, which caufe the rays of light to converge fo as to meet upon the retina: whereas myopes, or fhort-fighted people, ufe concave lenfes for fpectacles, which caufe the rays to diverge, and prevent their meeting ere they reach the retina. See OPTICS.

Some cafes of a peculiar nature have been met with where the fight receives no affiftance from the ufe of either convex or concave glaffes. To remedy this, the following method was contrived and fuccefsfully adopted. A man about fixty years of age having almoft entirely loft his fight, could fee nothing but a kind of thick mift with little black fpecks in it which feemed to float in the air. He could neither read, walk the ftreets, nor diftinguifh his friends who were moft familiar to him. In this deplorable fituation he procured fome fpectacles with large rings; and having taken out the glaffes, glasses, he substituted for them a conic tube of black Spanish copper. Looking through the large end of the cone he could read the smallest print placed at its other extremity. These tubes were of different lengths, and the openings at the end were also of different sizes; the smaller the aperture the better could he distinguish the smallest letters; the larger the aperture the more words or lines it commanded; and consequently the less occasion was there for moving the head and the hand in reading. Sometimes he used one eye, sometimes the other, alternately relieving each, for the rays of the two eyes could not unite upon the same object when thus separated by two opaque tubes. The thinner these tubes, the less troublesome are they. They must be totally blackened within so as to prevent all shining, and they should be made to lengthen or contract, and enlarge or reduce the aperture at pleasure.

When he placed convex glasses in these tubes, the letters indeed appeared larger, but not so clear and distinct as through the empty tube: he also found the tubes more convenient when not fixed in the spectacle rings; for when they hung loosely they could be raised or lowered with the hand, and one or both might be used as occasion required. It is almost needless to add, that the material of the tubes is of no importance, and that they may be made of iron or tin as well as of copper, provided the insides of them be sufficiently blackened *.

* Monthly Mag. 1799.

OCULAR SPECTRA, images presented to the eye after removing them from a bright object, or closing them. When any one has long and attentively looked at a bright object, as at the setting sun, on closing his eyes, or removing them, an image, which resembles in form the object he was attending to, continues some time to be visible. This appearance in the eye we shall call the ocular spectrum of that object.

Phil. Transf. 1786.

These ocular spectra are of four kinds: 1st, Such as are owing to a less sensibility of a defined part of the retina, or spectra from defect of sensibility. 2d, Such as are owing to a greater sensibility of a defined part of the retina, or spectra from excess of sensibility. 3d, Such as resemble their object in its colour as well as form; which may be termed direct ocular spectra. 4th, Such as are of a colour contrary to that of their object, which may be termed reverse ocular spectra.

SPECTRE, an apparition, or something supposed to be preternaturally visible to human sight, whether the ghosts of dead men or beings superior to man.

A belief that supernatural beings sometimes make themselves visible, and that the dead sometimes revisit the living, has prevailed among most nations, especially in the rudest stages of society. It was common among the Jews, among the Greeks, and among the Romans, as we find from the Scriptures, and from the poems of Homer and Virgil. Celestial appearances were indeed so often exhibited to the Jews, that the origin of their belief is not difficult to be explained.—The Divine Being manifested himself to each of the patriarchs by some sensible sign, generally by a flame of fire, as he did to Moses. Under this semblance also did he appear to the Israelites during their abode in the desert, and after they obtained a settlement in the land of Canaan. Nor did they believe that heavenly beings alone assumed a sensible appearance: They believed that deceased men also sometimes revisited this world. When Saul went to consult the witch at Endor, he asked her to bring up the person whom he should name unto her; a proof that he considered his demand as easy to be performed, and therefore that he probably acted under the influence of popular opinion. The same opinions had been generally entertained at a much earlier period; for necromancy and witchcraft, the arts by which the dead were supposed to be raised, had been prohibited while the Israelites were in the wilderness, and yet untainted with the vices of the Canaanites. They must therefore have derived them from Egypt, the cradle of superstition, as well as of the arts and sciences.

Among the Greeks and Romans the apparition of spectres was generally believed. On innumerable occasions the gods are said to have discovered themselves to the eyes of mortals, to have held conferences, and to have interposed their aid. The ghosts of the dead, too, are said to have appeared. When Æneas, amidst the distraction and confusion of his mind in flying from the destruction of Troy, had lost his wife by the way, he returned in search of her. Her shade appeared to him (for she herself had been slain) with the same aspect as before, but her figure was larger. She endeavoured to assuage the grief of her unhappy husband, by ascribing her death to the appointment of the gods, and by foretelling the illustrious honours which yet awaited him. But when Æneas attempted to clasp her in his arms, the phantom immediately vanished into air. From this story we may observe, that the ancients believed that the umbræ or shades, retained nearly the same appearance after death as before; that they had so far the resemblance of a body as to be visible; that they could think and speak as formerly, but could not be touched. This description applies equally well to those shades which had passed the river Styx, and taken up their residence in the infernal regions. Such were the shades of Dido, of Deiphobus, and all those which Æneas met with in his journey through the subterraneous world.

It appears from the writings of modern travellers who have visited rude and savage nations, that the belief of spectres is no less common among them. Mr Bruce tells us, that the priest of the Nile affirmed, that he had more than once seen the spirit of the river in the form of an old man with a white beard. Among the Mahometans the doctrine of spectres seems to be reduced to a regular system, by the accounts which they give of genii. Whoever has read the Arabian Nights Entertainments must have furnished his memory with a thousand instances of this kind. Their opinions concerning genii seem to be a corrupted mixture of the doctrines of the Jews and ancient Persians. In Christian countries, too, notwithstanding the additional light which their religion has spread, and the great improvement in the sciences to which it has been subservient, the belief of ghosts and apparitions is very general, especially among the lower ranks. They believe that evil spirits sometimes make their appearance in order to terrify wicked men, especially those who have committed murder.—They suppose that the spirits of dead men assume a corporeal appearance, hover about church-yards and the houses of the deceased, or haunt the places where murders have been committed. (See GHOST.) In some places it is believed that beings have been seen bearing a perfect resemblance to men alive. In the Highlands of Scotland, what is called the second sight is still believed;

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lieved by many (see *SECOND Sight*); viz. that future events are foretold by certain individuals by means of spectral representation.

So general has the belief of spectres been, that this circumstance alone may be thought by some sufficient to prove that it must have its foundation in human nature, or must rest upon rational evidence. When any doctrine has been universally received by all nations, by generations living several thousand years from one another, and by people in all the different stages of society, there is certainly the strongest presumption to conclude that such a doctrine has its foundation in reason and in truth. In this way we argue in favour of the existence of a God, concerning moral distinction, and the doctrine of a future state: and certainly so far we argue well. But if the same argument be applied to idolatry, to sacrifices, or to apparitions, we shall find that it is applied improperly. Idolatry was very general among ancient nations; so was the offering of sacrifices, so was polytheism: but they were by no means universal. Should we allow, for the sake of shortening the argument, that all ancient nations were polytheists and idolaters, and presented oblations to their imaginary deities, all that could be concluded from this concession is, that they fell into these mistakes from their ignorance and from the rude state of society, from which their imperfect knowledge of theology and moral philosophy was never able to rescue them. These erroneous notions fled before the brightness of the Christian system; while the doctrines of the existence of God, of moral distinction, and of a future state, have been more thoroughly confirmed and ascertained. The same thing may be said of the belief of spectres. However generally it has been adopted in the first stages of society, or by civilized nations who had made but little progress in the study of divine things, it has been rejected, we may say invariably, wherever theology and philosophy have gone hand in hand.

As all popular and long established opinions are objects of curiosity and research for the philosopher, we think the belief of spectres worthy of some attention even in this light. It will therefore, we hope, give some satisfaction to the philosophical reader to see a short account of the sources or principles from which this belief is derived. But as the belief of spectres is connected with other opinions which appear to us highly injurious to religion; opinions which have been supported by many learned men, and which are still believed by some men of literary education—it will also be proper, in the first place, to consider the evidence on which this belief rests, in which we must consider both their probability and credibility.

In the present investigation we mean to set aside altogether the celestial appearances recorded in Scripture, as being founded on unquestionable evidence, and perfectly agreeable to those rules by which the Deity acts in the usual course of his Providence. The Israelites, during the existence of their state, were immediately under the authority of God, not only as the moral governor of the world, but as the king of Israel. In the infancy of the world, while men were rude and unenlightened, and entirely under the influence of idolatry, many revelations were necessary to preserve in their minds pure ideas of the nature of God, and of the worship due to Him. They were necessary also to pave the way for that illustrious dispensation which the Lord Jesus came from Heaven to diffuse over the world. Every celestial appearance recorded in Scripture was exhibited for some wise and important purpose, which must be apparent to every person who considers these appearances with attention. But when the Scriptures were written and published, and the Christian religion fully established, revelation ceased, and miracles and heavenly messages were no longer requisite. What credit then ought we to give to those marvellous stories related in ancient authors concerning prodigies in the heavens, and the apparition of angels both good and bad?

It is not pretended that any of those prodigies and appearances were exhibited for purposes equally great and important with those which are described in Scripture: And can we suppose that the all-wise Governor of the world would permit his angels to render themselves visible to the eye of man for no purpose at all, or for a purpose which might have been equally well accomplished without their interposition? Would this be consistent with perfect wisdom, or would it be consistent even with the excellence and superiority of understanding which we are taught to ascribe to these elevated beings? The whole will of God is revealed to us in the Scriptures; what further use for the visible interposition of angels? It may be objected, Are they not all ministering spirits, sent forth to minister for them who shall be heirs of salvation *? We answer, That angels may animate and support good men by an invisible interposition. But the Apostle is not speaking of celestial spirits. The word αγγελος signifies " a messenger;" and in Scripture often refers to men. In the passage which we are now reviewing it certainly is applied with much more propriety to men than to angels: for the Apostle is stating a comparison between *the Prophets*, by whom God, at sundry times and in divers manners, spake in time past to the fathers, and *the Son*, by whom he hath spoken in these last days.

* Heb. i. 14.

And if God has given no commission to his angels to deliver to men since the publication of the Christian religion, is there any probability that he would give any commission or any licence to evil spirits? It will be said, that this doctrine is clearly taught in the New Testament, in these words, " The devil goeth about as a roaring lion seeking whom he may devour." We will not avail ourselves of the interpretation of some, who say that the word *devil*, which in the Greek language signifies an *adversary*, or *slanderer*, refers here to some human being, who was a violent enemy of the Christians. All that can be deduced from these words, upon the supposition that they refer to a malignant spirit, is merely that he goeth about seducing men to vice. But it is not by assuming a hideous form, and presenting himself to the midnight traveller, that such a purpose is to be accomplished. A spirit may probably have direct access to our minds without the intervention of any thing corporeal; and by exciting our passions may plunge us into vice, which is the only object such a being is supposed to have in view. None of the marvellous stories which we have heard concerning the apparition of evil spirits lead us to conclude that they appear to entice men to commit crimes. We never heard of any evil spirits that required men to steal, to perpetrate robbery or murder. They only appeared to terrify some crazy timorous individuals, who have whims and fancies

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enow of their own to agitate their minds, though no preternatural vision should ever appear to them. It is not consistent, therefore, with the character of God, and what he has revealed to us of his will, to believe that he would commission good angels, or permit evil angels, to appear to men since the propagation of the gospel, or indeed at any former period of the world, unless some great and mighty purpose was to be fulfilled. It is not consistent with what we know of the nature of good or bad angels to suppose, that though permission were granted them occasionally to show themselves to men, that they would appear in that way which storytellers describe.

It is equally improbable that the spirits of the dead who have removed from this world should again be permitted to visit it. At death men undergo as great, perhaps a greater change, than when they came first into the light of the sun. Is it not therefore as improbable that a man should return in a visible corporeal form after death, as that, after having arrived at manhood, he should return to the state in which he was before his birth? Such changes as these are evidently made permanent by the invariable laws of nature. But suppose it were possible, for what purpose should they return? To describe to us what is passing in the other world, to animate us to virtue, by informing us of the rewards which there await the good; or to alarm us, by describing the punishment of the wicked. These seem important reasons. But Divine Providence has wisely thrown a veil over futurity. We know every thing of the other world from the scripture which it is proper for us at present to know. And as to incentives to virtue, we are already blessed with a number sufficiently great and powerful for moral beings, who are to act from rational motives, and not from compulsion. "He that will not hear Moses and the prophets, will not be persuaded though one rose from the dead."

There is one strong objection against the probability of spectres, which is sufficient to prove that they are not intelligent creatures; or at least that they possess so small a degree of intelligence, that they are unqualified to act with prudence, to propose any end to themselves, or use the proper means to accomplish that end. Ghosts often appear in order to discover some crime that has been committed: but they never appear to a magistrate, or person in authority, but to some illiterate clown, who happens to live near the place where the crime was perpetrated; to some person who has no connection with the affair at all, and who in general is the most improper in the world for making the discovery. For instance, in Glanville's *Saducismus triumphatus* (a book written in the last century by a chaplain of Charles II. in support of the common opinions respecting witchcraft and apparitions), we have the following story: James Haddock, a farmer, was married to Elenor Welsh, by whom he had a son. After the death of Haddock, his wife married one Davis; and both agreed to defraud the son by the former marriage of a lease bequeathed to him by his father. Upon this the ghost of Haddock appeared to one Francis Taverner the servant of Lord Chichester, and desired him to go to Elenor Welsh, and to inform her that it was the will of her former husband that their son should enjoy the lease. Taverner did not at first execute this commission; but he was continually haunted by the apparition in the most hideous shapes, which even threatened to tear him in pieces, till at last he delivered the message. Now, had this spectre had the least common sense, it would have appeared first to Elenor Welsh and her husband Davis, and frightened them into compliance at once, and not have kept poor Taverner in such constant disquietude, who had no concern in the matter.

Another very odd circumstance respecting apparitions in general must not be omitted, which is, that they have no power to speak till they are addressed. In the 27th of Glanville's Relations we read of an old woman that appeared often to David Hunter, a neat-herd, at the house of the bishop of Down and Conners. Whenever she appeared, he found himself obliged to follow her; and for three quarters of a year poor David spent the whole of almost every night in scampering up and down through the woods after this old woman. How long this extraordinary employment might have continued, it is impossible to guess, had not David's violent fatigue made him one night exclaim, "Lord bless me! would I were dead!—shall I never be delivered from this misery!" On which the phantom replied, "Lord bless me too! It was happy you spoke first, for till then I had no power to speak, though I have followed you so long." Then she gave him a message to her two sons, though David told her he remembered nothing about her. David, it seems, neglected to deliver the message; at which the old beldam was so much provoked, that she returned and hit him a hearty blow on the shoulder, which made him cry out, and then speak to her. Now if she could not speak till David addressed her, why might she not have applied this oratorial medicine the first time she appeared to him? It would have saved both herself and him many a weary journey; and certainly David would much rather have had even half a dozen of blows from her choppy fists than have wanted so many nights sleep. To complete the story, we must add, that when David's wife found it impossible to keep him from following the troublesome visitor, she trudged after him, but never was gratified with a sight of the enchantress. David's little dog too was a dutiful attendant on his master during his pilgrimage.

It is remarked by Glanville, that ghosts are generally very eager to be gone. Indeed they are often so much so, that they do not stay to tell their errand. One would be induced from this, as well as the circumstances already mentioned, to think that they are the stupidest and dullest of the dead that assume the appearance of ghosts; unless we adopt the ingenious solution of Glanville, "that it is a very hard and painful thing for them to force their thin and tenuious bodies into a visible consistence; that their bodies must needs be exceedingly compressed; and that therefore they must be in haste to be delivered from the unnatural pressure."

With respect to the *evidence* in favour of spectres, if examined ever so slightly, it will be found very defective. They only appear to one person at a time; they are seen only in the night; they are visible only to ignorant, illiterate, and credulous persons, and never present themselves before men of education and learning.

That spectres only appear to one person at a time, even though there are more in company, is an objection against the credibility of their appearance quite insurmountable.

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mountable. How is it possible that two men of eye-sight equally good, directing their eyes to the same spot, should not see so large an object as that of a man or woman at a small distance equally well? Some will tell us that a mist is cast over the eyes of the one, while the view of the other is free from obstruction. But how is this to be proved? and besides, what purpose would it serve? Ghosts have seldom any secrets to disclose; they might be proclaimed to a multitude with as much propriety as confined to one person. Shall we be told, that the spectre has the power of becoming visible to some, and of remaining invisible to others? This cannot be allowed without adopting opinions destructive to revealed religion; for it would be a miracle: and we cannot be persuaded, without evidence, that God would empower any inferior being to controul at pleasure the wise laws which he has ordained for governing the world. To him who is of a different opinion, we would recommend Farmer on Miracles; a book in which this question is fully examined.

Spectres appear only in the night. But why should they shun the light of the sun? Those mischievous ghosts that Glanville mentions might indeed have some reason to choose midnight for the execution of their pranks, as they would be more easily detected in open day. Such was the roguish drummer that haunted Mr Mompesson's house, who beat his drum all night, threw the old gentlewoman's clothes about the room, hid her Bible in the ashes, plucked the clothes off the bed, and amused himself with tossing about Mr Mompesson's shoes. But why should a grave serious ghost appear at midnight? Might it not deliver its message with as much ease and more success in the day-time? In the day-time it would not excite much fear; it would be listened to therefore with more attention; and did it choose to exhibit itself before a number of witnesses, its grievances would be more speedily redressed, because more persons would interest themselves in seeing justice done to the injured ghost.

Spectres not only choose the most improper time, but the most improper persons. To render the testimony of any person credible, he must not only be a man of veracity, but he must have sufficient ability to judge of the subject to which he is to bear witness. It is not on the evidence of an ignorant illiterate person, who has more fancy and fear than judgement, that we are to rest our belief of what is supernatural. It is also worthy of remark, that we have never heard of a ghost appearing to any person who did not previously believe their existence. A man must be prejudiced in favour of this opinion, or he will never see a ghost. But sensible men know, that he who has been accustomed to hear frightful stories of ghosts and apparitions gliding through a churchyard, or haunting some particular place, can scarcely pass through a churchyard, or haunted spot without conjuring up in his imagination the hideous phantoms which he has been accustomed to associate with such places. Is it strange, then, that an ignorant man, with a mind uncultivated and uninformed, with all the prejudices of the nursery about him, should imagine he sees ghosts in those places where he believes they hover, especially in the dead hour of midnight, when, with the slightest aid of the imagination, a cow may be turned into a monstrous phantom, and the reflection of the beams of the moon from a little water be converted into a ghost with a winding-sheet? But why should apparitions shun men of understanding and learning? Why should learning be formidable to them (A)? It was not so with the celestial messengers mentioned in the Scriptures: they appeared to the patriarchs and prophets; and the miracles there recorded were performed in the most public places, before the eyes of Rabbies, of Scribes, and Pharisees. Indeed this circumstance is sufficient to destroy the evidence of spectres. They have never been seen by any but men of weak or distempered minds, or by men who have previously believed in them.

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Having now considered the evidence on which the belief of spectres rests, we will endeavour to give some account of the foundation of it. To trace an opinion that has prevailed so generally in the world to its source, is a labour not unworthy of the philosopher, even though the opinion be false. It is always gratifying to detect the causes of error: it is no less useful; for in order to refute error, it is often sufficient to point out the sources from which it has sprung. To reach the origin of the belief of spectres is not more difficult than to account for idolatry or polytheism. In the infant state of the intellectual powers every thing is considered as possessing life and intelligence. The child beats the stool

(A) The celebrated historian De Thou had a very singular adventure at Saumur, in the year 1598. One night, having retired to rest very much fatigued, while he was enjoying a sound sleep, he felt a very extraordinary weight upon his feet, which, having made him turn suddenly, fell down and awakened him. At first he imagined that it had been only a dream, but hearing soon after some noise in his chamber, he drew aside the curtains and saw, by help of the moon, which at that time shone very bright, a large white figure walking up and down, and at the same time observed upon a chair some rags, which he thought belonged to thieves who had come to rob him. The figure then approaching his bed, he had the courage to ask it what it was. "I am (said it) the Queen of Heaven." Had such a figure appeared to any credulous ignorant man in the dead of night, and made such a speech, would he not have trembled with fear, and have frightened the whole neighbourhood with a marvellous description of it? But De Thou had too much understanding to be so imposed upon. Upon hearing the words which dropped from the figure, he immediately concluded that it was some mad woman, got up, called his servants, and ordered them to turn her out of doors; after which he returned to bed and fell asleep. Next morning he found that he had not been deceived in his conjecture, and that having forgot to shut his door, this female figure had escaped from her keepers, and entered his apartment. The brave Schomberg, to whom De Thou related his adventure some days after, confessed that in such a case he would not have shown so much courage. The king also, who was informed of it by Schomberg, made the same acknowledgement.

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ſtool over which he has fallen with the ſame paſſion that he would treat his companion: The young girl talks to her doll as if it underſtood her: The ſavages aſcribe every change which they obſerve on the face of nature to the action of ſome animated being. As knowledge advances, they ſingle out thoſe beings which ſeem to produce the moſt ſtriking effects, arrange them into ſome kind of order, and divide the government of the world among them. Unable, at the ſame time, to conceive any notion of a pure ſpirit, they imagine thoſe divinities are corporeal beings. This is the foundation of idolatry. The belief of ſpectres is but another ſtep. That theſe animated corporeal beings, to whom they addreſs their prayers, and who preſide over the world, ſhould on particular occaſions diſplay themſelves to the human eye, is what they muſt be previouſly diſpoſed to expect. Hence the numberleſs appearances of the heathen gods, of the Perſian and Mahometan genii. The belief of ghoſts may be eaſily deduced from the opinions entertained reſpecting a future ſtate. Theſe opinions are founded on that eſſential doctrine of natural religion, that there is another world in which men ſhall exiſt when death has removed them hence. This doctrine has been univerſally received both by ſavage and civilized nations; but, as might be expected, men have formed very different ſentiments concerning the nature of a future ſtate, of the ſituation and employments of departed ſpirits, according to the degree of knowledge which they poſſeſſed. But the general opinion in ancient and rude nations was, that departed ſpirits retained the ſame external appearance, the ſame paſſions and principles as before. Nothing therefore was more natural than the opinion, that they might occaſionally reviſit this world, from an anxious deſire to alleviate the ſufferings of thoſe beloved friends and relations whom they had left behind them, or to communicate from the unſeen world what might be important to their welfare. Upon ſuch an errand did Creüſa appear to Æneas. The apparition of the ghoſts of murderers is eaſily explained upon the ſame general principles. The remorſe and horror of mind which the murderer feels are ſuppoſed to haunt him in the other world, and to render his ſituation there intolerable (eſpecially if the murder was never detected and puniſhed), till he return and give information againſt himſelf. In this way, then, we think it highly probable the belief of ſpectres has originated. But many other cauſes concur to confirm and propagate this belief. Theſe are, imperfect viſion united with fear, dreams, opium, diſeaſes, drunkenneſs, and opium.

1. Indiſtinct viſion is one ſource of apparitions, eſpecially when the mind is under the influence of fear. It is well known, that the ſenſe of ſeeing conveys no idea of diſtance till improved by experience and obſervation; and how we come at length to diſtinguiſh objects at a diſtance from thoſe that are near, has been explained in another place (ſee Metaphysics, N° 50.).

In the daytime we ſeldom commit miſtakes, becauſe we know the object at which we look; but at night, when we ſee objects obſcurely, and know not what they are, we have no diſtinct idea either of their diſtances or of their magnitude. We may miſtake a buſh that is near us for a tree at a diſtance; or if the imagination be under the influence of fear, it will eaſily convert it into a gigantic figure. "It is generally aſſerted (ſays Buffon) that theſe figures exiſt only in the imagination; yet they may have a real exiſtence in the eye; for whenever we have no other mode of judging of an unknown object but by the angle it forms in the eye, its magnitude will uniformly increaſe in proportion to its propinquity. If it appears, when at the diſtance of 20 or 30 paces, to be only a few feet high, its height, when within two or three feet of the eye, will be many fathoms. An object of this kind muſt naturally excite terror and aſtoniſhment in the ſpectator, till he approaches and recogniſes it by actual feeling; for the moment a man knows an object, the gigantic appearance it aſſumed in the eye inſtantly diminiſhes, and its apparent magnitude is reduced to its real dimenſions. But if, inſtead of approaching ſuch an object, the ſpectator flies from it, he can have no other idea of it but from the image which it formed in his eye; and, in this caſe, he may affirm with truth that he ſaw an object terrible in its aſpect, and enormous in its ſize. Thus the notions concerning ſpectres is founded in nature, and depend not, as ſome philoſophers affirm, upon the imagination alone."

In addition to theſe obſervations of Buffon, we may take notice, that objects are always magnified in a fog; ſo that when a fog happens in the night-time, objects may be magnified to an enormous ſize. But, at any rate, whether there be fog in the night or not, there is ſuch a great analogy between darkneſs and a fog, that if the latter deceive us with reſpect to the ſize of objects, the former will alſo deceive us. The writer of this article was paſſing the frith of Forth at Queensferry, near Edinburgh, one morning which was extremely foggy. Though the water be only two miles broad, the boat did not get within ſight of the ſouthern ſhore till it approached very near it. He then ſaw to his great ſurpriſe a large perpendicular rock, where he knew the ſhore was low and almoſt flat. As the boat advanced a little nearer, the rock ſeemed to ſplit perpendicularly into portions, which ſeparated at a little diſtance from one another. He next ſaw theſe perpendicular diviſions move; and upon approaching a little nearer, found it was a number of people ſtanding on the beach, waiting the arrival of the ferry-boat.

2. Dreams are another fertile ſource of apparitions. It is well known to every perſon, that while the mind is under the influence of a dream it conſiders it as much a reality as it does any particular action while awake. Now if a perſon of a weak ſuperſtitious mind ſhould have a very lively dream, which intereſts his paſſions, particularly the paſſion of fear, it may make ſo deep an impreſſion, that he may be firmly convinced that he has actually ſeen with his eyes what has only paſſed before his imagination (ſee Apparition) (b). We ſhall here tell a ſtory, by way of illuſtration, which we have

(b) When the thoughts are much troubled, and when a perſon ſleeps without the circumſtances of going to bed, or putting off his clothes, as when he nods in his chair, it is very difficult, as Hobbes remarks, to diſtinguiſh a dream from a reality. On the contrary, he that compoſes himſelf to ſleep, in caſe of any uncouth or abſurd fancy, eaſily ſuſpects it to have been a dream.—*Leviathan*, par. i. c. 1.

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have received on unquestionable authority. An East India captain had an honest faithful servant named *John*, for whom he had a great regard. John died, if we recollect right, on a voyage from England to the East Indies during a French war. As the ship approached the place of its destination the captain had a dream, in which John appeared to him, and earnestly besought him not to sail to the port for which he was bound, as it was in the hands of the French. The captain, though not addicted to superstition, thought it prudent to follow this admonition; and after landing at a different port, he was informed that the place to which he had intended to steer was, according to the information of the dream, captured by the French. On the voyage home, the captain had a second dream, in which John again appeared to him, and gave him notice that he should soon die, and that the ship should be taken in the mouth of the Channel by the French. Next morning the captain called his first mate, told him his dream, which he believed was prophetic, and delivered his papers, that he might take proper care of them after his decease. Every thing happened exactly as the dream had foretold; the captain died, and the vessel was taken by a French man of war in the mouth of the Channel. This dream, wonderful as it appears, is easily explained. In the voyage out to India, nothing was more natural than that the captain should sometimes be thinking, that amidst the various chances of war, the port to which he was bound might be taken; perhaps it was a place of consequence, which the French might be eager to possess. The captain being accustomed to revolve these thoughts in the day-time, they would naturally return at night; the regret which he felt for the loss of a faithful servant might mingle with his apprehensions, and thus produce the dream. Perhaps the advice was such as John would have given had he been alive. It is equally easy to explain the cause of the dream in the passage home. The captain, we are told, was very ill, and thought himself dying, at the very time he had the second dream, and therefore did not expect to reach England. This part of the dream, then, was only his own thoughts, delivered by his servant. As to the other part, that his ship should be taken in the mouth of the Channel, it may be thought unaccountable how the very place should be foreseen. But we must recollect, that the mouth of the Channel, being over against the coast of France, was by far the most dangerous place in the whole passage; and that, therefore, the captain had more reason to be afraid of losing his ship there than in any other place. The use which we mean to make of this story is this: Had the captain been a man of a weak mind, he would certainly have considered the dream as a reality, and believed that, instead of having dreamed of the things on which his imagination had dwelt, he had actually seen his servant return from the dead, and heard him deliver the message. But, on the other hand, the captain, though he believed the dream was prophetic, mentioned it without any signs of fear; and no man of courage and reflection ever sees an apparition. This sight is reserved for the weak, the timid, and the superstitious. Of this many instances might be mentioned.

3. Spectres are also sometimes occasioned by opium. Gassendi the philosopher found a number of people going to put a man to death for having intercourse with the devil; a crime which the poor wretch readily acknowledged. Gassendi begged of the people that they would permit him first to examine the wizard before putting him to death. They did so; and Gassendi, upon examination, found that the man firmly believed himself guilty of this impossible crime. He even offered to Gassendi to introduce him to the devil. The philosopher agreed; and when midnight came, the man gave him a pill, which he said it was necessary to swallow before setting off. Gassendi took the pill, but gave it to his dog. The man having swallowed his, fell into a profound sleep; during which he seemed much agitated by dreams. The dog was affected in a similar manner. When the man awoke, he congratulated Gassendi on the favourable reception he had met with from his sable highness. It was with difficulty Gassendi convinced him that the whole was a dream, the effect of soporific medicines, and that he had never stirred from one spot during the whole night.

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4. That diseases, especially the night-mare, the hypochondria, hysteric passion, and madness, are another source of spectres, we have the strongest reason to affirm. Persons subject to the night-mare often imagine that they see spectres. This is still more the case with hypochondriac and hysteric persons, and those who are in any degree deranged in their intellects. A fact which fell within the observation of the writer of this article will both prove and illustrate this assertion. In a village in one of the midland counties of Scotland, lived a widow distinguished among her neighbours for decency of manners, integrity, and respect for religion. She affirmed, that for several nights together she had heard a supernatural voice exclaiming aloud, *Murder! murder!* This was immediately reported through the neighbourhood; all were alarmed, and looked around them with solicitude for the detection of the murder which they supposed to have been committed; and it was not long till a discovery seemed actually to be made. It was reported, that a gentleman, who had relations at no great distance, and had been residing in the West Indies, had lately arrived with a considerable fortune; that he had lodged in an inn about three miles off; and that he had afterwards been seen entering a house in the village where the widow lived, from which he had never returned. It was next affirmed, that a tradesman passing the churchyard about twelve at midnight had seen four men carry a dead corpse into that cemetery. These three facts being joined together seemed perfectly to agree and to confirm one another, and all believed some horrible murder had been committed. The relations of the gentleman thought they were called upon to make inquiry into the truth of these allegations: they accordingly came first to the churchyard, where, in company with the sexton, they examined all the graves with great care, in order to discover whether any of them had been lately dug, or had the appearance of containing more than one coffin. But this search was to no purpose, for no alteration had been made upon the graves. It was next reported that the murdered man had been buried in a plantation about a mile distant from the village. As the alarm was now very general, a number of the inhabitants proposed of their own accord to explore it. They accordingly spread themselves over the wood, and searched it with care, but no grave nor new dug earth was found. The writer of this article, who was then a boy at school, was along with them. The matter

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ter did not rest here: The person who was said to have seen four men carry a dead corpse into the churchyard at midnight was summoned to appear before a meeting of the justices of the peace. Upon examination he denied any knowledge of the affair, but referred the court to another person from whom he had received his information. This person was examined, and the result was the same as the former. In short, one person had heard it from another, who had received it from a third, who had heard it from a fourth; but it had received a little embellishment from every person who repeated it. It turned out to be the same with Smollet's story of the three black crows, which some body was said to have vomited.

Upon inquiry at the inn where the West Indian gentleman had lodged, no such gentleman had been seen there. It was found afterwards he had never left the West Indies. Still, however, the veracity of the widow was not disputed; and some dark and secret transaction was suspected. But the whole affair was at length explained by discovering that she was somewhat deranged by melancholy. And the cries which she had at first imagined she had heard were afterwards imitated by some roguish person, who was highly amused with spreading terror among the credulous.

5. Drunkenness also has the power of creating spectres. Its natural effect in most cases is to derange the understanding, to throw it off its guard, and to give full scope to that passion which has a natural disposition to gain an ascendancy; and sometimes it excites passions which scarcely seem to exist at any other time. It makes some men licentious, some furious, some all benevolence and kindness, some from being cowards it renders undaunted heroes. It seldom, if ever, excites fear; and therefore it may be thought strange that men should imagine they see ghosts when intoxicated. But it must be remarked, that the ghosts which the drunkard sees, he sees not with the same alarm and terror as men who are sober. He is not afraid of them. He has the courage to converse with them, and even to fight with them, if they give him provocation. A man returning home intoxicated, affirmed that he had met with the devil; and that after a severe encounter he had vanquished him and brought him to the ground, to which he had nailed him fast by driving his staff through his body. Next morning the staff was found stuck with great violence into a heap of turfs!

6. Many apparitions of spectres have no other origin than the artifices of the waggish or self-interested. Dr Plot, in his Natural History of Oxfordshire, relates a marvellous story, which will illustrate this assertion. Soon after the murder of King Charles I. a commission was appointed to survey the king's house at Woodstock, with the manor, park, woods, and other demesnes to that manor belonging; and one Collins, under a feigned name, hired himself as secretary to the commissioners, who, upon the 13th of October 1649, met, and took up their residence in the king's own rooms. His majesty's bed-chamber they made their kitchen, the council hall their pantry, and the presence-chamber was the place where they sat for the dispatch of business. His majesty's dining-room they made their wood yard, and stored it with the wood of the famous royal-oak from the High Park, which, that nothing might be left with the name of king about it, they had dug up by the roots, and split and bundled up into faggots for their firing. Things being thus prepared, they sat on the 16th of the same month for the dispatch of business; and in the midst of their first debate there entered a large black dog (as they thought, which made a dreadful howling, overturned two or three of their chairs, and then crept under a bed and vanished. This gave them the greater surprise, as the doors were kept constantly locked, so that no real dog could get in or out. The next day their surprise was increased, when sitting at dinner in a lower room, they heard plainly the noise of persons walking over their heads, though they well knew the doors were all locked, and there could be no body there. Presently after they heard also all the wood of the king's oak brought by parcels from the dining-room, and thrown with great violence into the presence chamber; as also all the chairs, stools, tables, and other furniture, forcibly hurried about the room; their papers, containing the minutes of their transactions were torn, and the ink-glass broken. When all this noise had ceased, Giles Sharp, their secretary, proposed to enter first into these rooms; and in presence of the commissioners, from whom he received the key, he opened the doors, and found the wood spread about the room, the chairs tossed about and broken, the papers torn, the ink-glass broken (as has been said), but not the least track of any human creature, nor the least reason to suspect one, as the doors were all fast, and the keys in the custody of the commissioners. It was therefore unanimously agreed, that the power who did this mischief must have entered the room at the key-hole. The night following, Sharp the secretary, with two of the commissioners servants, as they were in bed in the same room, which room was contiguous to that where the commissioners lay, had their bed's feet lifted up so much higher than their heads, that they expected to have their necks broken, and then they were let fall at once with so much violence as shook the whole house, and more than ever terrified the commissioners. On the night of the 19th, as all were in bed in the same room for greater safety, and lights burning by them, the candles in an instant went out with a sulphureous smell; and that moment many trenchers of wood were hurled about the room, which next morning were found to be the same their honours had eaten on the day before, which were all removed from the pantry, though not a lock was found opened in the whole house. The next night they fared still worse; the candles went out as before; the curtains of their honours beds were rattled to and fro with great violence; their honours received many cruel blows and bruises, by eight great pewter-dishes and a number of wooden trenchers being thrown on their beds, which being heaved off, were heard rolling about the room, though in the morning none of these were to be seen. This night likewise they were alarmed with the tumbling down of oaken billets about their beds, and other frightful noise; but all was clear in the morning, as if no such thing happened. The next night the keeper of the king's house and his dog lay in the commissioners room, and then they had no disturbance. But on the night of the 22d, though the dog lay in the room as before, yet the candles went out, a number of brick-bats fell from the chimney into the room, the dog howled piteously, their bed clothes were all stripped off, and their terror increased. On the

24th

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This alarmed and raiſed all the neighbourhood, who coming into their honours room, gathered up the great ſtones, fourſcore in number, and laid them by in the corner of a field, where, in Dr Plot's time, who reports this ſtory, they were to be ſeen. This noiſe, like the diſcharge of cannon, was heard through all the country for 16 miles round. During theſe noiſes, which were heard in both rooms together, the commiſſioners and their ſervants gave one another over for loſt, and cried out for help; and Giles Sharp, ſnatching up a ſword, had well nigh killed one of their honours, miſtaking him for the ſpirit, as he came in his ſhirt from his own room to theirs. While they were together, the noiſe was continued, and part of the tiling of the houſe was ſtript off, and all the windows of an upper room were taken away with it. On the 30th at midnight ſomething walked into the chamber treading like a bear; it walked many times about, then threw the warming-pan violently on the floor; at the ſame time a large quantity of broken glaſs, accompanied with great ſtones and horſes bones, came pouring into the room with uncommon force. Theſe were all found in the morning to the aſtoniſhment and terror of the commiſſioners, who were yet determined to go on with their buſineſs. But on the firſt of November the moſt dreadful ſcene of all enſued: Candles in every part of the room were lighted up, and a great fire made; at midnight, the candles all yet burning, a noiſe like the burſting of a cannon was heard in the room, and the burning billets were toſſed about by it even into their honours beds; who called Giles and his companions to their relief, otherwiſe the houſe had been burnt to the ground; about an hour after the candles went out as uſual, the crack as if many cannon was heard, and many pailfuls of green ſtinking water were thrown upon their honours beds; great ſtones were alſo thrown in as before, the bed curtains and bedſteads torn and broken, the windows ſhattered, and the whole neighbourhood alarmed with the moſt dreadful noiſes; nay, the very rabbit-ſtealers that were abroad that night in the warren were ſo terrified, that they fled for fear and left their ferrets behind them. One of their honours this night ſpoke, and, *in the name of God, aſked what it was, and why it diſturbed them ſo?* No anſwer was given to this; but the noiſe ceaſed for a while, when the ſpirit came again; and, as they all agreed, *brought with it ſeven devils worſe than itſelf.* One of the ſervants now lighted a large candle, and ſet it in the door-way between the two chambers, to ſee what paſſed; and as he watched it, he plainly ſaw a hoof ſtriking the candle and candleſtick into the middle of the room, and afterwards making three ſcrapes over the ſnuff, ſcraped it out. Upon this the ſame perſon was ſo bold as to draw a ſword; but he had ſcarce got it out when he felt another inviſible hand holding it too, and pulling it from him; and at length prevailing, ſtruck him ſo violently on the head with the pummel, that he fell down for dead with the blow. At this inſtant was heard another burſt like the diſcharge of the broadſide of a ſhip of war, and at about a minute or two's diſtance each no leſs than 19 more ſuch: theſe ſhook the houſe ſo violently, that they expected every moment it would fall upon their heads. The neighbours, on this, as has been ſaid, being all alarmed, flocked to the houſe in great numbers, and all joined in prayer and pſalm ſinging; during which the noiſe ſtill continued in the other rooms, and the diſcharge of cannons was heard as from without, though no viſible agent was ſeen to diſcharge them. But what was the moſt alarming of all, and put an end to their proceedings effectually, happened the next day as they were all at dinner, when a paper, in which they had ſigned a mutual agreement to reſerve a part of the premiſes out of the general ſurvey, and afterwards to ſhare it equally amongſt themſelves, (which paper they had hid for the preſent under the earth in a pot in one corner of the room, and in which an orange-tree grew), was conſumed in a wonderful manner, by the earth's taking fire with which the pot was filled, and burning violently with a blue fume, and an intolerable ſtench; ſo that they were all driven out of the houſe, to which they could never again be prevailed upon to return.

This wonderful contrivance was all the invention of the memorable Joſeph Collins of Oxford, otherwiſe called *Funny Joe*, who having hired himſelf as ſecretary, under the name of *Giles Sharp*, by knowing the private traps belonging to the houſe, and the help of *pulvis fulminans* and other chemical preparations, and letting his fellow-ſervants into the ſcheme, carried on the deceit without diſcovery to the very laſt; inſomuch that the Dr Plot, in his Natural Hiſtory, relates the whole for fact, and concludes in this grave manner, "That though tricks have been often played in affairs of this kind, many of the things above related are not reconcileable with juggling; ſuch as the loud noiſes, beyond the power of man to make without ſuch inſtruments as were not there; the tearing and breaking the beds; the throwing about the fire; the hoof treading out the candle; and the ſtriving for the ſword, and the blow the man received from the pummel of it."

SPECTRE of the Broken, a ſingular phenomenon obſerved on the top of the *Broken*, one of the Hartz mountains in Hanover, of which M. Haue has given the following account. "After having been here (ſays he) for the thirtieth time, and having procured information reſpecting the above-mentioned atmoſpheric phenomenon, I was at length, on the 23d of May 1797, ſo fortunate as to have the pleaſure of ſeeing it; and perhaps my deſcription may afford ſatiſfaction to others who viſit the Broken through curioſity. The ſun roſe about four o'clock, and, the atmoſphere being quite ſerene towards the eaſt, his rays could paſs without any obſtruction over the Heinrichſhöhe. In the ſouth-weſt, however,

ever, towards Achtermannſhöhe, a briſk weſt wind carried before it thin tranſparent vapours, which were not yet condenſed into thick heavy clouds.

"About a quarter paſt four I went towards the inn, and looked round to ſee whether the atmoſphere would permit me to have a free proſpect to the ſouth-weſt; when I obſerved, at a very great diſtance towards Achtermannſhöhe, a human figure of a monſtrous ſize. A violent guſt of wind having almoſt carried away my hat, I clapped my hand to it by moving my arm towards my head, and the coloſſal figure did the ſame.

"The pleaſure which I felt on this diſcovery can hardly be deſcribed; for I had already walked many a weary ſtep in the hopes of ſeeing this ſhadowy image, without being able to gratify my curioſity. I immediately made another movement by bending my body, and the coloſſal figure before me repeated it. I was deſirous of doing the ſame thing once more—but my coloſſus had vaniſhed. I remained in the ſame poſition, waiting to ſee whether it would return; and in a few minutes it again made its appearance on the Achtermannſhöhe. I paid my reſpects to it a ſecond time, and it did the ſame to me. I then called the landlord of the Broken; and having both taken the ſame poſition which I had taken alone, we looked towards the Achtermannſhöhe, but ſaw nothing. We had not, however, ſtood long, when two ſuch coloſſal figures were formed over the above eminence, which repeated our compliments by bending their bodies as we did; after which they vaniſhed. We retained our poſition; kept our eyes fixed on the ſame ſpot, and in a little the two figures again ſtood before us, and were joined by a third. Every movement that we made by bending our bodies theſe figures imitated—but with this difference, that the phenomenon was ſometimes weak and faint, ſometimes ſtrong and well defined. Having thus had an opportunity of diſcovering the whole ſecret of this phenomenon, I can give the following information to ſuch of my readers as may be deſirous of ſeeing it themſelves. When the riſing ſun, and according to analogy the caſe will be the ſame at the ſetting ſun, throws his rays over the Broken upon the body of a man ſtanding oppoſite to fine light clouds floating around or hovering paſt him, he needs only fix his eyes ſtedfaſtly upon them, and, in all probability, he will ſee the ſingular ſpectacle of his own ſhadow extending to the length of five or ſix hundred feet, at the diſtance of about two miles before him."

SPECULARIS LAPIS, compoſed of large plates of extreme thinneſs. (See TALC, MINERALOGY *Index*). The white variety with large and broad leaves, commonly called *iſinglaſs and Muſcovy glaſs*, is imported in great quantities; the miniature-painters cover their pictures with it; the lantern-makers ſometimes uſe it inſtead of horn; and minute objects are uſually preſerved between two plates of it, for examination by the microſcope.

SPECULATIVE, ſomething relating to the theory of ſome art or ſcience, in contradiſtinction to practical.

SPECULUM for reflecting teleſcopes, is made of a kind of white copper conſiſting of 32 parts fine red copper, one of braſs, 15 of grain-tin, and three of white arſenic. The proceſs given by the late J. Edwards, who was rewarded by the Board of Longitude for diſcloſing it to the public, was publiſhed in the Nautical Almanack for 1787, and is as follows: Melt the copper in a large crucible, employing ſome black flux, compoſed of two parts of tartar and one of nitre: when melted, add to it the braſs and the ſilver. Let the pure tin be melted in another crucible, alſo with ſome black flux. Take them both from the fire, and pour the melted tin into the fuſed maſs in the large crucible. Stir the whole well with a dry ſpatula of birch, and pour off the fuſed metal immediately into a large quantity of cold water. The ſudden chill of the water will cauſe the fluid metal to divide into an infinite number of ſmall particles, which will cool inſtantly.

Cronſtedt's Mineralogy, vol. ii. p. 712.

If the copper be completely ſaturated, the fracture of one piece of this mixed metal will appear bright, and of a gloſſy look, reſembling the face of pure quickſilver. But if it is of a brown reddiſh colour, it wants a little more tin. To aſcertain the required proportion, melt a ſmall quantity, known by weight, of the mixed metal, with a known very ſmall part of tin; and, if neceſſary, repeat the trial with different doſes, till the fracture of the new mixture looks as already deſcribed. Having now aſcertained the neceſſary addition of tin that is required, proceed to the laſt melting of the whole metal, together with the additional proportional doſe of tin; fuſe the whole, obſerving the ſame cautions as before; and you will find that the mixture will melt with a much leſs heat than that for the firſt fuſion. Have ready as many ounces of white arſenic in coarſe powder as there are pounds in the weight of the metal; wrap up the arſenic in a ſmall paper, and put it, with a pair of tongs, into the crucible; ſtir it well with the ſpatula, retaining the breath to avoid the arſenical fumes or vapours (which however are not found to be hurtful to the lungs) till they diſappear; take the crucible off the fire, clear away the droſs from the top of the metal, pour in about one ounce of powdered roſin, with as much nitre, in order to give the metal a clean ſurface, and pour out the metal into the moulded flaſks.

The ſpeculum ſhould be moulded with the concave ſurface downwards, and many ſmall holes ſhould be made through the ſand upwards, to diſcharge the air. The moulding ſand from Highgate near London, uſed by the founders, is as good as any for caſting theſe metallic mirrors. The caſt metal ſhould be taken out from the ſand of the flaſks whilſt it is hot, or elſe it may happen to crack if left to cool within. See TELESCOPE.

But in addition to what has now been ſaid, we muſt notice ſome other information relative to the grinding, poliſhing, and other important circumſtances connected with the method of preparing the moſt perfect ſpeculum for teleſcopes. The metal being taken out of the flaſk, as already noticed, and this ſhould be done as ſoon as it has become ſolid, and while it is yet red hot, care muſt be taken to keep the face downwards to prevent it from ſinking. Holding it in that poſition by the git, force out the ſand from the hole in the middle of the mirror with a piece of wood or iron, and place the ſpeculum in an iron pot, with a large quantity of hot aſhes or ſmall coals, ſo as to bury the ſpeculum in them a ſufficient depth. If the ſand is not forced out of the hole in the manner above directed, the metal, by ſinking as it cools, will

will embrace the ſand in the middle of the ſpeculum ſo tight, as to cauſe it to crack before it becomes entirely cold. And if the metal be not taken out of the ſand, and put in a pot with hot aſhes or coals to anneal it, the moiſture from the ſand will always break the metal. Let the ſpeculum remain in the aſhes till the whole is become quite cold. The git may be eaſily taken off by marking it round with a common fine half round file, and giving it then a gentle blow. The metal is then to be rough ground and figured.

But before we proceed to deſcribe that proceſs, it may be proper to give an account of another compoſition for the ſpeculum of a reflecting teleſcope, which has been employed with great ſucceſs, by Rochon director of the marine obſervatory at Breſt. Of this compoſition the principal ingredient is platina; which, in grains, muſt be purified in a ſtrong fire by means of nitre and the ſalt of glaſs, or that flux which in the Engliſh glaſs-houſes is called by the workmen *ſandifer.* To the platina, when purified, add the eighth part of the metal employed in the compoſition of common ſpecula; for tin without red copper would not produce a good effect. This mixture is then to be expoſed to the moſt violent heat, which muſt be ſtill excited by the oxygen gas that diſengages itſelf from nitre when thrown into the fire. One melting would be inſufficient: five or ſix are requiſite to bring the mixture to perfection. It is neceſſary that the metal ſhould be in a ſtate of complete fuſion at the moment when it is poured into the mould. By this proceſs I have been enabled (ſays the author) to conſtruct a teleſcope with platina, which magnifies the diameters of objects five hundred times, with a degree of clearneſs and diſtinctneſs requiſite for the niceſt obſervations. The large ſpeculum of platina weighs fourteen pounds: it is eight inches in diameter, and its focus is ſix feet. Though the high price of platina will, in all probability, for ever prevent it from coming into general uſe for the ſpeculums of teleſcopes, we thought it proper to notice this diſcovery, and ſhall now proceed to the grinding of the ſpeculum.

For accompliſhing this object, a very complicated proceſs is recommended in Smith's Optics, and one not much more ſimple, by Mr Mudge in the 67th volume of the *Philoſophical Tranſactions;* but according to Mr Edwards, whoſe ſpeculums are confeſſedly the beſt, neither of theſe is neceſſary. Beſides a common grindſtone, all the tools that he made uſe of are a rough grinder, which ſerves alſo as a poliſher, and a bed of hones. When the ſpeculum was cold, he ground its ſurface bright on a common grindſtone, previouſly brought to the form of the gage; and then took it to the rough grinder.

The tool is compoſed of a mixture of lead and tin, or of pewter, and is made of an elliptical form, of ſuch dimenſions, that the ſhorteſt diameter of the ellipſe is equal to the diameter of the mirror or ſpeculum, and the longeſt diameter is to the ſhorteſt in the proportion of ten to nine. This rough grinder may be fixed upon a block of wood, in order to raiſe it higher from the bench; and as the metal is ground upon it with fine emery, Mr Mudge, with whom, in this particular, Mr Edwards agrees, directs a hole or pit to be made in the middle of it as a lodgement for the emery, and deep grooves to be cut out acroſs its ſurface with a graver for the ſame purpoſe. By means of a handle, fixed on the back of the metal with ſoft cement, the ſpeculum can be whirled round upon this grinder ſo rapidly, that a common labourer has been known to give a piece of metal, four inches in diameter, ſo good a face and figure as to fit it for the hones in the ſpace of two hours. The emery, however fine, will break up the metal very much; but that is remedied by the ſubſequent proceſſes of honing and poliſhing.

When the metal is brought to a true figure, it muſt be taken to a convex tool, formed of ſome ſtones from a place called Edgedon in Shropſhire, ſituated between Ludlow and Biſhop's Caſtle. The common blue hones, uſed by many opticians for this purpoſe, will ſcarcely touch the metal of Mr Edwards's ſpeculums; but where they muſt be employed for want of the others, as little water ſhould be uſed as poſſible when the metal is put upon them; becauſe it is found by experience that they cut better when but barely wet, than when drenched with water. The ſtones, however, from Edgedon are greatly preferable; for they cut the metal more eaſily, and having a very fine grain, they bring it to a ſmooth face. Theſe ſtones are directed by Mr Mudge to be cemented in ſmall pieces upon a thick round piece of marble, or of metal made of tin and lead like the former compoſition, in ſuch a manner, that the lines between the ſtones may run ſtraight from one ſide to the other; ſo that placing the teeth of a very fine ſaw in each of theſe diviſions, they may be cleared from one end to the other of the cement which riſes between the ſtones. As ſoon as the hones are cemented down, this tool muſt be fixed in the lathe, and turned as exactly true to the gage as poſſible. It ſhould be of a circular figure, and but very little larger than the metal intended to be figured upon it. If it be made conſiderably larger, it will grind the metal into a larger ſphere and a bad figure; and if it be made exactly of the ſame ſize, it will work the metal indeed into a figure truly ſpherical, but will be apt to ſhorten its focus, unleſs the metal and tool be worked alternately upwards. On theſe accounts, Mr Edwards recommends it to be made about one twentieth part longer in diameter than the ſpeculum, becauſe he has found that it does not then alter its focus; and he earneſtly diſſuades the uſe of much water on the hone pavement at the time of uſing it, otherwiſe, he ſays, that the metal in different parts of it will be of different degrees of brightneſs.

The metal being brought to a very fine face and figure by the bed of ſtones, is ready to receive a poliſh, which is given to it by the elliptical rough grinder covered with pitch. With reſpect to the conſiſtency of this pitch, Mr Mudge and Mr Edwards give very different directions. Whilſt the former ſays that it ſhould be neither too hard nor too ſoft, the latter affirms that the harder the pitch is, the better figure it will give to the metal. Pitch may be eaſily made of a ſufficient hardneſs by adding a proper quantity of roſin; and when it is hardened in this way, it is not ſo brittle as pitch alone, which is hardened by boiling. Mr Edwards adviſes to make the mixture juſt ſo hard as to receive, when cold, an impreſſion from a moderate preſſure of the nail of one's finger. When the elliptical tool is to be covered with this mixture, it muſt be made pretty warm, and in that ſtate have the mixture poured upon it when beginning to cool in the crucible. Our author

Speculum.

author recommends this coating to be made everywhere of about the thickneſs of half a crown; and to give it the proper form, it muſt, when ſomewhat cool, be preſſed upon the face of the mirror, which has firſt been dipped in cold water, or covered over with very fine writing paper. If it be not found to have taken the exact figure from the firſt preſſure, the ſurface of the pitch muſt be gently warmed, and the operation repeated as before. All the ſuperfluous pitch is now to be taken away from the edge of the poliſher with a pen knife, and a hole to be made in the middle, accurately round, with a conical piece of wood. This hole ſhould go quite through the tool, and ſhould be made of the ſame ſize, or ſomewhat leſs than the hole in the middle of the ſpeculum. Mr Edwards ſays, that he has always found that ſmall mirrors, though without any hole in the middle, poliſh much better, and take a more correct figure, for the poliſher's having a hole in the middle of it.

The poliſher being thus formed, it muſt be very gently warmed at the fire, and divided into ſeveral ſquares by the edge of a knife. Theſe, by receiving the ſmall portion of metal that works off in poliſhing, will cauſe the figure of the ſpeculum to be more correct than if no ſuch ſquares had been made. Mr Mudge directs the poliſher to be ſtrewed over with very fine *putty;* but Mr Edwards prefers COLCOTHAR of vitriol. Putty (ſays he) gives to metals a white luſtre, or, as workmen call it, a ſilver hue; but good colcothar of vitriol will poliſh with a very fine and high black luſtre, ſo as to give the metal finiſhed with it the complexion of poliſhed ſteel. To know if the colcothar of vitriol is good, put ſome of it into your mouth, and if you find it diſſolves away it is good; but if you find it hard, and crunch between your teeth, then it is bad, and not well burned. Good colcothar of vitriol is of a deep red, or of a deep purple colour, and is ſoft and oily when rubbed between the fingers; bad colcothar of vitriol is of a light red colour, and feels harſh and gritty. The colcothar of vitriol ſhould be levigated between two ſurfaces of poliſhed ſteel, and wrought with a little water; when it is worked dry, you may add a little more water, to carry it lower down to what degree you pleaſe. When the colcothar of vitriol has been wrought dry three or four times, it will acquire a black colour, and will be low enough, or ſufficiently fine, to give an exquiſite luſtre. This levigated colcothar of vitriol muſt be put into a ſmall phial, and kept with ſome water upon it. When it is to be uſed, every part of the pitch-poliſher muſt be firſt bruſhed over with a fine camel's hair bruſh, which has been dipped in pure water, and rubbed gently over a piece of dry clean ſoap. The waſhed colcothar of vitriol is then to be put upon the poliſher; and Mr Edwards directs a large quantity of it to be put on at once, ſo as to ſaturate the pitch, and form a fine coating. If a ſecond or third application of this powder be found neceſſary, it muſt be uſed very ſparingly, or the poliſh will be deſtroyed which has been already attained. When the metal is nearly poliſhed, there will always appear ſome black mud upon its ſurface, as well as upon the tool. Part of this muſt be wiped away with ſome very ſoft waſh leather; but if the whole of it be taken away, the poliſhing will not be ſo well completed.

With reſpect to the *parabolic figure* to be given to the mirror, Mr Edwards aſſures us, that a very little experience in theſe matters will enable any one to give it with certainty, by poliſhing the ſpeculum in the common manner, only with croſs ſtrokes in every direction, upon an elliptical tool of the proper dimenſions.

Speculum ‖ Spell.

SPECULUM, a looking glaſs or mirror, capable of reflecting the rays of the ſun.

SPECULUM, in *Surgery*, an inſtrument for dilating a wound, or the like, in order to examine it attentively. See SURGERY.

SPEECH, in general, the art or act of expreſſing a perſon's thoughts by means of articulate ſounds, which we call words. See LANGUAGE, GRAMMAR, READING, and ORATORY, Part IV.

SPEED, JOHN, an Engliſh hiſtorian, was born at Farington, in Cheſhire, in the year 1542. He was by profeſſion a taylor, and freeman of the company of merchant taylors in the city of London. In 1606, he publiſhed his Theatre of Great Britain, which was afterwards reprinted in folio, under the title of the *Theatre of the Empire of Great Britain.* His Genealogies of Scripture were firſt bound up with the Bible in 1611, when the firſt edition of the preſent tranſlation was printed. In 1614 appeared his *Hiſtory of Great Britain*, which has been tranſlated into Latin; and in 1616 he publiſhed his *Cloud of Witneſſes*, in octavo. He lived in marriage 57 years with his wife, by whom he had twelve ſons and ſix daughters; and died in 1629. He was interred in the church of St Giles's, Cripplegate, London, where a monument was erected to his memory.

SPEEDWELL. See VERONICA, BOTANY *Index.*

SPELL, a charm conſiſting of ſome words of occult power, generally attended with ſome ceremony.—In order to explain it, we will produce a few examples. On St Agnes's night, 21ſt of January, take a row of pins, and pull out every one, one after another, ſaying a Pater-noſter on ſticking a pin in your ſleeve, and you will dream of him or her you ſhall marry.

Another method to ſee a future ſpouſe in a dream. The party inquiring muſt lie in a different county from that in which he commonly reſides, and on going to bed muſt knit the left garter about the right-legged ſtocking, letting the other garter and ſtocking alone; and as he rehearſes the following verſes, at every comma knit a knot:

Groſe's Provincial Gloſſary.

This knot I knit,
To know the thing I know not yet;
That I may ſee
The man (woman) that ſhall my huſband (wife) be;
How he goes, and what he wears,
And what he does all days and years.

Accordingly, in a dream, he will appear with the inſignia of his trade or profeſſion.

Another, performed by charming the moon, thus: At the firſt appearance of the new moon, immediately after the new year's day, (though ſome ſay any other new moon is as good), go out in the evening, and ſtand over the ſpars of a gate or ſtile, and, looking on the moon, repeat the following lines:

All hail to the moon! all hail to thee!
I prithee, good moon, reveal to me
This night who my huſband (wife) muſt be.

Immediately after you muſt go to bed, when you will dream of the perſon deſtined for your future huſband or wife.

SPELLING, in *Grammar*, that part of orthography which teaches the true manner of reſolving words into their ſyllables.

All words are either ſimple or compound, as *uſe, diſuſe; done, undone;* and the rules for dividing each muſt be ſuch as are derived from the analogy of language in general, or from the eſtabliſhed cuſtom of ſpeaking; which, for the Engliſh language, are reduced to the following rules: 1. A conſonant between two vowels muſt be joined with the latter in ſpelling, as *na-ture, ve-ri-ly, ge-ne-rous;* except, however, the letter *x*, which is joined to the firſt, as in *flax-en, ox-en*, &c. and compound words, as in *up-on, un-uſed*, &c. 2. A double conſonant muſt be divided, as in *let-ter, man-ner*, &c. 3. Thoſe conſonants which can begin a word muſt not be parted in ſpelling, as in *de-fraud, re-prove, di-ſtinct;* however, this rule is found ſometimes to fail; for though *gn* begins a word, as *gnaw, gnat*, &c. yet it muſt be divided in ſpelling, as in *cog-ni-zance, ma-lig-ni-ty*, &c. 4. Thoſe conſonants which cannot begin a word muſt be divided, as *ld* in *ſeldom, lt* in *mul-ti-tude, mp* in *temper, rd* in *ar-dent;* but in final ſyllables there are exceptions, as *tl* in *ti-tle, dl* in *han-dle*, &c. 5. When two vowels come together, and are both of them diſtinctly ſounded, they muſt be ſeparated in ſpelling, as in *co-e-val, mu-tu-al*, &c. 6. The grammatical terminations or endings muſt be ſeparated in ſpelling, as *ed* in *wing-ed, edſt* in *de-li-ver-edſt, ing* in *hear-ing, ance* in *de-li-ver-ance*, &c. 7. Compound words muſt be reſolved into their ſimple or component words, as *up-on, in-to, ne-ver-the-leſs, not-with-ſtand-ing*, &c.

SPELMAN, Sir Henry, an eminent Engliſh antiquarian, was deſcended from an ancient family, and born at Cengham, near Lynn in Norfolk, about the year 1561. He was knighted by King James I. who had a particular eſteem for him on account of his known capacity for buſineſs; and he employed him ſeveral times in Ireland on public affairs. When he was about 50 years of age, he went to reſide in London; where falling into a ſtudy to which his own genius had always inclined him, he collected all ſuch books and MSS. as concerned the ſubject of antiquities, either foreign or domeſtic. In 1626, he publiſhed the firſt part of his well-known Gloſſary, which he never carried beyond the letter L; becauſe, as ſome have ſuggeſted, he had ſaid things under "Magna charta," and "Maximum conſilium," that could not then have appeared without giving offence. Upon his death all his papers came into the hands of his ſon Sir John Spelman, a gentleman who had abilities to have completed his father's deſign, if death had not prevented him. The ſecond part was afterwards publiſhed by Sir William Dugdale; but with all the marks of a ſcanty unfiniſhed performance. The next work he entered upon was an edition of the Engliſh Councils, of which he publiſhed the firſt volume about two years before his death, leaving the ſecond volume, as well of this as of his Gloſſary, to be publiſhed by Sir William Dugdale. Sir Henry wrote ſeveral other things, all relating to ancient laws and cuſtoms, and died in 1641. His Poſthumous Works were publiſhed in folio, 1698, under the inſpection of Mr Gibſon, afterwards biſhop of London.

SPELTER, in *Metallurgy*, the ſame with Zinc.

SPENCE, Joseph, an eminent writer, was fellow of New College, Oxford, where he took the degree of A.M. in 1727. About that time he became firſt known as an author, by an *Eſſay on Pope's Odyſſey, in which ſome particular beauties and blemiſhes of that work are conſidered;* a work of great merit, and which for ſound criticiſm and candid diſquiſition is almoſt without a parallel. He was elected profeſſor of poetry by the univerſity in 1728, and held that office ten years, which is as long as the ſtatutes will allow. His Hiſtory of Stephen Duck was firſt publiſhed in 1731; but it was afterwards much altered, and prefixed to an edition of Duck's poems.

About this time he travelled into Italy as tutor to the earl of Lincoln, afterwards duke of Newcaſtle.—In 1736 he republiſhed Gorboduc, at Mr Pope's deſire, with a preface giving an account of the author, the earl of Dorſet. He quitted his fellowſhip in 1742, upon being preſented by the Society of New College to the rectory of Great Harwood in Buckinghamſhire.—He never reſided in his living; but paid it an annual viſit, diſtributing large ſums of money among the poor, and providing for many of their children. The ſame year he was made profeſſor of modern hiſtory at Oxford. In 1747 he publiſhed *Polymetis;* or an inquiry concerning the agreement between the works of the Roman poets and the remains of ancient artiſts, being an attempt to illuſtrate them mutually from each other. This work was treated by Gray with a contempt which it did not deſerve. He raiſes objections becauſe the author did not illuſtrate his ſubject from Greek writers; that is, becauſe he failed to execute what he never undertook. He was inſtalled prebendary of the ſeventh ſtall at Durham the 24th May 1754. He publiſhed the ſame year, "An Account of the Life, Character, and Poems, of Mr Blacklock, ſtudent of philoſophy at Edinburgh;" which was afterwards prefixed to his Poems. The proſe pieces which he printed in the Muſeum he collected and publiſhed, together with ſome others, in a pamphlet called *Moralities*, by Sir Harry Beaumont. Under the ſame name he publiſhed "Crito, or a Dialogue on Beauty," and "A particular Account of the emperor of China's Gardens near Pekin, in a letter from F. Attiret, a French miſſionary now employed by that emperor to paint the apartments in thoſe gardens, to his friend at Paris." Both theſe treatiſes are printed in Dodſley's fugitive pieces, as is alſo "A Letter from a Swiſs Officer to his friend at Rome;" which Mr Spence firſt publiſhed in the Muſeum. In 1758 he publiſhed "A Parallel, in the Manner of Plutarch, between a moſt celebrated man of Florence and one ſcarce ever heard of in England." This was alſo inſerted in the fugitive pieces. The ſame year he made a journey into Scotland, which he deſcribed in an affectionate letter to Mr Shenſtone, publiſhed in Hall's Collection of Letters, 1778. In 1764 he was very well deſcribed by Mr James Ridley, in his admirable Tales of the Genii, under the name of *Pheſoi Ecneps* (his name read backwards), dervise of the groves. A letter from Mr Spence to that ingenious moraliſt, under the ſame ſignature, is preſerved in the 3d volume of "Letters

ters of Eminent Perſons." In 1768 he publiſhed "Remarks and Diſſertations on Virgil, with ſome other claſſical obſervations, by the late Mr Holdſworth." On the 20th of Auguſt the ſame year he was unfortunately drowned in a canal in his garden at Byfleet in Surrey. He was found flat upon his face at the edge of the canal, where the water was ſo ſhallow as not even to cover his head. The accident, it was ſuppoſed, for he was quite alone, was owing to a fit.

The duke of Newcaſtle poſſeſſes ſome manuſcript volumes of anecdotes collected by Mr Spence, from which Dr Johnſon was permitted to inſert many extracts in his Lives of the Poets.

SPENCER, Dr John, an eminent divine, was born in Kent in 1630, and educated at Cambridge. He was choſen fellow of his college, and took a doctor's degree in 1663. In 1667 he was choſen maſter of Corpus Chriſti College, and preferred to the deanery of Ely in 1677. He died on the 20th of May 1695. His works are, 1. The Righteous Ruler; a ſermon on Proverbs xxix. 2. preached June 28. 1660. 2. A Diſcourſe concerning Prodigies, wherein the vanity of preſages by them is reprehended, and their true and proper ends aſſerted and vindicated. To this excellent work was afterwards added, A Diſcourſe concerning vulgar prophecies, wherein the vanity of receiving them as the certain indications of any future event is expoſed; and ſome marks of diſtinction between true and pretended prophets are laid down. 3. A Latin Diſſertation concerning Urim and Thummim. 4. His famous treatiſe *De legibus Hebræorum ritualibus et earum rationibus.* The intention of this book, as he informs us himſelf, was to vindicate the Deity from the imputation of acting from arbitrary and fantaſtical motives. It has been highly and juſtly eſteemed both for the elegance of ſtyle and the uncommon erudition and ſound ſenſe which it diſplays. It has, however, (that part of it particularly which endeavours to deduce ſome of the Jewiſh ceremonies from the practices of their heathen neighbours), alarmed many perſons, as if ſuch a doctrine, if it could be proved, would derogate from the Divine wiſdom, and undermine revelation. But this is ſo far from being the caſe, that Dr Spencer's attempt, whether ſucceſsful or not, deſerves the gratitude of Chriſtians, becauſe it has a tendency to throw light on an important and difficult ſubject.

SPENSER, Edmund, the poet, was born in London in the year 1553, and deſcended from an ancient family of the Spenſers in Northamptonſhire. All we know concerning his education is, that he was admitted a ſizer of Pembroke-hall in Cambridge, and matriculated in 1569. At this time began his intimacy with Mr Gabriel Harvey, a man of genius and a poet. In 1576, having completed his degrees in arts, he left the univerſity, as it is conjectured, for want of ſubſiſtence, and retired to the north of England. Here he had the misfortune to become enamoured of his Roſalind, who, after flattering his paſſion for a time, at length preferred his happier rival. Spenſer continued in the country till the year 1578, when at the perſuaſion of his friend Mr Harvey he removed to London, where that gentleman introduced him to Mr Sidney (afterwards Sir Philip Sidney). Concerning his firſt introduction to Sir Philip, there is indeed a different ſtory, which was firſt told by the writer of his life, prefixed to his works in 1679, and tranſcribed by Hughes, Cibber, and ſeveral others; which, nevertheleſs, is certainly not true. The purport of it is, that Spenſer, being unknown to this Mecænas of the age, went to Leiceſter-houſe, and ſent in the 9th canto of the firſt book of the Fairy Queen; that, on reading part of it, Sir Philip ordered his ſteward to give the bearer 50l.; on reading a little farther 50l. more; then 200l. bidding him to make haſte and pay the money, leſt he ſhould give the poet his whole eſtate. The ſtory tells prettily enough; but it is very certain, that the Fairy Queen was begun long after his acquaintance with Sir Philip. By this univerſal patron of genius, however, he was preſented to Queen Elizabeth, who honoured him with the place of poet-laureat. About this time he finiſhed his Shepherd's Calendar, which was firſt printed in 1579; and in the following year, being recommended by his patron to the earl of Leiceſter, he went to Ireland as ſecretary to the lord Grey of Wilton, then appointed lord-lieutenant of that kingdom. Lord Grey was recalled in 1582, and with him Spenſer returned to London, where he continued till after the death of Sir Philip Sidney in 1586; a loſs which he bewailed to the end of his life. The following year, our poet, having obtained a royal grant of 3000 acres of forfeited lands in the county of Cork in Ireland, ſet out for that kingdom, took poſſeſſion of his eſtate, and fixed his reſidence in the caſtle of Kilcolman, which had belonged to the earl of Deſmond. In this retirement he reſumed his great work of the Fairy Queen; and continued in Ireland till, being viſited by his old friend Sir Walter Raleigh in 1589, he came over with him to England, but returned to Ireland the year following, where he fell in love with a country girl, and married her. Soon after his marriage, he paid another viſit to his native country, where we alſo find him in 1596. In the following year he returned once more to Kilcolman; but on the rebellion of Lord Tyrone, who ravaged the whole county of Cork, he was obliged to fly for ſafety with his family to England, where, in the year 1599, he died in extreme poverty (A). He was buried in Weſtminſter Abbey, according to his requeſt, near Chaucer. A monument was erected to his memory by Ann counteſs of Dorſet. We know but little of his character as a man; as a poet, conſidering the age in which he lived, he deſerves our utmoſt veneration. He wrote various pieces beſides thoſe above mentioned. His whole works, with his life by Hughes, were publiſhed in ſix volumes 12mo, in 1715 and 1750.

SPERGULA, Spurrey, a genus of plants belonging to the claſs of decandria; and in the natural ſyſtem arranged

(A) This is Camden's account, and it has been generally believed; but Mr Malone, the laſt editor of Shakeſpeare's works, by examining the patent roll, 33 Eliz. p. 3. has diſcovered, that in February 1690-1 Spenſer obtained from Queen Elizabeth an annuity or penſion of 50l. during his life; a ſum equivalent to 200l. at preſent.

arranged under the 22d order, *caryophylleæ*. See Botany *Index*.

SPERM, the feed whereof an animal is formed. See Physiology.

SPERMACETI, a whitifh, unctuous, flaky fubftance, prepared from oil, but chiefly from the brains of a fpecies of whale called *phyfeter macrocephalus*.

The method of preparing fpermaceti s kept a fecret; but the procefs is faid to be this: The brains being taken out of the animal, are then, as fome fay, melted over a gentle fire, poured into moulds, and when cold melted again; and this procefs is continued till they are purified. Others fay, that after being preffed and drained they are more thoroughly purified by fteeping them in a ley of alkaline falt and quicklime. The brains are then wafhed, and cut into thin flakes or flices with wooken knives. One fifh is faid to afford fome tons of brains. Good fpermaceti is gloffy and femitranfparent, in fine white flakes; foft and unctuous to the touch, yet dry and friable; in tafte, fomewhat like butter, and of a faint fmell like that of tallow. Some adulterate it with wax; but the deceit is difcovered, either by the fmell of the wax or by the dulnefs of the colour. Some alfo fell a preparation of oil taken from the tail of the whale inftead of that from the brain; but this kind turns yellow as foon as expofed to the air. Indeed it is apt in general to grow yellowifh, and to contract a rancid fifhy fmell if not carefully fecured from the air. The more perfectly it has been purified at firft, the lefs fufceptible it is of thefe alterations; and after it has been changed, it may be rendered white and fweet again by fteeping it afrefh in a ley of alkaline falt and quicklime. It melts in a fmall degree of heat, and congeals again as it cools.

Spermaceti is of ufe in medicine. Quincy fays it is a noble remedy in the afthma, &c. though chiefly ufed in bruifes, inward hurts, and after delivery. For internal ufe, it may be diffolved in aqueous liquors into the form of an emulfion, by trituration with almonds, the yolk or white of an egg, and more elegantly by mucilages; or made into a lohoch, by mixing two drams of it with a fuitable quantity of yolk of egg, then adding half an ounce of frefh drawn oil of almonds, and an ounce of balfamic fyrup. Spermaceti is not capable of being diffolved by cauftic alkalies, and of forming foaps, like other oily matters: but it is altogether foluble in oils, and unites by liquefaction with wax and refins; and in thefe forms is applied externally. But it is certain, its greateft property, and that which makes it fo much in vogue in many places, is its foftening the fkin. Whence it comes to be ufed by the ladies in paftes, wafhes, &c.

Spermaceti candles are of modern manufacture: they are made fmooth, with a fine glofs, free from rings and fcars, fuperior to the fineft wax candles in colour and luftre; and, when genuine, leave no fpot or ftain on the fineft filk, cloth, or linen.

A method has been lately propofed by Dr Smith Gibbes of Briftol, to convert animal mufcle into a fubftance much refembling fpermaceti. The procefs is remarkably fimple: Nothing more is neceffary than to take a dead carcafe and expofe it to a ftream of running water: it will in a fhort time be changed to a mafs of fatty matter. To remove the offenfive fmell, a quantity of nitrous acid may then be poured upon it, which uniting with the fetid matter, the fat is feparated in a pure ftate. This acid indeed turns it yellow, but it may be rendered white and pure by the action of the oxygenated muriatic acid. Mr Gibbes brought about the fame change in a much fhorter time. He took three lean pieces of mutton and poured on them the three mineral acids, and he perceived that at the end of three days each was much altered; that in the nitrous acid was much foftened, and on feparating the acid from it, he found it to be exactly the fame with that which he had before got from the water; that in the muriatic acid was not in that time fo much altered; the vitriolic acid had turned the other black.

Phil. Tranf. 1794.

SPERMACOCE, Button-wood, a genus of plants belonging to the clafs of tetrandria; and in the natural fyftem arranged under the 47th order, *ftellatæ*. See Botany *Index*.

SPERMATIC, in *Anatomy*, fomething belonging to the fperm or feed.

SPEUSIPPUS, an Athenian philofopher, the nephew and fucceffor of Plato. Contrary to the practice of Plato, Speufippus required from his pupils a ftated gratuity. He placed ftatues of the Graces in the fchool which Plato had built. On account of his infirm ftate of health, he was commonly carried to and from the academy in a vehicle. On his way thither he one day met Diogenes, and faluted him; the furly philofopher refufed to return the falute, and told him, that fuch a feeble wretch ought to be afhamed to live; to which Speufippus replied, that he lived not in his limbs, but in his mind. At length, being wholly incapacitated, by a paralytic ftroke, for the duties of the chair, he refigned it to Xenocrates. He is faid to have been of a violent temper, fond of pleafure, and exceedingly avaricious. Speufippus wrote many philofophical works, which are now loft, but which Ariftotle thought fufficiently valuable to purchafe at the expence of three talents. From the few fragments which remain of his philofophy, it appears that he adhered very ftrictly to the doctrine of his mafter.

SPEY, a river of Scotland, rifing from a lake of the fame name in Badenoch, and, after a ferpentine courfe of 76 miles, paffes by Rothes caftle, and falls into the German fea at Garnoch near Elgin. Mr Pennant tells us, that the Spey is a dangerous neighbour to Caftle Gordon, overflowing frequently in a dreadful manner, as appears by its ravages far beyond its banks. The bed of the river is wide and full of gravel, and the channel very fhifting. In 1746 the duke of Cumberland paffed this river at Belly church, near Caftle Gordon, when the channel was fo deep as to take an officer, from whom Mr Pennant had the account, and who was fix feet four inches high, up to the breaft. The banks are here very high and fteep; fo that had not the rebels been infatuated in fuch a manner as to neglect oppofition, the paffage muft have been attended with confiderable lofs. On this river there is a great falmon-fifhery; about 1700 barrels full are caught in the feafon, and the fhore was formerly rented for about 1200l. per annum: now it is probably doubled.

SPHACELUS, in *Surgery* and *Medicine*, an abfolute and perfect corruption or death of the parts.

SPHÆRANTHUS, a genus of plants belonging to the

the clafs of fyngenefia, and to the order of polygamia fegregata; and in the natural fyftem arranged under the 49th order, *Compofitæ*. See BOTANY *Index*.

SPHAGNUM, BOG-MOSS, a genus of plants belonging to the clafs of cryptogamia and order of mufci. See BOTANY *Index*.

Os SPHENOIDES, the feventh bone of the cranium or fkull. See ANATOMY, N° 11.

SPHERE, is a folid contained under one uniform round furface, every point of which is equally diftant from a certain point in the middle called its *centre;* and is formed by the revolution of a femicircle about its diameter. See GEOMETRY.

Projection of the SPHERE. See PROJECTION.

SPHERE, in *Aftronomy*, that concave orb or expanfe which invefts our globe, and in which the heavenly bodies appear to be fixed, and at an equal diftance from the eye.

The better to determine the places of the heavenly bodies in the fphere, feveral circles are fuppofed to be defcribed on the furface thereof, hence called the *circles of the fphere:* of thefe fome are called *great circles*, as the equinoctial, ecliptic, meridian, &c. and others *fmall circles*, as the tropics, parallels, &c. See GEOGRAPHY; and ASTRONOMY, *paffim*.

Armillary SPHERE. See GEOGRAPHY.

SPHERE *of Activity of a Body*, is that determinate fpace or extent to which, and no farther, the effluvia continually emitted from that body reach; and where they operate according to their nature.

SPHERES, in *Optics*, the fame with metalline mirrors, for telefcopes or other purpofes. See MIRROR.

SPHEROID, in *Geometry*, a folid approaching to the figure of a fphere. It is generated by the entire revolution of a femi-ellipfis about its axis. When the revolution is made round the largeft axis, the fpheroid is called *prolate;* and when round the fhorteft, *oblate*. This laft is the figure of the earth, and probably of all the planets.

SPHEX, ICHNEUMON WASP, or *Savage;* a genus of infects belonging to the order of *hymenopteræ*. See ENTOMOLOGY *Index*.

SPHINCTER, in *Anatomy*, a term applied to a kind of circular mufcles, or mufcles in form of rings, which ferve to clofe and draw up feveral orifices of the body, and prevent the excretion of the contents.

SPHINX, in fabulous hiftory, a monfter which had the head and breafts of a woman, the body of a dog, the tail of a ferpent, the wings of a bird, the paws of a lion, and a human voice. It fprang from the union of Orthos with the Chimæra, or of Typhon with Echidna. The Sphinx had been fent into the neighbourhood of Thebes by Juno, who wifhed to punifh the family of Cadmus, which fhe perfecuted with immortal hatred, and it laid this part of Bœotia under continual alarms, by propofing enigmas, and devouring the inhabitants if unable to explain them. In the midft of their confternation the Thebans were told by the oracle, that the fphinx would deftroy herfelf as foon as one of the enigmas fhe propofed was explained. In this enigma fhe wifhed to know what animal walked on four legs in the morning, two at noon, and three in the evening. Upon this Creon king of Thebes promifed his crown and his fifter Jocafta in marriage to him who could deliver his

Lempriere's Bibliotheca Claffica.

country from the monfter by a fuccefsful explanation of the enigma. It was at laft happily explained by Oedipus, who obferved, that man walked on his hands and feet when young, or in the morning of life; at the noon of life he walked erect; and in the evening of his days he fupported his infirmities upon a ftick. (*Vid. Oedipus*). The fphinx no fooner hear this explanation than fhe dafhed her head againft a rock, and immediately expired. Some mythologifts wifh to unriddle the fabulous traditions about the fphinx by the fuppofition that one of the daughters of Cadmus, or Laius, infefted the country of Thebes by her continual depredations, becaufe fhe had been refufed a part of her father's poffeffions. The lion's paw expreffed, as they obferve, her cruelty, the body of the dog her lafcivioufnefs, her enigmas the fnares fhe laid for ftrangers and travellers, and her wings the difpatch fhe ufed in her expeditions.

Among the Egyptians the fphinx was the fymbol of religion, by reafon of the obfcurity of its myfteries; and on the fame account the Romans placed a fphinx in the pronaos or porch of their temples. Sphinxes were ufed by the Egyptians to fhow the beginning of the water's rifing in the Nile: with this view, as it had the head of a woman and body of a lion, it fignified that the Nile began to fwell in the months of July and Auguft, when the fun paffes through the figns of Leo and Virgo. There are feveral of thefe ftill to be feen; one in particular, near the pyramids, much fpoken of by the ancients; being of a prodigious fize, and cut out of the rock; the head and neck appear only at prefent, the reft of the body being hid in the fand. This, according to Thevenot, is 26 feet high, and 15 feet from the ear to the chin: but Pliny affures us, the head was no lefs than 102 feet in circumference, and 62 feet high from the belly, and that the body was 143 feet long, and was thought to be the fepulchre of King Amafis.

The learned Mr Bryant * obferves, that the fphinx feems to have been originally a vaft rock of different ftrata; which, from a fhapelefs mafs, the Egyptians fafhioned into an object of beauty and veneration. The Egyptians ufed this figure in their building; from them the Greeks derived it, and afterwards improved it into an elegant ornament. It is alfo frequently ufed in modern architecture.

* *Ancient Mythology*, vol. iii. p. 532.

It is proper to obferve, that the fphinx of the Egyptians is faid in the Afiatic Refearches † to have been found in India. Colonel Pearfe was told by Murari Pandit, a man of learning among the Hindoos, that the fphinx, there called *fingh*, is to appear at the end of the world, and as foon as he is born will prey on an elephant: he is therefore figured feizing an elephant in his claws; and the elephant is made fmall, to fhow that the *fingh*, even a moment after his birth, will be very large in proportion to it. But in oppofition to this account given by Murari Pandit, the late Sir William Jones, the learned and illuftrious prefident of the Afiatic Society, was affured by feveral Brahmans, that the figure taken for a fphinx was a reprefentation of a lion feizing a young elephant. This point therefore requires farther inveftigation.

† Vol ii. p. 334.

SPHINX, *HAWK-Moth*, a genus of infects belonging to the order of *lepidopteræ*. See ENTOMOLOGY *Index*.

SPIGELIA, WORM-GRASS, a genus of plants belonging

longing to the claſs of pentandria; and in the natural ſyſtem arranged under the 47th order, *Stellatæ*. See BOTANY and MATERIA MEDICA *Index*.

SPICE, any kind of aromatic drug that has hot and pungent qualities: ſuch are pepper, nutmeg, ginger, cinnamon, cloves, &c.

SPICE-Iſlands, in the Eaſt Indies. See BANDA, *MOLUCCA-Iſlands*, and CEYLON.

SPIDER. See ARANEA, ENTOMOLOGY *Index*.

SPIDERWORT. See PHALANGIUM, } BOTANY *Index*.
SPIGNEL. See ATHAMANTA, }

SPIKE, or *Oil of SPIKE*, a name given to an eſſential oil diſtilled from lavender, and much uſed by the varniſh-makers and the painters in enamel.

SPIKENARD. See NARDUS, BOTANY *Index*.

SPILANTHUS, a genus of plants belonging to the claſs of ſyngeneſia. See BOTANY *Index*.

SPINA CERVINA, an old name for rhamnus catharticus. See RHAMNUS, BOTANY *Index*.

SPINA-Ventoſa, in *Surgery*, that ſpecies of corruption of the bones which takes its riſe in the internal parts, and by degrees enlarges the bone, and raiſes it into a tumor. See SURGERY.

SPINACIA, SPINAGE, a genus of plants belonging to the claſs of diœcia; and in the natural ſyſtem arranged under the 12th order, *Holoraceæ*. See BOTANY *Index*; and for an account of the method of cultivating ſpinage in the garden, ſee GARDENING.

SPINAGE, or SPINACH. See SPINACIA.

SPINÆ, in *Botany*, thorns, rigid prickles: a ſpecies of *arma*, growing on various parts of certain plants for their defence; *ſpinæ ramorum arcent pecora*. On the branches we find examples in the pyrus, prunus, citrus, hippophaes, gmelina, rhamnus, lycium, &c.; on the leaves, in the aloe, agave, yucca, ilex, hippomane, theophraſta, carlina, &c.; on the calyx, in the carduus cnicus, centaurea, moluccella, galeopſis, &c.; on the fruit, in the trapa, tribulus, murex, ſpinacia, agrimonia, datura, &c.

SPINAL MARROW. See ANATOMY *Index*.

SPINALIS, in *Anatomy*, the name of ſeveral muſcles, &c. of the ſpine.

SPINDLE, in *Geometry*, a ſolid body generated by the revolution of ſome curve line about its baſe or double ordinate; in oppoſition to a conoid, which is generated by the rotation of the curve about its axis or abſciſs, perpendicular to its ordinate. The ſpindle is denominated circular, elliptic, hyperbolic, or parabolic, according to the figure of its generating curve.

SPINDLE-TREE. See EUONYMUS, BOTANY *Index*.

SPINE, SPINA DORSI. See ANATOMY, N° 30.

SPINE. See SPINÆ.

SPINET, or SPINNET, a muſical inſtrument ranked in the ſecond or third place among harmonious inſtruments. It conſiſts of a cheſt or belly made of the moſt porous and reſinous wood to be found, and a table of fir glued on ſlips of wood called *ſummers*, which bear on the ſides. On the table are raiſed two little prominences or bridges, wherein are placed ſo many pins as there are chords or ſtrings to the inſtrument. It is played on by two ranges of continued keys, the former range being the order of the diatonic ſcale, and that behind the order of the artificial notes or ſemitones. The keys are ſo many flat pieces of wood, which, touched and preſſed down at the end, make the other raiſe a jack which ſtrikes and ſounds the ſtrings by means of the end of a crow's quill, wherewith it is armed. The 30 firſt ſtrings are of braſs, the other more delicate ones of ſteel or iron-wire; they are all ſtretched over the two bridges already mentioned. The figure of the ſpinet is a long ſquare or parallelogram; ſome call it an *harp couched*, and the harp an *inverted ſpinet*. See the article HARP.

This inſtrument is generally tuned by the ear, which method of the practical muſicians is founded on a ſuppoſition that the ear is a perfect judge of an octave and a fifth. The general rule is to begin at a certain note, as C, taken towards the middle of the inſtrument, and tuning all the octaves up and down, and alſo the fifths, reckoning ſeven ſemitones to each fifth, by which means the whole is tuned. Sometimes to the common or fundamental play of the ſpinet is added another ſimilar one in uniſon, and a third in octave to the firſt, to make the harmony the fuller; they are either played ſeparately or together by means of a ſtop: theſe are called *double* or *triple ſpinets*; ſometimes a play of violins is added, by means of a bow, or a few wheels parallel to the keys, which preſs the ſtrings and make the ſound laſt as long as the muſician pleaſes, and heighten and ſoften them more or leſs, as they are more or leſs preſſed. The harpſichord is a kind of ſpinet, only with another diſpoſition of the keys (ſee the article HARPSICHORD). The inſtrument takes its name from the ſmall quill ends which touch the ſtrings, reſembling *ſpinæ* or thorns.

SPINIFEX, a genus of plants belonging to the claſs of *polygamia*. See BOTANY *Index*.

SPINNING, in *Commerce*, the act or art of reducing ſilk, flax, hemp, wool, hair, or other matters, into thread. Spinning is either performed on the wheel, or with a diſtaff and ſpindle, or with other machines proper for the ſeveral kinds of working. Hemp, flax, nettle-thread, and other like vegetable matters, are to be wetted in ſpinning: ſilks, wools, &c. are ſpun dry, and do not need water; yet there is a way of ſpinning or reeling ſilk as it comes off the caſes or balls, where hot and even boiling water is to be uſed (ſee SILK). The vaſt variety, and the importance of thoſe branches of our manufactures, which are produced from cotton, wool, and flax, ſpun into yarn, together with the cheapneſs of proviſions, and the low price of labour in many foreign countries, which are our rivals in trade, have occaſioned many attempts at home to render ſpinning more eaſy, cheap, and expeditious; for which ſee *COTTON-Spinning* and *COTTON MILLS*.

To give an intelligible and accurate deſcription of a cotton mill would be abundant employment for a volume. Our limits admit of nothing like this; but as we are certain that many of our readers have viewed a cotton mill with wonder, but not with intelligence, or with leiſure to trace the ſteps by which the wool from the bag ultimately aſſumes the form of a very fine thread. Bewildered by ſuch a complication of machinery, all in rapid motion, very few, we imagine, are able to recollect with diſtinctneſs and intelligence the eſſential part of the progreſs by which the form of the cotton is ſo wonderfully changed. Such readers will not think a page or two miſemployed, if they are thereby able to underſtand this particular, to which all the reſt of the proceſs is ſubſervient.

We paſs over the operation of carding, by which all the

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the clots and inequalities of the cotton wool are removed, and the whole is reduced to an uniform thin fleece, about 20 inches broad. This is gradually detached from the finiſhing card, and, if allowed to hang down from it, would pile up on the floor as long as the mill continues to work; but it is guided off from the card, very tenderly, in a horizontal direction, by laying its detached end over a roller, which is ſlowly turned round by the machine. Another roller lies above the fleece, preſſing it down by its weight. By this preſſure, a gentle hold is taken of the fleece, and therefore the ſlow motion of the rollers draws it gently from the card at the ſame rate as it is diſengaged by the comb; but between the card and the rollers a ſet of ſmooth pins are placed in two rows, leading from the card to the rollers, and gradually approaching each other as we approach the rollers. By theſe pins the broad fleece is hemmed in on both ſides, and gradually contracted to a thick roll; and in this ſtate paſſes between the rollers, and is compreſſed into a pretty firm flat riband, about two inches broad, which falls off from the rollers, and piles up in deep tinplate cans ſet below to receive it.

It is upon this ſtripe or riband of cotton wool that the operation of ſpinning begins. The general effect of the ſpinning proceſs is to draw out this maſſive roll, and to twiſt it as it is drawn out. But this is not to be done by the fingers, pulling out as many cotton fibres at once as are neceſſary for compoſing a thread of the intended fineneſs, and continuing this manipulation regularly acroſs the whole end of the riband, and thus, as it were, nibbling the whole of it away. The fingers muſt be directed, for this purpoſe, by an attentive eye. But in performing this by machinery, the whole riband muſt be drawn out together, and twiſted as it is drawn. This requires great art, and very delicate management. It cannot be done at once; that is, the cotton roll cannot firſt be ſtretched or drawn out to the length that is ultimately produced from a tenth of an inch of the roll, and then be twiſted. There is not coheſion enough for this purpoſe; we ſhould only break off a bit of the roll, and could make no farther uſe of it. The fibres of cotton are very little implicated among each other in the roll, becauſe the operation of carding has laid them almoſt parallel in the roll; and though compreſſed a little by its contraction from a fleece of 20 inches to a riband of only two, and afterwards compreſſed between the diſcharging rollers of the carding machine, yet they cohere ſo ſlightly, that a few fibres may be drawn out without bringing many others along with them. For theſe reaſons, the whole thickneſs and breadth of two or three inches of the riband is ſtretched to a very minute quantity, and then a very ſlight degree of twiſt is given it, viz. about three turns in the inch; ſo that it ſhall now compoſe an extremely ſoft and ſpungy cylinder, which cannot be called a thread or cord, becauſe it has ſcarcely any firmneſs, and is merely rounder and much ſlenderer than before, being ſtretched to about thrice its former length. It is now called ſlab, or roove.

Although it be ſtill extremely tender, and will not carry a weight of two ounces, it is much more coheſive than before, becauſe the twiſt given to it makes all the longitudinal fibres bind each other together, and compreſs thoſe which lie athwart; therefore it will require more force to pull a fibre from among the reſt, but ſtill not nearly enough to break it. In drawing out a ſingle fibre, others are drawn out along with it; and if we take hold of the whole aſſemblage, in two places, about an inch or two inches aſunder, we ſhall find that we may draw it to near twice its length without any riſk of its ſeparating in any intermediate part, or becoming much ſmaller in one part than another. It ſeems to yield equably over all.

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Such is the ſtate of the ſlab or roove of the firſt formation. It is uſually called the *preparation;* and the operation of ſpinning is conſidered as not yet begun. This preparation is the moſt tedious, and requires more attendance and hand labour than any ſubſequent part of the proceſs. For the ſtripes or ribands from which it is made are ſo light and bulky, that a few yards only can be piled up in the cans ſet to receive them. A perſon muſt therefore attend each thread of ſlab, to join freſh ſtripes as they are expended. It is alſo the moſt important in the manufacture: for as every inch of the ſlab meets with preciſely the ſame drawing and the ſame twiſting in the ſubſequent parts of the proceſs, therefore every inequality and fault in the ſlab (indeed in the fleece as it quits the finiſhing card) will continue through the whole manufacture. The ſpinning of cotton yarn now divides into two branches. The firſt, performed by what are called *jennies*, perfectly reſembles the ancient ſpinning with the diſtaff and ſpindle; the other, called *ſpinning of twiſt*, is an imitation of the ſpinning with the fly-wheel. They differ in the ſame manner as the ſpinning with the old wool or cotton wheel differs from the ſpinning with the flax-wheel. Mr Arkwright's chief invention, the ſubſtitution of machinery for the immediate work of the human finger, is ſeen only in the manufacture of twiſt. We ſhall therefore confine our attention to this.

The reſt of the proceſs is little more than a repetition of that gone through in making the firſt ſlab or roove. It is formed on bobins. Theſe are ſet on the back part of the drawing frame; and the end of the ſlab is brought forwards toward the attending workman. As it comes forward, it is ſtretched or drawn to about four-thirds of its former length, or lengthened one-third; and is then twiſted about twice as much as before, and in this ſtate wound up on another bobin. In ſome mills two rooves, after having been properly drawn, are brought together through one hole, and twiſted into one; but we believe that, in the greater number of mills, this is deferred to the ſecond drawing. It is only after the firſt drawing that the produce of the operation gets the name of *ſlab;* before this it is called *preparation*, or *roove*, or by ſome other name. The ſlab is is ſtill a very feeble, ſoft, and delicate yarn, and will not carry much more weight than it did before in the form of roove. The perfection of the ultimate thread or yarn depends on this extreme ſoftneſs; for it is this only which makes it ſuſceptible of an equable ſtretching; all the fibres yielding and ſeparating alike.

The next operation is the *ſecond drawing*, which no way differs from the firſt, except in the different proportionings of the lengthening, and the proportion between the lengthening and the ſubſequent twiſt. On theſe points we cannot give any very diſtinct information. It is different in different mills, and with different ſpecies of cotton wool, as may be eaſily imagined. The immediate mechaniſm or manipulation muſt be ſkilfully accommodated to the nature of that friction which

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which the fibres of cotton exert on each other, enabling one of them to pull others along with it. This is greatly aided by the contorted curled form of a cotton fibre, and a confiderable degree of elafticity which it poffeffes. In this refpect it greatly refembles woollen fibres, and differs exceedingly from thofe of flax: and it is for this reafon that it is fcarcely poffible to fpin flax in this way: its fibres become lank, and take any fhape by the flighteft compreffion, efpecially when damp in the flighteft degree. But befides this, the furface of a cotton fibre has a harfhnefs or roughnefs, which greatly augments their mutual friction. This is probably the reafon why it is fo unfit for tents and other dreffings for wounds, and is refufed by the furgeon even in the meaneft hofpitals. But this harfhnefs and its elafticity fit it admirably for the manufacture of yarn. Even the fhortnefs of the fibre is favourable; and the manufacture would hardly be poffible if the fibre were thrice as long as it generally is. If it be juft fo long that in the finifhed thread a fibre will rather break than come out from among the reft, it is plain that no additional length can make the yarn any ftronger with the fame degree of compreffion by twining. A longer fibre will indeed give the fame firmnefs of adherence with a fmaller compreffion. This would be an advantage in any other yarn; but in cotton yarn the compreffion is already as flight as can be allowed; were it lefs, it would become woolly and rough by the fmalleft ufage, and is already too much difpofed to teazle out. It can hardly be ufed as fewing thread. Now fuppofe the fibres much longer; fome of them may chance to be ftretched along the flab through their whole length. If the flab is pulled in oppofite directions, by pinching it at each end of fuch fibres, it is plain that it will not ftretch till this fibre be broken or drawn out; and that while it is in its extended ftate, it is acting on the other fibres in a very unequal manner, according to their pofitions, and renders the whole apt to feparate more irregularly. This is one great obftacle to the fpinning of flax by fimilar machinery; and it has hitherto prevented (we believe) the working up of any thing but the *fhorts* or tow, which is feparated from the long fine flax in the operation of hatcheling.

A third, and fometimes even a fourth, drawing is given to the flab formed on the bobins of this fecond operation. The flab produced is now a flender, but ftill extremely foft cord, fufceptible of confiderable extenfion, without rifk of feparation, and without the fmalleft chance of breaking a fingle fibre in the attempt. In one or more of the preparatory drawings now defcribed, two, and fometimes three flabs, of a former drawing, are united before the twift is given them. The practice is different in different mills. It is plain, that unlefs great care be taken to preferve the flab extremely foft and compreffible during the whole procefs, the fubfequent drawing becomes more precarious, and we run a rifk of at laft making a bad loofe thread inftead of a uniform and fimple yarn. Such a thread will have very little lateral connection, and will not bear much handling without feparating into ftrands. The perfection of the yarn depends on having the laft flab as free of all appearance of ftrands as poffible.

The laft operation is the fpinning this flab. This hardly differs from the foregoing drawings in any thing but the twift that is given it after the laft ftretching in its length. This is much greater than any of the preceding, being intended to give the yarn hardnefs and firmnefs, fo that it will now break rather than ftretch any more.

The reader, moderately acquainted with mechanics, cannot but perceive that each of the operations now defcribed, by which the roove is changed into the foft flab, and each of thefe into one flenderer and fomewhat firmer, by alternately teazling out and twining the foft cord, is a fubftitute for a fingle pull of the finger and thumb of the fpinfter, which fhe accommodates precifely to the peculiar condition of the lock of wool which fhe touches at the moment. She can follow this through all its irregularities; and perhaps no two fucceeding plucks are alike. But when we cannot give this momentary attention to every minute portion, we muft be careful to introduce the roove in a ftate of perfect uniformity; and then every inch being treated in the fame manner, the final refult will be equable—the yarn will be uniform.

We are now to defcribe the mechanifm by which all this is effected. But we do not mean to defcribe a cotton mill; we only mean to defcribe what comes into immediate contact with the thread; and in fo doing, to confine ourfelves to what is neceffary for making the reader perceive its ability to perform the required tafk. We fee many cafes where individuals can apply this knowledge to ufeful purpofes. More than this would, we think, be improper, in a national point of view.

Plate CCCCXCIX

Let ABC reprefent the fection of a roller, whofe pivot D does not turn in a pivot hole, but in the bottom of a long narrow notch DE, cut in an iron ftandard. *a b c* is the fection of another iron roller, whofe pivot *d* is in the fame notches at each end, while the roller itfelf lies or refts on the roller ABC below it. The furfaces of thefe rollers are fluted lengthwife like a column; only the flutings are very fmall and fharp, like deep ftrokes of engraving very clofe together. It is plain, that if the roller ABC be made to turn flowly round its axis by machinery, in the direction ABC (as expreffed by the dart), the roughnefs of the flutings will take hold of the fimilar roughnefs of the upper roller *a b c*, and carry it round alfo in the direction of the dart, while its pivots are engaged in the notches DE, which they cannot quit. If therefore we introduce the end F of the cotton ftring or riband, formed by the carding machine, it will be pulled in by this motion, and will be delivered out on the other fide at H, confiderably compreffed by the weight of the upper roller, which is of iron, and is alfo preffed down by a lever which refts on its pivots, or other proper places, and is loaded with a weight. There is nothing to hinder this motion of the riband thus compreffed between the rollers, and it will therefore be drawn through from the cans. The compreffed part at H would hang down, and be piled up on the floor as it is drawn through; but it is not permitted to hang down in this manner, but is brought to another pair of fharp fluted iron rollers K and L. Suppofing this pair of rollers to be of the fame diameter, and to turn round in the fame time, and in the fame direction, with the rollers ABC, *a b c*; it is plain that K and L drag in the compreffed riband at I, and would deliver it on the other fide at M, ftill more compreffed. But the roller K is made (by the wheelwork) to turn round more fwiftly than

than ABC. The difference of velocity at the ſurface of the rollers is, however, very ſmall, ſeldom exceeding one part in 12 or 15. But the conſequence of this difference is, that the ſkein of cotton HI will be lengthened in the ſame proportion; for the upper rollers preſſing on the under ones with a conſiderable force, their ſharp flutings take good hold of the cotton between them; and ſince K and L take up the cotton faſter than ABC and *abc* deliver it out, it muſt either be forcibly pulled through between the firſt rollers, or it muſt be ſtretched a little by the fibres ſlipping among each other, or it muſt break. When the extenſion is ſo very moderate as we have juſt now ſaid, the only effect of it is merely to begin to draw the fibres (which at preſent are lying in every poſſible direction) into a more favourable poſition for the ſubſequent extenſions.

The fibres being thus drawn together into a more favourable poſition, the cotton is introduced between a third pair of rollers O, P, conſtructed in the ſame way, but ſo moved by the wheelwork that the ſurface of O moves nearly or fully twice as faſt as the ſurface of K. The roller P being alſo well loaded, they take a firm hold of the cotton, and the part between K and O is nearly or fully doubled in its length, and now requires a little twining to make it roundiſh, and to conſolidate it a little.

It is therefore led ſloping downwards into a hole or eye in the upper pivot of the firſt fly, called a *jack*. This turns round an upright axis or ſpindle; the lower end of which has a pulley on it to give it motion by means of a band or belt, which paſſes round a drum that is turned by the machinery. This jack is of a very ingenious and complicated conſtruction. It is a ſubſtitute for the fly of the common ſpinning wheel. If made preciſely in the form of that fly, the thread, being ſo very bulky and ſpongy, and unable to bear cloſe packing on the bobin, would ſwag out by the whirling of the fly, and would never coil up. The bobin therefore is made to lie horizontally; and this occaſions the complication, by the difficulty of giving it a motion round a horizontal axis, in order to coil up the twiſted roove. Mr Arkwright has accompliſhed this in a very ingenious manner; the eſſential circumſtances of which we ſhall here briefly deſcribe. A is a roller of hard wood, having its ſurface cut into ſharp flutes longitudinally. On the axis, which projects through the ſide of the general frame, there is a pulley P, connected by a band with another pulley Q, turning with the horizontal axis QR. This axis is made to turn by a contrivance which is different in every different cotton mill. The ſimpleſt of all is to place above the pulley C (which is turned by the great band of the machinery, and thus gives motion to the jack), a thin circular diſc D, looſe upon the axis, ſo as to turn round on it without obſtruction. If this diſc exceed the pulley in breadth about $\frac{1}{10}$th of an inch, the broad belt which turns the pulley will alſo turn it; but as its diameter is greater than that of the pulley, it will turn ſomewhat ſlower, and will therefore have a relative motion with reſpect to the axis QR. This can be employed, in order to give that axis a very ſlow motion, ſuch as one turn of it for 20 or 30 of the jack. This we leave to the ingenuity of the reader. The bobin B, on which the roove is to be coiled up, lies on this roller, its pivots paſſing through upright ſlits in the ſides of the general frame. It lies on A, and is moved round by it, in the ſame manner as the uppermoſt of a pair of drawing rollers lies on the under one, and receives motion from it. It is evident that the fluted ſurface of A, by turning ſlowly round, and carrying the weight of the bobin, compreſſes a little the cotton that is between them; and its flutings, being ſharp, take a ſlight hold of it, and cauſe it to turn round alſo, and thus coil up the roove, pulling it in through the hole E in the upper pivot (which reſembles the fore pivot or eye of a ſpinning wheel fly) in ſo gentle a manner as to yield whenever the motion of the bobin is too great for the ſpeed with which the cotton ſkein is diſcharged by the rollers O and P.—N. B. The axis QR below, alſo gives motion to a guide within the jack, which leads the roove gradually from one end of the bobin to the other, and back again, ſo as to coil it with regularity till the bobin is full. The whole of this internal mechaniſm of the jack is commonly ſhut up in a tin cylinder. This is particularly neceſſary when the whirling motion muſt be rapid, as in the ſecond and third drawings. If open, the jacks would meet with much reſiſtance from the air, which would load the mill with a great deal of uſeleſs work.

The reader is deſired now to return to the beginning of the proceſs, and to conſider it attentively in its different ſtages. We apprehend that the deſcription is ſufficiently perſpicuous to make him perceive the efficacy of the mechaniſm to execute all that is wanted, and prepare a ſlab that is uniform, ſoft, and ſtill very extenſible; in ſhort, fit for undergoing the laſt treatment, by which it is made a fine and firm yarn.

As this part of the proceſs differs from each of the former, merely by the degree of twiſt that is given to the yarn, and as this is given by means of a fly, not materially different from that of the ſpinning wheel for flax, we do not think it at all neceſſary to ſay any thing more about it.

The intelligent reader is ſurely ſenſible that the yarn produced in this way muſt be exceedingly uniform. The uniformity really produced even exceeds all expectation; for even although there be ſome ſmall inequalities in the carded fleece, yet if theſe are not matted clots, which the card could not equaliſe, and only conſiſt of a little more thickneſs of cotton in ſome places than in others, when ſuch a piece of the ſtripe comes to the firſt roller, it will be rather more ſtretched by the ſecond, and again by the bobin, after the firſt very ſlight twining. That this may be done with greater certainty, the weights of the firſt rooving rollers are made very ſmall, ſo that the middle part of the ſkein can be drawn through, while the outer parts remain faſt held.

It is ſaid that a pound of the fineſt Bourbon cotton has been ſpun into a yarn extending a few yards beyond 119 miles!

Theſe contrivances have in ſome parts of Scotland been applied to the ſpinning of flax.

Tranſactions of the Society for the Encouragement of Arts.

SPINNING Wheel. A very conſiderable improvement has been made by Mr Antis of Fulneck near Leeds of the common ſpinning wheel. It is well known, that hitherto much time has been loſt by ſtopping the wheel in order to ſhift the thread from one ſtaple on the flyer to another; but in Mr Antis's wheel the bobbin is made to move backwards and forwards, ſo as to prevent the neceſſity of this perpetual interruption, as well as to obviate

viate the danger of breaking the thread and losing the end. This is effected by the axis of the great wheel being extended through the pillar next the spinner, and formed into a pinion of one leaf A, which takes into a wheel B, seven inches diameter, having on its periphery 97 teeth; so that 97 revolutions of the great wheel cause one of the lesser wheel. On this lesser wheel is fixed a ring of wire *c c c;* which, being supported on six legs, stands obliquely to the wheel itself, touching it at one part, and projecting nearly three quarters of an inch at the opposite one: near the side of this wheel is an upright lever C, about 15 inches long, moving on a centre, three inches from its lower extremity, and connected at the top to a sliding bar D; from which rises an upright piece of brass E, which working in the notch of a pulley drives the bobin F backward and forward, according as the oblique wire forces a pin G in or out, as the wheel moves round. To regulate and assist the alternate motion, a weight H hangs by a line to the sliding bar, and passing over a pulley I rises and falls as the bobin advances or recedes, and tends constantly to keep the pin in contact with the wire. It is evident, from this description, that one staple only is wanted to the flyer; which, being placed near the extremity K, the thread passing through it is by the motion of the bobin laid regularly thereon. For this invention the Society instituted at London for the Encouragement of Arts, &c. gave the author a premium of twenty guineas.

SPINOSUS CAULIS, in *Botany*, a stem covered with strong woody prickles, whose roots are not superficial, but proceeding from the body of the stem. When applied to a leaf, *spinosum folium*, it indicates the margin running out into rigid points or prickles, *quod margine exit in acumina duriora, rigida, pungentia.*

SPINOUS, in botany. See SPINOSUS.

SPINOUS Fishes, such as have some of the rays of the back fins running out into thorns or prickles, as the perch, &c.

SPINOZA, BENEDICT, was born at Amsterdam the 24th November 1632. His father was a Jew of Portugal, by profession a merchant. After being taught Latin by a physician, he applied himself for many years to the study of theology, and afterwards devoted himself entirely to philosophy. He began very early to be dissatisfied with the Jewish religion; and as his temper was open, he did not conceal his doubts from the synagogue. The Jews, it is said, offered to tolerate his infidelity, and even promised him a pension of a thousand dollars per annum, if he would remain in their society, and continue outwardly to practise their ceremonies. But if this offer was really made, he rejected it, perhaps from his aversion to hypocrisy, or rather because he could not endure the restraint which it would have imposed. He also refused being constituted heir to an independent fortune, to the prejudice of the natural claimants; and he learned the art of polishing glass for spectacles, that he might subsist independently of every one.

He would probably have continued in the synagogue for some time longer, had it not been for an accident. As he was returning home one evening from the theatre he was stabbed by a Jew: the wound was slight; but the attempt naturally led Spinoza to conclude that the Jews had formed the design of assassinating him. After leaving the synagogue, he became a Christian, and frequented the churches of the Lutherans and Calvinists. He now devoted himself more than ever to his favourite philosophical speculations; and finding himself frequently interrupted by the visits of his friends, he left Amsterdam, and settled at the Hague, where he often continued for three months together without ever stirring from his lodging. During his residence in that city, his hostess, who was a Lutheran, asked him one day if she could be saved while she continued in her religion? "Yes (replied Spinoza), provided you join to your religion a peaceable and virtuous life." From this answer it has been concluded that he was a Christian in appearance only, while in reality he regarded all religions as indifferent. But this conclusion would be too severe, even if the woman had been a Mahometan. His *Tractatus Theologico-politicus*, which was published about that time, is a better proof of his insincerity than a thousand such conclusions; for this book contains all those doctrines in embryo which were afterwards unfolded in his *Opera Posthuma*, and which are generally considered as a system of atheism.

His fame, which had now spread far and wide, obliged him sometimes to interrupt his philosophical reveries. Learned men visited him from all quarters. While the prince of Conde commanded the French army in Utrecht, he intreated Spinoza to visit him; and though he was absent when the philosopher arrived, he returned immediately, and spent a considerable time with him in conversation. The elector Palatine offered to make Spinoza professor of philosophy at Heidelberg; which, however, he declined.

He died of a consumption at the Hague on the 21st February 1677, at the age of 45. His life was a perpetual contradiction to his opinions. He was temperate, liberal, and remarkably disinterested; he was sociable, affable, and friendly. His conversation was agreeable and instructive, and never deviated from the strictest propriety.

The only edition of the works of Spinoza that we have seen is in two volumes small 4to; the former of which was printed at Hamburg in the year 1670, and the latter we know not where, in 1677, a few months after his death. In the *Tractatus Theologico-politicus*, already mentioned, he treats of *prophecy* and *prophets;* and of the *call of the Hebrews*, whom he affirms to have been distinguished from other nations only by the admirable form of their government, and the fitness of their laws for long preserving their political state. He is likewise of opinion, or at least pretends to be so, that God may, in what we call a *supernatural way*, have given political institutes to other nations as well as to the Hebrews, who were, he says, at no time a peculiar people to the Supreme Lord of heaven and earth; for according to him, all history, sacred and profane, testifies that every nation was blessed with the light of prophecy. That light indeed, if his notions of it be just, was of very little value. He labours to prove, that the prophets were distinguished from other men only by their piety and virtue; that their revelations depended wholly on their imaginations and the dispositions of their minds; that they were often grossly ignorant and highly prejudiced; that the speculative opinions of one prophet are seldom in unison with those of another; and that their writings are valuable to us only for the excellent rules which he acknowledges they contain respecting the practice

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tice of piety and virtue. He then proceeds to treat of the divine law and of miracles; and endeavours to prove that no miracle, in the proper ſenſe of the word, can have been at any time performed; becauſe every thing happens by a neceſſity of nature, the reſult of the divine decrees, which are from all eternity neceſſary themſelves. He acknowledges, that in the Scriptures, which he profeſſes to admit as true hiſtory, miracles are often mentioned; but he ſays that they were only ſingular events which the ſacred hiſtorians *imagined* to be miraculous: and he then gives ſome very extraordinary rules for interpreting the books of the Old and New Teſtaments where they treat of miracles, or appear to foretel future events. See our articles MIRACLE and PROPHECY.

Having thus diveſted the Scriptures of every thing characteriſtic of a revelation from heaven, he next calls in queſtion their authenticity. He affirms, in contradiction to the cleareſt internal evidence, that the Pentateuch and all the other hiſtorical books muſt have been written by one man; and that man, he thinks, could not have flouriſhed at a period earlier than that of Ezra. The grounds of this opinion are unworthy of the talents of Spinoza; for that he had talents is incontrovertible. His principal objection to the authenticity of the Pentateuch is, that Moſes is made to ſpeak of himſelf in the third perſon, and to talk of the Canaanites being then in the land; and becauſe he finds in his writings, as well as in the books of Joſhua, Judges, Ruth, Samuel, &c. places deſigned by names which he ſuppoſes they had not in the early ages of which theſe books contain the hiſtory, he concludes that theſe writings muſt be one compilation from ancient records made at a very late period; more eſpecially as the author often ſpeaks of things of great antiquity remaining to this day. The books of Eſther, Ezra, Nehemiah, and Chronicles, muſt have been compiled, he thinks, under the Maccabees; and he ſeems to conſider as of equal value with them the ſtory of Tobit, and the other two apocryphal treatiſes intitled the Wiſdom of Solomon and Eccleſiaſticus.

Theſe ſenſeleſs cavils, worthy only of one of thoſe modern freethinkers whoſe learning, in the opinion of Biſhop Warburton, is not ſufficient to carry them even to the confines of rational doubt, we have ſufficiently obviated in another place (ſee SCRIPTURE, N° 8—31.) Spinoza urges them againſt the other books of the Old Teſtament. The prophecies of Iſaiah, Jeremiah, Ezekiel, Daniel, Hoſea, and Jonah, are, as we have them, only fragments, he ſays, of the writings of thoſe men compiled by the Phariſees under the ſecond temple from ancient and voluminous records.

In the midſt of this dogmatical ſcepticiſm, if we may uſe ſuch a phraſe, he bears ſuch a teſtimony to the laſt chapters of the book of Daniel, as we ſhould not have looked for in the writings either of a Jew or of a Deiſt. After detailing the various hypotheſes which in his time were held reſpecting the author and the intention of the book of *Job*; in which, he ſays, MOMUS is called SATAN, he proceeds in theſe words: "Tranſeo ad Danielis librum; hic ſine dubio ex cap. 8. ipſius Danielis ſcripta continet. Undenam autem priora ſeptem capita deſcripta fuerint, neſcio *;" thus admitting the famous prophecy of the ſeventy weeks. The canon of the Old Teſtament, he ſays, was finally ſettled by rabbins of the Phariſaical ſect, who wiſhed to exclude from it the books of *Proverbs*, *Eccleſiaſtes*, and *Ezekiel*, as they had actually excluded others of equal value; but the three books in queſtion were inſerted by the influence of two of the rabbis of greater wiſdom and integrity than the reſt.

* *Tractatus*, cap. x p. 130.

That ſo paradoxical a writer, who had been originally a Jew, and was now almoſt a Deiſt, ſhould have treated the New Teſtament with as little ceremony as the Old, will not ſurpriſe the intelligent reader. He begins his remarks, however, with affirming, that no man can peruſe the Chriſtian Scriptures, and not acknowledge the apoſtles to have been prophets; but he thinks that their mode of propheſying was altogether different from that which prevailed under the Moſaic diſpenſation; and that the gift, whatever it was, forſook them the inſtant that they left off *preaching*, as their *writings* have to him every appearance of human compoſitions. This diſtinction between Chriſtian and Jewiſh prophecy is the more wonderful, that he founds it principally on the diſſimilarity of *ſtyle* viſible in the writings of the Old and New Teſtaments; though, in his ſecond chapter, which treats of the works of the Jewiſh prophets, he ſays expreſsly, "Stylus deinde prophetiæ pro eloquentia cujuſque prophetæ variabat, prophetiæ enim Ezekielis et Amoſis non ſunt, ut illæ Eſaiæ, Nachumi, eleganti, ſed rudiore ſtylo ſcriptæ." That the Hebrew ſcholar may be convinced of the truth of this remark, he recommends to him to ſtudy diligently the writings of theſe prophets, and to conſider the occaſions on which their prophecies were uttered: "Quæ ſi omnia rectè perpendentur (ſays he) facilè oſtendant, Deum nullum habere ſtylum peculiarem dicendi, ſed tantum pro eruditione, et capacitate prophetæ eatenus eſſe elegantem, compendioſum, ſeverum, rudem, prolixum, et obſcurum." Another objection brought by Spinoza againſt the prophecies of the New Teſtament ariſes from the authors of them having been at all times maſters of themſelves. This, ſays he, was peculiarly the caſe of St Paul, who often confirms his doctrine by *reaſoning*, which the Jewiſh prophets never condeſcended to do, as it would have ſubmitted their dogmas to the examination of *private judgment*. Yet, with ſingular inconſiſtency, he affirms, that the Jewiſh prophets could not know that the impreſſions made on their imaginations proceeded from God, but by a ſign given them, which by their own *reaſon* or *judgment* they knew would never be vouchſafed to an impious or a wicked man.

After theſe very free remarks on the Scriptures of the Old and New Teſtaments, he naturally enough expreſſes a ſuſpicion, that by thoſe who conſider the Bible as the epiſtle of God ſent from heaven to men, he will be thought to have ſinned againſt the Holy Ghoſt by vilifying his dictates. This leads him to inquire in what ſenſe the Scriptures are the word of God; and he gravely determines them to be ſo only as they *actually* contribute to make men more virtuous and holy. It is not enough that they are *calculated* to improve virtue and holineſs: for ſhould the words of the languages in which they are written acquire in proceſs of time a ſignification different from what they had originally; ſhould mankind loſe all knowledge of theſe languages; or even ſhould they agree to neglect the books, whether from ignorance or from wilfulneſs—thoſe books would ceaſe

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to be the word of God, and become nothing better than waste paper and ink; just as the two tables, which Moses broke on observing the idolatry of his countrymen, were not the covenant between Jehovah and the Israelites, but merely two pieces of stone! The Scriptures, however, are the word of God, because they teach the true religion of which God is the author; and they have taught it in such a manner, he says, that it can never be lost or corrupted whatever become of the books of the Old and New Testaments, or of the languages in which they are written. The whole of religion, as the Scriptures themselves testify, consists in the love of God above all things, and of our neighbours as ourselves: whence it follows, that we must believe that God exists, and watcheth over all things by his providence; that he is omnipotent, and has decreed the pious to be ultimately happy, and the impious miserable; and that our final salvation depends solely on His grace or favour. These truths, with their necessary consequences, are the word of God: they are clearly taught in the Scriptures, and can never be corrupted; but every thing else in these volumes is vain, he says, and of no greater importance to us than facts related in any other ancient and authentic history.

Such are the opinions which were entertained of revelation by a man, whom a critic, writing in a Christian country, and professing to be a zealous Christian himself, has lately pronounced to have been a *chosen vessel*. For what purpose he was *chosen* it is not easy to conceive. His religion, as it appears in the *Tractatus*, is the worst kind of Deism; and his politics are such as our monthly critics are not wont to teach, and such as we trust shall never be seriously taught by any British subject. By the law of nature, he says, every man before the formation of civil government has an unquestionable right to whatever appears eligible either to his reason or to his appetites; and may get possession of it by *intreaty*, by *violence*, by *fraud*, or by *any other means* attended with less trouble to himself (*sive vi, sive dolo, sive precibus, sive quocunque demum modo facilius poterit*); and may treat as an enemy every person who shall attempt to obstruct his purpose. But when men agree to devolve this right upon others, and to constitute a political state, which both reason and appetite must persuade them to do, then are they in duty bound to obey every mandate of the government, however absurd it may be (*omnia mandata tametsi absurdissima*), as long as that government can enforce its edicts, and no longer; for, according to him, right and power are so inseparably united, that when a government loses its power, it has no longer the smallest claim to obedience. This doctrine, he says, is most *obviously* just when taught of democratical governments; but it is in fact equally true of monarchies and aristocracies: "Nam quisquis summam habet potestatem, sive unus sit, sive pauci, sive denique omnes, certum est ei summum jus *quicquid velit imperandi*, competere: et præterea quisquis potestatem se defendendi, sive sponte, sive *vi coactus*, in alium transtuiit, eum suo jure naturali planè cessisse, et consequenter eidem ad omnia absolutè parere decrevisse quod omnia præstare tenetur, quamdiu rex, sive nobiles, sive populus summam, quam acceperunt, potestatem, quæ juris transferendi fundamentum fuit, conservant; nec his plura addere opus est*." We heartily agree with him, that to this precious conclusion it is needless to add a single word.

* *Tractatus*, cap. xvi. p. 181.

Taking our leave therefore of his *Tractatus Theologico-politicus*, we shall now give our readers a short account of his *Opera Posthuma*. These consist of, 1. ETHICA, *more geometrico demonstrata*; 2. POLITICA; 3. DE EMENDATIONE INTELLECTUS; 4. EPISTOLÆ, *et ad eas* RESPONSIONES; 5. COMPENDIUM GRAMMATICES LINGUÆ HEBRÆÆ.

The ETHICA are divided into five parts, which treat in order, *de* DEO; *de natura et origine* MENTIS; *de origine et natura* AFFECTUUM; *de* SERVITUTE *humana*, *seu de* AFFECTUUM VIRIBUS; *de* POTENTIA INTELLECTUS, *seu de* LIBERTATE *humana*. As the author professes to tread in the footsteps of the geometers, and to deduce all his conclusions by rigid demonstration from a few self-evident truths, he introduces his work, after the manner of Euclid, with a collection of *definitions* and *axioms*. These are couched in terms generally ambiguous; and therefore the reader will do well to consider attentively in what sense, if in any, they can be admitted; for it will not be found easy to grant his premises, and at the same time refuse his conclusions. His definition of substance, for instance, is so expressed as to admit of two senses; in one of which it is just, whilst in the other it is the parent of the most impious absurdity. We shall give it in his own words: "Per substantiam intelligo id, quod in se est, et per se concipitur: hoc est id, cujus conceptus non indiget conceptu alterius rei, à quo formari debeat." If by this be meant, that a substance is that which we can conceive by itself without *attending* to any thing else, or *thinking* of its formation, the definition, we believe, will be admitted by every reflecting mind as sufficiently distinguishing the thing defined from an attribute, which, he says, is that which we perceive *of* a substance, and which we certainly cannot conceive as existing by itself. Thus the writer of this article can shut his eyes and contemplate in idea the small 4to volume now before him, without attending to any thing else, or thinking of its paradoxical author, or even of the Great Being who created the matter both of him and of it; but he cannot for an instant contemplate the yellow colour of its vellum boards without thinking of triple extension, or, in other words, of body. The book therefore is a *substance*, because conceivable by itself; the colour is an *attribute* or *quality*, because it cannot be conceived by itself, but necessarily leads to the conception of something else. But if Spinoza's meaning be, that nothing is a substance but what is conceived as existing from eternity, independent of every thing as a cause, his definition cannot be admitted; for every man conceives that which in himself thinks, and wills, and is conscious, as a substance; at the same time that he has the best evidence possible that he existed not as a conscious, thinking, and active being, from eternity.

His fourth axiom is thus expressed: "Effectus cognitio à cognitione causæ dependet, et eandem involvit;" and his fifth, "Quæ nihil commune cum se invicem habent, etiam per se invicem intelligi non possunt, sive conceptus unius alterius conceptum non involvit." The former of these propositions, so far from being self-evident, is not even true; and the latter is capable of two senses very different from each other. That every ef-

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fect proceeds from *a cause*, is indeed an axiom; but surely we may know the effect accurately, though we be ignorant of the *particular* cause from which it proceeds (see PHILOSOPHY, N° 36; and PHYSICS, N° 91, &c.); nor does the knowledge of the one by any means involve the knowledge of the other. If different things have nothing in common, it is indeed true that the knowledge of one of them will not give us an *adequate conception* of the other; but it will in many cases compel us to believe, that the other *exists* or has existed. A parcel of gunpowder lying at rest has nothing in common with the velocity of a cannon-ball; yet when we know that a ball has been driven with velocity from a cannon, we infer with certainty that there has been a parcel of powder at rest in the chamber of that cannon.

It is upon such ambiguous definitions and axioms as these that Spinoza has raised his pretended demonstrations, that one substance cannot produce another; that every substance must necessarily be infinite; that no substance exists or can be conceived besides God; and that extended substance or body is one of the infinite *attributes* of God. We shall not waste our own time or the readers with a formal confutation of these impious absurdities. We trust they are sufficiently confuted in other articles of this work (see METAPHYSICS, Part III. PROVIDENCE, and THEOLOGY, Part I.); and whoever wishes for a more particular examination of the author's principles, may find it in Dr Clarke's Demonstration of the Being and Attributes of God. The truth, however, is, that no man will need the assistance of that eminent metaphysician to discover the fallacy of the reasoning by which they are attempted to be proved, if he affix *any one precise meaning* to the definitions and axioms, and adhere to that meaning steadily through the whole process of the pretended demonstrations.

By way of apology for this jargon, it has been lately said, that "Spinoza takes the word *substance* in its most simple and perfect sense; which is necessary, as he writes mathematically, and proposes a simple idea as the foundation of his theory. What is the proper signification of a substance? Is it not that which stands alone, which has the cause of its existence within itself? I wish that this simple meaning of the word could be universally admitted in philosophy. Strictly speaking, no worldly thing is a substance; since all mutually depend on each other, and finally on God, who, in this exalted sense, is the only *substance*. The word *modification* sounds harsh and improper, and therefore it cannot be expected to gain a place in philosophy; but if the school of Leibnitz may term matter the *appearance of substances*, why may not Spinoza be allowed a bolder term? Worldly substances are kept in union by divine power, as it was by divine power that they had existence. They represent also, if you please, *modified* appearances of divine power; each according to the station, the time, and the organs, in and with which it appears. The phrase used by Spinoza is concise, and it gives an unity and simplicity to his whole system, however strange it may sound in our ears."

Herder's Dialogues concerning God.

From this account of Spinozism, one who had never looked into the works of the author would be led to suppose that his system is the same with that of Berkeley; which, denying the existence of material substance, attributes all our perceptions of what we call the qualities of body to the immediate agency of the Deity on our minds (see METAPHYSICS, Part II. chap. 3.). But Spinoza's doctrine is very different. According to him, bodies are either attributes or affections of God; and as he says there is but one extended substance, he affirms that substance to be indivisible, and employs a long scholium † to prove that those are mistaken who suppose it finite and not *essential to the Deity*. That we do not misrepresent his sentiments, the learned reader will be convinced by the two following definitions, with which he introduces that part of his ethics which treats of the nature and origin of mind. 1. "Per corpus intelligo modum, qui Dei essentiam, quatenus, ut res extensa consideratur, certo et determinato modo exprimit." 2. "Ad essentiam alicujus rei id pertinere dico, quo dato res necessario ponitur, et quo sublato res necessario tollitur; vel id, sine quo res, et vice versa quod sine re nec esse nec concipi potest." In conformity with these definitions, he attempts to prove that God is an extended as well as a thinking substance; that as a thinking substance he is the cause of the *idea* of a circle, and as an extended substance of the *circle* itself; and that the minds of men are not substances, but certain modifications of the divine attributes; or, as he sometimes expresses it. "Quod humanæ mentis actuale constituit, est idea rei singularis actu existentis." Hence, he says, it follows that the human mind is a part of the intellect of the infinite God; so that when we speak of the human mind perceiving this or that, we can only mean that God, not as he is infinite, but as he appears in the human mind or constitutes its essence, has this or that idea; and when we speak of God's having this or that idea, we must conceive of Him not only as constituting the human mind, but as, together with it, having the idea of something else (A). In another place he tells us, that the human mind is nothing but the *idea* which God has of the human body as actually existing; that this *idea* of the body, and the *body* itself, are one and the same thing; and that thinking and extended substances are in reality but one and the same substance, which is sometimes comprehended under one attribute of the Deity, and sometimes under another*.

† See his Prop. xv. &c.

Prop. vii. xi. Part ii.

* Prop. vii. xiii. xxi. Part 2.

If this impious jargon be not Atheism, or as it has been sometimes called Pantheism, we know not what it is (See PANTHEISM). According to Spinosa, there is but one substance, which is extended, infinite, and indivisible. That substance indeed he calls God; but he labours to prove that it is corporeal; that there is no difference between mind and matter; that both are attributes

(A) Hinc sequitur mentem humanam partem esse infiniti intellectus Dei; ac proinde cum dicimus, mentem humanam hoc vel illud percipere, nihil aliud dicimus quam quod Deus, non quatenus infinitus est, sed quatenus per naturam humanæ mentis explicatur, sive quatenus humanæ mentis essentiam constituit, hanc vel illam habet ideam: et cum dicimus Deum hanc vel illam ideam habere, non tantum, quatenus naturam humanæ mentis constituit; sed quatenus simul cum mente humana alterius rei etiam habet ideam. *Corol.* prop. xi. part 2.

tributes of the Deity variously considered; that the human soul is a part of the intellect of God; that the same soul is nothing but the idea of the human body; that this idea of the body, and the body itself, are one and the same thing; that God could not exist, or be conceived, were the visible universe annihilated; and therefore that the visible universe is either the one substance, or at least an essential attribute or modification of that substance. He sometimes indeed speaks of the *power* of this substance; but when he comes to explain himself, we find that by power he means nothing but blind necessity *; and though he frequently talks of the *wisdom* of God, he seems to make use of the word without meaning. This we think evident from the long appendix to his 36th proposition; in which he labours to prove that the notion of final causes is an idle figment of the imagination, since, according to him, nothing but the prejudices of education could have led men to fancy that there is any real distinction between *good* and *evil*, *merit* and *demerit*, *praise* and *reproach*, *order* and *confusion*; that *eyes* were given them that they might be enabled to *see*; *teeth* for the purpose of chewing their *food*; *herbs* and *animals* for the *matter* of that *food*; that the *sun* was formed to give light, or the *ocean* to nourish *fishes*. If this be true, it is impossible to discover wisdom in the operations of his *one substance*; since, in common apprehension, it is the very characteristic of folly to act without any end in view.

* Prop. xxxii. Part I.

Such are the reveries of that writer, whose works a German philosopher of some name has lately recommended to the public, as calculated to convey to the mind more just and sublime conceptions of God than are to be found in most other systems. The recommendation has had its effect. A literary journalist of our own, reviewing the volume in which it is given, feels a peculiar satisfaction from the discovery, that Spinoza, instead of a formidable enemy to the cause of virtue and religion, was indeed their warmest friend; and piously hopes that we shall become more cautious not to suffer ourselves to be deceived by empty names, which those who *cannot* reason (Sir Isaac Newton and Dr Clarke perhaps) give to those who can (Hobbes, we suppose, and Spinoza). But though we have the honour to think on this question with our illustrious countrymen, we have no desire to depict Spinoza as a *reprobate*, which the critic says has often been done by ignorance and enthusiasm. We admit that his conduct in active life was irreproachable; and for his speculative opinions, he must stand or fall to his own Master. His Ethics appear to us indeed a system shockingly impious; and in the tract intitled POLITICA, *power* and *right* are confounded as in the former volume; but in the treatise DE INTELLECTUS EMENDATIONE, are scattered many precepts of practical wisdom, as well as some judicious rules for conducting philosophical investigation; and we only regret, that the reader must wade to them through pages of fatalism, scepticism, and palpable contradictions. His *Compendium Grammatices Linguæ Hebrææ*, though left imperfect, appears to have so much merit, that it is to be wished he had fulfilled his intention of writing a philosophical grammar of that language, instead of wasting his time on abstruse speculations, which though they seem not to have been injurious to his own virtue, are certainly not calculated to promote the virtue of others, or to increase the sum of human happiness.

SPIRÆA, a genus of plants belonging to the class of icosandria, and to the order of pentagynia; and in the natural system arranged under the 26th order, *Pomaceæ*. See BOTANY *Index*.

SPIRAL, in *Geometry*, a curve line of the circular kind, which in its progress recedes from its centre.

SPIRE, in *Architecture*, was used by the ancients for the base of a column, and sometimes for the astragal or tore; but among the moderns it denotes a steeple that continually diminishes as it ascends, whether conically or pyramidally.

SPIRIT, in *Metaphysics*, an incorporeal being or intelligence; in which sense God is said to be a spirit, as are angels and the human soul. See METAPHYSICS, Part III.

SPIRIT, in *Chemistry* and *Pharmacy*, a name applied to every volatile liquid which is not insipid like phlegm or water; and hence the distinction into acid, alkaline, and vinous spirits.

SPIRIT of Wine. See ALCOHOL, CHEMISTRY *Index*; DISTILLATION, and MATERIA MEDICA *Index*.

SPIRITS, or ANIMAL SPIRITS. See ANATOMY, Part V. n° 136.

SPIRITUAL, in general, something belonging to or partaking of the nature of spirit. See SPIRIT.

SPIRITUOUS LIQUORS have in all nations been considered as a proper subject of heavy taxation for the support of the state. This has naturally occasioned a nice examination of their strength. It having been at last found that this was intimately connected with the specific gravity, this has been examined with the most scrupulous attention to every circumstance which could affect it, so that the duties might be exactly proportioned to the quantity of spirit in any strong liquor, independent on every other circumstance of flavour or taste, or other valued quality. The chemist at last found that the basis of all strong liquors is the same, produced by the vinous fermentation of pure saccharine matter dissolved in water. He also found, that whether this vegetable salt be taken as it is spontaneously formed in the juices of plants and fruits, or as it may be formed or extricated from farinaceous fruits and roots by a certain part of the process of vegetation, it produces the same ardent spirit, which has always the same density in every mixture with water. The minute portions of aromatic oils, which are in some degree inseparable from it, and give it a different flavour according to the substance from which it was obtained, are not found to have any sensible effect on its density or specific gravity. This seems very completely established in consequence of the unwearied attempts of the manufacturers to lessen the duties payable on their goods by mixtures of other substances, which would increase their density without making them less palatable. The vigilance of the revenue officers was no less employed to detect every such contrivance. In short, it is now an acknowledged point, that the specific gravity is an accurate test of the strength.

But though this is true in general, we cannot derive much benefit from it, unless we know the precise relation between the strength and the density of a spirituous liquor. Do they increase *pari passu*, or by what law

Spirituous. law are they connected? It was natural to expect that equal additions of ardent spirits or alcohol to a given quantity of water would produce equal diminutions of density. Areometers were accordingly made on this principle above 200 years ago, as may be seen in the works of Gaspar Schottus, Sturmius, Agricola, and other old authors. But when mathematical physics became more generally known, this was easily discovered to be erroneous; and it was shown (we think first by Mr Boyle) that equal additions to the specific gravity would be produced by successively taking out of any vessel a certain measure of alcohol and replacing it with an equal measure of water. This was the most convenient discovery for all parties, because then the duties payable on a cask of spirits would be in the exact proportion of the diminution of its density. But it was soon found by those who were appointed guardians of the revenue that this conclusion was erroneous, and that a mixture which appeared by this rule to contain 35 gallons of alcohol, did really contain $35\frac{1}{2}$. This they found by actually making such a mixture: 18 gallons of alcohol mixed with 18 of water produced only 35 gallons of spirits. The revenue officers, finding that this condensation was most remarkable in mixtures of equal parts of water and the strongest spirits which could then be procured, determined to levy the duties by this mixture; because, whether the spirituous liquor was stronger or weaker than this, it would appear, by its specific gravity, rather stronger than it really was. This sagacious observation, and the simplicity of the composition, which could at all times be made for comparison, seem to be the reasons for our excise offices selecting this mode of estimating the strength and levying the duties. A mixture of nearly equal measures of water and alcohol is called PROOF SPIRIT, and pays a certain duty per gallon; and the strength of a spirituous liquor is estimated by the gallons, not of alcohol, but of proof spirit which the cask contains. But because it might be difficult to procure at all times this proof spirit for comparison, such a mixture was made by order of the board of excise: and it was found, that when six gallons of it was mixed with one gallon of water, a wine gallon of the mixture weighed 7 pounds 13 ounces avoirdupois. The board therefore declared, that the spirituous liquor of which the gallon weighed 7 pounds 13 ounces should be reckoned 1 to 6 or 1 in 7 under proof. This is but an aukward and complex formula; it was in order to suit matters to a mode of examination which had by time obtained the sanction of the board. Mr Clarke, an ingenious artist of that time, had made a hydrometer incomparably more exact than any other, and constructed on mathematical principles fit for computation. This had a set of weights corresponding to the additions of water or proof spirit, and the mixture 1 to 6 or 1 in 7 was the only one which weighed an exact number of ounces per gallon without a fraction. Spirituous.

Thus stands the excise law; and Clarke's hydrometer is still the instrument of authority, although others have been since constructed by DICAS, QUIN, and others, which are much more ingenious and convenient. The mathematician who examines Dicas's hydrometer, with its sliding scale, by which it is adjusted to the different temperatures, and points out the condensations, will perceive a beautiful and sagacious combination of quantities, which he will find it difficult to bring under any analytical formula. Perhaps Quin's may have some preference in respect of conveniency; but *facile inventis addere*. Mr Dicas's was original (A).

As naturalists became more accustomed to exact observations in every topic of inquiry, the condensation which obtains in the mixture of different substances became more familiarly known. This evidently affects the present question; and both the excise and the distillers are interested in its accurate decision. This occasioned an application to the Royal Society; and a most scrupulous examination of the strength of spirituous liquors was made by Sir Charles Blagden and Mr Gilpin, of which they have given a very particular account in the Philosophical Transactions for 1790 and 1792.

We have taken notice of this in the article SPECIFIC GRAVITY, mentioning such circumstances of the results as suited our purposes of physical discussion. At present

(A) Among the various contrivances which have been thought of, among manufacturers and dealers, as well as for the purposes of revenue, for ascertaining the specific gravity, and consequently the real strength and value of high-priced and high-taxed liquids, we are persuaded there is none equal, in point of accuracy, simplicity, and facility of application, to the areometrical beads lately announced to the public by Mrs Lovi of Edinburgh, under the privilege of a patent; and with this persuasion we have no hesitation in recommending them to those to whom the use of a simple and accurate instrument is of great importance in determining the value of high-priced spirituous liquors. Our recommendation rests not solely on our own opinion, but is supported by that of others who are well acquainted with such subjects. We know, too, that the beads have been examined and compared by several intelligent manufacturers and dealers with some of the most accurate hydrometrical instruments, and after a fair trial, a decided preference has been given to the beads. The whole apparatus consists of 30 beads, a sliding rule, a thermometer, a glass jar and brass hook, which are packed in a neat small box; and it is accompanied with directions, which point out, 1. In what manner the real strength of spirits may be ascertained at any given temperature between 40° and 80°. 2. How much per cent. the spirit to be tried is over or under proof according to the practice of spirit-dealers; and, 3. The proportion of water and the strongest spirits or alcohol, according to the views and language of excisemen. The advantages of these beads are, that being made of a substance which is little acted on by chemical agents, they are less liable to be injured by use, than instruments composed of metal; and when a bead happens to be broken, it can be easily replaced. They possess this farther advantage, that with the application of the thermometer, and the calculation of the sliding rule, the real strength of the spirits may be taken at all temperatures. It has been suggested, that these beads, from their being less liable to change than other instruments, might be usefully employed in checking the errors and variations of other hydrometers. Beads are prepared by Mrs Lovi on the same principle for ascertaining the strength of worts, acids, &c.

Spirituous

fent we give the general refult in the table of fpecific gravity, as peculiarly belonging to fpirituous liquors, affording the moft exact account of their denfity in every ftate of dilution of alcohol with water. And as the relation between the proportion of ingredients and the denfity is peculiar to every fubftance, fo that fcarcely any inference can be made from one to another, the reader will confider the tables here given as characteriftic with refpect to alcohol. In all folutions of falts we found that the condenfation increafes continually with the dilution, whereas it is greateft when equal bulks of water and alcohol are mixed; yet we do not confider this as an exception; for it is certain, that in the ftrongeft brine the faline ingredient bears but a fmall proportion to the water—and when we mix two folutions, the condenfation is greateft when they are nearly equal in bulk. But we think ourfelves entitled to infer, that alcohol is not a dilution of a fubftance in a quantity of water; but that water, in a certain proportion, not very diftant from what we can produce by flow diftillation, is an ingredient of alcohol, or is one of its component parts, and not merely a vehicle or menftruum. We therefore imagine that proof fpirit contains nearly equal bulks of water and ardent fpirits.

The great difficulty in this examination arofe from the very diffimilar expanfions of water and alcohol by heat. This determined Sir Charles Blagden to eftimate the proportions of ingredients by weight, and made it abfolutely neceffary to give a fcale of fpecific gravity and ftrength for every temperature. For it muft be remarked, that the queftion (whether in commerce or philofophy) always is, "How many gallons of alcohol and of water, taken juft now and mixed together, will produce a hundred gallons of the fpirit we are examining?" The proportion of thefe two will be different according to the temperature of both. As many mixtures therefore muft have been made in each proportion as there were temperatures confidered; but by taking the ingredients by weight, and examining the denfity of the compound in one temperature, it is then heated and cooled, and its change of denfity obferved. Calculation then can tell us the change in the proportion of the bulks or numbers of gallons in the mixture, by means of a previous table fhowing the expanfions of water and of alcohol.

The alcohol felected for this examination had the fpecific gravity 0.825. This is not the pureft that can be procured; fome was produced of 0.816, of 0.814, and 0.813, both obtained from rum, from brandy, and from malt fpirit. We are informed that Dr Black has obtained it of the fpecific gravity 0.8 by digefting alcohol with fixed ammoniac (muriatic acid united with lime) made very dry. It dephlegmates alcohol very powerfully without decompofing it, which always happens when we ufe cauftic alkali. Alcohol of 0.825 was chofen becaufe expreffed by a number of eafy management in computation.

The examination commenced by afcertaining the expanfions of water and alcohol. The temperature 60° of Fahrenheit's fcale was felected for the general temperature of comparifon, being eafily attainable even in cold weather, and allowing the examinator to operate at eafe. The firft and laft compartments of the tables contain the weights and fpecific gravities of alcohol and water for every fifth degree of heat from 30° to 100°. From thefe we have conftructed the two following little tables of expanfion. The bulk of 1000 ounces, pounds, or other weight of water and of alcohol of the temperature 60°, occupies the bulks expreffed in the tables for every other temperature. Water could not be eafily or ufefully examined when of the temperature 30°, becaufe it is with great difficulty kept fluid in that temperature. It is very remarkable, that when it can be fo kept, it expands inftead of contracting; while cooling down from 35° or thereabouts, and as it approaches to 32°, it expands rapidly. We obferve the fame thing in the cryftallization of Glauber falt, martial vitriol, and fome others, which contain much water in their cryftals. We obferve, on the other hand, a remarkable contraction in the zeolite juft before its beginning to fwell into bubbles by a red heat.

Heat.	Bulk of 100,000 ounces.			
	Of Water.		Of Alcohol.	
		Diff.		Diff.
30°			119195	
35	99910		119514	319
40	999 6	— 4	119839	325
45	99914	+ 8	120172	332
50	99932	18	120514	342
55	99962	30	120868	348
60	100000	38	121122	350
65	100050	50	121565	353
70	100106	56	121919	354
75	100170	64	122279	360
80	100241	71	122645	366
85	100320	79	123017	372
90	100404	84	123393	376
95	100500	96	123773	380
100	100608	108	124157	384

This being premifed, the examination was conducted in the following manner. It was determined to mix 100 parts by weight of pure alcohol with five, ten, fifteen, twenty, parts of diftilled water, till they were compounded in equal quantities, and then to mix 100 parts of diftilled water with, 95, 90, 85, 80, &c. parts of alcohol, till they were mixed in the proportion of 100 to 5. Thus a feries of mixtures would be obtained, extending from pure alcohol to pure water. This feries would be fuch, that the examinations would be moft frequent in the cafes moft ufual in the commerce of ftrong liquors. A fet of phials, fitted with ground ftoppers, were provided, of fizes fit to hold the intended mixtures. Thefe mixtures were made by fufpending the phial to the arm of a very nice balance, in the oppofite fcale of which (befides the counterpoife of the phial) there was placed the weight 100. Spirit was then poured into the phial till it exactly balanced the weight 100. The weight for the water to be added was then put into the oppofite fcale, and water was poured into the phial by means of a flender glafs funnel, by fmall quantities at a time, and the phial frequently agitated to promote the mixture. When the additional weight was exactly balanced, the phial was taken off, its ftopper put in, and leather tied over it, and it was fet by, for at leaft a month, that the mixture and the whole procefs of condenfation might be completed. The fame method

Spirituous Liquors.

method was followed in the mixtures where the water was predominant.

When the ingredients of these mixtures were judged to have completely incorporated, their specific gravity was examined by weighing with the most scrupulous precision the contents of a vessel which held 2925 troy grains of water, of the temperature 60°. The balance was so exceedingly sensible, that the 50th part of a grain greatly deranged its position when loaded with the scales and their contents. It was constructed by Mr Ramsden, and some account of its exquisite sensibility may be seen in the *Journal de Physique*, vol. xxxiii. This quantity of materials was therefore thought abundantly sufficient for ascertaining the density of the liquor. It is needless to detail the precautions which were taken for having the contents of the weighing bottle brought to the precise temperature proper for the experiment. They were such as every person conversant with such things is accustomed to take.—The bottle had a slender neck, and being put on a lathe, a mark was made round it with a diamond. The bottle was filled till the bottom of the hollow surface of the fluid was in the plane of this mark; and to judge of the accuracy attainable in filling the bottle, the operation was several times repeated and the contents weighed, without the difference of $\frac{1}{30}$th of a grain in 2925. The only source of error which was to be guarded against was air-bubbles adhering to the inside of the bottle, or moisture condensing (in the experiments with low temperatures) on the outside. Both of these were attended to as much as possible.

This method of determining the specific gravity was preferred to the usual method, observing the weight lost by a lump of glass when suspended in water; for Mr Gilpin had been enabled, by means of this nice balance, to discover, even in pure water and in alcohol, a want of perfect fluidity. Something like viscidity rendered the motion of a lump of glass through the liquor sensibly sluggish, so that when the balance was brought to a level, there was not a perfect equilibrium of weights: (See what we have said of this matter in SPECIFIC GRAVITY). Mr Gilpin also tried the ingenious instrument proposed for such experiments by Mr Ramsden, and described by him in a pamphlet on this very subject; and he found the anomalies of experiment much greater than in this method by weighing.—Indeed the regular progression of weights to be seen in the annexed tables is an unquestionable proof of the sufficiency of the method; and it has the evident advantage of all other methods in point of simplicity and practicability without any uncommon apparatus. Any person possessed of a good ordinary balance and a set of exact weights may examine all questions of this kind, by weighing pure water and the liquor which he may have occasion to examine in a common 6 or 8 ounce phial. For this reason, it is recommended (in preference to all hydrometers) to the board of excise to provide this simple apparatus in every principal office.

Every experiment was made at least three times; and the mean result (which never differed one grain from the extreme) was taken.

From these experiments the annexed tables were constructed. The first is the simple abstract of the experiments, containing the weights of the contents of the bottle of every mixture. The second contains the specific gravities deduced from them.

We have said that the experiments appear surprisingly accurate. This we say on the authority of the regular progression of the specific gravity in any of the horizontal rows. In the series, for instance, for the temperature 60°, the greatest anomaly is in the mixture of 50 parts of spirit with 100 of water. The specific gravity is 95804, wanting 3 or 4 of the regular progression. This does not amount to 1 in 18000.

TABLE I. Weights at the different Degrees of Temperature.

Heat.	The pure Spirit.	100 grains of ſpirit to 5 grains of water.	100 grains of ſpirit to 10 grains of water.	100 grains of ſpirit to 15 grains of water.	100 grains of ſpirit to 20 grains of water.	100 grains of ſpirit to 25 grains of water.	100 grains of ſpirit to 30 grains of water.	100 grains of ſpirit to 35 grains of water.	100 grains of ſpirit to 40 grains of water.	100 grains of ſpirit to 45 grains of water.	100 grains of ſpirit to 50 grains of water.	100 grains of ſpirit to 55 grains of water.	100 grains of ſpirit to 60 grains of water.	100 grains of ſpirit to 65 grains of water.
deg.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
30	2487.35	2519.92	2548.42	2573.80	2596.66	2617.30	2636.23	2653.73	2669.83	2684.74	2698.51	2711.14	2722.89	2733.87
35	2480.87	2513.43	2541.84	2567.26	2590.16	2610.87	2629.92	2647.47	2663.64	2678.60	2692.43	2705.14	2716.92	2727.87
40	2474.30	2506.75	2535.41	2560.74	2583.66	2604.50	2623.56	2641.08	2657.23	2672.30	2686.32	2698.94	2710.81	2721.83
45	2467.62	2500.14	2528.75	2554.09	2577.10	2597.98	2617.03	2634.64	2650.87	2666.04	2679.99	2692.77	2704.57	2715.62
50	2460.75	2493.33	2521.96	2547.47	2570.42	2591.38	2610.54	2628.21	2644.43	2659.55	2673.64	2686.54	2698.42	2709.48
55	2453.80	2486.37	2515.03	2540.60	2563.64	2584.65	2603.80	2621.50	2637.86	2653.04	2667.14	2679.98	2691.83	2702.98
60	2447.00	2479.56	2508.27	2533.83	2556.90	2577.95	2597.22	2615.03	2631.37	2646.53	2660.62	2673.55	2685.52	2696.73
65	2440.12	2472.75	2501.53	2526.99	2550.22	2571.24	2590.55	2608.37	2624.75	2640.01	2654.04	2667.07	2679.15	2690.32
70	2433.23	2465.88	2494.56	2520.03	2543.32	2564.47	2583.88	2601.67	2617.96	2633.32	2647.52	2660.63	2672.74	2684.02
75	2426.23	2458.78	2487.62	2513.08	2536.39	2557.61	2576.93	2594.80	2611.19	2626.55	2640.81	2653.99	2666.06	2677.34
80	2419.02	2451.67	2480.45	2506.08	2529.24	2550.50	2569.86	2587.93	2604.29	2619.72	2633.99	2647.12	2659.36	2670.69
85	2411.92	2444.63	2473.33	2499.01	2522.29	2543.54	2563.01	2580.93	2597.45	2613.02	2627.39	2640.60	2652.78	2664.16
90	2404.90	2437.62	2466.32	2491.99	2515.28	2536.63	2556.11	2574.02	2590.60	2606.16	2620.52	2633.74	2646.00	2657.41
95	2397.68	2430.33	2459.13	2484.74	2508.10	2529.46	2549.13	2567.03	2583.65	2599.24	2613.57	2626.94	2639.25	2650.63
100	2390.60	2423.22	2452.13	2477.64	2500.91	2522.30	2541.92	2559.96	2576.56	2592.14	2606.50	2619.75	2632.17	2643.75

Heat.	100 grains of ſpirit to 70 grains of water.	100 grains of ſpirit to 75 grains. of water.	100 grains of ſpirit to 80 grains of water.	100 grains of ſpirit to 85 grains of water.	100 grains of ſpirit to 90 grains of water.	100 grains of ſpirit to 95 grains of water.	100 grains of ſpirit to 100 grains of water.	95 grains of ſpirit to 100 grains of water.	90 grains of ſpirit to 100 grains of water.	85 grains of ſpirit to 100 grains of water.	80 grains of ſpirit to 100 grains of water.	75 grains of ſpirit to 100 grains of water.	70 grains of ſpirit to 100 grains of water.	65 grains of ſpirit to 100 grains of water.
deg.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
30	2744.20	2753.75	2762.72	2771.08	2778.99	2786.36	2793.22	2799.85	2806.61	2813.85	2821.35	2828.90	2836.39	2844.16
35	2738.13	2747.74	2756.91	2765.32	2773.22	2780.59	2787.54	2794.19	2801.14	2808.52	2816.07	2823.68	2831.36	2839.26
40	2732.24	2741.86	2750.96	2759.50	2767.48	2774.90	2781.84	2788.69	2795.70	2803.17	2810.73	2818.36	2826.31	2834.40
45	2726.09	2735.77	2744.82	2753.36	2761.42	2768.85	2775.94	2782.99	2789.99	2797.45	2805.08	2812.93	2821.00	2829.28
50	2719.93	2729.64	2738.74	2747.27	2755.37	2762.95	2770.14	2777.19	2784.30	2791.72	2799.58	2807.56	2815.71	2824.12
55	2713.60	2723.51	2732.64	2741.24	2749.27	2756.83	2764.09	2771.29	2778.54	2785.96	2793.82	2801.89	2810.23	2818.80
60	2707.40	2717.30	2726.52	2735.17	2743.28	2750.93	2758.17	2765.40	2772.70	2780.26	2788.25	2796.45	2804.85	2813.65
65	2701.05	2710.96	2720.25	2728.98	2737.09	2744.86	2752.21	2759.47	2766.73	2774.43	2782.62	2790.81	2799.38	2808.31
70	2694.76	2704.64	2713.87	2722.75	2730.94	2738.73	2746.06	2753.41	2760.75	2768.45	2776.72	2785.06	2793.80	2802.88
75	2688.14	2698.07	2707.49	2716.35	2724.64	2732.39	2739.89	2747.23	2754.73	2762.58	2770.93	2779.26	2788.00	2797.21
80	2681.50	2691.50	2700.94	2709.76	2718.12	2726.06	2733.53	2740.93	2748.42	2756.43	2764.87	2773.33	2782.14	2791.52
85	2674.95	2684.98	2694.53	2703.33	2711.86	2719.74	2727.25	2734.80	2742.31	2750.22	2758.80	2767.44	2776.33	2785.81
90	2668.29	2678.49	2687.99	2696.91	2705.37	2713.32	2721.01	2728.59	2736.23	2744.24	2752.76	2761.51	2770.59	2780.11
95	2661.51	2671.82	2681.34	2690.33	2698.86	2706.88	2714.61	2722.23	2729.89	2737.98	2746.57	2755.34	2764.57	2774.25
100	2654.76	2664.99	2674.62	2683.63	2692.25	2700.33	2708.04	2715.73	2723.35	2731.55	2740.43	2749.28	2758.48	2768.43

Heat.	60 grains of ſpirit to 100 grains of water.	55 grains of ſpirit to 100 grains of water.	50 grains of ſpirit to 100 grains of water.	45 grains of ſpirit to 100 grains of water.	40 grains of ſpirit to 100 grains of water.	35 grains of ſpirit to 100 grains of water.	30 grains of ſpirit to 100 grains of water.	25 grains of ſpirit to 100 grains of water.	20 grains of ſpirit to 100 grains of water.	15 grains of ſpirit to 100 grains of water.	10 grains of ſpirit to 100 grains of water.	5 grains of ſpirit to 100 grains of water.	Water.	
deg.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	
30	2852.03	2859.71	2867.12	2874.43	2881.34	2887.77	2894.22	2900.85	2908.21	2917.19	2928.80	2944.53		
35	2847.45	2855.32	2863.16	2870.87	2878.21	2885.06	2892.07	2899.31	2907.45	2916.95	2928.99	2945.02	2967.14	
40	2842.62	2850.88	2859.06	2867.08	2874.81	2882.30	2889.78	2897.61	2906.39	2916.41	2928.93	2945.25	2967.45	
45	2837.64	2846.16	2854.67	2863.04	2871.22	2879.22	2887.33	2895.67	2904.98	2915.55	2928.49	2945.20	2967.40	
50	2832.76	2841.52	2850.29	2858.96	2867.52	2875.98	2884.57	2893.58	2903.39	2914.42	2927.81	2944.73	2967.05	
55	2827.68	2836.69	2845.72	2854.75	2863.75	2872.67	2881.69	2891.11	2901.42	2913.02	2926.73	2943.98	2966.34	
60	2822.65	2831.90	2841.10	2850.50	2859.87	2869.15	2878.72	2888.62	2899.35	2911.32	2925.50	2942.98	2965.39	
65	2817.49	2826.90	2836.30	2845.97	2855.65	2865.45	2875.49	2885.85	2897.09	2909.43	2923.90	2941.69	2964.11	
70	2812.16	2821.78	2831.61	2841.42	2851.53	2861.63	2872.06	2882.90	2894.56	2907.33	2922.24	2940.13	2[illegible]2.66	
75	2806.75	2816.63	2826.56	2836.80	2847.14	2857.70	2868.49	2879.67	2891.79	2905.04	2920.17	2938.33	2960.97	
80	2801.25	2811.23	2821.38	2831.92	2842.56	2853.38	2864.54	2876.22	2888.73	2902.35	2917.83	2936.31	2959.07	
85	2795.69	2805.85	2816.32	2827.12	2838.07	2849.28	2860.86	2872.88	2885.56	2899.55	2915.46	2934.14	2956.94	
90	2790.13	2800.40	2811.05	2822.15	2833.38	2844.81	2856.80	2869.16	2882.25	2896.58	2912.84	2931.77	2954.70	
95	2784.36	2794.91	2805.79	2817.08	2828.46	2840.26	2852.47	2865.15	2878.71	2898.44	2910.02	2929.15	2952.08	
100	2778.64	2789.32	2800.25	2811.80	2823.55	2835.30	2848.18	2861.12	2875.07	2890.04	2906.97	2926.28	2949.34	

Table II. Real Specific Gravities at the different Temperatures.

Heat.	The pure spirit.	100 grains of spirit to 5 grains of water.	100 grains of spirit to 10 grains of water.	100 grains of spirit to 15 grains of water.	100 grains of spirit to 20 grains of water.	100 grains of spirit to 25 grains of water.	100 grains of spirit to 30 grains of water.	100 grains of spirit to 35 grains of water.	100 grains of spirit to 40 grains of water.	100 grains of spirit to 45 grains of water.	100 grains of spirit to 50 grains of water.	100 grains of spirit to 55 grains of water.	100 grains of spirit to 60 grains of water.	100 grains of spirit to 65 grains of water.
deg.														
30	.83896	.84995	.85957	.86825	.87585	.88282	.88921	.89511	.90054	.90558	.91023	.91449	.91847	.92217
35	.83672	.84769	.85729	.86587	.87357	.88059	.88701	.89294	.89839	.90345	.90811	.91241	.91640	.92009
40	.83445	.84539	.85507	.86361	.87134	.87838	.88481	.89073	.89617	.90127	.90596	.91026	.91428	.91799
45	.83214	.84310	.85277	.86131	.86907	.87613	.88255	.88849	.89396	.89909	.90380	.90812	.91211	.91584
50	.82977	.84076	.85042	.85902	.86676	.87384	.88030	.88626	.89174	.89684	.90160	.90596	.90997	.91370
55	.82736	.83834	.84802	.85664	.86441	.87150	.87796	.88393	.88945	.89458	.89933	.90367	.90768	.91144
60	.82500	.83599	.84568	.85430	.86208	.86918	.87568	.88169	.88720	.89232	.89707	.90144	.90549	.90927
65	.82262	.83362	.84334	.85193	.85976	.86686	.87337	.87938	.88490	.89006	.89479	.89920	.90328	.90707
70	.82023	.83124	.84092	.84951	.85736	.86451	.87105	.87705	.88254	.88773	.89252	.89695	.90104	.90484
75	.81780	.82878	.83851	.84710	.85493	.86212	.86864	.87466	.88018	.88538	.89018	.89464	.89872	.90252
80	.81530	.82631	.83603	.84467	.85248	.85966	.86623	.87228	.87776	.88301	.88781	.89225	.89639	.90021
85	.81283	.82386	.83355	.84221	.85006	.85723	.86380	.86984	.87541	.88067	.88551	.88998	.89409	.89793
90	.81039	.82142	.83111	.83977	.84762	.85483	.86139	.86743	.87302	.87827	.88312	.88758	.89173	.89558
95	.80788	.81888	.82860	.83724	.84511	.85232	.85896	.86499	.87060	.87586	.88069	.88521	.88937	.89322
100	.80543	.81643	.82618	.83478	.84262	.84984	.85646	.86254	.86813	.87340	.87824	.88271	.88691	.89082

Heat.	100 grains of spirit to 70 grains of water.	100 grains of spirit to 75 grains of water.	100 grains of spirit to 80 grains of water.	100 grains of spirit to 85 grains of water.	100 grains of spirit to 90 grains of water.	100 grains of spirit to 95 grains of water.	100 grains of spirit to 100 grains of water.	95 grains of spirit to 100 grains of water.	90 grains of spirit to 100 grains of water.	85 grains of spirit to 100 grains of water.	80 grains of spirit to 100 grains of water.	75 grains of spirit to 100 grains of water.	70 grains of spirit to 100 grains of water.	65 grains of spirit to 100 grains of water.
deg.														
30	.92563	.92889	.93191	.93474	.93741	.93991	.94222	.94447	.94675	.94920	.95173	.95429	.95681	.95944
35	.92355	.92680	.92986	.93274	.93541	.93790	.94025	.94249	.94484	.94734	.94988	.95246	.95502	.95772
40	.92151	.92476	.92783	.93072	.93341	.93592	.93827	.94058	.94295	.94547	.94802	.95060	.95328	.95602
45	.91937	.92264	.92570	.92859	.93131	.93382	.93621	.93860	.94096	.94348	.94605	.94871	.95143	.95423
50	.91723	.92050	.92358	.92647	.92919	.93177	.93419	.93658	.93897	.94149	.94414	.94683	.94958	.95243
55	.91502	.91837	.92145	.92436	.92707	.92963	.93208	.93452	.93696	.93948	.94213	.94486	.94767	.95057
60	.91287	.91622	.91933	.92225	.92499	.92758	.93002	.93247	.93493	.93749	.94018	.94296	.94579	.94876
65	.91066	.91400	.91715	.92010	.92283	.92546	.92794	.93040	.93285	.93546	.93822	.94099	.94388	.94689
70	.90847	.91181	.91493	.91793	.92069	.92333	.92580	.92828	.93076	.93337	.93616	.93898	.94193	.94500
75	.90617	.90952	.91270	.91569	.91849	.92111	.92364	.92613	.92865	.93132	.93413	.93695	.93989	.94301
80	.90385	.90723	.91042	.91340	.91622	.91891	.92142	.92393	.92646	.92917	.93201	.93488	.93785	.94102
85	.90157	.90496	.90818	.91119	.91403	.91670	.91923	.92179	.92432	.92700	.92989	.93282	.93582	.93902
90	.89925	.90270	.90590	.90891	.91177	.91446	.91705	.91962	.92220	.92491	.92779	.93075	.93381	.93703
95	.89688	.90037	.90358	.90662	.90949	.91221	.91481	.91740	.91998	.92272	.92562	.92858	.93170	.93497
100	.89453	.89798	.90123	.90428	.90718	.90992	.91252	.91513	.91769	.92047	.92346	.92646	.92957	.93293

Heat.	60 grains of spirit to 100 grain of water.	55 grains of spirit to 100 grains of water.	50 grains of spirit to 100 grains of water.	45 grains of spirit to 100 grains of water.	40 grains of spirit to 100 grains of water.	35 grains of spirit to 100 grain of water.	30 grains of spirit to 100 grains of water.	25 grains of spirit to 100 grains of water.	20 grains of spirit to 100 grains of water.	15 grains of spirit to 100 grains of water.	10 grains of spirit to 100 grains of water.	5 grains of spirit to 100 grains of water.	Water.
deg.													
30	.96209	.96470	.96719	.96967	.97200	.97418	.97635	.97860	.98108	.98412	.98804	.99334	
35	.96048	.96315	.96579	.96840	.97086	.97319	.97556	.97801	.98076	.98397	.98804	.99344	1.00090
40	.95879	.96159	.96434	.96706	.96967	.97220	.97472	.97737	.98033	.98373	.98795	.99345	1.00094
45	.95705	.95993	.96280	.96563	.96840	.97110	.97384	.97666	.97980	.98338	.98774	.99338	1.00086
50	.95534	.95831	.96126	.96420	.96708	.96995	.97284	.97589	.97920	.98293	.98745	.99316	1.00068
55	.95357	.95662	.95966	.96272	.96575	.96877	.97181	.97500	.97847	.98239	.98702	.99284	1.00038
60	.95181	.95493	.95804	.96122	.96437	.96752	.97074	.97409	.97771	.98176	.98654	.99244	1.00000
65	.95000	.95318	.95635	.95962	.96288	.96620	.96959	.97309	.97688	.98106	.98594	.99194	.99950
70	.94813	.95139	.95469	.95802	.96143	.96484	.96836	.97203	.97596	.98028	.98527	.99134	.99894
75	.94623	.94957	.95292	.95638	.95987	.96344	.96708	.97086	.97495	.97943	.98454	.99066	.99830
80	.94431	.94768	.95111	.95467	.95826	.96192	.96568	.96963	.97385	.97845	.98367	.98991	.99759
85	.94236	.94579	.94932	.95297	.95667	.96046	.96437	.96843	.97271	.97744	.98281	.98912	.99681
90	.94042	.94389	.94748	.95123	.95502	.95889	.96293	.96711	.97153	.97637	.98185	.98824	.99598
95	.93839	.94196	.94563	.94944	.95328	.95727	.96139	.96568	.97025	.97523	.98082	.98729	.99502
100	.93638	.93999	.94368	.94759	.95152	.95556	.95983	.96424	.96895	.97401	.97969	.98625	.99402

We formerly obferved, that the feries of mixtures chofen by Sir Charles Blagden, for the advantages attending it in making the experiment, was not fuited for folving the queftions which commonly occur in the fpirit bufinefs. He accordingly fuggefts the propriety of forming tables in a convenient feries from the data furnifhed by thefe experiments, indicating the proportion of ingredients contained in fome conftant weight or bulk.

To facilitate the conftruction of fuch tables, it is neceffary to confider the fubject in the moft general manner. Therefore let a reprefent the conftant number 100. Let w and s reprefent the quantities of water and fpirit by weight in any mixture; that is, the pounds, ounces, or grains of each. Let x reprefent the quantity per cent. of fpirits alfo by weight; that is, the number of pounds of fpirits contained in 100 pounds of the mixture; and let y be its quantity per cent. in gallons, or the number of gallons contained in 100 gallons of the unmixed ingredients. Let m be the bulk of a pound of fpirit of any given temperature, the bulk of a pound of water *of the fame temperature* being accounted 1.

Then $w+s$ is the weight of any mixture, and $w+ms$ is its bulk.

We have the following proportions: 1. $w+s:s=a:x$, and $x=\frac{as}{w+s}$ (Equation 1ft); and hence s may be found when x the per centage in weight is given, for $s=\frac{wx}{a-x}$ (Equation 2.)

2. $w+ms:ms=a:y$, and $y=a\frac{ms}{w+ms}$ (Equation 3d); and s may be found when y, the per centage in gallons, is given; for $s=\frac{my}{a-y}$ (Equation 4th).

The ufual queftions which can be folved from thefe experiments are,

1. To afcertain the quantity of fpirits per cent. in bulk from obfervation of the fpecific gravity, or to tell how many gallons of fpirit are in 100 gallons of mixture.

Look for the fpecific gravity in the table, and at the head of the column will be found the w and s correfponding. If the precife fpecific gravity obferved is not in the tables, the s muft be found by interpolation. And here it is proper to remark, that taking the fimple proportional parts of fpecific gravity will not be fufficiently exact, efpecially near the beginning or the end of the table, becaufe the denfities correfponding to the feries of mixtures do not change uniformly. We muft have recourfe to the general rules of interpolation, by means of firft and fecond differences, or be provided with a fubfidiary table of differences. A good deal of practice in computations of this kind fuggefted the following method of making fuch interpolations with great difpatch and abundant accuracy. On a plate of wood or metal, or ftiff card-paper, draw a line EF (fig. 1.), as a fcale of equal parts, reprefenting the leading or equable arithmetical feries of any table. (In the prefent cafe EF is the fcale on which s is computed.)—Through every point of divifion draw the perpendiculars BA, EC, FD, &c. Make one of them AB more confpicuous than the reft, and diftinguifh the others alfo in fuch fort, that the eye fhall readily catch their diftance from the principal line AB. Let GPL be a thin flip of whalebone, of uniform breadth and thicknefs, alfo divided into equal parts properly diftinguifhable. Laftly, let there be a pin P fixed near the middle of the principal line AB.

Plate CCCCXCIX Fig. 1.

Now fuppofe that a value of s is to be interpolated by means of an obferved fpecific gravity not in the table. Look for the neareft to it, and note its diftance from the preceding and the following. Let thefe be PH and PK on the flexible fcale. Alfo take notice of the lines K 10 and H 10, whofe diftances from AB are equal to the conftant difference between the fucceffive values of S, or to any eafily eftimated multiple of it (as in the prefent cafe we have taken 10 and 10, inftead of 5 and 5, the running difference of Sir Charles Blagden's table). Then, leaning the middle point P of the whalebone on the pin P in the board, bend it, and place it flantwife till the points K and H fall fomewhere on the two parallels K 10 and H 10. No matter how oblique the pofition of the whalebone is. It will bend in fuch a manner that its different points of divifion (reprefenting different fpecific gravities) will fall on the parallels which reprefent the correfponding values of s. We can fay that all this may be done in lefs than half a minute, and lefs time than is neceffary for infpecting a table of proportional parts, and not the tenth part of that neceffary for interpolating by fecond differences. Yet it is exact enough (if of the fize of a duodecimo page) for interpolating three decimal places. This is ten times more exact than the prefent cafe requires. To return from this digreffion.

Having thus found s in the table, we get x or y by the equations $\frac{as}{w+s}=x$, and $a\frac{ms}{w+ms}=y$.

But here a material circumftance occurs. The weight of alcohol s, and its per centage x, was rightly determined by the fpecific gravity, becaufe it was interpolated between two values, which were experimentally connected with this fpecific gravity. But in making the tranfition from x to y, we only give the per centage in gallons before mixture, but not the number of gallons of alcohol contained in an hundred gallons of mixed liquor. For when we have taken $\overline{a-y}$ and y inftead of w and s, they will indeed make a fimilar compound when mixed, becaufe the proportion of their ingredients is the fame. But they will not make 100 gallons of this compound, becaufe there is a fhrinking or condenfation by mixture, and the fpecific gravity by which we interpolated s is the phyfical or real fpecific gravity correfponding to w and s; while $\frac{w+s}{w\times ms}$, the fpecific gravity implied in the value of y, is the mathematical denfity independent on this condenfation. Since therefore y, together with $\overline{a-y}$, make lefs than 100 gallons of the compound, there muft in 100 gallons of it be more alcohol than is expreffed by y.

Let G be the mathematical fpecific gravity $\left(=\frac{w+s}{w+ms}\right)$, and g the phyfical or real obferved fpecific gravity (which we cannot exprefs algebraically); and let z be the gallons of alcohol really contained in 100 gallons of the compound. The bulk being inverfely as the denfity or fpecific gravity, it is evident that the bulk of the compound muft be to 100 gallons as g to

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to G. And since we want to make it still up to 100 gallons, we must increase it in the proportion of G to g. And because this augmentation must be of the same strength with this contracted liquor, both ingredients must be increased in the proportion of G to g, and we must have $G : g = y : z$, and $z = g \times \frac{y}{G}$. Now, instead of y, write $a \frac{m s}{w + m s}$, and instead of $\frac{1}{G}$ write $\frac{w + m s}{w + s}$, which are respectively equal to them. This gives us $z = g\,a \times \frac{w + m s}{w + s} \times \frac{m s}{w + s}, = g\,a \times \frac{m s}{w + s}$.

All this will be illustrated by an example.

Suppose that we have observed the specific gravity of a spirituous liquor of the temperature 60° to be 0.94128. Looking into Sir Charles Blagden's table, we find the gravities 0.94018 and 0.94296, and the s corresponding to them is 80 and 75, the water in each mixture being 100. By interpolation we obtain the s corresponding to 0.94128, viz. 78. At this temperature $m = \frac{1}{0.825}, = 1.21212$, and $m s = 94.54545$. Therefore $z = 0.94128 \times 100 \times \frac{94.54545}{194.54545}, = 49{,}997$, or very nearly 50.

We have seen even persons not unacquainted with subjects of this kind puzzled by this sort of paradox. z is said to be the per centage of spirit in the compound. The compound has the same proportion of ingredients when made up to 100 gallons as before, when y was said to be its per centage, and yet y and z are not the same. The fact is, that although z is the number of gallons of alcohol really contained in 100 gallons of the compound, and this alcohol is in the same proportion as before to the water, this proportion is not that of 50 to 50: for if the ingredients were separated again, there would be 50 gallons of alcohol and 52,876 of water.

The proportion of the ingredients in their separate state is had by the 3d equation $y = a \frac{m s}{w + m s}$, which is equivalent to $G\,a \frac{m s}{w + s}$. For the present example y will be found 48.599, and $a - y$, or the water per cent. 51.401, making 100 gallons of unmixed ingredients. We see then that there has been added 1.398 gallons of alcohol; and since both ingredients are augmented in the proportion of G to g, there have also been added 1.478 of water, and the whole addition for making up the 100 gallons of compound is 2.876 gallons; and if the ingredients of the compound were separate, they would amount to 102,876 gallons. This might have been found at the first, by the proportion, $G : g - G = 100$: (*The addition*).

The next question which usually occurs in business is to find what density will result from any proposed mixture per gallon. This question is solved by means of the equation $\frac{w y}{m (a - y)} = s$. In this examination it will be most convenient to make $w = a$. If the value of s found in this manner falls on a value in the tables, we have the specific gravity by inspection. If not, we must interpolate.

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N. B. The value of m, which is employed in these reductions, varies with the temperature. It is always obtained by dividing the specific gravity of alcohol of that temperature by the specific gravity of water of the same temperature. The quotient is the real specific gravity of alcohol for that temperature. Both of these are to be had in the first and last copartments of Sir Charles Blagden's table.

These operations for particular cases give the answers to particular occasional questions. By applying them to all the numbers in the table, tables may be constructed for solving every question by inspection.

There is another question which occurs most frequently in the excise transactions, and also in all compositions of spirituous liquors, viz. What strength will result from a mixture of two compounds of known strength, or mixing any compound with water? To solve questions of this kind by the table so often quoted, we must add into one sum the water per gallon of the different liquors. In like manner, take the sum of the spirits, and say, as the sum of the waters is to that of the alcohols, so is a to s; and operate with a and s as before.

Analogous to this is the question of the duties. These are levied on proof spirit; that is, a certain duty is charged on a gallon of proof spirit; and the gauger's business is to discover how many gallons of proof spirit there is in any compound. The specification of proof spirit in our excise laws is exceedingly obscure and complex. A gallon weighing 7 pounds 13 ounces (at 55°) is accounted 1 to 6 under proof. The gallon of water contains 58476 grains, and this spirit is 54688. Its density therefore is 0.93523 at 55°, or (as may be inferred from the table) 0.9335 at 60°. This density corresponds to a mixture of 100 grains of water with 93.457 of alcohol. If this be supposed to result from the mixture of 6 gallons of alcohol with 1 of water (as is supposed by the designation of 1 to 6 under proof), the gallon of proof spirits consists of 100 parts of spirits by weight, mixed with 75 parts of water. Such a spirit will have the density 0.9162 nearly.

This being premised, in order to find the gallons of proof spirits in any mixture, find the quantity of alcohol by weight, and then say, as 100 to 175, so is the alcohol in the compound to the proof spirit that may be made of it, and for which the duties must be paid.

We have considered this subject at some length, because it is of great importance in the spirit-trade to have these circumstances ascertained with precision; and because the specific gravity is the only sure criterion that can be had of the strength. Firing of gunpowder, or producing a certain bubble by shaking, are very vague tests; whereas, by the specific gravity, we can very securely ascertain the strength within one part in 500, as will presently appear.

Sir Charles Blagden, or Mr Gilpin, has published * a most copious set of tables, calculated from these valuable experiments. In these, computations are made for every unit of the hundred, and for every degree of the thermometer. But these tables are still not in the most commodious form for business. Mr John Wilson, an ingenious gentleman residing at Dundee, has just published

* *Philos. Transact.* 1794.

lished at Edinburgh tables somewhat similar, founded on the same experiments. Both of these tables show the quantities by measure corresponding to every unit by weight of Sir Charles Blagden's experiments, and for every degree of temperature. They also show the per centage of alcohol, and the condensation or the quantity lost by mixture. But as they both retain the original series of parts by weight, which is very unusual, the spirit traders will find considerable difficulty in making use of them. Retaining this series also causes all the per centage numbers (which are the only interesting ones to the trader) to be fractional, and no answer can be had without a double interpolation.

We have therefore calculated a table in the form in which it must be most useful and acceptable to those who are engaged in the spirit trade, showing at once the specific gravity which results from any proportion of admixture in hundredth parts of the whole. This answers immediately the chief questions in the terms in which they are usually conceived and proposed. The two first or leading columns show the proportion in gallons, pints, or other cubic measures, of the mixture, the whole quantity being always 100. The second column shows the corresponding specific gravity: so that we can either find the proportion of the ingredients by the observed specific gravity, or find the gravity resulting from any proportion of the ingredients. A third column shows how much the hundred measures of the two ingredients fall short of making an hundred measures of the compound. A simple proportion, which can be done without the pen, will determine what part of this deficiency must be made up by spirit. The use of this table must now be so familiar to the reader's mind, that we need not give further instructions about it.

This is followed by another similar table, giving an immediate answer to the most usual question, "How many measures of alcohol are there really contained in 100 measures? This is also accompanied by a column of condensation. It would have been somewhat more elegant, had the specific gravities in this table made the equable series and leading column. But we did not advert to this till we had computed the table, and the labour was too great to be repeated for slight reasons. The tables are only for the temperature 60°. To this the spirituous liquors can always be brought in these climates; and in cases where we cannot, a moment's inspection of Sir Charles Blagden's table will point out very nearly (or exactly, by a short computation) the necessary corrections.

Compound.		Specific Gravity.	Cond. per cent.	Compound.		Specific Gravity.	Cond. per cent.	Compound.		Specific Gravity.	Cond. per cent.
S.	W.			S.	W.			S.	W.		
100	0	0.8250		66	34	0.9073	2.5	33	67	0.9640	2.3
99	1	0.8278	0.19	65	35	0.9095	2.6	32	68	0.9651	2.3
98	2	0.8306	0.33	64	36	0.9116	2.6	31	69	0.9662	2.2
97	3	0.8333	0.4	63	37	0.9137	2.6	30	70	0.9673	2.1
96	4	0.8360	0.5	62	38	0.9157	2.6	29	71	0.9683	2.
95	5	0.8387	0.6	61	39	0.9177	2.7	28	72	0.9693	1.9
94	6	0.8413	0.7	60	40	0.9198	2.7	27	73	0.9704	1.9
93	7	0.8439	0.8	59	41	0.9218	2.7	26	74	0.9713	1.8
92	8	0.8465	1.9	58	42	0.9238	2.7	25	75	0.9724	1.7
91	9	0.8491	1.	57	43	0.9257	2.7	24	76	0.9734	1.6
90	10	0.8516	1.1	56	44	0.9277	2.8	23	77	0.9744	1.6
89	11	0.8542	1.2	55	45	0.9296	2.8	22	78	0.9754	1.5
88	12	0.8567	1.3	54	46	0.9316	2.8	21	79	0.9763	1.4
87	13	0.8592	1.4	53	47	0.9335	2.8	20	80	0.9773	1.3
86	14	0.8617	1.5	52	48	0.9353	2.8	19	81	0.9783	1.2
85	15	0.8641	1.5	51	49	0.9371	2.8	18	82	0.9793	1.2
84	16	0.8666	1.6	50	50	0.9388	2.8	17	83	0.9802	1.1
83	17	0.8690	1.7	49	51	0.9406	2.8	16	84	0.9812	1.
82	18	0.8713	1.7	48	52	0.9423	2 8	15	85	0.9822	0.9
81	19	0.8737	1.7	47	53	0.9440	2.8	14	86	0.9832	0.9
80	20	0.8760	1.8	46	54	0.9456	2.7	13	87	0.9842	0.8
79	21	0.8764	1.9	45	55	0.9473	2.7	12	88	0.9853	0.7
78	22	0.8807	2.	44	56	0.9489	2.7	11	89	0.9863	0.7
77	23	0.8830	2.	43	57	0.9505	2.7	10	90	0.9874	0.6
76	24	0.8853	2.1	42	58	0.9520	2.7	9	91	0.9886	0.5
75	25	0.8876	2.1	41	59	0.9535	2.6	8	92	0.9897	0.4
74	26	0.8899	2.2	40	60	0.9549	2.6	7	93	0.9909	0.3
73	27	0.8921	2.2	39	61	0.9563	2.6	6	94	0.9921	0.3
72	28	0.8944	2.3	38	62	0.9577	2.5	5	95	0.9933	0.2
71	29	0.8966	2.3	37	63	0.9590	2.5	4	96	0.9946	0.1
70	30	0.8988	2.4	36	64	0.9603	2.4	3	97	0.9959	0.07
69	31	0.9010	2.5	35	65	0.9616	2.4	2	98	0.9972	0.03
68	32	0.9031	2.5	34	66	0.9628	2.3	1	90	0.9985	0.01
67	33	0.9053	2.5	33	67	0.9640	2.3	0	100	1.0000	0.00
66	34	0.9073	2.5								

Spir. per cent.	Specific Gravity.	Contr.	Spir. per cent.	Specific Gravity.	Contr.	Spir. per cent.	Specific Gravity.	Contr.
100	0.82500		66	0.91095	2.59	33	0.96481	2.27
99	0.82629	0.18	65	0.91306	2.62	32	0.96587	2.21
98	0.83142	0.34	64	0.91511	2.64	31	0.96691	2.15
97	0.83449	0.46	63	0.91714	2.66	30	0.96793	2.08
96	0.83750	0.57	62	0.91914	2.68	29	0.96894	2.00
95	0.84048	0.68	61	0.92112	2.70	28	0.96992	1.93
94	0.84339	0.8	60	0.92308	2.72	27	0.97089	1.86
93	0.84621	0.9	59	0.92501	2.74	26	0.97185	1.79
92	0.84900	1.01	58	0.92692	2.76	25	0.97280	1.71
91	0.85172	1.11	57	0.92883	2.77	24	0.97374	1.63
90	0.85443	1.21	56	0.93072	2.78	23	0.97468	1.56
89	0.85704	1.31	55	0.93258	2.80	22	0.97561	1.48
88	0.85971	1.39	54	0.93436	2.81	21	0.97654	1.4
87	0.86228	1.47	53	0.93612	2.81	20	0 97747	1.32
86	0.86483	1.54	52	0.93786	2.82	19	0.97841	1.24
85	0.86737	1.61	51	0.93958	2.81	18	0.97936	1.17
84	0.86987	1.67	50	0.94128	2.79	17	0.98032	1.08
83	0.87235	1.74	49	0.94293	2.78	16	0.98129	1.00
82	0.87481	1.81	48	0.94455	2.76	15	0.98228	.93
81	0.87726	1.88	47	0.94610	2.73	14	0.98328	.85
80	0.87969	1.94	46	0.94768	2.71	13	0.98430	.78
79	0.88207	2.	45	0.94923	2.70	12	0.98634	.71
78	0.88445	2.05	44	0.95074	2.68	11	0.98640	.66
77	0.88676	2.11	43	0.95219	2.66	10	0.98748	.61
76	0.88909	2.17	42	0.95364	2.63	9	0.98858	.51
75	0.89140	2.22	41	0.95502	2.60	8	0.98973	.43
74	0.89367	2.26	40	0.95636	2.58	7	0.99091	.34
73	0.89593	2.31	39	0 95766	2.54	6	0.99211	.25
72	0.89815	2.36	38	0 95894	2.49	5	0.99334	.18
71	0.90035	2.41	37	0.96019	2.46	4	0.99461	.12
70	0.90241	2.49	36	0.96141	2.43	3	0.99591	.7
69	0.90464	2.47	35	0.96258	2.38	2	0.99725	.3
68	0.90675	2.51	34	0.96371	2.33	1	0.99861	.1
67	0.90885	2.55	33	0.96481	2.27	0	1.00000	.0
66	0.91095	2.59						

"In the firſt table, of which the ſole intention is to point out the proportion of ingredients, the ſpecific gravities are computed only to four places, which will always give the anſwer true to $\frac{1}{8000}$th part. In the laſt, which is more immediately intereſting to the merchant in his tranſactions with the exciſe office, the computation is carried one place further."

The conſideration of the firſt of theſe two tables will furniſh ſome uſeful information to the reader who is intereſted in the philoſophy of chemical mixture, and who endeavours to inveſtigate the nature of thoſe forces which connect the particles of tangible matter. Theſe vary with the diſtance of the particle; and therefore the law of their action, like that of univerſal gravitation, is to be diſcovered by meaſuring their ſenſible effects at their various diſtances. Their change of diſtance is ſeen in the change of denſity or ſpecific gravity.

Did the individual denſities of the water and ſpirit remain unchanged by mixture, the ſpecific gravity would change by equal differences in the ſeries of mixtures on which this table is conſtructed; for the bulk being always the ſame, the change of ſpecific gravity muſt be the difference between the weight of the gallon of water which is added and that of the gallon of ſpirit which is taken out. The whole difference of the ſpecific gravities of ſpirits and water being 1.750 parts in 10,000, the augmentation by each ſucceſſive change of a meaſure of ſpirit for a meaſure of water would be the 100th part of this, or 17.5. But, by taking the ſucceſſive differences of denſity as they occur in the table, we ſee that they are vaſtly greater in the firſt additions of water, being then about 10; after which they gradually diminiſh to the medium quantity $17\frac{1}{4}$, when water and ſpirits are mixed in nearly equal bulks. The differences of ſpecific gravity ſtill diminiſh, and are reduced to 9, when about 75 parts of water are mixed with 25 of ſpirit. The differences now increaſe again; and the laſt, when 99 parts of water are mixed with one part of ſpirit, the difference from the ſpecific gravity of pure water is above 14.

The mechanical effect, therefore, of the addition of a meaſure of water to a great quantity of ſpirit is greater than the ſimilar effect of the addition of a meaſure of ſpirits to a great quantity of water. What we call mechanical effect is the local motion, the change of diſtance of the particles, that the corpuſcular forces may again be in equilibrio. Obſerve, too, that this change is greater than in the proportion of the diſtance of the particles;

particles; for the density of water is to that of spirits nearly as 6 to 5, and the changes of specific gravity are nearly as 6 to 3.

We also see that the changing cause, which produces the absolute condensation of each ingredient, ceases to operate when 75 parts of water have been mixed with 25 of alcohol: for the variation of specific gravity, from diminishing comes now to increase; and therefore, in this particular state of composition, is equable. Things are now in the same state as if we were mixing two fluids which did not act on each other, but were mutually disseminated, and whose specific gravities are nearly as 9 to 10; for the variation 9 of specific gravity may be considered as the 100th part of the whole difference, in the same manner as 17.7 would have been had water and alcohol sustained no contraction.

The imagination is greatly assisted in the contemplation of geometrical quantity by exhibiting it in its own form. Specific gravity, being an expression of density (a notion purely geometrical), admits of this illustration.

Plate CCCCXCIX. Fig. 2.

Therefore let AB (fig. 2.) represent the bulk of any mixture of water and alcohol. The specific gravity of water may be represented by a line of such a length, that AB shall be the difference between the gravities of alcohol and water. Suppose it extended upwards, towards a, till B a is to A a as 10,000 to 8250. It will suit our purpose better to represent it by a parallelogram a BF e, of any breadth BF. In this case the difference of the specific gravities of alcohol and water will be expressed by the parallelogram ABFE. If there were no change produced in the density of one or both ingredients, the specific gravity of the compound would increase as this parallelogram does, and AGHE would be the augmentation corresponding to the mixture of the quantity AG of alcohol with the quantity GB of water, and so of other mixtures. But, to express the augmentation of density as it really obtains, we must do it by some curvilineal area DABCHD, which varies at the rate determined by Sir Charles Blagden's experiments. This area must be precisely equal to the rectangle ABFE. It must therefore fall without it in some places, and be deficient in others. Let DMHKC be the curve which corresponds with these experiments. It is evident to the mathematical reader, that the ordinates LM, GH, IK, &c. of this curve are in the ultimate ratio of the differences of the observed specific gravities. If A α, $\omega\beta$, &c. are each $= 5$, the little spaces A $\omega\delta$ D, $\omega\beta b\delta$, &c. will be precisely equal to the differences of the specific gravities 0.8250; 0.8387; 0.8516; &c. corresponding to the different mixtures of water and alcohol. The curve cuts the side of the parallelogram in K, where the ordinate GK expresses the mean variation of density 0.0017.5. IK is the smallest variation. The condensation may be expressed by drawing a curve $d\,m\,G\,f\,k$ parallel to DMGKF, making D d = AE. The condensation is now represented by the spaces comprehended between this last curve and the abscissa AGB, reckoning those negative which lie on the other side of it. This shows, not only that the condensation is greatest in the mixture AG $\times$ GB, but also that in mixing such a compound with another AI $\times$ IB, there is a rarefaction. Another curve ANOPB may be drawn, of which the ordinates LN, GP, IO, &c. are proportional to the areas ALmd, AGmD, AIkGmd (=AGmd—GIk), &c. This curve shows the whole condensation.

This manner of representing the specific gravities of mixtures will suggest many curious inferences to such as will consider them in the manner of Boscovich, with a view to ascertain the nature of the forces of cohesion and chemical affinities: And this manner of viewing the subject becomes every day more promising, in consequence of our improvements in chemical knowledge; for we now see, that mechanism, or motive forces, are the causes of chemical action. We see in almost every case, that chemical affinities are comparable with mechanical pressures; because the conversion of a liquid into a vapour or gas is prevented by atmospheric pressure, and produced by the great chemical agent heat. The action of heat, therefore, or of the cause of heat, is a mechanical action, and the forces are common mechanical forces, with which we are familiarly acquainted.

"It may be also remarked in the column of contractions, that in the beginning the contractions augment nearly in the proportion of the quantity of spirits (but more slowly); whereas, in the end, the contractions are nearly in the duplicate proportion of the quantity of water. This circumstance deserves the consideration of the philosopher. We have represented it to the eye by the curve $\kappa\,g\,h\,d$."

We should here take some notice of the attempt made to elude some part of the duties, by adding some ingredient to the spirits. But our information on this subject is not very exact; and besides it would be doing no service to the trader to put fraud more in his power. There are some salts which make a very great augmentation of density, but they render the liquor unpalatable. Sugar is frequently used with this view; 16 grains of refined sugar dissolved in 1000 grains of proof spirits gave it no suspicious taste, and increased its specific gravity from 0.920 to 0.925, which is a very great change, equivalent to the addition of 9 grains of water to a mixture of 100 grains of alcohol and 80 of water.

SPIRLING, a species of fish. See SALMO, ICHTHYOLOGY, p. 99.

SPITHEAD, a road between Portsmouth and the isle of Wight, where the royal navy of Great Britain frequently rendezvous.

SPITTLE, in *Physiology*. See SALIVA.

SPITZBERGEN. See GREENLAND, N° 10.

SPLACHNUM, a genus of plants belonging to the class of cryptogamia, and order of musci. See BOTANY *Index*.

SPLEEN. See ANATOMY *Index*.

SPLEEN-Wort. See ASPLENIUM, BOTANY *Index*.

SPLENETIC, a person afflicted with an obstruction of the spleen.

SPLENT, or SPLINT, among farriers, a callous insensible excrescence, breeding on the shank-bone of horses. See FARRIERY.

SPLICING, in the sea-language, is the untwisting the ends of two cables or ropes, and working the several strands into one another by a fidd, so that they become as strong as if they were but one rope.

SPOILS, whatever is taken from the enemy in time of war. Among the ancient Greeks, the spoils were divided among the whole army; only the general's share was

was largeſt: but among the Romans, the ſpoils belonged to the republic.

SPOLETTO, a duchy of Italy, bounded on the north by the marquiſate of Ancona and duchy of Urbino, on the eaſt by Farther Abruzzo, on the ſouth by Sabina and the patrimony of St Peter, and on the weſt by Orvieto and Perugino. It is about 55 miles in length and 40 in breadth. It was anciently a part of Umbria, and now belongs to the pope.—The name of the capital city is alſo *Spoletto*. It was formerly a large place, but in 1703 was ruined by an earthquake; from whence it has never recovered itſelf.

SPOLIATION, in eccleſiaſtical law, is an injury done by one clerk or incumbent to another, in taking the fruits of his benefice without any right thereunto, but under a pretended title. It is remedied by a decree to account for the profits ſo taken. This injury, when the *jus patronatus*, or right of advowſon, doth not come in debate, is cognizable in the ſpiritual court: as if a patron firſt preſents A to a benefice, who is inſtituted and inducted thereto; and then, upon pretence of a vacancy, the ſame patron preſents B to the ſame living, and he alſo obtains inſtitution and induction. Now if A diſputes the fact of the vacancy, then that clerk who is kept out of the profits of the living, whichever it be, may ſue the other in the ſpiritual court for the ſpoliation, or taking the profits of his benefice. And it ſhall there be tried, whether the living were or were not vacant; upon which the validity of the ſecond clerk's pretenſions muſt depend. But if the right of patronage comes at all into diſpute, as if one patron preſented A, and another patron preſented B, there the eccleſiaſtical court hath no cognizance, provided the tithes ſued for amount to a fourth part of the value of the living, but may be prohibited at the inſtance of the patron by the king's writ of *indicavit*. So alſo if a clerk, without any colour of title, ejects another from his parſonage, this injury muſt be redreſſed in the temporal courts: for it depends upon no queſtion determinable by the ſpiritual law (as plurality of benefices or no plurality, vacancy or no vacancy), but is merely a civil injury.

SPONDEE, in ancient poetry, a foot conſiſting of two long ſyllables, as *omnes*.

SPONDIAS, Brasilian or Jamaica Plum, a genus of plants belonging to the claſs of decandria. See Botany *Index*.

SPONGIA, Sponge; a genus of animals belonging to the claſs of vermes, and order of zoophyta. It is fixed, flexible, and very torpid, growing in a variety of forms, compoſed either of reticulated fibres, or maſſes of ſmall ſpines interwoven together, and clothed with a living gelatinous fleſh, full of ſmall mouths or holes on its ſurface, by which it ſucks in and throws out the water. Fifty ſpecies have already been diſcovered, of which 10 belong to the Britiſh coaſts. See Helminthology *Index*.

So early as the days of Ariſtotle ſponges were ſuppoſed to poſſeſs animal life; the perſons employed in collecting them having obſerved them ſhrink when torn from the rocks, thus exhibiting ſymptoms of ſenſation. The ſame opinion prevailed in the time of Pliny: But no attention was paid to this ſubject till Count Marſigli examined them, and declared them vegetables. Dr Peyſonell, in a paper which he ſent to the Royal Society in the year 1752, and in a ſecond in 1757, affirmed they were not vegetables, but the production of animals; and has accordingly deſcribed the animals, and the proceſs which they performed in making the ſponges. Mr Ellis, in the year 1762, was at great pains to diſcover theſe animals. For this purpoſe he diſſected the ſpongia urens, and was ſurpriſed to find a great number of ſmall worms of the genus of nereïs or ſea ſcolopendra, which had pierced their way through the ſoft ſubſtance of the ſponge in queſt of a ſafe retreat. That this was really the caſe, he was fully aſſured of, by inſpecting a number of ſpecimens of the ſame ſort of ſponge, juſt freſh from the ſea. He put them into a glaſs filled with ſea-water; and then, inſtead of ſeeing any of the little animals which Dr Peyſonell deſcribed, he obſerved the papillæ or ſmall holes with which the papillæ are ſurrounded contract and dilate themſelves. He examined another variety of the ſame ſpecies of ſponge, and plainly perceived the ſmall tubes inſpire and expire the water. He therefore concluded, that the ſponge is an animal, and that the ends or openings of the branched tubes are the mouths by which it receives its nouriſhment, and diſcharges its excrements.

SPONSORS, among Chriſtians, are thoſe perſons who, in the office of baptiſm, anſwer or are ſureties for the perſons baptized.

SPONTANEOUS, a term applied to ſuch motions of the body and operations of the mind as we perform of ourſelves without any conſtraint.

SPOON-bill. See Platalea, Ornithology *Index*.

SPOONING, in the ſea-language, is ſaid of a ſhip, which being under ſail in a ſtorm at ſea, is unable to bear it, and conſequently forced to go right before the wind.

SPORADES, among ancient aſtronomers, a name given to ſuch ſtars as were not included in any conſtellation.

SPORADIC diseases, among phyſicians, are ſuch as ſeize particular perſons at any time or ſeaſon, and in any place; in which ſenſe they are diſtinguiſhed from epidemical and endemical diſeaſes.

SPOTS, in *Aſtronomy*, certain places of the ſun's or moon's diſk, obſerved to be either more bright or dark than the reſt; and accordingly called *faculæ et maculæ*. See Astronomy *Index*.

SPOTSWOOD, John, archbiſhop of St Andrew's in Scotland, was deſcended from the lairds of Spotſwood in the Merſe, and was born in the year 1565. He was educated in the univerſity of Glaſgow, and ſucceeded his father in the parſonage of Calder when but 18 years of age. In 1601 he attended Lodowick duke of Lennox as his chaplain, in an embaſſy to the court of France for confirming the ancient amity between the two nations, and returned in the ambaſſador's retinue through England. When he entered into the archbiſhopric of Glaſgow, he found there was not 100l. ſterling of yearly revenue left; yet ſuch was his care for his ſucceſſors, that he greatly improved it, and much to the ſatisfaction of his dioceſe. After having filled this ſee 11 years, he was raiſed to that of St Andrew's in 1615, and made primate and metropolitan of all Scotland. He preſided in ſeveral aſſemblies for reſtoring the ancient diſcipline, and bringing the church of Scotland to ſome degree of uniformity with that of England. He continued in high eſteem with King James I. nor was he leſs valued by King

King Charles I. who was crowned by him in 1633, in the abbey-church of Holyroodhouſe. In 1635, upon the death of the earl of Kinnoul chancellor of Scotland, our primate was advanced to that poſt; but had ſcarcely held it four years, when the confuſions beginning in Scotland, he was obliged to retire into England; and being broken with age, grief, and ſickneſs, died at London in 1639, and was interred in Weſtminſter-abbey. He wrote A Hiſtory of the Church of Scotland from the year 203 to the reign of King James VI. in folio.

SPOUT, or *Water-Spout*. See *WATER-Spout*.

SPOUT-Fiſh. See SOLEN, CONCHOLOGY *Index*.

SPRAT, DR THOMAS, biſhop of Rocheſter, was born in 1636. He had his education at Oxford, and after the Reſtoration entered into holy orders. He became fellow of the Royal Society, chaplain to George duke of Buckingham, and chaplain in ordinary to King Charles II. In 1667 he publiſhed the Hiſtory of the Royal Society, and a Life of Mr Cowley; who, by his laſt will, left to his care his printed works and MSS. which were accordingly publiſhed by him. In 1668 he was inſtalled prebendary of Weſtminſter; in 1680, was appointed canon of Windſor; in 1683, dean of Weſtminſter; and in 1684, conſecrated to the biſhopric of Rocheſter. He was clerk of the cloſet to King Jas. II.; in 1685, was made dean of the chapel royal; and the year following, was appointed one of the commiſſioners for eccleſiaſtical affairs. In 1692 his lordſhip, with ſeveral other perſons, was charged with treaſon by two men, who drew up an aſſociation, in which they whoſe names were ſubſcribed declared their reſolution to reſtore King James; to ſeize the princeſs of Orange, dead or alive; and to be ready with 30,000 men to meet King James when he ſhould land. To this they put the names of Sancroft, Sprat, Marlborough, Saliſbury, and others. The biſhop was arreſted, and kept at a meſſenger's, under a ſtrict guard, for eleven days. His houſe was ſearched, and his papers ſeized, among which nothing was found of treaſonable appearance, except one memorandum, in the following words: *Thorough-paced doctrine.* Being aſked at his examination the meaning of the words, he ſaid that, about 20 years before, curioſity had led him to hear Daniel Burgeſs preach; and that being ſtruck with his account of a certain kind of doctrine, which he ſaid *entered at one ear, and pacing through the head went out at the other*, he had inſerted the memorandum in his table-book, that he might not loſe the ſubſtance of ſo ſtrange a ſermon. His innocence being proved, he was ſet at liberty, when he publiſhed an account of his examination and deliverance; which made ſuch an impreſſion upon him, that he commemorated it through life by an yearly day of thankſgiving. He lived to the 79th year of his age, and died May 20. 1713. His works, beſides a few poems of little value, are, "The Hiſtory of the Royal Society;" "The Life of Cowley;" "The Anſwer to Sorbiere;" "The Hiſtory of the Rye-houſe Plot;" "The Relation of his own Examination;" and a volume of "Sermons." Dr Johnſon ſays, "I have heard it obſerved with great juſtneſs, that every book is of a different kind, and that each has its diſtinct and characteriſtical excellence."

SPRAT. See CLUPEA, ICHTHYOLOGY *Index*.

SPRAY, the ſprinkling of the ſea, which is driven from the top of a wave in ſtormy weather. It differs from ſpoon-drift, as being only blown occaſionally from the broken ſurface of a high wave; whereas the latter continues to fly horizontally along the ſea, without intermiſſion, during the exceſs of a tempeſt or hurricane.

SPRING, in *Natural Hiſtory*, a fountain or ſource of water riſing out of the ground.

Many have been the conjectures of philoſophers concerning the origin of fountains, and great pains have been taken both by the members of the Royal Society and thoſe of the Academy of Sciences at Paris, in order to aſcertain the true cauſe of it. It was Ariſtotle's opinion, and held by moſt of the ancient philoſophers after him, that the air contained in the caverns of the earth, being condenſed by cold near its ſurface, was thereby changed into water; and that it made its way through, where it could find a paſſage. But we have no experience of any ſuch tranſmutation of air into water.

Thoſe who imagine that fountains owe their origin to waters brought from the ſea by ſubterraneous ducts, give a tolerable account how they loſe their ſaltneſs by percolation as they paſs through the earth: but they find great difficulty in explaining by what power the water riſes above the level of the ſea to near the tops of mountains, where ſprings generally abound; it being contrary to the laws of hydroſtatics, that a fluid ſhould riſe in a tube above the level of its ſource. However, they have found two ways whereby they endeavour to extricate themſelves from this difficulty. The one is that of Des Cartes, who imagines, that after the water is become freſh by percolation, it is raiſed out of the caverns of the earth in vapour towards its ſurface; where meeting with rocks near the tops of mountains in the form of arches or vaults, it ſticks to them, and runs down their ſides, (like water in an alembic), till it meets with proper receptacles, from which it ſupplies the fountains. Now this is a mere hypotheſis, without foundation or probability: for, in the firſt place, we know of no internal heat of the earth to cauſe ſuch evaporation; or if that were allowed, yet it is quite incredible that there ſhould be any caverns ſo ſmooth and void of protuberances as to anſwer the ends of an alembic, in collecting and condenſing the vapours together in every place where fountains ariſe. There are others (as Varenius, &c.) who ſuppoſe that the water may riſe through the pores of the earth, as through capillary tubes by attraction. But hereby they ſhow, that they are quite unacquainted with what relates to the motion of a fluid through ſuch tubes: for when a capillary tube opens into a cavity at its upper end, or grows larger and larger, ſo as to ceaſe to be capillary at that end, the water will not aſcend through that tube into the cavity, or beyond where the tube is capillary; becauſe that part of the periphery of the cavity, which is partly above the ſurface of the water and partly below it, is not of the capillary kind. Nay, if the cavity is continually ſupplied with water, it will be attracted into the capillary tube, and run down it as through a funnel, if the lower end is immerged in the ſame fluid, as in this caſe it is ſuppoſed to be.

It has been a generally received opinion, and much eſpouſed by Mariotte (a diligent obſerver of nature), that the riſe of ſprings is owing to the rains and melted ſnow. According to him, the rain-water which falls upon the hills and mountains, penetrating the ſurface, meets

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meets with clay or rocks contiguous to each other; along which it runs, without being able to penetrate them, till, being got to the bottom of the mountain, or to a confiderable diftance from the top, it breaks out of the ground, and forms fprings.

In order to examine this opinion, Mr Perrault, De la Hire, and D. Sideleau, endeavoured to make an eftimate of the quantity of rain and fnow that falls in the fpace of a year, to fee whether it would be fufficient to afford a quantity of water equal to that which is annually difcharged into the fea by the rivers. The refult of their inquiries was, that the quantity of rain and fnow which fell in a year into a cylindrical veffel would fill it (if fecured from evaporating) to the height of about nineteen inches. Which quantity D. Sideleau fhowed, was not fufficient to fupply the rivers; for that thofe of England, Ireland, and Spain, difcharge a greater quantity of water annually, than the rain, according to that experiment, is able to fupply. Befides which, another obfervation was made by them at the fame time, viz. that the quantity of water raifed in vapour, one year with another, amounted to about thirty-two inches, which is thirteen more than falls in rain: a plain indication that the water of fountains is not fupplied by rain and melted fnow.

Thus the true caufe of the origin of fountains remained undifcovered, till Dr Halley, in making his celeftial obfervations upon the tops of the mountains at St Helena, about 800 yards above the level of the fea, found, that the quantity of vapour which fell there (even when the fky was clear) was fo great, that it very much impeded his obfervations, by covering his glaffes with water every half quarter of an hour; and upon that he attempted to determine by experiment the quantity of vapour exhaled from the furface of the fea, as far as it rifes from heat, in order to try whether that might be a fufficient fupply for the water continually difcharged by fountains. The procefs of his experiment was as follows: He took a veffel of water falted to the fame degree with that of fea water, in which he placed a thermometer; and by means of a pan of coals brought the water to the fame degree of heat, which is obferved to be that of the air in our hotteft fummer; this done, he fixed the veffel of water with the thermometer in it to one end of a pair of fcales, and exactly counterpoifed it with weights on the other: then, at the end of two hours, he found, by the alteration made in the weight of the veffel, that about a fixtieth part of an inch of the depth of the water was gone off in vapour; and therefore, in twelve hours, one tenth of an inch would have gone off. Now this accurate obferver allows the Mediterranean fea to be forty degrees long; and four broad, (the broader parts compenfating for the narrower, fo that its whole furface is 160 fquare degrees); which, according to the experiment, muft yield at leaft 5,280,000,000 tons of water: In which account no regard is had to the wind and the agitation of the furface of the fea, both which undoubtedly promote the evaporation.

It remained now to compare this quantity of water with that which is daily conveyed into the fame fea by the rivers. The only way to do which was to compare them with fome known river; and accordingly he takes his computation from the river Thames; and, to avoid all objections, makes allowances, probably greater than what were abfolutely neceffary.

The Mediterranean receives the following confiderable rivers, viz. the Iberus, the Rhone, the Tyber, the Po, the Danube, the Niefter, the Boryfthenes, the Tanais, and the Nile. Each of thefe he fuppofes to bring down ten times as much water as the Thames, whereby he allows for fmaller rivers which fall into the fame fea. The Thames, then, he finds by meafuration to difcharge about 20,300,000 tons of water a-day. If therefore the above-faid nine rivers yield ten times as much water as the Thames doth, it will follow, that all of them together yield but 1827 millions of tons in a day, which is but little more than one-third of what is proved to be raifed in vapour out of the Mediterranean in the fame time. We have therefore from hence a fource abundantly fufficient for the fupply of fountains.

Now having found that the vapour exhaled from the fea is a fufficient fupply for the fountains, he proceeds in the next place to confider the manner in which they are raifed; and how they are condenfed into water again, and conveyed to the fources of fprings.

In order to this he confiders, that if an atom of water was expanded into a fhell or bubble, fo as to be ten times as big in diameter as when it was water, that atom would become fpecifically lighter than air; and therefore would rife fo long as the warmth which firft feparated it from the furface of the water fhould continue to diftend it to the fame degree; and confequently, that vapours may be raifed from the furface of the fea in that manner, till they arrive at a certain height in the atmofphere, at which they find air of equal fpecific gravity with themfelves. Here they will float till, being condenfed by cold, they become fpecifically heavier than the air, and fall down in dew; or being driven by the winds againft the fides of mountains (many of which far furpafs the ufual height to which the vapours would of themfelves afcend), are compelled by the ftream of the air to mount up with it to the tops of them; where being condenfed into water, they prefently precipitate, and gleeting down by the crannies of the ftones, part of them enters into the caverns of the hills; which being once filled, all the overplus of water that comes thither runs over by the loweft place, and breaking out by the fides of the hills forms fingle fprings. Many of thefe running down by the valleys between the ridges of the hills, and coming to unite, form little rivulets or brooks: many of thefe again meeting in one common valley, and gaining the plain ground, being grown lefs rapid, become a river; and many of thefe being united in one common channel, make fuch ftreams as the Rhine and the Danube; which latter, he obferves, one would hardly think to be a collection of water condenfed out of vapour, unlefs we confider how vaft a tract of ground that river drains, and that it is the fum of all thofe fprings which break out on the fouth fide of the Carpathian mountains, and on the north fide of the immenfe ridge of the Alps, which is one continued chain of mountains from Switzerland to the Black fea.

Thus one part of the vapours which are blown on the land is returned by the rivers into the fea from whence it came. Another part falls into the fea before it reaches the land; and this is the reafon why the rivers do not return fo much water into the Mediterranean

 nean

nean as is raiſed in vapour. A third part falls on the low lands, where it affords nouriſhment to plants; yet it does not reſt there, but is again exhaled in vapour by the action of the ſun, and is either carried by the winds to the ſea to fall in rain or dew there, or elſe to the mountains to become the ſources of ſprings.

However, it is not to be ſuppoſed that all fountains are owing to one and the ſame cauſe; but that ſome proceed from rain and melted ſnow, which, ſubſiding through the ſurface of the earth, makes its way into certain cavities, and thence iſſues out in the form of ſprings; becauſe the waters of ſeveral are found to increaſe and diminiſh in proportion to the rain which falls: that others again, eſpecially ſuch as are ſalt, and ſpring near the ſea-ſhore, owe their origin to ſea-water percolated through the earth; and ſome to both theſe cauſes: though without doubt moſt of them, and eſpecially ſuch as ſpring near the tops of high mountains, receive their waters from vapours, as before explained.

This reaſoning of Dr Halley's is confirmed by more recent obſervations and diſcoveries. It is now found, that though water is a tolerable conductor of the electric fluid, dry earth is an electric *per ſe*, conſequently the dry land muſt always be in an electrified ſtate compared with the ocean, unleſs in ſuch particular caſes as are mentioned under the article EARTHQUAKE, N° 82. It is alſo well known, that ſuch bodies as are in an electrified ſtate, whether *plus* or *minus*, will attract vapour, or other light ſubſtances that come near them. Hence the vapours that are raiſed from the ocean muſt neceſſarily have a tendency to approach the land in great quantity, even without the aſſiſtance of the wind, though this laſt muſt undoubtedly contribute greatly towards the ſame purpoſe, as Dr Halley juſtly obſerves. In like manner, the higher grounds are always in a more electrified ſtate than the lower ones: and hence the vapours having once left the ocean and approached the ſhore, are attracted by the high mountains; of which Mr Pennant gives an inſtance in Snowdon. Hence we may ſee the reaſon why ſprings are ſo common in the neighbourhood of mountains, they being ſo advantageouſly formed in every reſpect for collecting and condenſing the vapours into water.

The heat of ſprings is generally the ſame with the mean temperature of the atmoſphere. The mean temperature of the ſouth of England is 48°; in Scotland, near Edinburgh, it is 45°; in the north of Ireland it is 48°, and on the ſouth coaſt about 51°. At Upſal, in Sweden, it is 43°, and in Paris 53°. According to accurate experiments made by eminent philoſophers, the heat of the ſprings in theſe different countries correſponds with the medium temperature. We have not heard that ſimilar experiments have been made in other countries, or we ſhould have been careful to collect them. We do not, however, doubt but they have been made in moſt countries of Europe; yet we ſuſpect little attention has been paid to this ſubject within the tropical regions.

Though this coincidence of the heat of ſprings with the mean temperature of the climate where they flow, ſeems to be a general fact, yet it admits of many exceptions. In many parts of the world there are ſprings which not only exceed the mean temperature, but even the ſtrongeſt meridian heat ever known in the torrid regions. The following table will give a diſtinct notion of the degrees of heat which different ſprings have been found to poſſeſs, according to the experiments of philoſophers. It is neceſſary to remark, that experiments made upon the ſame ſprings, made by different perſons, vary a little from one another, which may be owing to many accidents eaſily accounted for. Where this is the caſe, we ſhall mention both the loweſt and higheſt degree of heat which has been aſcribed to the ſame ſpring, according to Fahrenheit's thermometer.

Places.	Springs.	Higheſt degree of heat.	Loweſt degree of heat.
Briſtol,	St Vincent's or the hot well,	84	76
Buxton,	Gentleman's bath,	82	
Matlock,		69	
Bath,	King's bath,	119	113
Aix-la-Chapelle,		146	136
Barege,		122	
Piſa,		104	
Caroline baths in Bohemia,	Prudel or furious,	165	
Iceland,	Geyzer,	212	

In cold countries, where congelation takes place, the heat of the earth is conſiderably above the freezing point, and continues ſo through the whole year. From experiments that have been made in mines and deep pits, it appears that this heat is uniform and ſtationary at a certain depth. But as the heat of theſe ſprings far exceeds the common heat of the internal parts of the earth, it muſt be occaſioned by cauſes peculiar to certain places; but what theſe cauſes are it is no eaſy matter to determine. We are certain, indeed, that hot ſprings receive their heat from ſome ſubterranean cauſe; but it is a matter of difficulty to inveſtigate how this heat is produced and preſerved. Theories, however, have been formed on this ſubject. The ſubterranean heat has been aſcribed to the electrical fluid, and to a great body of fire in the centre of the earth: But we ſuſpect that the nature of the electrical fluid and its effects are not ſufficiently underſtood. As to the ſuppoſition that the heat of ſprings is owing to a central fire, it is too hypothetical to require any refutation. From what then does this heat originate, and whence is the fuel which has produced it for ſo many ages? To enable us to anſwer theſe queſtions with preciſion, more information is neceſſary than we have hitherto obtained reſpecting the ſtructure of the internal parts of the earth. It is peculiarly requiſite that we ſhould be made acquainted with the foſſils which are moſt common in thoſe places where hot ſprings abound. We ſhould then perhaps diſcover that hot ſprings always paſs through bodies of a combuſtible nature. It is well known to chemiſts, that when water is mixed with the vitriolic acid, a degree of heat is produced ſuperior to that of boiling water. It is alſo an eſtabliſhed fact, that when water meets with pyrites, that is, a mixture of ſulphur and iron, a violent inflammation takes place. If, therefore, we could prove that theſe materials exiſt in the ſtrata from which hot ſprings are derived, we ſhould be enabled to give a ſatisfactory account of this curious phenomenon. As ſome apology for this ſuppoſition, we may add, that moſt of the hot ſprings mentioned above have been found by analyſis to be impregnated with ſulphur, and ſome of them with iron.

iron. It muſt, however, be acknowledged, that the hot ſprings of Iceland, which are 212°, the heat of boiling water, according to an accurate analyſis of their contents by the ingenious Dr Black, were neither found to contain iron nor ſulphur. It will therefore, perhaps, be neceſſary that we ſhould wait with patience, and continue to collect facts, till the ſciences of chemiſtry and mineralogy ſhall be ſo far advanced as to enable us to form a permanent theory on this ſubject.

Gray's Letters from Germany and Switzerland.

Springs are of different kinds. Some are perennial, or continue to flow during the whole year; others flow only during the rainy ſeaſon; ſome ebb and flow. At Torbay there is one of this kind, which ebbs and flows five or ſix inches every hour. There is another near Coriſo in Italy, which ebbed and flowed three times a-day in the time of Pliny, and continues to do ſo ſtill. A ſpring near Henly ſometimes flows for two years together, and then dries up for an equal period. For the ingredients found in ſprings, ſee *MINERAL-Waters*.

SPRING, in *Mechanics*, denotes a thin piece of tempered ſteel, or other elaſtic ſubſtance, which being wound up ſerves to put machines in motion by its elaſticity, or endeavours to unbend itſelf; ſuch is the ſpring of a watch, clock, or the like.

SPRING, *Ver*, in coſmography, denotes one of the ſeaſons of the year; commencing, in the northern parts of the world, on the day the ſun enters the firſt degree of Aries, which is about the 10th day of March, and ending when the ſun leaves Gemini; or, more ſtrictly and generally, the ſpring begins on the day when the diſtance of the ſun's meridian altitude from the zenith, being on the increaſe, is at a medium between the greateſt and leaſt. The end of the ſpring coincides with the beginning of ſummer. See SUMMER.

Elater SPRING, in *Phyſics*, denotes a natural faculty or endeavour of certain bodies, to return to their firſt ſtate, after having been violently put out of it by compreſſing, or bending them. This faculty is, by philoſophers, uſually denominated *elaſtic force*, or *elaſticity*.

SPRING-Tide. See ASTRONOMY *Index*, and TIDE.

Burning SPRINGS. See *BURNING-Springs*.

SPRINGER, or *SPRING-Bok*. See CAPRA, MAMMALIA *Index*.

SPRIT, a ſmall boom or pole which croſſes the ſail of a boat diagonally, from the maſt to the upper hindmoſt corner of the ſail, which it is uſed to extend and elevate; the lower end of the ſprit reſts in a ſort of wreath or collar called the *ſnotter*, which encircles the maſt in that place.

SPRITSAIL. See SAIL and SHIP.

SPRITSAIL-Topſail. See SAIL and SHIP.

SPRUCE-TREE. See PINUS, BOTANY *Index*.

SPRUCE-Beer, a cheap and wholeſome liquor, which is thus made: Take of water 16 gallons, and boil the half of it. Put the water thus boiled, while in full heat, to the reſerved cold part, which ſhould be previouſly put into a barrel or other veſſel; then add 16 pounds of treacle or molaſſes, with a few table ſpoonfuls of the eſſence of ſpruce, ſtirring the whole well together; add half a pint of yeaſt, and keep it in a temperate ſituation, with the bung hole open, for two days, till the fermentation be abated. Then cloſe it up or bottle it off, and it will be fit for being drunk in a few days afterwards. In North America, and perhaps in other countries, where the black and white ſpruce-firs abound, inſtead of adding the *eſſence* of the ſpruce at the ſame time with the molaſſes, they make a decoction of the leaves and ſmall branches of theſe trees, and find the liquor equally good. It is a powerful antiſcorbutic, and may prove very uſeful in long ſea voyages.

SPUNGE, or SPONGE. See SPONGIA.

SPUNGING, in *Gunnery*, the cleaning of the inſide of a gun with a ſpunge, in order to prevent any ſparks of fire from remaining in it, which would endanger the life of him that ſhould load it again.

SPUN-YARN, among ſailors, is a kind of line made from rope yarn, and uſed for ſeizing or faſtening things together.

SPUNK. See BOLETUS, BOTANY *Index*.

SPUR, a piece of metal conſiſting of two branches encompaſſing a horſeman's heel, and a rowel in form of a ſtar, advancing out behind to prick the horſe.

SPUR-Winged Water-Hen. See PARRA, ORNITHOLOGY *Index*.

SPURGE. See EUPHORBIA, }
SPURGE-Laurel. See DAPHNE, } BOTANY *Index*.
SPURREY. See SPERGULA, }

SPY, a perſon hired to watch the actions, motions, &c. of another; particularly what paſſes in a camp. When a ſpy is diſcovered, he is hanged immediately.

SQUADRON, in military affairs, denotes a body of horſe whoſe number of men is not fixed; but is uſually from 100 to 200.

SQUADRON of Ships, either implies a detachment of ſhips employed on any particular expedition, or the third part of a naval armament.

SQUADS, in a military ſenſe, are certain diviſions of a company into ſo many ſquads, generally into three or four. The uſe of forming companies into as many ſquads of inſpection as it has ſerjeants and corporals, is proved by thoſe regiments who have practiſed that method; as by it the irregularity of the ſoldiers is conſiderably reſtrained, their dreſs improved, and the diſcipline of the regiment in general moſt remarkably forwarded. Every officer ſhould have a roll of his company by ſquads.

SQUALL, a ſudden and violent blaſt of wind, uſually occaſioned by the interruption and reverberation of the wind from high mountains. Theſe are very frequent in the Mediterranean, particularly that part of it which is known by the name of the *Levant*, as produced by the repulſion and new direction which the wind meets with in its paſſage between the various iſlands of the Archipelago.

SQUALUS, the SHARK; a genus of fiſhes arranged by Linnæus under the claſs of amphibia, and the order of nantes, but by Gmelin referred to the claſs of piſces, and order of chondropterygii. See ICHTHYOLOGY *Index*.

SQUAMARIA. See LATHRÆA, BOTANY *Index*.

SQUAMOUS, in *Anatomy*, a name given to the ſpurious or falſe ſutures of the ſkull, becauſe compoſed of ſquamæ or ſcales like thoſe of fiſhes.

SQUARE, in *Geometry*, a quadrilateral figure both equilateral and equiangular. See GEOMETRY.

SQUARE-Root. See ALGEBRA and ARITHMETIC, N° 33. and 34.

Hollow SQUARE, in the military art, a body of foot drawn

drawn up with an empty ſpace in the middle, for the colours, drums, and baggage, faced and covered by the pikes every way to keep off the horſe.

SQUARE, among *Mechanics*, an inſtrument conſiſting of two rules or branches, faſtened perpendicularly at one end of their extremities, ſo as to form a right angle. It is of great uſe in the deſcription and menſuration of right angles, and laying down perpendiculars.

T SQUARE, or *Tee Square*, an inſtrument uſed in drawing, ſo called from its reſemblance to the capital letter T.

SQUARE-Rigged, an epithet applied to a ſhip whoſe yards are very long. It is alſo uſed in contradiſtinction to all veſſels whoſe ſails are extended by ſtays or lateen-yards, or by booms and gaffs; the uſual ſituation of which is nearly in the plane of the keel; and hence,

SQUARE-Sail, is a ſail extended to a yard which hangs parallel to the horizon, as diſtinguiſhed from the other ſails which are extended by booms and ſtays placed obliquely. This ſail is only uſed in fair winds, or to ſcud under in a tempeſt. In the former caſe, it is furniſhed with a large additional part called the *bonnet*, which is then attached to its bottom, and removed when it is neceſſary to SCUD. See SCUDDING.

SQUARING, or *QUADRATURE of the Circle*, ſignifies the finding a ſquare exactly equal to the area of a given circle. This problem however has not been, and probably cannot be, ſtrictly reſolved by the commonly admitted principles of geometry; mathematicians having hitherto been unable to do more than to find a ſquare that ſhall differ from the area of any propoſed circle by as ſmall a quantity as they pleaſe. The quadrature of the circle is a problem of the ſame degree of difficulty, and indeed may be regarded as identical with another geometrical problem, namely, the *Rectification of the circle*, or the finding a ſtraight line equal to its circumference; for the area of a circle is equal to that of a rectangle contained by the radius and a ſtraight line equal to half the circumference (GEOMETRY, Sect. VI. Prop. 3.): therefore, if a ſtraight line exactly equal to the circumference could be found, a rectilineal ſpace preciſely equal to the area might alſo be found, and the contrary. But although no perfectly accurate reſolution of the problem has been obtained under either form, we can always find approximate values of the area and circumference; and therefore it is now cuſtomary to apply the terms *quadrature* and *rectification* of the circle alſo to theſe.

The problem of the quadrature of the circle appears to have engaged the attention of geometers at a very early period; for we are told that Anaxagoras, who lived about 500 years before Chriſt, attempted its ſolution while confined in priſon on account of his philoſophical opinions. We are ignorant of the reſult of his reſearches; but although we cannot ſuppoſe they were attended with any ſucceſs, we may reaſonably conclude that we are indebted to them for the diſcovery of ſome of the properties of the figure, which are now known as elementary propoſitions in geometry.

Hippocrates of Chios was likewiſe engaged in trying to reſolve the ſame problem, and it was no doubt in the courſe of his inquiries into this ſubject that he diſcovered the quadrature of the curvilineal ſpace, which is now known by the name of the *Lune* of Hippocrates. The nature of this diſcovery may be briefly explained as follows. Let ABCD be a circle (Plate D. fig. 1.), H its centre, AC its diameter, ADC a triangle inſcribed in the ſemicircle, having its ſides AD, DC equal to one another. On D as a centre, with DA or DC as a radius, let the quadrantal arch AEC be deſcribed, then ſhall the curvilineal ſpace bounded by the ſemicircle ABC and the quadrantal arch AEC (which is the *Lune* of Hippocrates) be equal to the rectilineal triangle ADC. For becauſe circles are to one another as the ſquares of the radii (GEOMETRY, Sect. VI. Prop. 4.); the circle having DA for its radius will be to the circle having HA for its radius as the ſquare of DA to the ſquare of HA, that is, as 2 to 1; hence the former of theſe circles will be double the latter, and conſequently one fourth of the former will be equal to one half of the latter; that is, the quadrant AECD will be equal to the ſemicircle ABC; from theſe equals take away the common ſpace bounded by the diameter AC and the arch AEC, and there will remain the triangle ADC equal to the lunular ſpace AECBA.

Plate D. Fig. 1.

Although Hippocrates's diſcovery has led to no important concluſion either relating to the quadrature of the circle or that of any other curve, yet at the time it was made it might be regarded as of ſome conſequence, chiefly becauſe it ſhewed the poſſibility of exhibiting a rectilineal figure equal to a ſpace bounded by curve lines, a thing which we have reaſon to ſuppoſe was then done for the firſt time, and might have been fairly doubted, conſidering the inſuperable difficulty that was found to attend the quadrature of the circle or its rectification.

Ariſtotle ſpeaks of two perſons, viz. Bryſon and Antiphon, who about his time, or a little earlier, were occupied with the quadrature of the circle. The former appears, according to the teſtimony of Alexander Aprodiſeus, to have erred moſt egregiouſly; he having concluded that the circumference was exactly $3\frac{1}{4}$ times the diameter. And the latter ſeems to have proceeded pretty much in the ſame manner as Archimedes afterwards did in ſquaring the parabola, that is, by firſt inſcribing a ſquare in the circle, then an iſoſceles triangle in each of the ſegments of the curve, having for its baſe a ſide of the ſquare; and next again a ſeries of triangles in the ſegments, having for their baſes the ſides of the former ſeries, and ſo on: this mode of procedure however, could not be attended with any ſucceſs, as it is well known that the ſpaces thus formed do not, as in the caſe of the parabola, admit of being abſolutely ſummed.

It may naturally be ſuppoſed that Archimedes exerted his utmoſt efforts to reſolve this problem; and probably it was only after long meditation on the ſubject that he loſt all hopes of ſucceſs, and contented himſelf with that approximation to the ratio of the diameter to the circumference which is contained in his treatiſe *De Circuli Dimenſione*, which has been preſerved from the period in which he wrote, about 250 years before Chriſt, to the preſent times. He found his approximation to the ratio, by ſuppoſing a regular polygon of 96 ſides to be deſcribed about the circle, and another of the ſame number of ſides to be inſcribed in it, and by ſhewing that the perimeter of the circumſcribing polygon was leſs than $3\frac{10}{70}$, or $3\frac{1}{7}$ times the diameter, but that the perimeter of the inſcribed figure was greater than $3\frac{10}{71}$ times the

SQUARING or Quadrature of the Circle. Plate D.

Fig. 1.

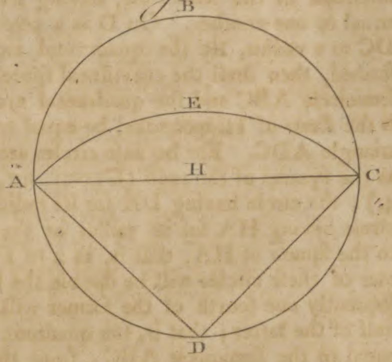
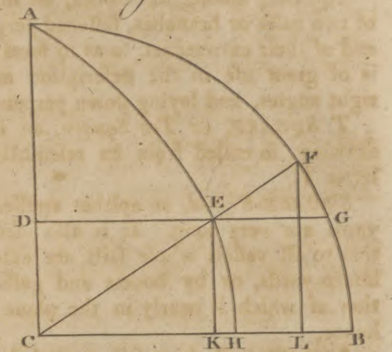


Fig. 2.



STARCH manufacture of.

Fig. 1.

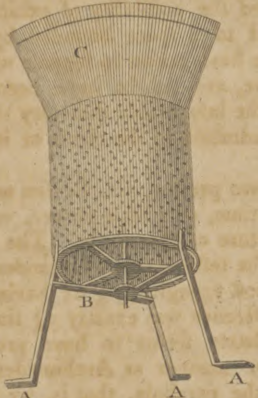


Fig. 6.

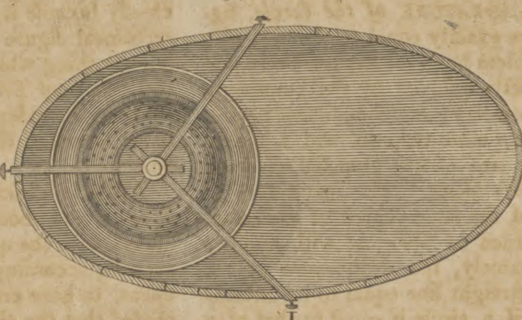


Fig. 4.

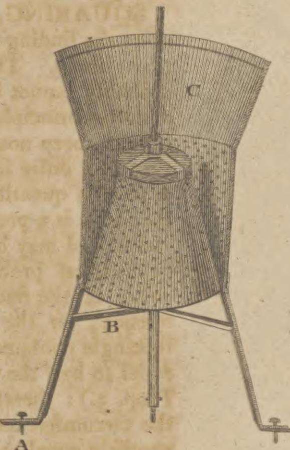


Fig. 2.

Fig. 7.

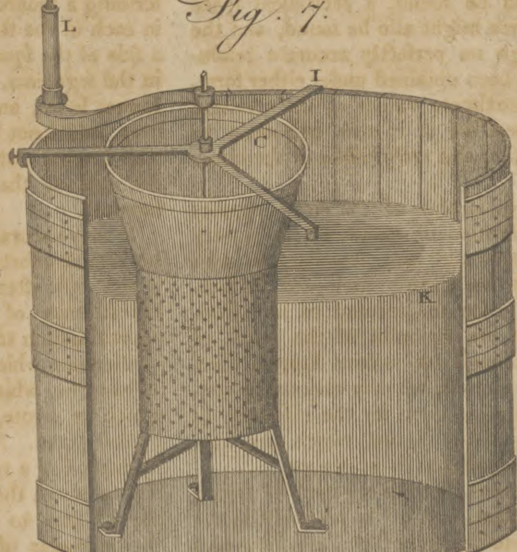


Fig. 5.

Fig. 3.

W. Train Sculpt.

Squaring.

the diameter; now the circumference of the circle being less than the perimeter of the one polygon but greater than that of the other, it follows that the circumference must be less than $3\frac{1}{7}$ times the diameter, but greater than $3\frac{10}{71}$ times; so that, taking the first of these limits as being expressed by the smallest numbers, the circumference will be to the diameter as $3\frac{1}{7}$ to 1, or as 22 to 7 nearly.

Although the approximate ratio investigated by Archimedes be the oldest known to have been found in the western world, yet one more accurate seems to have been known at a much earlier period in India. This we learn from the *Institutes of Akbar (Ayeen Akberry)* where it is said that the Hindoos suppose the diameter of a circle to be to its circumference as 1250 to 3927. Now this ratio, which is the same as that of 1 to 3.1416, when found in the simplest and most elementary manner must have required the inscription of a polygon of 768 sides in the circle, and must have been attended with nine extractions of the square root, each carried as far as ten places of figures.

We learn from Simplicius that Nicomedes and Apollonius both attempted to square the circle, the former by means of a curve which he called the *Quadratrix*; the invention of which, however, is ascribed to Dinostratus, and the latter also by the help of a curve denominated the sister to the tortuous line or *spiral*, and which was probably no other than the quadratrix of Dinostratus; the nature of which, and the manner of its application to the subject in question, we shall briefly explain.

Fig. 2.

Let AFB be a quadrant of a circle (fig. 2.) and C its centre; and conceive the radius CF to revolve uniformly about C from the position CA until at last it coincide with CB; while at the same time a line DG is carried with an uniform motion from A towards CB; the former line continuing always parallel to the latter, until at last they coincide; both motions being supposed to begin and end at the same instant. Then the point E in which the revolving radius CF and the moveable line DG intersect one another will generate a certain curve line AEH, which is the *Quadratrix* of Dinostratus.

Draw EK,FL both perpendicular to CB; then because the radius AC and the quadrantal arch AFB are uniformly generated in the same time by the points D and F, the contemporaneous spaces described will have to one another the same ratio as the whole spaces; that is, AD : AF : : AC : AB; hence we have AC : AB : : DC, or EK : FB. Now as the moveable point F approaches to B, the ratio of the straight line EK to the arch FB will approach to, and will manifestly be ultimately the same as the ratio of the straight line EK to the straight line FL, which again is equal to the ratio of CE to CF; therefore the ratio of the radius AC to the quadrantal arch AFB is the limit of the ratio of CE to CF, and consequently equal to the ratio of CH to CB, H being the point in which the quadratrix meets CB. Since therefore CH : CB : : CA or CB : quad. arch AFB, if by any means we could determine the point H, we might then find a straight line equal to the quadrantal arch, (by finding a third proportional to CH and CB) and consequently a straight line equal to the circumference. The point H, however, cannot be determined by a geometrical construction, and therefore all the ingenuity evinced by the person who first thought of this method of rectifying the circle (which certainly is considerable) has been unavailing.

The Arabs, who succeeded the Greeks in the cultivation of the sciences, would no doubt have their pretended squarers of the circle. We however know nothing more than that some one of them believed he had discovered that the diameter being unity, the circumference was the square root of 10; a very gross mistake; for the square root of 10 exceeds 3.162; but Archimedes had demonstrated that the circumference was less than 3.143.

It appears that, even during the dark ages, some attempts were made at the resolution of this famous problem, which however have always remained in manuscripts buried in the dust of old libraries. But upon the revival of learning the problem was again agitated by different writers, and particularly by the celebrated Cardinal De Cusa, who distinguished himself by his unfortunate attempt to resolve it. His mode of investigation, which had no solid foundation in geometry, led him to conclude, that if a line equal to the sum of the radius of a circle and the side of its inscribed square were made the diameter of another circle, and an equilateral triangle were inscribed in this last, the perimeter of this triangle would be equal to the circumference of the other circle. This pretended quadrature of the cardinal's was refuted by Regiomontanus; and indeed the task was not difficult; for, according to his construction, the diameter being 1, the circumference was greater than $3\frac{1}{7}$; a conclusion which must be absurd, seeing that Archimedes had demonstrated that it must be less than that number.

It would be trespassing too much upon the patience of our readers, were we to mention all the absurd and erroneous attempts which have been made during the last three centuries to square the circle. In a supplement to Montucla's excellent work, *Histoire des Mathematiques*, we find upwards of forty pretenders to the honour of this discovery enumerated. These were almost all very ignorant of geometry; and many of them were wild visionaries, pretending to discover inexplicable relations between the plain truths of mathematics and the most mysterious doctrines of religion. If those who have sought the quadrature of the circle had been previously initiated in the doctrines of geometry, although they missed attaining the object they had in view, yet they could not have failed to have extended the boundaries of the science by the discovery of many new propositions. From such persons, however, as have generally pursued this inquiry, no improvement whatever of the science was to be expected; although, indeed, in some instances, it has derived advantage from the labours of such as have undertaken to expose the absurdity of their conclusions; as in the case of Metius, who in refuting the quadrature of one *Simon à Quercu*; found a much nearer approximation to the ratio of the diameter to the circumference than had been previously known, at least in Europe, viz. that of 113 to 355, which reduced to decimals is the same as the ratio of 1 to 3.1415929, differing from the truth only in the seventh place of decimals.

Among the most remarkable of those who have recorded their own folly by publishing erroneous resolutions of the problem, we may reckon the celebrated Joseph Scaliger. Full of self-conceit, he believed that, entering

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tering upon the ſtudy of geometry, he could not fail to ſurmount by the force of his genius thoſe obſtacles which had completely ſtopt the progreſs of all preceding inquirers. He gave the reſult of his meditations to the world in 1592, under the title *Nova Cyclometria;* but he was refuted by Clavius, by Vieta, and others, who ſhewed that the magnitude he had aſſigned to the circumference was a little *leſs* than the perimeter of the inſcribed polygon of 192 ſides, which proved beyond a doubt that he was wrong. Scaliger, however, was not to be convinced of the abſurdity of his concluſion; and indeed, in almoſt every inſtance, pretenders to this diſcovery have not been more remarkable for their folly in committing abſurd blunders, than for their obſtinacy in maintaining that they were in the right, and all who held a contrary opinion in an error.

The famous Hobbes came alſo upon the field about the year 1650, with pretenſions not only to the quadrature of the circle, but alſo to the triſection of an angle, the rectification of the parabola, &c.; but his pretended ſolutions were refuted by Dr Wallis. And this circumſtance afforded him occaſion to write not only againſt geometers, but even againſt the ſcience of geometry itſelf.

We find it recorded by *Montucla*, as a ſort of phenomenon, that one Richard White, an Engliſh Jeſuit, having happened upon what he conceived to be a quadrature of the circle, which he publiſhed under the title, *Chryſaeſpis ſeu Quadratura Circuli*, ſuffered himſelf at laſt to be convinced by ſome of his friends that he was wrong both in his quadrature of the circle, and in his rectification of the ſpiral. But a ſolution of the ſame problem found out by one Mathulen of Lyons, did not produce in the end ſo much advantage to its author. This man in 1728 announced to the learned world that he had diſcovered both the quadrature of the circle and a perpetual motion; and he was ſo certain of the truth of theſe diſcoveries, that he conſigned 1000 *ecus* (about 125l.) to be paid to any one who ſhould demonſtrate that he was deceived in either. The taſk was not difficult. Nicole of the Academy of Sciences demonſtrated that he was wrong, and he himſelf allowed it; but he heſitated to pay the money, which Nicole had relinquiſhed in favour of the *Hotel Dieu* of Lyons. The affair went before a court of juſtice, which adjudged the money to be paid, as Nicole had deſtined it, to the poor. At a later period, viz. in 1753, the Chevalier de Cauſans, a French officer, and a man who was never expected to be a mathematician, ſuddenly found a quadrature of the circle in procuring a circular piece of turf to be cut; and riſing from one truth to another, he explained by his quadrature the doctrine of original ſin, and the Trinity. He engaged himſelf by a public writing to depoſit with a notary the ſum of 300,000 francs, to be wagered againſt ſuch as ſhould oppoſe him, and he actually lodged 10,000, which were to devolve to him who ſhould demonſtrate his error. This was eaſily done, as it reſulted from his diſcovery that a circle was equal to its circumſcribing ſquare, that is, a part to the whole! Some perſons came forward to anſwer his challenge, and in particular a young lady ſued him at one of the courts of law; but the French king judged that the Chevalier's fortune ought not to ſuffer on account of his whim; for, ſetting aſide this piece of folly, in every other reſpect he was a worthy man. The procedure was therefore ſtopt, and the wager declared void.

We ſhall not enter farther into the hiſtory of theſe vain and abſurd attempts to reſolve this important problem, but proceed to ſtate what has actually been done by men of ſound minds and real mathematical acquirements towards its ſolution. And in the firſt place it may be obſerved that the problem admits of being propoſed under two different forms: for it may be required to find either the area of the whole circle, or, which is the ſame thing, the length of the whole circumference; or elſe to find the area of any propoſed ſector or ſegment, or, which is equivalent, the length of the arch of the ſector or ſegment. The former is termed the *definite* and the latter the *indefinite* quadrature of the circle. The latter evidently is more general than the former, and includes it as a particular caſe. Now if we could find by any means a finite algebraic equation that ſhould expreſs the relation between any propoſed arch of a circle, and ſome known ſtraight line, or lines, the magnitude of one or more of which depended on that arch, then we would have an abſolute rectification of the arch, and conſequently a rectification or quadrature alſo of the whole circle. We here ſpeak of an analytical ſolution of the problem; the ancients, however, who were almoſt entirely ignorant of this branch of mathematical ſcience, muſt have endeavoured to treat it entirely upon geometrical principles. It is now well known, however, that all geometrical problems may be ſubjected to analyſis; and that it is only by ſuch a mode of proceeding they have in many caſes been reſolved.

With reſpect to the definite quadrature of the circle, it is commonly underſtood that no unexceptionable demonſtration of its impoſſibility has hitherto been publiſhed. It is true that James Gregory, in his *vera circuli et Hyperbolæ quadratura*, has given what he conſidered as ſuch a demonſtration; but it has been objected to, particularly by Huygens, one of the beſt geometers of his time. We are, however, certain that the ratio of the diameter to the circumference, as alſo, that the ratio of the ſquare of the diameter to the ſquare of a ſtraight line equal to the circumference, cannot be expreſſed by rational numbers, for this has been ſtrictly demonſtrated by Lambert, in the Berlin Memoirs for 1761. A demonſtration is alſo given in Legendre's *Geometrie.* As to the indefinite quadrature, if Newton's demonſtration of the 28th lemma of the firſt book of his *Principia* be correct, the thing ought to be abſolutely impoſſible. For the object of that propoſition is to prove that in no oval figure whatever, that returns into itſelf, can the area cut off by ſtraight lines at pleaſure be univerſally found by an equation of a finite dimenſion, and compoſed of a finite number of terms. If this be true, then it will be impoſſible to expreſs any ſector of a circle taken at pleaſure in finite terms. It is however to be remarked, that the accuracy of the reaſoning by which Newton has attempted to eſtabliſh the truth of the general propoſition has been queſtioned by no leſs a geometer than D'Alembert; and indeed we know one oval curve, which returns into itſelf, and which according to Newton's propoſition ought therefore not to admit of an indefinite quadrature; yet this is by no means the caſe, for it does really admit of ſuch a quadrature. The curve we mean is the *lemniſcata*, the equation of which is $(x^2+y^2)^2=a^2(x^2-y^2)$, where x and y denote its coordinates,

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We come now to speak of the different methods which have been found for approximating to the area or to the circumference. We have already noticed the approximation to the ratio of the diameter to the circumference found by Archimedes, and the earlier and more accurate approximation of the Indian mathematicians. Archimedes's ratio is the only one found by the ancients in the western world that has descended to modern times, and it appears to have been the most accurate known, until about the year 1585, when Metius, in refuting a pretended quadrature, found the more accurate ratio of 113 to 355, as we have already noticed. About the same time Vieta, and Adrianus Romanus published their ratios expressed in decimals, the former carrying the approximation to ten decimals instead of six, (which was the number of accurate figures expressed by Metius's ratio), and the latter extending it to 17 figures. Vieta also gave a kind of series, which being continued to infinity, gave the value of the circle.

These approximations, however, were far exceeded by that of Ludolph Van Ceulen, who in a work published in Dutch in 1610, carried it as far as 36 figures, showing that if the diameter were unity, the circumference would be greater than 3.14159,26535,89793, 23846,26433,83279,50288, but less than the same number with the last figure increased by an unit. This work was translated into Latin by Snellius, and published under the title, *De Circulo et Adscriptis*. In finding this approximation, Van Ceulen followed the method of Archimedes, doubling continually the number of sides of the inscribed and circumscribed polygons, until at length he found two which differed only by an unit in the 36th place of decimals in the numbers expressing their perimeters. This, however, must have been rather a work of patience than of genius; and indeed the labour must have been prodigious. He seems to have valued highly this singular effort, for in imitation of Archimedes, whose tomb was adorned with a sphere and cylinder, in commemoration of his discovery of the proportion which these solids bear to one another, he requested that the ratio he had found might be inscribed on his tomb, which was accordingly done.

Snellius found means to abridge greatly the labour of calculation by some very ingenious theorems; and although he did not go beyond Van Ceulen, yet he verified his result. His discoveries on this subject are contained in a work called *Willebrordi Snellii Cyclometricus de Circuli Dimensione*, &c. *Lugd. Bat.* 1621.

Descartes found also a geometrical construction, which being repeated continually, gave the circumference, and from which he might easily have deduced an expression in the form of a series.

Gregory of St Vincent distinguished himself also on this subject. It is true he committed a great error in supposing he had discovered the quadrature of both the circle and hyperbola; but he had previously made so many beautiful geometrical discoveries, deduced with much elegance after the manner of the ancients, that it would be wrong to number him with those absurd pretenders which we have already noticed. Gregory's mistake was the cause of a sharp controversy carried on between his disciples on the one side, and by Huygens, Mersennus and Lestaud on the other; and it was this that gave Huygens occasion to consider particularly the quadrature of the circle, and to investigate various new and curious theorems relating to it, which are contained in his *Theoremata de Quadratura Hyperboles, Ellipsis et Circuli*, 1651; and in his work *De Circuli Magnitudine Inventa*, 1654. In particular he showed, that if c denote the chord of an arch, and s its sine, then the arch itself will be greater than $c+\frac{1}{3}(c-s)$, but less than $c+\dfrac{4c+s}{2c+3s}\times\frac{1}{3}(c-s)$: he also showed that the arch is less than the sum of $\frac{2}{3}$ of its sine and $\frac{1}{3}$ of its tangent. These theorems greatly shorten the labour of approximating to the ratio of the diameter to the circumference, by means of inscribed and circumscribed figures, insomuch that by the inscribed polygons of 6 and 12 sides, we may obtain it to the same degree of accuracy as Archimedes did by the inscribed and circumscribed polygons of 96 sides.

James Gregory, in his *Vera Circuli et Hyperbolæ Quadratura*, gave several curious theorems upon the relation of the circle to its inscribed and circumscribed polygons, and their ratios to one another; and by means of these he found with infinitely less trouble than by the ordinary methods, and even by those of Snellius, the measure of the circle as far as 20 places of figures. He gave also, after the example of Huygens, constructions for finding straight lines nearly equal to arches of a circle, and of which the degree of accuracy was greater. For example, he found that if A be put for the chord of an arch of a circle, and B for twice the chord of half the arch, and C be taken such that $A+B : B :: 2B : C$, then the arch itself is nearly equal to $\dfrac{8C+8B-A}{15}$, but a little less, the error in the case of a complete semicircle being less than its $\frac{1}{3500}$ part; and when the arch does not exceed 120°, it is less than its $\frac{1}{40000}$ part; and finally, for a quadrant the error is not greater than its $\frac{1}{500000}$ part. And farther, that if D be such that $A : B :: B : D$, then the arch is nearly equal to $\dfrac{12C+4B-D}{15}$, but a little greater, the error in the semicircle being less than its $\frac{1}{1400}$ part, and in a quadrant less than its $\frac{1}{60000}$ part.

The discoveries of Dr Wallis, delivered in his *Arithmetica Infinitorum* published in 1655, led him to a singular expression for the ratio of the circle to the square of its diameter. He found that the former was to the latter as 1 to the product

$$\frac{3\times3\times5\times5\times7\times7\times9\times9\times11\times11\text{ \&c.}}{2\times4\times4\times6\times6\times8\times8\times10\times10\times12}$$

the fractions $\frac{3}{2}, \frac{3}{4}, \frac{5}{4}, \frac{5}{6}$, &c. being supposed infinite in number. The products being supposed continued to infinity, we have the ratio exactly; but if we stop at any finite number of terms, as must necessarily be the case in its application, the result will be alternately too great and too small, according as we take an odd or an even number of terms of the numerator and denominator. Thus

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Thus the fraction $\frac{4}{3}$ is too great; on the other hand, $\frac{3\times3}{2\times4}=\frac{9}{8}$ is too small, and $\frac{3\times3\times5}{2\times4\times4}=\frac{45}{32}$ too great, and so on. But to approach as near as possible in each case, Wallis directs to multiply the product by the square root of a fraction formed by adding to unity the reciprocal of the last factor in either its numerator or denominator; then the result, although much nearer, will be too great if the number whose reciprocal is taken be the last in the numerator, but too small if it be the number in the denominator. Thus the following series of expressions will give approximate values of the infinite product $\frac{3\times3\times5\times5\times7\times7 \text{ \&c.}}{2\times4\times4\times6\times6\times8\times8}$ which are alternately too great and too small.

$$\frac{3.3.5.5}{2.4.4.6}\sqrt{(1+\tfrac{1}{5})};\ \frac{3.3.5.5}{2.4.4.6}\sqrt{(1+\tfrac{1}{6})};$$

$$\frac{3.3.5.5.7.7}{2.4.4.6.6.8}\sqrt{1+\tfrac{1}{7})};\ \frac{3.3.5.5.7.7}{2.4.4.6.6.8}\sqrt{(1+\tfrac{1}{8})};\ \text{\&c.}$$

these values, alternately too great and too small, fall between the known limits.

An expression of another kind for the ratio of the circle to the square of the diameter was found by Lord Brounker. He showed that the circle being unity, the square of the diameter is expressed by the continued fraction

$$1+\cfrac{1}{2+\cfrac{9}{2+\cfrac{25}{2+\cfrac{49}{2+,\text{\&c.}}}}}$$

which is supposed to go on to infinity, the numerators 1, 9, 25, 49, &c. being the squares of the odd numbers 1, 3, 5, 7, &c. By taking two, three, four, &c. terms of this fraction, we shall have a series of approximate values which are alternately greater and less than its accurate value.

Such were the chief discoveries relating to the quadrature of the circle made before the time of Newton: many others, however, were quickly added by that truly great man, as well as by his contemporaries. In particular, Newton himself showed that if s denote the sine, and v the versed sine of an arch, then the radius being unity, the arch is equal to either of the following series,

$$s+\frac{1.s^3}{2.3}+\frac{1.3\,s^5}{2.4.5}+\frac{1.3.5\,s^7}{2.4.6.7}+\frac{1.3.5.7\,s^9}{2.4.6.8.9}+\text{\&c.}$$

$$\sqrt{2v}\times\left(1+\frac{1.v}{2.3.2}+\frac{1.3\,v^2}{2.4.5.2^2}+\frac{1.3.5\,v^3}{2.4.6.7.2^3}+\frac{1.3.5.7\,v^4}{2.4.6.8.9.2^4}+\text{\&c.}\right)$$

And James Gregory found that t being put for the tangent, the arch is expressed by the very simple series

$$t-\frac{t^3}{3}+\frac{t^5}{5}-\frac{t^7}{7}+\frac{t^9}{9}-\text{\&c.}$$

We have investigated the first of these series at § 140, and the third at § 137, of the article FLUXIONS: the second is easily obtained from the first by considering that since the sine of an arch is half the chord of twice the arch, that is, half of a mean proportional between the diameter and versed sine of twice the arch; we have therefore only to multiply the first series by 2, and to substitute $\frac{1}{2}\sqrt{2v}$ instead of s, and we get the second series.

By taking $s=\frac{1}{2}$, then, because in this case the arch contains 30°, we have half the circumference to the radius 1, or the whole circumference to the diameter 1, expressed by the infinite series

$$3\left(1+\frac{1}{2.3.2^2}+\frac{1.3}{2.4.5.2^4}+\frac{1.3.5}{2.4.6.7.2^6}+\frac{1.3.5.7}{2.4.6.8.9.2^8}+\text{\&c.}\right)$$

And by supposing that in the third series $t=1$, in which case the arch is one-eighth of the circumference, we have the same things expressed by the series

$$4\left(1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-\frac{1}{11}+\text{\&c.}\right)$$

which was given by Leibnitz as a quadrature of the circle in the Leipsic Acts in the year 1682; but was discovered by him 1673. Gregory, however, had found the series under its general form several years before. By the first of these two numeral series we can readily compute the circumference of the circle to a tolerable degree of accuracy; but the second is altogether inapplicable in its present form on account of the slowness of its convergency; for Newton has observed that to exhibit its value exact to twenty places of figures, there would be occasion for no less than five thousand millions of its terms, to compute which would take up above a thousand years.

The slowness of the convergency has arisen from our supposing $t=1$. If we had supposed t greater than 1, then the series would not have converged at all, but on the contrary diverged. But by giving to t a value less than 1, then the rate of convergency will be increased, and that so much the more, as t is smaller.

If we suppose the arch of which t is the tangent to be 30°, then t will be $\sqrt{\frac{1}{3}}=\frac{1}{3}\sqrt{3}$, and therefore half the circumference to radius unity, or the circumference to the diameter unity, which in this case is $6t\left(1-\frac{t^2}{3}+\frac{t^4}{5}-\frac{t^6}{7}+\frac{t^8}{9}-\text{\&c.}\right)$ will be

$$\sqrt{12}\left(1-\frac{1}{3.3}+\frac{1}{5.3^2}-\frac{1}{7.3^3}+\frac{1}{9.3^4}-\text{\&c.}\right).$$

By means of this series, in an hour's time the circumference may be found to be nearly 3.141592653590, which is true to 11 decimal places, and is a very considerable degree of accuracy, considering the smallness of the labour. But Mr Machin, enticed by the easiness of the process, was induced, about the beginning of the last century, to continue the approximation as far as 100 places of figures, thus finding the diameter to be to the circumference as 1 to 3.14159,26535,89793, 23846,26433,83279,50288,41971,69399,37510,58209 74944,59230,78164,06286,20899,86280,34825,34211 70680. After him, De Lagny continued it as far as

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Squaring. 128 figures. But he has alſo been outdone; for in Radcliffe's library at Oxford, there is a manuſcript in which it is carried as far as 150 figures!

Although this laſt ſeries, which was firſt propoſed by Dr Halley, gives the ratio of the diameter to the circumference with wonderful facility when compared with the operoſe method employed by Van Ceulen, yet others have been ſince found which accompliſh it with ſtill greater eaſe. In Halley's ſeries we have to compute the irrational quantity $\sqrt{12}$, becauſe of the irrational value which it was neceſſary to give to t in order to render it ſufficiently ſmall, and at the ſame time an exact part of the whole circumference; but Mr Machin contrived, by a very ingenious artifice, to reduce the computation of an arch of 45°, and conſequently the length of the whole circumference, to two ſeries which contain only rational quantities, and which at the ſame time converge with great rapidity. The nature of this artifice, and the manner in which it occurred to its author, is explained by Dr Hutton in his very excellent treatiſe on Menſuration, as follows: "Since the chief advantage (in the application of Gregory's ſeries to the rectification of the circle) conſiſts in taking ſmall arches, whoſe tangents ſhall be numbers eaſy to manage, Mr Machin very properly conſidered, that ſince the tangent of 45° is 1, and that the tangent of any arch being given, the tangent of the double of that arch can eaſily be had; if there be aſſumed ſome ſmall ſimple number as the tangent of an arch, and then the tangent of the double arch be continually taken, until a tangent be found nearly equal to 1, which is the tangent of 45°, by taking the tangent anſwering to the ſmall difference of 45° and this multiple, there would be found two very ſmall tangents, viz. the tangent firſt aſſumed, and the tangent of the difference between 45° and the multiple arch; and that therefore the lengths of the arches correſponding to theſe two tangents being calculated, and the arch belonging to the tangent firſt aſſumed being ſo often doubled as the multiple directs, the reſult, increaſed or diminiſhed by the other arch, according as the multiple ſhould be below or above it, would be the arch of 45°.

"Having thus thought of his method, by a few trials he was lucky enough to find a number (and perhaps the only one) proper for his purpoſe; viz. knowing that the tangent of $\frac{1}{4}$ of 45° is nearly $=\frac{1}{5}$, he aſſumed $\frac{1}{5}$ as the tangent of an arch. Then, ſince if t be the tangent of an arch, the tangent of the double arch will be $\frac{2t}{1-t^2}$, the radius being 1; the tangent of the double arch to that of which $\frac{1}{5}$ is the tangent will $\frac{5}{12}$, and the tangent of the double of this arch will be $\frac{120}{119}$, which being very nearly equal to 1, ſhews, that the arch which is equal to four times the firſt arch is very near 45°. Then, ſince the tangent of the difference between an arch of 45°, and an arch greater than 45°, whoſe tangent is T, is $\frac{T-1}{T+1}$, we ſhall have the tangent of the difference between 45°, and the arch whoſe tangent is $\frac{120}{119}$ equal to $\frac{1}{239}$. Now, by calculating from the general ſeries the arches whoſe tangents are $\frac{1}{5}$ and $\frac{1}{239}$, (which may be quickly done by reaſon of the ſmallneſs and ſimplicity of the numbers), and taking the latter arch from four times the former, the remainder will be the arch of 45°." Squaring.

If we ſubſtitute $\frac{1}{5}$ inſtead of t in the general ſeries, we ſhall have the arch whoſe tangent is $\frac{1}{5}$ expreſſed by the ſeries $\frac{1}{5}-\frac{1}{3\cdot5^3}+\frac{1}{5\cdot5^5}-\frac{1}{7\cdot5^7}+$, &c.; and, in like manner, by ſubſtituting $\frac{1}{239}$ for t, we get the arch whoſe tangent is $\frac{1}{239}$ expreſſed by the ſeries $\frac{1}{239}-\frac{1}{3\cdot239^3}+\frac{1}{5\cdot239^5}-\frac{1}{7\cdot239^7}+$, &c. Now, ſince four times the arch to tan. $\frac{1}{5}$ diminiſhed by the arch to tan. $\frac{1}{239}$ is equal to the arch to tan. 1, that is, to the arch of 45°, or $\frac{1}{4}$ of the ſemicircumference; therefore, half the circumference of a circle to rad. $=1$, or the whole circumference, the diameter being 1, is equal to

$$16\left(\frac{1}{5}-\frac{1}{3\cdot5^3}+\frac{1}{5\cdot5^5}-\frac{1}{7\cdot5^7}+\frac{1}{9\cdot5^9}-,\ \&c.\right)$$
$$-4\left(\frac{1}{239}-\frac{1}{3\cdot239^3}+\frac{1}{5\cdot239^5}-\frac{1}{7\cdot239^7}+\frac{1}{9\cdot239^9}-,\ \&c.\right)$$

and this is Machin's ſeries for the rectification of the circle.

The happy idea which Machin had conceived of reducing the rectification of the arch whoſe tangent is unity to that of two arches whoſe tangents are ſmall rational fractions, having each unity for a numerator, appears alſo to have occurred to Euler; and the ſame thought has, ſince his time, been purſued by other mathematicians, who have contrived to reſolve an arch of 45° into three or more ſuch arches. We ſhall ſhew how this may be done, beginning with the inveſtigation of the following problem.

Problem. Suppoſing n, x, and y, to denote three whole numbers, ſuch, that the arch whoſe tangent is $\frac{1}{n}$ is equal to the ſum of two arches whoſe tangents are $\frac{1}{x}$ and $\frac{1}{y}$, radius being unity, it is required to determine all poſſible values of the numbers x and y in terms of the number n.

Solution. It is manifeſt from the formula for the tangent of the ſum of two arches (Algebra, § 368.) that $\frac{1}{n}=\frac{\frac{1}{x}+\frac{1}{y}}{1-\frac{1}{xy}}$; hence we have $\frac{1}{n}=\frac{x+y}{xy-1}$, and $nx+ny=xy-1$, and $y(x-n)=nx+1$; and, laſtly, $y=\frac{nx+1}{x-n}=n+\frac{n^2+1}{x-n}$. Now, as by hypotheſis, y is a whole number, it is manifeſt that $\frac{n^2+1}{x-n}$ muſt be a whole number; therefore, $x-n$ muſt be a diviſor of n^2+1. Let p be any diviſor of n^2+1, and q the quotient, that is, let $pq=n^2+1$, then $x-n=p$, and $x=n+p$: And ſince $\frac{n^2+1}{x-n}=\frac{pq}{p}=q$, therefore $y=n+q$; thus the values of x and y are determined in terms of n as required; and by giving to p and q all poſſible values, we ſhall have

have all the values of x and y that can exist. This solution affords us the following theorem.

THEOREM. Let n denote any whole number, and let n^2+1 be resolved into any two factors p and q, (one of which may be unity), that is, let $pq=n^2+1$; the arch whose tangent is $\frac{1}{n}$ is equal to the sum of the arches whose tangents are $\frac{1}{n+p}$, and $\frac{1}{n+q}$ respectively.

For the sake of brevity, let $A\frac{1}{n}$ be put to denote the arch, having for its tangent $\frac{1}{n}$; then, according to this notation, our theorem will be expressed thus, $A\frac{1}{n}= A\frac{1}{n+p}+A\frac{1}{n+q}$. Let us now suppose $n=1$, then $n^2+1=2=1\times 2$, therefore, the only values which we can give in this case to p and q are $p=1$, $q=2$, and these being substituted, we have

$$A\,1=A\tfrac{1}{2}+A\tfrac{1}{3}.$$

From which it appears, that the arch whose tangent is unity (that is, $\frac{1}{8}$ of the circumference), is the sum of the arches whose tangents are $\frac{1}{2}$ and $\frac{1}{3}$. This is Euler's theorem, and by means of it, putting $\frac{1}{2}$ and $\frac{1}{3}$ for t in the general series $t-\frac{1}{3}t^3+\frac{1}{5}t^5-\frac{1}{7}t^7+$, &c. we get half the circumference to radius 1 equal to

$$4\left\{\begin{array}{l}\frac{1}{2}-\frac{1}{3\cdot 2^3}+\frac{1}{5\cdot 2^5}-\frac{1}{7\cdot 2^7}+\frac{1}{9\cdot 2^9}-\text{, \&c.}\\[4pt] +\frac{1}{3}-\frac{1}{3\cdot 3^3}+\frac{1}{5\cdot 3^5}-\frac{1}{7\cdot 3^7}+\frac{1}{9\cdot 3^9}-\text{, \&c.}\end{array}\right\}$$

Let us now suppose $n=2$, then $n^2+1=5=1\times 5$, hence the only values which p and q can have are 1 and 5; and in this case our general formula gives $A\frac{1}{2}=A\frac{1}{3}+A\frac{1}{7}$.

If now from the two equations

$$A\,1=A\tfrac{1}{2}+A\tfrac{1}{3}; \qquad A\tfrac{1}{2}=A\tfrac{1}{3},+A\tfrac{1}{7},$$

we eliminate successively $A\frac{1}{2}$ and $A\frac{1}{3}$, we shall obtain the two following:

$$A\,1=2\,A\tfrac{1}{3}+A\tfrac{1}{7}; \qquad A\,1=2\,A\tfrac{1}{2}-A\tfrac{1}{7}.$$

From the first of these it appears that $\frac{1}{8}$ of the circumference is equal to the sum of twice the arch to tan. $\frac{1}{3}$, and once the arch to tan. $\frac{1}{7}$; and from the second, that the same quantity is equal to the excess of twice the arch to tan. $\frac{1}{2}$ above the arch to tan. $\frac{1}{7}$; and from each of these, an expression for the whole circumference may be obtained analogous to that which we have found above from Euler's formula, but which will converge faster, and therefore is better.

The resolution of an arch of 45° into three other arches, may be effected by means of our general formula, as follows: Put $n=3$, then $n^2+1=10=1\times 10=2\times 5$, hence we have $p=1$, and $q=10$, and also $p=2$, and $q=5$; therefore, substituting, we get two different values of $A\frac{1}{3}$, viz.

$$A\tfrac{1}{3}=A\tfrac{1}{4}+A\tfrac{1}{13}; \qquad A\tfrac{1}{3}=A\tfrac{1}{5}+A\tfrac{1}{8}.$$

From these, and the equation $A\,1=2\,A\frac{1}{3}+A\frac{1}{7}$, we get, by exterminating $A\frac{1}{3}$, the two following expressions for A 1, an arch of 45°.

$$A\,1=2\,A\tfrac{1}{4}+A\tfrac{1}{7}+2\,A\tfrac{1}{13}; \qquad A\,1=2\,A\tfrac{1}{5}+A\tfrac{1}{7}+2A\tfrac{1}{8}.$$

These give each an expression for the circumference composed of three series. The labour, however, of computing by either of them, particularly the latter, will probably be less than by any of the formulas composed of two series, on account of the greater degree of quickness with which the series will converge. All the preceding formulas have been investigated in different ways by different mathematicians. That, however, which we are about to investigate, we believe is new. Let n in the general formula be taken equal to 5; then $n^2+1=26=1\times 26=2\times 13$, therefore $p=1$, $q=26$, also $p=2$, $q=13$, hence we find $A\frac{1}{5}=A\frac{1}{6}+A\frac{1}{31}$, and also $A\frac{1}{5}=A\frac{1}{7}+A\frac{1}{18}$. From this last equation, and the equation $A\,1=2\,A\frac{1}{5}+A\frac{1}{7}+2\,A\frac{1}{8}$, let $A\frac{1}{5}$ be eliminated, and the result is

$$A\,1=3\,A\tfrac{1}{7}+2\,A\tfrac{1}{8}+2\,A\tfrac{1}{18}.$$

This appears to be the most convenient expression of any we have yet found, because the fractions are smaller, while at the same time two of the denominators consist of only one figure, and the third, which consists of two, admits of being resolved into factors. By the same mode of reasoning we have found this expression

$$A1=2A\tfrac{1}{8}+3A\tfrac{1}{9}+2A\tfrac{1}{18}+3A\tfrac{1}{32},$$

which consists of four terms; but for the sake of brevity we omit its investigation.

We shall now apply the formula $A1=3A\frac{1}{7}+2A\frac{1}{8}+2A\frac{1}{18}$ to the actual calculation of the arch of 45°, the radius of the circle being unity.

I. Calculation of the length of the arch whose tangent is $\frac{1}{7}$.

In this case, because $t=\frac{1}{7}$, we have

$$A\frac{1}{7}=\frac{1}{7}-\frac{1}{3\cdot 7^3}+\frac{1}{5\cdot 7^5}-\frac{1}{7\cdot 7^7}+\frac{1}{9\cdot 7^9}-\text{, \&c.}$$

$\frac{1}{7}=.1428571428571$ $\qquad$ $\frac{1}{3\cdot 7^3}=.0009718172983$

$\frac{1}{5\cdot 7^5}=.0000118998037$ $\qquad$ $\frac{1}{7\cdot 7^7}=.0000001734665$

$\frac{1}{9\cdot 7^9}=.0000000027534$ $\qquad$ $\frac{1}{11\cdot 7^{11}}=.0000000000460$

$\frac{1}{13\cdot 7^{13}}=.0000000000008$ $\qquad$ $.0009719908108$

+.1428690454150 amount of positive terms.
—.0009719908108 amount of negative terms.

$A\frac{1}{7}=.1418970546042$

II. Calculation of the length of the arch whose tangent is $\frac{1}{8}$.

Here $t=\frac{1}{8}$, therefore,

$$A\frac{1}{8}=\frac{1}{8}-\frac{1}{3\cdot 8^3}+\frac{1}{5\cdot 8^5}-\frac{1}{7\cdot 8^7}+\text{, \&c.}$$

Squaring.

$\frac{1}{8} = .125000000000$

$\frac{1}{5.8^5} = .000006103515 6$

$\frac{1}{9.8^9} = .000000008278$

$\frac{1}{13.8^{13}} = .000000000001$

$+.125006104343 5$

$-.000651109796 9$

$A\frac{1}{8} = .124354994546 6$

$\frac{1}{3.8^3} = .000651041666 7$

$\frac{1}{7.8^7} = .000000068119 6$

$\frac{1}{11.8^{11}} = .000000000010 6$

$.000651109796 9$

III. Calculation of the arch whose tangent is $\frac{1}{18}$.

Here $t = \frac{1}{18}$, therefore,

$$A\frac{1}{18} = \frac{1}{18} - \frac{1}{3.18^3} + \frac{1}{5.18^5} - \frac{1}{7.18^7} +, \&c.$$

$\frac{1}{18} = .055555555555 6$

$\frac{1}{5.18^5} = .000000105844 3$

$\frac{1}{9.18^9} = .000000000000 6$

$+.055555661400 5$

$-.000057156154 7$

$A\frac{1}{18} = .055498505245 8$

$\frac{1}{3.18^3} = .000057155921 4$

$\frac{1}{7.18^7} = .000000000233 3$

$.000057156154 7$

$3A\frac{1}{7} = .425691163812 6$
$2A\frac{1}{8} = .248709989093 2$
$2A\frac{1}{18} = .110997010491 6$

$\frac{1}{8}$ of the circum. or $A1 = .785398163397$

Thus by a very easy calculation we have obtained one-fourth of the circumference true to 12 decimal places; and indeed by this method we may find an approximate value of the ratio of the diameter to the circumference to 200 places of figures with, perhaps, as much ease as Vieta or Romanus found it to 10 or 15 figures. We have already observed that Van Ceulen desired that his quadrature, which extended only to 35 decimals, might be inscribed on his tomb; from which we may reasonably infer that the time and labour he had bestowed in the calculation must have been very great; but by an artifice of the kind we have been explaining, Euler in 18 hours verified Lagny's quadrature of 128 figures.

In concluding this article we shall briefly notice some series for the indefinite rectification of the circle, which have just appeared in the sixth volume of the Edinburgh Philosophical Transactions. They are given by Mr W. Wallace of the Royal Military College, in a paper entitled, *New Series for the Quadrature of the Conic Sections, and the Computation of Logarithms.* These series do not give the arch directly, but only its reciprocal, or the powers of that reciprocal; it is however evident, that any one of these being known, the arch itself becomes immediately known. The first series is as follows. Let a denote any arch of a circle, and let its tangent, the tangents of its half, &c. be briefly denoted by tan. a, tan $\frac{1}{2}a$, &c. Then shall

$$\frac{1}{a} = \frac{1}{\tan. a} + \tfrac{1}{2}\tan.\tfrac{1}{2}a + \tfrac{1}{4}\tan.\tfrac{1}{4}a + \tfrac{1}{8}\tan.\tfrac{1}{8}a.$$
$$+ \tfrac{1}{16}\tan.\tfrac{1}{16}a \ldots\ldots + T + T' + S.$$

Here the arches a, $\frac{1}{2}a$, $\frac{1}{4}a$, $\frac{1}{8}a$, &c. constitute a geometrical progression, having the number of its terms infinite, and their common ratio $\frac{1}{2}$. The letters T and T′ are put for any two adjoining terms (after the first) of the series, and S is put for the sum of all the terms following these; and this sum is always contained between two limits, one of which is $\frac{1}{3}$ of the latter of the two terms T, T′, and the other is a third proportional to their difference; and the last of the two being always less than the first of these limits, but greater than the second. As a specimen of the way of applying this series, we shall give the calculation of the length of an arch of 90° to six decimal places. In this case $\frac{1}{\tan. a} = \text{cotan. } a = 0$, tan. $\frac{1}{2}a = 1$, the remaining quantities tan. $\frac{1}{4}a$, tan. $\frac{1}{8}a$, &c. are to be computed from tan. $\frac{1}{2}a$ by this formula, $\tan.\frac{1}{2}A = \sqrt{\left(\frac{1}{\tan.^2 A} + 1\right)} - \frac{1}{\tan. A}$.

Accordingly we find

tan. $\frac{1}{2}a = 1.$	tan. $\frac{1}{16}a = .0984914$
tan. $\frac{1}{4}a = .4142136$	tan. $\frac{1}{32}a = .0491268$
tan. $\frac{1}{8}a = .1989123$	tan. $\frac{1}{64}a = .0245486$

$\frac{1}{2}$ tan. $\frac{1}{2}a = .5000000$
$\frac{1}{4}$ tan. $\frac{1}{4}a = .1035534$
$\frac{1}{8}$ tan. $\frac{1}{8}a = .0248640$
$\frac{1}{16}$ tan. $\frac{1}{16}a = .0061557$
$T = \frac{1}{32}$ tan. $\frac{1}{32}a = .0015352$
$T' = \frac{1}{64}$ tan. $\frac{1}{64}a = .0003836$

$S < .0001278,7$
$S > .0001277,7$ Hence $S = .0001278$

$\frac{1}{a} = .6366197$

Arch of $90° = a = 1.570796.$

The second series given in this paper is expressed as follows. Let cos. a, cos. $\frac{1}{2}a$, &c. denote the cosine of the arch, the cosine of its half, &c. Then

$$\frac{1}{a^2} = \frac{1}{4}\,\frac{1+\cos. a}{1-\cos. a} + \frac{1}{6}$$
$$-\left(\frac{1}{4^2}\,\frac{1-\cos.\frac{1}{2}a}{1+\cos.\frac{1}{2}a} + \frac{1}{4^3}\,\frac{1-\cos.\frac{1}{4}a}{1+\cos.\frac{1}{4}a}\right.$$
$$\left. + \frac{1}{4^4}\,\frac{1-\cos.\frac{1}{8}a}{1+\cos.\frac{1}{8}a} \ldots + T + T' + S\right)$$

Here, as before, the letters T, T′ denote any two adjacent terms of the series in the parenthesis, and S is put for the sum of all the following terms, which in this case is always less than $\frac{1}{15}$T′, but greater than a third proportional to T—T′ and T′. This second series converges

verges quicker than the firſt, and is beſides better adapted to calculation, becauſe the coſines of the ſeries of arches $\frac{1}{2}a$, $\frac{1}{4}a$, &c. are more eaſily deduced from the coſine of a and one another than the tangents. The formula in this caſe being $\text{coſ.}\ \frac{1}{2}\ A = \sqrt{\left(\frac{1+\text{coſ.}\ A}{2}\right)}$.

There are various other ſeries for the rectification of any arch of a circle given in the ſame paper, ſome of which converge faſter than either of the two we have here ſpecified, and all have the property of being applicable to every poſſible caſe, and of having very ſimple limits, between which the ſum of all their terms following any propoſed term are always contained. It may alſo be obſerved that the principles from which they are deduced are of the moſt ſimple and elementary kind, inſomuch that the author has ſtated it as his opinion, that their inveſtigation might even be admitted into and form a part of the elements of geometry.

SQUATINA. See SQUALUS, ICHTHYOLOGY *Index*.

SQUILL. See SCILLA, BOTANY and MATERIA MEDICA *Index*.

SQUILLA, the name of a ſpecies of cancer. See CANCER, ENTOMOLOGY *Index*.

SQUINTING. See MEDICINE, N° 383.

SQUIRREL. See SCIURUS, MAMMALIA *Index*.

STABBING, in *Law*. The offence of mortally ſtabbing another, though done upon ſudden provocation, is puniſhed as murder; the benefit of clergy being taken away from it by ſtatute. (See MURDER). For by Ja. I. c. 8. when one thruſts or ſtabs another, not then having a weapon drawn, or who hath not then firſt ſtricken the party ſtabbing, ſo that he dies thereof within ſix months after, the offender ſhall not have the benefit of clergy, though he did it not of malice aforethought. This ſtatute was made on account of the frequent quarrels and ſtabbings with ſhort daggers between the Scotch and the Engliſh, at the acceſſion of James I.; and being therefore of a temporary nature, ought to have expired with the miſchief which it meant to remedy. For, in point of ſolid and ſubſtantial juſtice, it cannot be ſaid that the mode of killing, whether by ſtabbing, ſtrangling, or ſhooting, can either extenuate or enhance the guilt; unleſs where, as in the caſe of poiſoning, it carries with it internal evidence of cool and deliberate malice. But the benignity of the law hath conſtrued the ſtatute ſo favourably in behalf of the ſubject, and ſo ſtrictly when againſt him, that the offence of ſtabbing now ſtands almoſt upon the ſame footing as it did at the common law. Thus, (not to repeat the caſes mentioned under MANSLAUGHTER, of ſtabbing an adultereſs, &c. which are barely manſlaughter, as at common law), in the conſtruction of this ſtatute it hath been doubted, whether, if the deceaſed had ſtruck at all before the mortal blow given, this does not take it out of the ſtatute, though in the preceding quarrel the ſtabber had given the firſt blow; and it ſeems to be the better opinion, that this is not within the ſtatute. Alſo it hath been reſolved, that the killing a man, by throwing a hammer or other weapon, is not within the ſtatute; and whether a ſhot with a piſtol be ſo or not is doubted. But if the party ſlain had a cudgel in his hand, or had thrown a pot or a bottle, or diſcharged a piſtol at the party ſtabbing, this is a ſufficient reaſon for having a weapon drawn on his ſide within the words of the ſtatute.

Blackſt. Comment. vol. iv. p. 193.

STACHYS, HEDGE-NETTLE, or ALL-HEAL, a genus of plants belonging to the claſs of didynamia, and order of gymnoſpermia; and in the natural ſyſtem arranged under the 42d order, *Verticillatæ*. See BOTANY *Index*.

STADIUM, an ancient Greek long meaſure, containing 125 geometrical paces, or 625 Roman feet, correſponding to our furlong. The word is ſaid to be formed from the Greek word στασις "a ſtation," or ιστημι "to ſtand," becauſe it is reported that Hercules having run a ſtadium at one breath, ſtood ſtill at the end of it. The Greeks uſually meaſured diſtances by ſtadia, which they called σταδιασμος. Stadium alſo ſignified the courſe on which their races were run.

STADTHOLDER, formerly the principal magiſtrate or governor of the Seven United Provinces. Although this office is now aboliſhed by the uſurped influence of France, our readers will probably not be ill pleaſed with a ſhort account of the ſeveral powers and claims connected with it. To render that account the more intelligible, we ſhall trace the office of a ſtadtholder from its origin.

The Seven Provinces of the Low Countries were long governed by princes inveſted with the ſovereignty, though limited in their powers, and under various titles; as *Counts of Holland*, *Dukes of Guelder*, *Biſhop of Utrecht*, &c. When theſe countries fell to the princes of the houſe of Burgundy, and afterwards to thoſe of Auſtria, who had many other dominions, the abſence of the ſovereign was ſupplied by a ſtadtholder or governor, veſted with very ample powers. Theſe ſtadtholders or lieutenants had the adminiſtration of the government, and preſided in the courts of juſtice, whoſe juriſdiction was not at that time confined merely to the trial of cauſes, but extended to affairs of ſtate. The ſtadtholders ſwore allegiance to the princes at their inauguration, jointly with the ſtates of the provinces they governed. They likewiſe took an oath to the ſtates, by which they promiſed to maintain their fundamental laws and privileges.

It was upon this footing that William the Firſt, prince of Orange, was made governor and lieutenant-general of Holland, Zealand, and Utrecht, by Philip the Second, upon his leaving the Low Countries to go into Spain. The troubles beginning ſoon after, this prince found means to bring about an union, in 1576, between Holland and Zealand; the ſtates of which two provinces put into his hands, as far as was in their power, the ſovereign authority (for ſo long time as they ſhould remain in war and under arms), upon the ſame footing as Holland had intruſted him with it the year before. In 1581 the ſame authority was again renewed to him by Holland, as it was ſoon after by Zealand likewiſe; and in 1584, being already elected count of Holland, upon certain conditions he would have been formally inveſted with the ſovereignty, had not a wretch, hired and employed by the court of Spain, put an end to his life by a horrid aſſaſſination.

In the preamble of the inſtruments by which the ſtates in 1581 conferred the ſovereign authority upon Prince William the Firſt, we find theſe remarkable words, which are there ſet down as fundamental rules: "That all republics and communities ought to preſerve

Stadtholder.

ſerve, maintain, and fortify themſelves by unanimity; which being impoſſible to be kept up always among ſo many members, often differing in inclinations and ſentiments, it is conſequently neceſſary that the government ſhould be placed in the hands of one ſingle chief magiſtrate." Many good politicians, and the greateſt part of the inhabitants of theſe provinces, ſince the eſtabliſhment of the republic, looked upon the ſtadtholderian government as an eſſential part of her conſtitution; nor has ſhe been without a ſtadtholder but twice, that is to ſay, from the end of 1650 to 1672, and again from March 1702 till April 1747. The provinces of Frieſland and Groningen, with Ommelands, had always a ſtadtholder without interruption: their inſtructions may be ſeen in Aitzema; but formerly the powers of the ſtadtholder of theſe provinces were confined within narrower bounds, and till William the Fourth there was no ſtadtholder of the ſeven provinces together.

The ſtadtholder could not declare war or make peace, but he had, in quality of captain general of the union, the command in chief of all the forces of the ſtate (A); and military perſons were obliged to obey him in every thing that concerned the ſervice. He was not limited by inſtructions; but he had the important power of giving out orders for the march of troops, and the diſpoſition of all matters relative to them. He not only directed their marches, but provided for the garriſons, and changed them at pleaſure. All military edicts and regulations came from him alone; he conſtituted and authorized the high council of war of the United Provinces, and, as captain-general of every province, diſpoſed of all military offices, as far as the rank of colonel incluſively. The higher poſts, ſuch as thoſe of veltmarſhals, generals, lieutenant-generals, major-generals, were given by the ſtates-general, who choſe the perſons recommended by his highneſs. He made the governors, commandants, &c. of towns and ſtrong places of the republic, and of the barrier. The perſons nominated preſented their inſtruments of appointment to their high mightineſſes, who provided them with commiſſions. The ſtates-general had likewiſe great regard to the recommendation of the prince ſtadtholder in the diſpoſition of thoſe civil employments which were in their gift.

The power of the ſtadtholder as high-admiral, extended to every thing that concerned the naval force of the republic, and to all the other affairs that were here within the juriſdiction of the admiralty. He preſided at theſe boards either in perſon or by his repreſentatives; and as chief of them all in general, and of every one in particular, he had power to make their orders and inſtructions be obſerved by themſelves and others. He beſtowed the poſts of lieutenant-admiral, vice-admiral, and rear-admiral, who commanded under him; and he made likewiſe poſt-captains.

The ſtadtholder granted likewiſe letters of grace, pardon, and abolition, as well for the crimes called *Communia Delicta*, as for military offences. In Holland and Zealand theſe letters were made out for crimes of the firſt ſort, in the name of the ſtates, with the advice of his highneſs. In military offences he conſulted the high council of war; and upon the *communia delicta* he took the advice of the courts of juſtice, of the counſellors, committees of the provinces, of the council of ſtate, and the tribunals of juſtice in the reſpective towns, according to the nature of the caſe.

In the provinces of Holland and Zealand, the ſtadtholder elected the magiſtrates of the towns annually, out of a double number that were returned to him by the towns themſelves.

When any of theſe offices became vacant, which, at the time there was no governor, were in the diſpoſal of the ſtates of Holland, or as formerly in that of the chamber of accounts, the ſtadtholder had his choice of two, or, in ſome caſes, of three candidates, named by their noble and great mightineſſes. He choſe likewiſe the counſellors, inſpectors of the dykes of Rynland, Delfland, and Scheeland, out of three perſons preſented to him by the boards of the counſellors inſpectors; which boards were of very ancient eſtabliſhment in Holland.

His highneſs preſided in the courts of Holland, and in the courts of juſtice of the other provinces; and his name was placed at the head of the proclamations and acts, called in Dutch *Mandamenten*, or *Proviſion van Juſtitie*. In Overyſſel and in the province of Utrecht the poſſeſſors of fiefs held of the prince ſtadtholder. He was ſupreme curator of the univerſities of Guelder, Frieſland, and Groningen; grand foreſter and grand veneur in Guelder, in Holland, and other places. In the province of Utrecht, his highneſs, by virtue of the regulation of 1674, diſpoſed of the provoſtſhips and other benefices which remained to the chapters, as alſo of the canonical prebends that fell in the months which were formerly the papal months.

By the firſt article of the council of ſtate of the United Provinces, the ſtadtholder was the firſt member of it, and had a right of voting there, with an appointment of 25,000 guilders a-year. He aſſiſted alſo, as often as he thought it for the ſervice of the ſtate, at the deliberations of the ſtates-general, to make propoſitions to them, and ſometimes alſo at the conferences which the deputies of their high mightineſſes held in their different committees, in conſequence of their ſtanding orders. He likewiſe aſſiſted at the aſſemblies of the ſtates of each particular province, and at that of the counſellors committees. In Guelder, Holland, and Utrecht, his highneſs had a ſhare of the ſovereignty, as chief or preſident of the body of nobles; and in Zealand, where he poſſeſſed the marquiſate of Veer and Fluſhing, as firſt noble, and repreſenting the whole nobility. In his abſence he had

(A) In times of war, however, the ſtates had always named deputies for the army, to accompany the ſtadtholders in the field, and to ſerve them as counſellors in all their enterpriſes, particularly in the moſt important affairs, ſuch as giving battle, or undertaking a ſiege, &c. This was always practiſed till the acceſſion of King William the Third to the crown of Great Britain, and after his death was continued with regard to the general in chief of the army of the republic. In 1747 and 1748 there were likewiſe deputies with the army, but with more limited power.

had in Zealand his representatives, who had the first place and the first voice in all the councils, and the first of whom was always first deputy from the province to the assembly of their high mightinesses.

In 1749 the prince stadtholder was created by the states-general, governor-general and supreme director of the East and West India companies; dignities which gave him a great deal of authority and power, and which had never been conferred upon any of his predecessors, nor had they hitherto been made hereditary. He had his representatives in the several chambers of the company, and chose their directors out of a nomination of three qualified persons. The prince enjoyed this prerogative in Zealand from the time of his elevation to the stadtholderate.

The revenues of the stadtholderate of the seven United Provinces were reckoned (including the 25,000 guilders which the prince enjoyed annually as the first member of the council of state, and what he had from the India company's dividends) to amount to 300,000 guilders a-year. As captain-general of the union, his serene highness had 120,000 guilders per annum; besides 24,000 from Friesland, and 12,000 from Groningen, in quality of captain-general of those provinces. In times of war the state allowed extraordinary sums to the captain-general for the expence of every campaign.

All these powers and privileges were held by the prince of Orange previous to the revolutionary war of France. The influence of the usurper of that kingdom has extended to the states of Holland, and attached them as a province to France under the name of a kingdom, at the head of which is a brother of Bonaparte.

STÆHELINA, a genus of plants belonging to the class of syngenesia, and order of polygamia æqualis; and in the natural system arranged under the 49th order, *Compositæ*. See BOTANY *Index*.

STAFF, an instrument ordinarily used to rest on in walking. The staff is also frequently used as a kind of natural weapon both of offence and defence; and for several other purposes.

STAFF, a light pole erected in different parts of a ship, whereon to hoist and display the colours.

The principal of these is reared immediately over the stern, to display the ensign; another is fixed on the bowsprit, to extend the jack; three more are erected at the three mast heads, or formed by their upper ends, to show the flag or pendant of the respective squadron or division to which the ship is appropriated. See ENSIGN, MAST, JACK, and PENDANT.

STAFF, in military matters, consists of a quarter-master-general, adjutant-general, and majors of brigade. The staff properly exists only in time of war. See *QUARTER-Master General*, &c.

Regimental STAFF, consists in the adjutant, quarter-master, chaplain, surgeon, &c.

STAFF, in music, five lines, on which, with the intermediate spaces, the notes of a song or piece of music are marked.

Fore-STAFF. See *FORE Staff*.

STAFFA, one of the Hebrides or Western Islands of Scotland, remarkable for its basaltic pillars. It was visited by Sir Joseph Banks, who communicated the following account of it to Mr Pennant.

"The little island of Staffa lies on the west coast of Mull, about three leagues north-east from Iona, or Icolumbkill: its greatest length is about an English mile, and its breadth about half a one. On the east side of the island is a small bay where boats generally land; a little to the southward of which the first appearance of pillarsis to be observed; they are small; and instead of being placed upright, lie down on their sides, each forming a segment of a circle. From thence you pass a small cave, above which the pillars, now grown a little larger, are inclining in all directions: in one place in particular, a small mass of them very much resembles the ribs of a ship. From hence having passed the cave, which, if it is not low-water, you must do in a boat, you come to the first ranges of pillars, which are still not above half as large as those a little beyond. Over against this place is a small island, called in Erse *Boo-sha-la*, separated from the main by a channel not many fathoms wide. This whole island is composed of pillars without any stratum above them; they are still small, but by much the neatest formed of any about the place.

"The first division of the island, for at high water it is divided into two, makes a kind of a cone, the pillars converging together towards the centre: on the other they are in general laid down flat: and in the front next to the main, you see how beautifully they are packed together, their ends coming out square with the bank which they form. All these have their transverse sections exact, and their surfaces smooth; which is by no means the case with the large ones, which are cracked in all directions. I must question, however, if any part of this whole island of Boo-sha-la is two feet in diameter.

"The main island opposite to Boo-sha-la, and farther towards the north-west, is supported by ranges of pillars pretty erect, and, though not tall (as they are not uncovered to the base), of large diameters; and at their feet is an irregular pavement, made by the upper sides of such as have been broken off, which extends as far under water as the eye can reach. Here the forms of the pillars are apparent; these are of three, four, five, six, and seven sides; but the numbers of five and six are by much the most prevalent. The largest I measured was of seven; it was four feet five inches in diameter.

"The surfaces of these large pillars, in general, are rough and uneven, full of cracks in all directions; the transverse figures in the upright ones never fail to run in their true directions. The surfaces upon which we walked were often flat, having neither concavity nor convexity; the larger number, however, was concave, though some were very evidently convex. In some places, the interstices within the perpendicular figures were filled up with a yellow spar: in one place, a vein passed in among the mass of pillars, carrying here and there small threads of spar. Though they were broken and cracked through in all directions, yet their perpendicular figures might easily be traced: from whence it is easy to infer, that whatever the accident might have been that caused the dislocation, it happened after the formation of the pillars.

"From hence proceeding along shore, you arrive at Fingal's cave. Its dimensions I have given in the form of a table:

	Feet.	In.
Length of the cave from the rock without,	371	6
From the pitch of the arch,	250	0

Breadth

Staffa.

Breadth of ditto at the mouth, -	53	7
At the farther end, - -	20	0
Height of the arch at the mouth,	117	6
At the end, - - -	70	0
Height of an outfide pillar, -	39	6
Of one at the north-weft corner,	54	0
Depth of water at the mouth, -	18	0
At the bottom, - - -	9	0

"The cave runs into the rock in the direction of north-eaft by eaft by the compafs.

"Proceeding farther to the north-weft, you meet with the higheft ranges of pillars; the magnificent appearance of which is paft all defcription. Here they are bare to their very bafis, and the ftratum below them is alfo vifible: in a fhort time, it rifes many feet above the water, and gives an opportunity of examining its quality. Its furface is rough, and has often large lumps of ftone fticking in it as if half immerfed: itfelf, when broken, is compofed of a thoufand heterogeneous parts, which together have very much the appearance of a lava; and the more fo, as many of the lumps appear to be of the very fame ftone of which the pillars are formed. This whole ftratum lies in an inclined pofition, dipping gradually towards the fouth-eaft. As hereabouts is the fituation of the higheft pillars, I fhall mention my meafurements of them, and the different ftrata in this place, premifing, that the meafurements were made with a line, held in the hand of a perfon who ftood at the top of the cliff, and reaching to the bottom; to the lower end of which was tied a white mark, which was obferved by one who ftaid below for the purpofe: when this mark was fet off from the water, the perfon below noted it down, and made fignal to him above, who made then a mark in his rope: whenever this mark paffed a notable place, the fame fignal was made, and the name of the place noted down as before: the line being all hauled up, and the diftances between the marks meafured and noted down, gave, when compared with the book kept below, the diftances, as for inftance in the cave:

"N° 1. in the book below, was called from the water to the foot of the firft pillar in the book above; N° 1. gave 36 feet eight inches, the higheft of that afcent, which was compofed of broken pillars.

"N° 1. Pillar at the weft corner of Fingal's cave.

	Feet.	In.
1 From the water to the foot of the pillar,	12	10
2 Height of the pillar, - -	37	3
3 Stratum above the pillar, -	66	9

"N° 2. Fingal's cave.

1 From the water to the foot of the pillar,	36	8
2 Height of the pillar - -	39	6
3 From the top of the pillar to the top of the arch, - - -	31	4
4 Thicknefs of the ftratum above,	34	4
By adding together the three firft meafurements, we got the height of the arch from the water, - - -	117	6

"N° 3. Corner pillar to the weftward of Fingal's cave.

Stratum below the pillar of lava-like matter,	11	0
Length of pillar, - - -	54	0
Stratum above the pillar, - -	61	6

Staffa ‖ Stafford-fhire.

"N° 4. Another part to the weftward.

Stratum below the pillar, -	17	1
Height of the pillar, - -	50	0
Stratum above. - -	51	1

"N° 5. Another pillar farther to the weftward.

Stratum below the pillar, -	19	8
Height of the pillar, - -	55	1
Stratum above, - - -	54	7

"The ftratum above the pillars, which is here mentioned, is uniformly the fame, confifting of numberlefs fmall pillars, bending and inclining in all directions, fometimes fo irregularly that the ftones can only be faid to have an inclination to affume a columnar form; in others more regular, but never breaking into or difturbing the ftratum of large pillars, whofe tops everywhere keep an uniform and regular line.

"Proceeding now along the fhore round the north end of the ifland, you arrive at *Oua na fcarve*, or the Corvorant's Cave. Here the ftratum under the pillars is lifted up very high; the pillars above it are confiderably lefs than thofe at the north-weft end of the ifland, but ftill very confiderable. Beyond is a bay, which cuts deep into the ifland, rendering it in that place not more than a quarter of a mile over. On the fides of this bay, efpecially beyond a little valley, which almoft cuts the ifland into two, are two ftages of pillars, but fmall; however, having a ftratum between them exactly the fame as that above them, formed of innumerable little pillars, fhaken out of their places, and leaning in all directions.

"Having paffed this bay, the pillars totally ceafe; the rock is of a dark brown ftone, and no figns of regularity occur till you have paffed round the fouth-eaft end of the ifland (a fpace almoft as large as that occupied by the pillars), which you meet again on the weft fide, beginning to form themfelves irregularly, as if the ftratum had an inclination to that form, and foon arrive at the bending pillars where I began.

"The ftone of which the pillars are formed, is a coarfe kind of bafaltes, very much refembling the Giant's Causeway in Ireland, though none of them are near fo neat as the fpecimens of the latter which I have feen at the Britifh Mufeum; owing chiefly to the colour, which in ours is a dirty brown, in the Irifh a fine black; indeed the whole production feems very much to refemble the Giant's Caufeway."

STAFFORD, the county town of Staffordfhire, in W. Long. 2. 0. N. Lat. 53. 0. It ftands on the river Sow, has two parifh-churches, a fine fquare market-place, and a flourifhing cloth-manufacture. It fends two members to parliament, and is 135 miles from London.

STAFFORDSHIRE, a county of England, bounded on the fouth by Worcefterfhire, by Chefhire and Derbyfhire on the north, by Warwickfhire and Derbyfhire on the eaft, and Shropfhire and Chefhire on the weft. The length is reckoned 62 miles, the breadth 33, and the circumference 180. It contains five hundreds, 150 parifhes, 810,000 acres, 18 market-towns, and

 239,153

239,153 inhabitants. The air, except in thoſe parts that are called the Moorlands and Woodlands, and about the mines, is good, eſpecially upon the hills, where it is accounted very fine. The ſoil in the northern mountainous parts is not fertile; but in the middle, where it is watered by the Trent, the third river in England, it is both fruitful and pleaſant, being a mixture of arable and meadow grounds. In the ſouth, it abounds not only with corn, but with mines of iron and pits of coal. The principal rivers of this county, beſides the Trent, which runs almoſt through the middle of it, and abounds with ſalmon, are the Dove and Tame, both of which are well ſtored with fiſh. In this county are alſo a great many lakes, and meres or pools, as they are called; which, having ſtreams either running into them or from them, cannot be ſuppoſed to be of any great prejudice to the air; they yield plenty of fiſh. In divers parts of the county are medicinal waters, impregnated with different ſorts of minerals, and conſequently of different qualities and virtues; as thoſe at Hints and Breſsford-houſe, which are mixed with bitumen; thoſe at Ingeſtre, Codſalwood, and Willoughbridge park, which are ſulphureous. Of the ſaline kind are the Brine-pits at Chertley, Epſom, Penſnet-cloſe, of which very good ſalt is made. There is a well at Newcaſtle-under-Line that is ſaid to cure the king's evil; another called *Elder-well* near Blemhill, ſaid to be good for ſore eyes; and a third called the *Spa*, near Wolverhampton.

Great flocks of ſheep are bred in this county, eſpecially in the moorlands, or mountains of the northern part of it; but the wool is ſaid to be ſomewhat coarſer than that of many other counties. Of this wool, however, they make a variety of manufactures, particularly felts. In the low grounds along the rivers are rich paſtures for black cattle; and vaſt quantities of butter and cheeſe are made. In the middle and ſouthern parts not only grain of all kinds, but a great deal of hemp and flax are raiſed. This country produces alſo lead, copper, iron; marble, alabaſter, millſtones, limeſtone; coal, ſalt, and marles of ſeveral ſorts and colours; brick-earth, fullers earth, and potters clay, particularly a ſort uſed in the glaſs manufacture at Amblecot, and ſold at ſeven-pence a buſhel; tobacco-pipe clay; a ſort of reddiſh earth called *ſlip*, uſed in painting divers veſſels; red and yellow ochres; fire-ſtones for hearths of iron furnaces, ovens, &c.; iron-ſtones of ſeveral ſorts; blood-ſtones, or hæmatites, found in the brook Tent, which, when wet a little, will draw red lines like ruddle; quarry-ſtones, and grind-ſtones. For fuel the country is well ſupplied with turf, peat, and coal of ſeveral ſorts, as cannel-coal, peacock-coal, and pit-coal. The peacock-coal is ſo called, becauſe, when turned to the light, it diſplays all the colours of the peacock's tail; but it is fitter for the forge than the kitchen. Of the pit-coal there is an inexhauſtible ſtore: it burns into white aſhes, and leaves no ſuch cinder as that of the Newcaſtle coal. It is not uſed for malting till it is charred, and in that ſtate it makes admirable winter-fuel for a chamber.

This county is in the dioceſe of Litchfield and Coventry, and the Oxford circuit. It ſends ten members to parliament; namely, two for the county, two for the city of Litchfield, two for Stafford, two for Newcaſtle-under-Line, and two for Tamworth.

STAG. See CERVUS, MAMMALIA *Index*.

STAG-Beetle. See LUCANUS, ENTOMOLOGY *Index*.

STAGE, in the modern drama, the place of action and repreſentation, included between the pit and the ſcenes, and anſwering to the proſcenium or pulpitum of the ancients. See PLAYHOUSE and THEATRE.

STAGGERS. See FARRIERY *Index*.

STAHL, GEORGE ERNEST, an eminent German chemiſt, was born in Franconia in 1660, and choſen profeſſor of medicine at Hall, when a univerſity was founded in that city in 1694. The excellency of his lectures while he filled that chair, the importance of his various publications, and his extenſive practice, ſoon raiſed his reputation to a very great height. He received an invitation to Berlin in 1716, which having accepted, he was made counſellor of ſtate and phyſician to the king. He died in 1734, in the 75th year of his age. Stahl is without doubt one of the greateſt men of which the annals of medicine can boaſt: his name marks the commencement of a new and more illuſtrious era in chemiſtry. He was the author of the doctrine of phlogiſton, which, though now completely overturned by the diſcoveries of Lavoiſier and others, was not without its uſe; as it ſerved to combine the ſcattered fragments of former chemiſts into a ſyſtem, and as it gave riſe to more accurate experiments and a more ſcientific view of the ſubject, to which many of the ſubſequent diſcoveries were owing. This theory maintained its ground for more than half a century, and was received and ſupported by ſome of the moſt eminent men which Europe has produced; a ſufficient proof of the ingenuity and the abilities of its author. He was the author alſo of A Theory of Medicine, founded upon the notions which he entertained of the abſolute dominion of mind over body; in conſequence of which, he affirmed, that every muſcular action is a voluntary act of the mind, whether attended with conſciouſneſs or not. This theory he and his followers carried a great deal too far, but the advices at leaſt which he gives to attend to the ſtate of the mind of the patient are worthy of the attention of phyſicians.

His principal works are, 1. *Experimenta et Obſervationes Chemicæ et Phyſicæ*, Berlin, 1731, 8vo. 2. *Diſſertationes Medicæ*, Hall, 2 vols 4to. This is a collection of theſes. 3. *Theoria Medica vera*, 1737, 4to. 4. *Opuſculum Chymico-phyſico-medicum*, 1740, 4to. 5. A Treatiſe on Sulphur, both Inflammable and Fixed, written in German. 6. *Negotium Otioſum*, Hall, 1720, 4to. It is in this treatiſe chiefly that he eſtabliſhes his ſyſtem concerning the action of the ſoul upon the body. 7. *Fundamenta Chymicæ Dogmaticæ et Experimentalis*, Nuremberg, 1747, 3 vols 4to. 8. A treatiſe on Salts, written in German. 9. *Commentarium in Metallurgiam Beccheri*, 1723.

STAINING *or* COLOURING *of* BONE, HORN, MARBLE, PAPER, WOOD, &c. See theſe articles.

STAIRCASE, in *Architecture*, an aſcent incloſed between walls, or a baluſtrade conſiſting of ſtairs or ſteps, with landing places and rails, ſerving to make a communication between the ſeveral ſtories of a houſe. See ARCHITECTURE, N° 89, &c.

STALACTITES, in *Mineralogy*, cryſtalline ſpars formed into oblong, conical, round, or irregular bodies, compoſed of various cruſts, and uſually found hanging in form of iſicles from the roofs of grottoes, &c.

STALAGMITIS, a genus of the monœcia order, belonging

belonging to the polygamia claſs of plants; and in the natural method ranking under the 38th order, *Tricoccæ*. See BOTANY and MATERIA MEDICA *Index*.

STALE, among ſportſmen, a living fowl put in a place to allure and bring others where they may be taken. For want of theſe, a bird ſhot, his entrails taken out, and dried in an oven in his feathers, with a ſtick thruſt through to keep it in a convenient poſture, may ſerve as well as a live one.

STALE is alſo a name for the urine of cattle.

ANIMATED STALK. This remarkable animal was found by Mr Ives at Cuddalore: and he mentions ſeveral kinds of it; ſome appearing like dry ſtraws tied together, others like graſs; ſome have bodies much larger than others, with the addition of two ſcaly imperfect wings; their neck is no bigger than a pin, but twice as long as their bodies; their heads are like thoſe of an hare, and their eyes vertical and very briſk. They live upon flies, and catch theſe inſects very dexterouſly with the two fore-feet, which they keep doubled up in three parts cloſe to their head, and dart out very quick on the approach of their prey; and when they have caught it, they eat it very voraciouſly, holding it in the ſame manner as a ſquirrel does its food. On the outer joints of the fore-feet are ſeveral very ſharp hooks for the eaſier catching and holding of their prey; while, with the other feet, which are four in number, they take hold of trees or any other thing, the better to ſurpriſe whatever they lie in wait for. They drink like a horſe, putting their mouths into the water. Their excrements, which are very white, are almoſt as large as the body of the animal, and as the natives ſay, dangerous to the eyes.

STALLION, or STONE-HORSE, in the manege, a horſe deſigned for the covering of mares, in order to propagate the ſpecies. See EQUUS, MAMMALIA *Index*.

STAMFORD, an ancient town of Lincolnſhire in England; ſeated on the river Welland, on the edge of Northamptonſhire. It is a large handſome place, containing ſix pariſh-churches, ſeveral good ſtreets, and fine buildings. It had formerly a college, the ſtudents of which removed to Brazen Noſe college in Oxford. It has no conſiderable manufactories, but deals chiefly in malt. W. Long. 0. 31. N. Lat. 54. 42.

STAMINA, in *Botany*, are thoſe upright filaments which, on opening a flower, we find within the corolla ſurrounding the piſtillum. According to Linnæus, they are the male organs of generation, whoſe office it is to prepare the pollen. Each ſtamen conſiſts of two diſtinct parts, viz. the FILAMENTUM and the ANTHERA.

STAMINA, in the animal body, are defined to be thoſe ſimple original parts which exiſted firſt in the embryo or even in the ſeed; and by whoſe diſtinction, augmentation, and accretion by additional juices, the animal body at its utmoſt bulk is ſuppoſed to be formed.

STAMP-DUTIES, a branch of the perpetual revenue. See REVENUE.

In Great Britain there is a tax impoſed upon all parchment and paper, whereon any legal proceedings or private inſtruments of almoſt any nature whatſoever are written; and alſo upon licenſes for retailing wines, of all denominations; upon all almanacs, newſpapers, advertiſements, cards, dice, &c. Theſe impoſts are very various; being higher or lower, not ſo much according to the value of the property transferred, as according to the nature of the deed. The higheſt do not exceed ſix pounds upon every ſheet of paper or ſkin of parchment; and theſe high duties fall chiefly upon grants from the crown, and upon certain law proceedings, without any regard to the value of the ſubject. There are in Great Britain no duties on the regiſtration of deeds or writings, except the fees of the officers who keep the regiſter; and theſe are ſeldom more than a reaſonable recompenſe for their labour. The crown derives no revenue from them.

Smith's Wealth of Nations, vol. iii.

The ſtamp-duties conſtitute a tax which, though in ſome inſtances it may be heavily felt, by greatly increaſing the expence of all mercantile as well as legal proceedings, yet (if moderately impoſed) is of ſervice to the public in general, by authenticating inſtruments, and rendering it much more difficult than formerly to forge deeds of any ſtanding; ſince, as the officers of this branch of the revenue vary their ſtamps frequently, by marks perceptible to none but themſelves, a man that would forge a deed of King William's time, muſt know and be able to counterfeit the ſtamp of that date alſo. In France and ſome other countries the duty is laid on the contract itſelf, not on the inſtrument in which it is contained; as, with us too in England (beſides the ſtamps on the indentures), a tax is laid, by ſtatute 8 Ann. c. 9. on every apprentice-fee; of 6d. in the pound if it be 50l. or under, and 1s, in the pound if a greater ſum: but this tends to draw the ſubject into a thouſand nice diſquiſitions and diſputes concerning the nature of his contract, and whether taxable or not; in which the farmers of the revenue are ſure to have the advantage. Our general method anſwers the purpoſes of the ſtate as well, and conſults the eaſe of the ſubject much better. The firſt inſtitution of the ſtamp-duties was by ſtatute 5 and 6 W. and M. c 21. and they have ſince, in many inſtances, been increaſed to five times their original amount.

STANCHION, or STANCHIONS, a ſort of ſmall pillars of wood or iron uſed for various purpoſes in a ſhip; as to ſupport the decks, the quarter-rails, the nettings, the awnings, &c. The firſt of thoſe are two ranges of ſmall columns fixed under the beams, throughout the ſhip's length between decks; one range being on the ſtarboard and the other on the larboard ſide of the hatchways. They are chiefly intended to ſupport the weight of the artillery.

STAND, in commerce, a weight from two hundred and an half to three hundred of pitch.

STANDARD, in *War*, a ſort of banner or flag borne as a ſignal for the joining together of the ſeveral troops belonging to the ſame body.

STANDARD, in *Commerce*, the original of a weight, meaſure, or coin, committed to the keeping of a magiſtrate, or depoſited in ſome public place, to regulate, adjuſt, and try the weights uſed by particular perſons in traffic. See MONEY.

STANHOPE PHILIP DORMER, EARL OF CHESTERFIELD, was born in 1695, and educated in Trinity-hall, Cambridge; which place he left in 1714, when, by his own account, he was an abſolute pedant. In this character he went abroad, where a familiarity with good company ſoon convinced him he was totally miſtaken in almoſt all his notions: and an attentive ſtudy of the air, manner, and addreſs of people of faſhion, ſoon poliſhed a man whoſe predominant deſire was to pleaſe; and who, as it afterwards appeared, valued exterior accompliſh-

Stanhope.

ments beyond any other human acquirement. While Lord Stanhope, he got an early seat in parliament; and in 1722, succeeded to his father's estate and titles. In 1728, and in 1745, he was appointed ambassador extraordinary and plenipotentiary to Holland: which high character he supported with the greatest dignity; serving his own country, and gaining the esteem of the states-general. Upon his return from Holland, he was sent lord-lieutenant of Ireland; and during his administration there, gave general satisfaction to all parties. He left Dublin in 1746, and in October succeeded the earl of Harrington as secretary of state, in which post he officiated until February 6th 1748. Being seized with a deafness in 1752 that incapacitated him for the pleasures of society, he from that time led a private and retired life, amusing himself with books and his pen; in particular, he engaged largely as a volunteer in a periodical miscellaneous paper called *The World*, in which his contributions have a distinguished degree of excellence. He died in 1773, leaving a character for wit and abilities that had few equals. He distinguished himself by his eloquence in parliament on many important occasions; of which we have a characteristic instance, of his own relating. He was an active promoter of the bill for altering the style; on which occasion, as he himself writes in one of his letters to his son, he made so eloquent a speech in the house, that every one was pleased, and said he had made the whole very clear to them; "when (says he), God knows, I had not even attempted it. I could just as soon have talked Celtic or Sclavonian to them, as astronomy; and they would have understood me full as well." Lord Macclesfield, one of the greatest mathematicians in Europe, and who had a principal hand in framing the bill, spoke afterwards, with all the clearness that a thorough knowledge of the subject could dictate; but not having a flow of words equal to Lord Chesterfield, the latter gained the applause from the former, to the equal credit of the speaker and the auditors. The high character Lord Chesterfield supported during life, received no small injury soon after his death, from a fuller display of it by his own hand. He left no issue by his lady, but had a natural son, Philip Stanhope, Esq. whose education was for many years a close object of his attention, and who was afterward envoy extraordinary at the court of Dresden, but died before him. When Lord Chesterfield died, Mr Stanhope's widow published a course of letters, written by the father to the son, filled with instructions suitable to the different gradations of the young man's life to whom they were addressed. These letters contain many fine observations on mankind, and rules of conduct: but it is observable that he lays a greater stress on exterior accomplishments and address, than on intellectual qualifications and sincerity; and allows greater latitude to fashionable pleasures than good morals will justify, especially in paternal instructions. Hence it is that a celebrated writer §, and of manners somewhat different from those of the polite earl of Chesterfield, is said to have observed of these letters, that "they inculcate only the morals of a whore, with the manners of a dancing-master."

§ *Dr Johnson.*

Stanhope, *Dr George*, an eminent divine, was born at Hertishorn in Derbyshire, in the year 1660. His father was rector of that place, vicar of St Margaret's church in Leicester, and chaplain to the earls of Chesterfield and Clare. His grandfather, Dr George Stanhope, was chaplain to James I. and Charles I.; had the chancellorship of York, where he was also a canon-residentiary, held a prebend, and was rector of Weldrake in that county. He was for his loyalty driven from his home with eleven children; and died in 1644. Our author was sent to school, first at Uppingham in Rutland, then at Leicester; afterwards removed to Eaton; and thence chosen to King's college in Cambridge, in the place of W. Cleaver. He took the degree of B. A. in 1681; M. A. 1685; was elected one of the syndics for the university of Cambridge, in the business of Alban Francis, 1687; minister of Quoi near Cambridge, and vice-proctor, 1688; was that year preferred to the rectory of Tring in Hertfordshire, which after some time he quitted. He was in 1689 presented to the vicarage of Lewisham in Kent by Lord Dartmouth, to whom he had been chaplain, and tutor to his son. He was also appointed chaplain to King William and Queen Mary, and continued to enjoy that honour under Queen Anne. He commenced D. D. July 5th 1697, performing all the offices required to that degree publicly and with great applause. He was made vicar of Deptford in 1703; succeeded Dr Hooper as dean of Canterbury the same year; and was thrice chosen prolocutor of the lower house of convocation. His uncommon diligence and industry, assisted by his excellent parts, enriched him with a large stock of polite, solid, and useful learning. His discourses from the pulpit were equally pleasing and profitable; a beautiful intermixture of the clearest reasoning with the purest diction, attended with all the graces of a just elocution. The good Christian, the solid divine, and the fine gentleman, in him were happily united. His conversation was polite and delicate, grave without preciseness, facetious without levity. His piety was real and rational, his charity great and universal, fruitful in acts of mercy, and in all good works. He died March 18th 1728, aged 68 years; and was buried in the chancel of the church at Lewisham. The dean was twice married: first to Olivia Cotton, by whom he had one son and four daughters. His second lady, who was sister to Sir Charles Wager, survived him, dying October 1st 1730, aged about 54. One of the dean's daughters was married to a son of Bishop Burnet. Bishop Moore of Ely died the day before Queen Anne; who, it has been said, designed our dean for that see when it should become vacant. Dr Felton says, "The late dean of Canterbury is excellent in the whole. His thoughts and reasoning are bright and solid. His style is just, both for the purity of the language and for the strength and beauty of expression; but the periods are formed in so peculiar an order of the words, that it was an observation, nobody could pronounce them with the same grace and advantage as himself." His writings, which are an inestimable treasure of piety and devotion are, A Paraphrase and Comment upon the Epistles and Gospels, 4 vols, 1705, 8vo. Sermons at Boyle's Lectures, 1706, 4to. Fifteen Sermons, 1700, 8vo. Twelve Sermons on several Occasions, 1727, 8vo. Thomas à Kempis, 1696, 8vo. Epictetus's Morals, with Simplicius's Comment, and the Life of Epictetus, 1700, 8vo. Parson's Christian Directory, 1716, 8vo. Rochefoucault's Maxims, 1706, 8vo. A Funeral Sermon on Mr Richard Sare bookseller, 1724; two editions 4to. Twenty Sermons, published singly between

Stanhope, Staniſlaus.

between the years 1692 and 1724. Private Prayers for every Day in the Week, and for the ſeveral Parts of each Day; tranſlated from the Greek Devotions of Biſhop Andrews, with Additions, 1730. In his tranſlations, it is well known, Dr Stanhope did not confine himſelf to a ſtrict and literal verſion: he took the liberty of paraphraſing, explaining, and improving upon his author; as will evidently appear (not to mention any other work) by the ſlighteſt peruſal of St Auguſtine's Meditations, and the Devotions of Biſhop Andrews.

STANISLAUS Leczinski, king of Poland, was born at Leopold the 20th of October 1677. His father was a Poliſh nobleman, diſtinguiſhed by his rank and the important offices which he held, but ſtill more by his firmneſs and courage. Staniſlaus was ſent ambaſſador in 1704 by the aſſembly of Warſaw to Charles XII. of Sweden, who had conquered Poland. He was at that time 27 years old, was general of Great Poland, and had been ambaſſador extraordinary to the Grand Signior in 1699. Charles was ſo delighted with the frankneſs and ſincerity of his deportment, and with the firmneſs and ſweetneſs which appeared in his countenance, that he offered him the crown of Poland, and ordered him to be crowned at Warſaw in 1705. He accompanied Charles XII. into Saxony, where a treaty was concluded with King Auguſtus in 1705, by which that prince reſigned the crown, and acknowledged Staniſlaus king of Poland. The new monarch remained in Saxony with Charles till 1707, when they returned into Poland and attacked the Ruſſians, who were obliged to evacuate that kingdom in 1708. But Charles being defeated by Peter the Great in 1709, Auguſtus returned into Poland, and being aſſiſted by a Ruſſian army, obliged Staniſlaus to retire firſt into Sweden, and afterwards into Turkey. Soon after he took up his reſidence at Weiſſenburg, a town in Alſace. Auguſtus diſpatched Sum his envoy to France to complain of this; but the duke of Orleans, who was then regent, returned this anſwer: "Tell your king, that France has always been the aſylum of unhappy princes." Staniſlaus lived in obſcurity till 1725, when Louis XV. eſpouſed the princeſs Mary his daughter. Upon the death of King Auguſtus in 1733, he returned to Poland in hopes of remounting the throne of that kingdom. A large party declared for him; but his competitor the young elector of Saxony, being ſupported by the emperor Charles VI. and the empreſs of Ruſſia, was choſen king, though the majority was againſt him. Dantzic, to which Staniſlaus had retired, was quickly taken, and the unfortunate prince made his eſcape in diſguiſe with great difficulty, after hearing that a price was ſet upon his head by the Ruſſians. When peace was concluded in 1736 between the emperor and France, it was agreed that Staniſlaus ſhould abdicate the throne, but that he ſhould be acknowledged king of Poland and grand duke of Lithuania, and continue to bear theſe titles during life; that all his effects and thoſe of the queen his ſpouſe ſhould be reſtored; that an amneſty ſhould be declared in Poland for all that was paſt, and that every perſon ſhould be reſtored to his poſſeſſions, rights, and privileges: that the elector of Saxony ſhould be acknowledged king of Poland by all the powers who acceded to the treaty: that Staniſlaus ſhould be put in peaceable poſſeſſion of the duchies of Lorraine and Bar; but that immediately after his death theſe duchies ſhould be united for ever to the crown of France. Staniſlaus ſucceeded a race of princes in Lorraine, who were beloved and regretted: and his ſubjects found their ancient ſovereigns revived in him. He taſted then the pleaſure which he had ſo long deſired, the pleaſure of making men happy. He aſſiſted his new ſubjects; he embelliſhed Nancy and Lunéville; he made uſeful eſtabliſhments; he founded colleges and built hoſpitals. He was engaged in theſe noble employments, when an accident occaſioned his death. His night-gown caught fire, and burnt him ſo ſeverely before it could be extinguiſhed, that he was ſeized with a fever, and died the 23d of February 1766. His death occaſioned a public mourning: the tears of his ſubjects indeed are the beſt eulogium upon this prince. In his youth he had accuſtomed himſelf to fatigue, and had thereby ſtrengthened his mind as well as his conſtitution. He lay always upon a kind of mattreſs, and ſeldom required any ſervice from his domeſtics. He was temperate, liberal, adored by his vaſſals, and perhaps the only nobleman in Poland who had any friends. He was in Lorraine what he had been in his own country, gentle, affable, compaſſionate, treating his ſubjects like equals, participating their ſorrows and alleviating their misfortunes. He reſembled completely the picture of a philoſopher which he himſelf has drawn. "The true philoſopher (ſaid he) ought to be free from prejudices, and to know the value of reaſon: he ought neither to think the higher ranks of life of more value than they are, nor to treat the lower orders of mankind with greater contempt than they deſerve: he ought to enjoy pleaſures without being a ſlave to them, riches without being attached to them, honours without pride or vanity: he ought to ſupport diſgraces without either fearing or courting them: he ought to reckon what he poſſeſſes ſufficient for him, and to regard what he has not as uſeleſs: he ought to be equal in every fortune, always tranquil, always gay: he ought to love order, and to obſerve it in all his actions: he ought to be ſevere to himſelf, but indulgent to others: he ought to be frank and ingenuous without rudeneſs, polite without falſehood, complaiſant without baſeneſs: he ought to have the courage to diſregard every kind of glory, and to reckon as nothing even philoſophy itſelf." Such was Staniſlaus in every ſituation. His temper was affectionate. He told his treaſurer one day to put a certain officer on his liſt, to whom he was very much attached: "In what quality (ſaid the treaſurer) ſhall I mark him down?" "As my friend" (replied the monarch). A young painter conceiving hopes of making his fortune if his talents were made known to Staniſlaus, preſented him with a picture, which the courtiers criticiſed ſeverely. The prince praiſed the performance, and paid the painter very generouſly: then turning to his courtiers, he ſaid, "Do ye not ſee, gentlemen, that this poor man muſt provide for his family by his abilities? if you diſcourage him by your cenſures, he is undone. We ought always to aſſiſt men; we never gain any thing by hurting them." His revenues were ſmall; but were we to judge of him by what he did, we ſhould probably reckon him the richeſt potentate in Europe. A ſingle inſtance will be ſufficient to ſhow the well-judged economy with which his benevolent plans were conducted. He gave 18,000 crowns to the magiſtrates of Bar to be employed in purchaſing grain, when at a low price, to be ſold out again to the poor at a moderate rate when the price should rise above a certain sum. By this arrangement (say the authors of *Dictionaire Historique)*, the money increases continually, and its good effects may in a short time be extended over the whole province.

He was a protector of the arts and sciences: he wrote several works of philosophy, politics, and morality, which were collected and published in France in 1765, in 4 vols, 8vo, under the title of *Oeuvres de Philosophe Bienfaisant*, "the works of the Benevolent Philosopher."

STANITZAS, villages or small districts of the banks of the Don, inhabited by Cossacs.

STANLEY, Thomas, a learned English writer in the 17th century, was the son of Sir Thomas Stanley of Cumberlow-Green in Herefordshire, knight. He was born at Cumberlow about 1644, and educated in his father's house, whence he removed to the university of Cambridge. He afterwards travelled; and, upon his return to England, prosecuted his studies in the Middle Temple. He married, when young, Dorothy, the eldest daughter of Sir James Engan of Flower, in Northamptonshire. He wrote, 1. A volume of Poems. 2. History of Philosophy, and Lives of the Philosophers. 3. A Translation of Eschylus, with a Commentary; and several other works. He died in 1678.

STANNARIES, the mines and works where tin is dug and purified; as in Cornwall, Devonshire, &c.

STANNARY courts, in Devonshire and Cornwall, for the administration of justice among the tinners therein. They are held befoie the lord-warden and his substitutes, in virtue of a privilege granted to the workers in the tin-mines there, to sue and be sued only in their own courts, that they may not be drawn from their business, which is highly profitable to the public, by attending their law-suits in other courts. The privileges of the tinners are confirmed by a charter, 33 Edw. I. and fully expounded by a private statute, 50 Edw. III. which has since been explained by a public act. 16 Car. I. c. 15. What relates to our present purpose is only this: That all tinners and labourers in and about the stannaries shall, during the time of their working therein, *bona fide*, be privileged from suits of other courts, and be only pleaded in the stannary court in all matters, excepting pleas of land, life, and member. No writ of error lies from hence to any court in Westminster-hall; as was agreed by all the judges, in 4 Jac. I. But an appeal lies from the steward of the court to the underwarden; and from him to the lord-warden; and thence to the privy-council of the prince of Wales, as duke of Cornwall, when he hath had livery or investiture of the same. And from thence the appeal lies to the king himself, in the last resort.

Blackstone's Comment. vol. iii. p. 79 and 80.

STANNUM, Tin. See Tin, Chemistry and Mineralogy *Index*.

STANZA, in *Poetry*, a number of lines regularly adjusted to each other; so much of a poem as contains every variation of measure or relation of rhyme used in that poem.

STAPELIA, a genus of plants belonging to the class pentandria and order digynia, and in the natural orders arranged under the *Succulentæ*. See Botany *Index*.—This singular tribe of plants is peculiar to the sandy deserts of Africa and Arabia. They are extremely succulent. From this peculiarity of structure, the power of retaining water to support and nourish them, they are enabled to live during the prevalent droughts of those arid regions. On this account the stapelia has been compared to the camel; and we are told that, by a very apt similitude, it has been denominated "the *camel* of the vegetable kingdom." We must confess ourselves quite at a loss to see the propriety or aptitude of this comparison. In many parts of the animal and vegetable economy there is doubtless a very obvious and striking analogy: but this analogy has been often carried too far; much farther than fair experiment and accurate observation will in any degree support. It is perhaps owing to this inaccuracy in observing the peculiarity of structure and diversity of functions, that a resemblance is supposed to exist, as in the present case, where in reality there is none. The camel is provided with a bag or fifth stomach, in addition to the four with which ruminant animals are furnished. This fifth stomach is destined as a reservoir to contain water; and it is sufficiently capacious to receive a quantity of that necessary fluid, equal to the wants of the animal, for many days: and this water, as long as it remains in the fifth stomach, is said to be perfectly pure and unchanged. The *stapelia*, and other succulent plants, have no such reservoir. The water is equally, or nearly so, diffused through the whole plant. Every vessel and every cell is fully distended. But besides, this water, whether it be received by the roots, or absorbed from the atmosphere, has probably undergone a complete change, and become, after it has been a short time within the plant, a fluid possessed of very different qualities.

The peculiar economy in the stapelia, and other succulent plants, seems to exist in the absorbent and exhalant systems. The power of absorption is as much increased as the power of the exhalant or perspiratory vessels is diminished. In these plants, a small quantity of nourishment is required. There is no solid part to be formed, no large fruit to be produced. They generally have very small leaves, often are entirely naked; so that taking the whole plant, a small surface only is exposed to the action of light and heat, and consequently a much smaller proportion of water is decomposed than in plants which are much branched and furnished with leaves.

Two species of stapelia only were known at the beginning of the century. The unfortunate Forskal, the companion of Niebhur, who was sent out by the king of Denmark to explore the interior of Arabia, and who fell a sacrifice to the pestilential diseases of those inhospitable regions, discovered two new species. Thunberg, in his *Prodromus*, has mentioned five more. Forty new species have been discovered by Mr Masson of Kew Gardens, who was sent out by his present Majesty for the purpose of collecting plants round the Cape of Good Hope. Descriptions of these, with elegant and highly finished coloured engravings, have lately been published. They are chiefly natives of the extensive deserts called *Karro*, on the western side of the Cape.

STAPHYLEA, Bladder-nut, a genus of plants belonging to the class of pentandria and order of trigynia; and in the natural system arranged under the 23d order, *Trihilatæ*. See Botany *Index*.

STAPHYLINUS, a genus of insects belonging to the order of coleoptera. See Entomology *Index*.

STAPLE,

STAPLE, primarily ſignifies a public place or market, whither merchants, &c. are obliged to bring their goods to be bought by the people; as the Greve, or the places along the Seine, for ſale of wines and corn, at Paris, whither the merchants of other parts are obliged to bring thoſe commodities.

Formerly, the merchants of England were obliged to carry their wool, cloth, lead, and other like ſtaple commodities of this realm, in order to expoſe them by wholeſale; and theſe ſtaples were appointed to be conſtantly kept at York, Lincoln, Newcaſtle-upon-Tyne, Norwich, Weſtminſter, Canterbury, Chicheſter, Wincheſter, Exeter, and Briſtol; in each whereof a public mart was appointed to be kept, and each of them had a court of the mayor of the ſtaple, for deciding differences, held according to the law-merchant, in a ſummary way.

STAR, in *Aſtronomy*, a general name for all the heavenly bodies, which, like ſo many brilliant ſtuds, are diſperſed throughout the whole heavens. The ſtars are diſtinguiſhed, from the phenomena of their motion, &c. into fixed, and erratic or wandering ſtars: theſe laſt are again diſtinguiſhed into the greater luminaries, viz. the ſun and moon; the planets, or wandering ſtars, properly ſo called, and the comets; which have been all fully conſidered and explained under the article ASTRONOMY. As to the fixed ſtars, they are ſo called, becauſe they ſeem to be fixed, or perfectly at reſt, and conſequently appear always at the ſame diſtance from each other.

Falling STARS, in *Meteorology*, fiery meteors which dart through the ſky in form of a ſtar. See METEOR.

Twinkling of the STARS. See OPTICS.

STAR, is alſo a badge of honour, worn by the knights of the garter, bath, and thiſtle. See GARTER.

STAR of Bethlehem. See ORNITHOGALUM, BOTANY *Index*

STAR, in *Fortification*, denotes a ſmall fort, having five or more points, or ſaliant and re-entering angles, flanking one another, and their faces 90 or 100 feet long.

Court of STAR-CHAMBER, (*camera ſtellata*), a famous, or rather infamous, Engliſh tribunal, ſaid to have been ſo called either from a Saxon word ſignifying to *ſteer* or govern; or from its puniſhing the *crimen ſtellionatus*, or coſenage; or becauſe the room wherein it ſat, the old council-chamber of the palace of Weſtminſter, (Lamb. 148.) which is now converted into the lottery-office, and forms the eaſtern ſide of New-Palace yard, was full of windows; or, (to which Sir Edward Coke, 4 Inſt. 66. accedes), becauſe *haply* the roof thereof was at the firſt garniſhed with gilded *ſtars*. As all theſe are merely conjectures, (for no ſtars are now in the roof, nor are any ſaid to have remained there ſo late as the reign of Queen Elizabeth), it may be allowable to propoſe another conjectural etymology, as plauſible perhaps as any of them. It is well known, that, before the baniſhment of the Jews under Edward I. their contracts and obligations were denominated in our ancient records *ſtarra* or *ſtarrs*, from a corruption of the Hebrew word, *ſhetar*, a covenant. (Tovey's *Angl. Judaic.* 32. Selden. tit. of hon. ii. 34. *Uxor Ebraic.* i. 14.). Theſe ſtarrs, by an ordinance of Richard I. preſerved by Hoveden, were commanded to be enrolled and depoſited in cheſts under three keys in certain places; one, and the moſt conſiderable, of which was in the king's exchequer at Weſtminſter: and no ſtarr was allowed to be valid, unleſs it were found in ſome of the ſaid repoſitories. (*Memorand. in Scac' P. 6. Edw. I.* prefixed to Maynard's year-book of Edw. II. fol. 8. Madox hiſt. exch. c. vii. § 4, 5, 6.). The room at the exchequer, where the cheſts containing theſe ſtarrs were kept, was probably called the *ſtar-chamber*; and, when the Jews were expelled the kingdom, was applied to the uſe of the king's council, ſitting in their judicial capacity. To confirm this, the firſt time the ſtar-chamber is mentioned in any record, it is ſaid to have been ſituated near the receipt of the exchequer at Weſtminſter: (the king's council, his chancellor, treaſurer, juſtices, and other ſages, were aſſembled *en la chaumbre des eſteilles pres la reſceipt al Weſtminſter. Clauſ.* 41 *Edw. III. m.* 13.). For in proceſs of time, when the meaning of the Jewiſh *ſtarrs* were forgotten, the word *ſtar-chamber* was naturally rendered in law French, *la chaumbre des eſteilles*, and in law Latin *camera ſtellata*; which continued to be the ſtyle in Latin till the diſſolution of that court.

Blackſtone's Comment. vol. iv. p. 266.

This was a court of very ancient original; but new-modelled by ſtatutes 3 Hen. VII. c. 1. and 21 Henry VIII. c. 20. conſiſting of divers lords ſpiritual and temporal, being privy-counſellors, together with two judges of the courts of common law, without the intervention of any jury. Their juriſdiction extended legally over riots, perjury, miſbehaviour of ſheriffs, and other notorious miſdemeanors, contrary to the laws of the land. Yet this was afterwards (as Lord Clarendon informs us) ſtretched "to the aſſerting of all proclamations and orders of ſtate; to the vindicating of illegal commiſſions and grants of monopolies; holding for honourable that which pleaſed, and for juſt that which profited; and becoming both a court of law to determine civil rights, and a court of revenue to enrich the treaſury: the council-table by proclamations enjoining to the people that which was not enjoined by the laws, and prohibiting that which was not prohibited; and the ſtar-chamber, which conſiſted of the ſame perſons in different rooms, cenſuring the breach and diſobedience to thoſe proclamations by very great fines, impriſonments, and corporal ſeverities: ſo that any diſreſpect to any acts of ſtate, or to the perſons of ſtateſmen, was in no time more penal, and the foundations of right never more in danger to be deſtroyed." For which reaſons, it was finally aboliſhed by ſtatute 16 Car. I. c. 10. to the general joy of the whole nation. See *KING's-Bench*. There is in the Britiſh Muſeum (Harl. MSS. vol. i. N° 126.) a very full, methodical, and accurate account of the conſtitution and courſe of this court, compiled by William Hudſon of Gray's Inn, an eminent practitioner therein. A ſhort account of the ſame, with copies of all its proceſs, may alſo be found in 18 Rym. Foed. 192, &c.

STAR-Board, the right ſide of the ſhip when the eye of the ſpectator is directed forward.

STAR-Fiſh. See ASTERIAS, HELMINTHOLOGY *Index*.

STAR-Shot, a gelatinous ſubſtance frequently found in fields, and ſuppoſed by the vulgar to have been produced from the meteor called a *falling-ſtar*: but, in reality, is the half-digeſted food of herons, ſea-mews, and

Star, Starch.

and the like birds; for these birds have been found when newly shot, to disgorge a substance of the same kind.

STAR-Stone, in *Natural History*, a name given to certain extraneous fossil stones, in form of short, and commonly somewhat crooked columns, composed of several joints, each resembling the figure of a radiated star, with a greater or smaller number of rays in the different species: they are usually found of about an inch in length, and of the thickness of a goose-quill. Some of them have five angles or rays, and others only four; and in some the angles are equidistant, while in others they are irregularly so: in some also they are short and blunt, while in others they are long, narrow, and pointed; and some have their angles very short and obtuse. The several joints in the same specimen are usually all of the same thickness; this, however, is not always the case: but in some they are larger at one end, and in others at the middle, than in any other part of the body; and some species have one of the rays bifid, so as to emulate the appearance of a six-rayed kind.

STAR-Thistle. See CENTAUREA, } BOTANY *Index*.
STAR-Wort. See ASTER, }

STARCH, a fecula or sediment, found at the bottom of vessels wherein wheat has been steeped in water, of which fecula, after separating the bran from it, by passing it through sieves, they form a kind of loaves, which being dried in the sun or an oven, is afterwards cut into little pieces, and so sold. The best starch is white, soft, and friable, and easily broken into powder. Such as require fine starch, do not content themselves, like the starchmen, with refuse wheat, but use the finest grain. The process is as follows: The grain, being well cleaned, is put to ferment in vessels full of water, which they expose to the sun while in its greatest heat; changing the water twice a-day, for the space of eight or twelve days, according to the season. When the grain bursts easily under the finger, they judge it sufficiently fermented. The fermentation perfected, and the grain thus softened, it is put, handful by handful, into a canvas-bag, to separate the flour from the husks; which is done by rubbing and beating it on a plank laid across the mouth of an empty vessel that is to receive the flour.

As the vessels are filled with this liquid flour, there is seen swimming at top a reddish water, which is to be carefully scummed off from time to time, and clean water is to be put in its place, which, after stirring the whole together, is also to be strained through a cloth or sieve, and what is left behind put into the vessel with new water, and exposed to the sun for some time. As the sediment thickens at the bottom, they drain off the water four or five times, by inclining the vessel, but without passing it through the sieve. What remains at bottom is the starch, which is cut in pieces to get out, and left to dry in the sun. When dry, it is laid up for use.

The following mill, was invented by M. Baumé for grinding potatoes, with a view to extract starch from them.

Plate D. Fig. 1.

He had a grater made of plate iron, in a cylindrical form (fig. 1) about seven inches in diameter, and about eight inches high; the burs made by stumping the holes are on the inside. This grater is supported upon three feet AAA, made of flat iron bars, seven feet high, strongly rivetted to the grater; the bottom of each foot is bent horizontally, and has a hole in it which receives a screw, as at A, fig. 4. A little below the upper end of the three feet is fixed a cross piece B (fig. 1. and 4.), divided into three branches, and rivetted to the feet. This cross piece not only serves to keep the feet at a proper distance from each other, and to prevent their bending; but the centre of it having a hole cut in it, serves to support an axis or spindle of iron, to be presently described.

Starch.

The upper end of this cylindrical grater has a diverging border of iron C (fig. 1. 4. and 7.), about 10 inches in diameter at the top, and five inches in height.

Within this cylindrical grater is placed a second grater (fig. 2. and 3.), in the form of a cone, the point of which is cut off. The latter is made of thick plate iron, and the burs of the holes are on the outside; it is fixed, with the broad end at the bottom, as in fig. 4. At the upper end of the cone is rivetted a small triangle, or cross piece of iron, consisting of three branches D (fig. 2.), in the middle of which is made a square hole, to receive an axis or spindle; to give more resistance to this part of the cone, it is strengthened by means of a cap of iron E, which is fixed to the grater by means of rivets, and has also a square hole made in it, to let the axis pass through.

Fig. 3. represents the same cone seen in front; the base F has also a cross piece of three branches, rivetted to a hoop of iron, which is fixed to the inner surface of the cone; the centre of this cross piece has also a square hole for the passage of the axis.

Fig. 5. is a spindle or axis itself; it is a square bar of iron about 16 inches long, and more than half an inch thick; round at the bottom, and also towards the top, where it fits into the cross piece I, fig. 7. and B, fig. 1. and 4.; in these pieces it turns round, and by them it is kept in its place. It must be square at its upper extremity, that it may have a handle, about nine inches long, fixed to it, by means of which the conical grater is turned round. At G, (fig. 5.), a small hole is made through the axis, to receive a pin H, by means of which the conical grater is kept at its proper height within the cylindrical one.

Fig. 6. is a bird's-eye view, in which the mill is represented placed in an oval tub, like a bathing-tub. I is the fore-mentioned triangular iron cross, fixed with screws to the side of the tub; the centre of it has a round hole, for the axis of the mill to move in when it is used.

Fig. 7. represents the mill in the oval tub; it is placed at one end of it, that the other end may be left free for any operation to be performed in it which may be necessary. A part of the tub is cut off, that the inside of it, and the manner of fixing the mill, may be seen. That the bottom of the tub may not be worn by the screws which pass through the feet of the mill, a deal board, about an inch thick, and properly shaped, is placed under the mill.

When we wish to make use of this mill, it is to be fixed by the feet, in the manner already described; it is also fixed at the top, by means of the cross piece I, fig. 6. and 7. The tub is then to have water poured into it as high as K, and the top of the mill is to be filled with potatoes, properly washed and cut; the handle L is to be turned round, and the potatoes, after being ground between

between the two graters, go out gradually at the lower part, being aſſiſted by the motion produced in the water by the action of the mill.

To prepare ſtarch from potatoes, ſays M. Baumé, any quantity of theſe roots may be taken, and ſoaked in a tub of water for about an hour; they are afterwards to have their fibres and ſhoots taken off, and then to be rubbed with a pretty ſtrong bruſh, that the earth, which is apt to lodge in the inequalities of their ſurface, may be entirely removed; as this is done, they are to be waſhed, and thrown into another tub full of clean water. When the quantity which we mean to make uſe of has been thus treated, thoſe which are too large are to be cut into pieces about the ſize of eggs, and thrown into the mill; that being already fixed in the oval tub, with the proper quantity of water: the handle is then turned round, and as the potatoes are grated they paſs out at the bottom of the mill. The pulp which collects about the mill muſt be taken off from time to time with a wooden ſpoon, and put aſide in water.

When all the potatoes are ground, the whole of the pulp is to be collected in a tub, and mixed up with a great quantity of clean water. At the ſame time, another tub, very clean, is to be prepared, on the brim of which are to be placed two wooden rails, to ſupport a hair ſieve, which muſt not be too fine. The pulp and water are to be thrown into the ſieve; the flour paſſes through with the water, and freſh quantities of water are ſucceſſively to be poured on the remaining pulp, till the water runs through as clear as it is poured in. In this way we are to proceed till all the potatoes that were ground are uſed.

The pulp is commonly thrown away as uſeleſs; but it ſhould be boiled in water, and uſed as food for animals; for it is very nouriſhing, and is about $\frac{7}{8}$ths of the whole quantity of potatoes uſed.

It is farther to be obſerved that the liquor which has paſſed through the ſieve is turbid, and of a browniſh colour, on account of the extractive matter which is diſſolved in it; it depoſits, in the ſpace of five or ſix hours, the flour which was ſuſpended in it. When all the flour is ſettled to the bottom, the liquor is to be poured off and thrown away, being uſeleſs; a great quantity of very clean water is then to be poured upon the flour remaining at the bottom of the tub, which is to be ſtirred up in the water, that it may be waſhed, and the whole is to ſtand quiet till the day following. The flour will then be found to have ſettled at the bottom of the tub; the water is again to be poured off as uſeleſs, the flour waſhed in a freſh quantity of pure water, and the mixture paſſed through a ſilk ſieve pretty fine, which will retain any ſmall quantity of pulp which may have paſſed through the hair ſieve. The whole muſt once more be ſuffered to ſtand quiet till the flour is entirely ſettled; if the water above it is perfectly clear and colourleſs, the flour has been ſufficiently waſhed; but if the water has any ſenſible appearances either of colour or of taſte, the flour muſt be again waſhed, as it is abſolutely neceſſary that none of the extractive matter be ſuffered to remain.

When the flour is ſufficiently waſhed, it may be taken out of the tub with a wooden ſpoon; it is to be placed upon wicker frames covered with paper, and dried, properly defended from duſt. When it is thoroughly dry, it is to be paſſed through a ſilk ſieve, that if any clotted lumps ſhould have been formed they may be divided. It is to be kept in glaſs-veſſels ſtopped with paper only.

A patent was granted in 1796 to Lord William Murray for his diſcovery of a method by which ſtarch may be extracted from horſe-cheſnuts. It is as follows:

Take the horſe-cheſnuts out of the outward green prickly huſks; and either by hand, with a knife, or other tool, or elſe with a mill adapted for that purpoſe, very carefully pare off the brown rind, being particular not to leave the ſmalleſt ſpeck, and to entirely eradicate the ſprout or growth. Next take the nuts, and raſp, grate, or grind them fine into water, either by hand, or by a mill adapted for that purpoſe. Waſh the pulp, which is thereby formed in this water, as clean as poſſible, through a coarſe horſe-hair ſieve; this again waſh through a finer ſieve, and then again through a ſtill finer, conſtantly adding clean water, to prevent any ſtarch from adhering to the pulp. The laſt proceſs is, to put it with a large quantity of water (about four gallons to a pound of ſtarch) through a fine gauze, muſlin, or lawn, ſo as entirely to clear it of all bran or other impurities. As ſoon as it ſettles, pour off the water; then mix it up with clean water, repeating this operation till it no longer imparts any green, yellow, or other colour to the water. Then drain it off till nearly dry, and ſet it to bake, either in the uſual mode of baking ſtarch, or elſe ſpread out before a briſk fire; being very attentive to ſtir it frequently to prevent its horning, that is to ſay, turning to a paſte or jelly, which, on being dried, turns hard like horn. The whole proceſs ſhould be conducted as quickly as poſſible.

Mention is here made of a mill which may be employed to grind the horſe-cheſnuts; but it is not deſcribed; perhaps the one deſcribed above for grinding potatoes might anſwer the purpoſe.

STARK, Dr William, known to the public by a volume containing Clinical and Anatomical Obſervations, with ſome curious Experiments on Diet, was born at Mancheſter in the month of July 1740; but the family from which he ſprang was Scotch, and reſpectable for its antiquity. His grandfather John Stark of Killermont was a covenanter; and having appeared in arms againſt his ſovereign at the battle of Bothwel bridge in the year 1679, became obnoxious to the government, and, to conceal himſelf, withdrew into Ireland. There is reaſon to believe that he had not imbibed either the extravagant zeal or the ſavage manners of the political and religious party to which he adhered; for after reſiding a few years in the country which he had choſen for the ſcene of his baniſhment, he married Elizabeth daughter of Thomas Stewart, Eſq. of Balydrone in the north of Ireland; who, being deſcended of the noble family of Galloway, would not probably have matched his daughter to ſuch an exile as a ruthleſs fanatic of the laſt century. By this lady Mr Stark had ſeveral children; and his ſecond ſon Thomas, who ſettled at Mancheſter as a wholeſale linen-draper, and married Margaret Stirling, daughter of William Stirling, Eſq. of Northwoodſide, in the neighbourhood of Glaſgow, was the father of the ſubject of this article. Another of his ſons, the reverend John Stark, was miniſter of Lecropt in Perthſhire; and it was under the care of this gentleman that our author received the rudiments of his education, which, when we conſider the character of the maſter, and

and reflect on the relation between him and his pupil, we may presume was calculated to store the mind of Dr Stark with those virtuous principles which influenced his conduct through life.

From Lecropt young Stark was sent to the university of Glasgow, where, under the tuition of the doctors Smith and Black, with other eminent masters, he learned the rudiments of science, and acquired that mathematical accuracy, that logical precision, and that contempt of hypotheses, with which he prosecuted all his future studies. Having chosen physic for his profession. he removed from the university of Glasgow to that of Edinburgh, where he was soon distinguished, and honoured with the friendship of the late Dr Cullen; a man who was not more eminently conspicuous for the superiority of his own genius, than quick-sighted in perceiving, and liberal in encouraging, genius in his pupils. Having finished his studies at Edinburgh, though he took there no degree, Mr Stark, in the year 1765, went to London, and devoted himself entirely to the study of physic and the elements of surgery; and looking upon anatomy as one of the principal pillars of both these arts, he endeavoured to complete with Dr Hunter what he had begun with Dr Monro; and under these two eminent professors he appears to have acquired a high degree of anatomical knowledge. He likewise entered himself about this time a pupil at St George's hospital; for being disgusted, as he often confessed, with the inaccuracy or want of candour observable in the generality of practical writers, he determined to obtain an acquaintance with diseases at a better school and from an abler master; and to have from his own experience a standard, by which he might judge of the experience of others. With what industry he prosecuted this plan, and with what success his labours were crowned, may be seen in a series of Clinical and Anatomical Observations, which were made by him during his attendance at the hospital, and were published after his death by his friend Dr Carmichael Smyth. These observations give the public no cause to complain of want of candour in their author; for whatever delicacy he may have observed, when relating the cases of patients treated by other physicians, he has related those treated by himself with the utmost impartiality. Whilst attending the hospital, he likewise employed himself in making experiments on the blood, and other animal fluids; and also in a course of experiments in chemical pharmacy; but though accounts of these experiments were left behind him, we believe they have not yet been given to the public.

In the year 1767 Mr Stark went abroad, and obtained the degree of M. D in the university of Leyden, publishing an inaugural dissertation on the dysentery. On his return to London, he recommenced his studies at the hospital; and when Dr Black was called to the chemical chair in Edinburgh, which he has long filled with so much honour to himself and credit to the university, Dr Stark was solicited by several members of the university of Glasgow to stand a candidate for their professorship of the theory and practice of physic, rendered vacant by Dr Black's removal to Edinburgh. This however Dr Stark declined, being influenced by the advice of his English friends, who wished to detain him in London, and having likewise some prospects of an appointment in the hospital.

In the mean time he had commenced (1769) a series of experiments on diet, which he was encouraged to undertake by Sir John Pringle and Dr Franklin, whose friendship he enjoyed, and from whom he received many hints respecting both the plan and its execution. These experiments, or rather the imprudent zeal with which he prosecuted them, proved, in the opinion of his friends, fatal to himself; for he began them on the 12th of July 1769 in perfect health and vigour, and from that day, though his health varied, it was seldom if ever good, till the 23d of February 1770, when he died, after suffering much uneasiness. His friend and biographer Dr Smyth thinks, that other causes, particularly chagrin and disappointment, had no small share in hastening his death; and as the Doctor was intimately acquainted with his character and disposition, his opinion is probably well-founded, though the pernicious effects of the experiments are visible in Dr Stark's own journal. When he entered upon them, the weight of his body was 12 stone 3 lb. avoirdupois, which in a very few days was reduced to 11 stone 10 lb. 8 oz.: and though some kinds of food increased it, by much the greater part of what he used had a contrary effect, and it continued on the whole to decrease till the day of his death. This indeed can excite no wonder. Though the professed object of his experiments was to prove that a *pleasant* and varied diet is equally conducive to health with a more strict and simple one, most of the dishes which he ate during these experiments were neither pleasant nor simple, but compounds, such as every stomach must nauseate. He began with *bread* and *water*; from which he proceeded to *bread*, *water*, and *sugar*; then to *bread*, *water*, and *oil of olives*; then to *bread* and *water* with *milk*; afterwards he tried *bread* and *water* with *roasted goose*; *bread* and *water* with *boiled beef*; *stewed lean of beef* with the *gravy* and *water* without bread; *stewed lean of beef* with the *gravy*, *oil* of *fat* or *suet* and *water*; *flour*, *oil of suet*, *water* and *salt*; *flour*, *water*, and *salt*; and a number of others infinitely more disagreeable to the stomach than even these, such as *bread*, *fat of bacon ham*, *infusion of tea* with *sugar*; and *bread* or *flour* with *honey* and the infusion of *rosemary*. But though we consider Dr Stark's experiments as whimsical, it cannot be denied that they indicate eccentricity of genius in the person who made them; and such of our readers as think genius hereditary, may perhaps be of opinion, that he derived a ray from the celebrated NAPIER the inventor of the logarithms, who was his ancestor by both parents. At any rate, these experiments, of which a full account is given in the same volume with his clinical and anatomical observations, display an uncommon degree of fortitude, perseverance, self-denial, and zeal for the promoting of useful knowledge in their author; and with respect to his moral character, we believe it is with great justice that Dr Smyth compares him to Cato, by applying to him what was said of that virtuous Roman by Sallust—" Non divitiis cum divite, neque factione cum factioso; sed cum strenuo virtute, cum modesto pudore, cum innocente abstinentia certabat; esse, quam videri, bonus malebat *."

* *Bellum Catilinarium.*

STARLING. See STURNUS, ORNITHOLOGY *Index*.

STARLINGS, or STERLINGS, the name given to the strong pieces of timber which were driven into the bed of the river to protect the piles, on the top of which were laid the flat beams upon which were built the bafes of the ftone piers that fupport the arches of London bridge. In general, ftarlings are large piles placed on the outfide of the foundation of the piers of bridges, to break the force of the water, and to protect the ftone work from injury by floating ice. They are otherwife called *jettes*, and their place is often fupplied by large ftones thrown at random round the piers of bridges, as may be feen at Stirling bridge when the river is low; and as was done by Mr Smeaton's direction round the piers of the centre arch of London bridge, when it was thought in danger of being undermined by the current.

STATE of a Controversy. See Oratory, Part I. N° 14.

STATES, or Estates, a term applied to feveral orders or claffes of people affembled to confult of matters for the public good.

Thus ftates-generals, in the old government of Holland, is the name of an affembly confifting of the deputies of the feven United Provinces. Thefe were ufually 30 in number, fome provinces fending two, others more; and whatever refolution the ftates-general took was confirmed by every province, and by every city and republic in that province, before it had the force of a law. The deputies of each province, of what number foever they were, had only one voice, and were efteemed as but one perfon, the votes being given by provinces. Each province prefided in the affembly in its turn, according to the order fettled among them. Guelderland prefided firft, then Holland, &c.

States of Holland were the deputies of eighteen cities, and one reprefentative of the nobility, conftituting the ftates of the province of Holland: the other provinces had likewife their ftates, reprefenting their fovereignty; deputies from which made what was called the ftates-general. In an affembly of the ftates of a particular province, one diffenting voice prevented their coming to any refolution.

STATICE, Thrift, a genus of plants belonging to the clafs of pentandria, and order of pentagynia; and in the natural fyftem ranging under the 48th order, *Aggregatæ*. See Botany *Index*.

STATICS, a term which the modern improvements in knowledge have made it neceffary to introduce into phyfico-mathematical fcience. It was found convenient to diftribute the doctrines of univerfal mechanics into two claffes, which required both a different mode of confideration and different principles of reafoning.

Till the time of Archimedes little fcience of this kind was poffeffed by the ancients, from whom we have received the firft rudiments. His inveftigation of the centre of gravity, and his theory of the lever, are the foundations of our knowledge of common mechanics; and his theory of the equilibrium of floating bodies contains the greateft part of our hydroftatical knowledge. But it was as yet limited to the fimpleft cafes; and there were fome in which Archimedes was ignorant, or was miftaken. The marquis Guido Ubuldi, in 1578, publifhed his theory of mechanics, in which the doctrines of Archimedes were well explained and confiderably augmented. Stevinus, the celebrated Dutch engineer, publifhed about 20 years after an excellent fyftem of mechanics, containing the chief principles which now form the fcience of equilibrium among folid bodies. In particular, he gave the theory of inclined planes, which was unknown to the ancients, though it is of the very firft importance in almoft every machine. He even ftates in the moft exprefs terms the principle afterwards made the foundation of the whole of mechanics, and publifhed as a valuable difcovery by Varignon, viz. that three forces, whofe directions and intenfities are as the fides of a triangle, balance each other. His theory of the preffure of fluids, or hydroftatics, is no lefs eftimable, including every thing that is now received as a leading principle in the fcience. When we confider the ignorance, even of the moft learned, of that age, in mechanical or phyfico-mathematical knowledge, we muft confider thefe performances as the works of a great genius; and we regret that they are fo little known, being loft in a crowd of good writings on thofe fubjects which appeared foon after.

Hitherto the attention had been turned entirely to equilibrium, and the circumftances neceffary for producing it. Mechanicians indeed faw, that the energy of a machine might be fomehow meafured by the force which could be oppofed or overcome by its intervention: but they did not remark, that the force which prevented its motion, but did no more than prevent it, was an *exact* meafure of its energy, becaufe it was in immediate equilibrio with the preffure exerted by that part of the machine with which it was connected. If this oppofed force was lefs, or the force acting at the other extremity of the machine was greater, the mechanicians knew that the machine would move, and that work would be performed; but what would be the rate of its motion or its performance, they hardly pretended to conjecture. They had not ftudied the action of moving forces, nor conceived what was done when motion was communicated.

The great Galileo opened a new field of fpeculation in his work on Local Motion. He there confiders a change of motion as the indication and exact and adequate meafure of a moving force; and he confiders every kind of preffure as competent to the production of fuch changes.—He contented himfelf with the application of this principle to the motion of bodies by the action of gravity, and gave the theory of projectiles, which remains to this day without change, and only improved by confidering the changes which are produced in it by the refiftance of the air.

Sir Ifaac Newton took up this fubject nearly as Galileo had left it. For, if we except the theory of the centrifugal forces arifing from rotation, and the theory of pendulums, publifhed by Huygens, hardly any thing had been added to the fcience of motion. Newton confidered the fubject in its utmoft extent; and in his mathematical principles of natural philofophy he confiders every conceivable variation of moving force, and determines the motion refulting from its action.—His firft application of thefe doctrines was to explain the celeftial motions; and the magnificence of this fubject caufed it to occupy for a while the whole attention of the mathematicians. But the fame work contained propofitions equally conducive to the improvement of common mechanics, and to the complete underftanding of the mechanical actions of bodies. Philofophers began to make thefe applications alfo. They faw that every kind of work which is to be performed by a machine may be confidered abftractedly as a retarding force; that the impulfe of water or wind, which are employed as moving powers,

 act

act by means of preſſures which they exert on the impelled point of the machine; and that the machine itſelf may be conſidered as an aſſemblage of bodies moveable in certain limited circumſtances, with determined directions and proportions of velocity. From all theſe conſiderations reſulted a general abſtract condition of a body acted on by known powers. And they found, that after all conditions of equilibrium were ſatisfied, there remains a ſurplus of moving force. They could now ſtate the motion which will enſue, the new reſiſtance which this will excite, the additional power which this will abſorb; and they at laſt determined a new kind of equilibrium, not thought of by the ancient mechanicians, between the reſiſtance to the machine performing work and the moving power, which exactly balance each other, and is indicated, not by the *reſt*, but by the *uniform motion* of the machine.—In like manner, the mathematician was enabled to calculate that preciſe motion of water which would completely abſorb, or, in the new language, balance the ſuperiority of preſſure by which water is forced through a ſluice, a pipe, or canal, with a conſtant velocity.

Thus the general doctrines of motion came to be conſidered in two points of view, according as they balanced each other in a ſtate of reſt or of uniform motion. Theſe two ways of conſidering the ſame ſubject required both different principles and a different manner of reaſoning. The firſt has been named *ſtatics*, as expreſſing that reſt which is the teſt of this kind of equilibrium. The ſecond has been called DYNAMICS or UNIVERSAL MECHANICS, becauſe the different kinds of motion are characteriſtic of the powers or forces which produce them. A knowledge of both is indiſpenſably neceſſary for acquiring any uſeful practical knowledge of machines; and it was ignorance of the doctrines of accelerated and retarded motions which made the progreſs of practical mechanical knowledge ſo very ſlow and imperfect. The mechanics, even of the moderns, before Galileo, went no further than to ſtate the proportion of the power and reſiſtance which would be balanced by the intervention of a given machine, or the proportion of the parts of a machine by which two known forces may balance each other. This view of the matter introduced a principle, which even Galileo conſidered as a mechanical axiom, viz. that *what is gained in force by means of a machine is exactly compenſated by the additional time which it obliges us to employ*. This is falſe in every inſtance, and not only prevents improvement in the conſtruction of machines, but leads us into erroneous maxims of conſtruction. The true principles of dynamics teach us, that there is a certain proportion of the machine, dependent on the kind and proportion of the power and reſiſtance, which enables the machine to perform the greateſt poſſible work.

It is highly proper therefore to keep ſeparate theſe two ways of conſidering machines, that both may be improved to the utmoſt, and then to blend them together in every practical diſcuſſion.

Statics therefore is preparatory to the proper ſtudy of mechanics; but it does not hence derive all its importance. It is the ſole foundation of many uſeful parts of knowledge. This will be beſt ſeen by a brief enumeration.

1. It comprehends all the doctrines of the excitement and propagation of preſſure through the parts of ſolid bodies, by which the energies of machines are produced. A preſſure is exerted on the impelled point of a machine, ſuch as the float-boards or buckets of a mill-wheel. This excites a preſſure at the pivots of its axle, which act on the points of ſupport. This muſt be underſtood, both as to direction and intenſity, that it may be effectually reſiſted. A preſſure is alſo excited at the acting tooth of the cog-wheel on the ſame axle, by which it urges round another wheel, exciting ſimilar preſſures on its pivots and on the acting tooth perhaps of a third wheel.—Thus a preſſure is ultimately excited in the working point of the machine, perhaps a wiper, which lifts a heavy ſtamper, to let it fall again on ſome matter to be pounded. Now ſtatics teaches us the intenſities and direction of all thoſe preſſures, and therefore how much remains at the working point of the machine unbalanced by reſiſtance.

2. It comprehends every circumſtance which influences the ſtability of heavy bodies; the inveſtigation and properties of the centre of gravity; the theory of the conſtruction of arches, vaults, and domes; the attitudes of animals.

3. The ſtrength of materials, and the principles of conſtruction, ſo as to make the proper adjuſtment of ſtrength and ſtrain in every part of a machine, edifice, or ſtructure of any kind. Statics therefore furniſhes us with what may be called *a theory of carpentry*, and gives us proper inſtructions for framing floors, roofs, centres, &c.

4. Statics comprehends the whole doctrine of the preſſure of fluids, whether liquid or aeriform, whether ariſing from their weight or from any external action. Hence therefore we derive our knowledge of the ſtability of ſhips, or their power of maintaining themſelves in a poſition nearly upright, in oppoſition to the action of the wind on their ſails. We learn on what circumſtances of figure and ſtowage this quality depends, and what will augment or diminiſh it.

Very complete examples will be given in the remaining part of this work of the advantages of this ſeparate conſideration of the condition of a machine at reſt and in working motion; and in what yet remains to be delivered of the hydraulic doctrines in our account of *WATER-Works* in general, will be perceived the propriety of ſtating apart the equilibrium which is indicated by the uniform motion of the fluid. The obſervations too which we have to make on the ſtrength of the materials employed in our edifices or mechanical ſtructures, will be examples of the inveſtigation of thoſe powers, preſſures, or ſtrains, which are excited in all their parts.

STATIONARY, in *Aſtronomy*, the ſtate of a planet when, to an obſerver on the earth, it appears for ſome time to ſtand ſtill, or remain immoveable in the ſame place in the heavens. For as the planets, to ſuch an obſerver, have ſometimes a progreſſive motion, and ſometimes a retrograde one, there muſt be ſome point between the two where they muſt appear ſtationary.

STATISTICS, a word lately introduced to expreſs a view or ſurvey of any kingdom, county, or pariſh.

A Statiſtical view of Germany was publiſhed in 1790 by Mr B. Clarke: giving an account of the imperial and territorial conſtitutions, forms of government, legiſlation, adminiſtration of juſtice, and of the eccleſiaſtical ſtate;

ſtate; with a ſketch of the character and genius of the Germans; a ſhort inquiry into the ſtate of their trade and commerce; and giving a diſtinct view of the dominions, extent, number of inhabitants to a ſquare mile; chief towns, with their ſize and population; revenues, expences, debts, and military ſtrength of each ſtate. In Pruſſia, in Saxony, Sardinia, and Tuſcany, attempts have alſo been made to draw up ſtatiſtical accounts; but they were done rather with a view of aſcertaining the preſent ſtate of theſe countries, than as the means of future improvement.

A grand and extenſive work of this kind, founded on a judicious plan, conducted by the moſt patriotic and enlightened motives, and drawn up from the communications of the whole body of the clergy, was undertaken in Scotland in the year 1790 by Sir John Sinclair of Ulbſter, one of the moſt uſeful members of his country. Many praiſes are heaped upon genius and learning; but to genius and learning no applauſe is due, except when exerted for the benefit of mankind: but gratitude and praiſe is due to him whoſe talents ſhine only in great undertakings, whoſe happineſs ſeems to conſiſt in partriotic exertions, and whoſe judgement is uniformly approved by his ſucceſs. A work of this kind, ſo important in its object, ſo comprehenſive in its range, ſo judicious in its plan, and drawn up by more than 900 men of literary education, many of them men of great genius and learning, muſt be of immenſe value. It was completed about 1799, in 21 volumes 8vo.

The great object of this work is to give an accurate view of the ſtate of the country, its agriculture, its manufactures, and its commerce; the means of improvement, of which they are reſpectively capable; the amount of the population of a ſtate, and the cauſes of its increaſe or decreaſe; the manner in which the territory of a country is poſſeſſed and cultivated; the nature and amount of the various productions of the ſoil; the value of the perſonal wealth or ſtock of the inhabitants, and how it can be augmented; the diſeaſes to which the people are ſubject, their cauſes and their cure; the occupations of the people; where they are entitled to encouragement, and where they ought to be ſuppreſſed; the condition of the poor, the beſt mode of maintaining them, and of giving them employment; the ſtate of ſchools, and other inſtitutions, formed for purpoſes of public utility; the ſtate of the villages and towns, and the regulations beſt calculated for their police and good government; the ſtate of the manners, the morals, and the religious principles of the people, and the means by which their temporal and eternal intereſts can beſt be promoted.

To ſuch of our readers as have not an opportunity of peruſing this national work, or of examining its plan, we will preſent the ſcheme for the ſtatiſtical account of a parochial diſtrict which Sir John Sinclair publiſhed for the conſideration of the clergy, and which has been generally followed by them, though often with great improvements.

The name of the pariſh and its origin; ſituation and extent of the pariſh; number of acres; deſcription of the ſoil and ſurface; nature and extent of the ſea coaſt; lakes, rivers, iſlands, hills, rocks, caves, wood, orchards, &c.; climate and diſeaſes; inſtances of longevity; ſtate of property; number of proprietors; number of reſiding proprietors; mode of cultivation; implements of huſbandry; manures; ſeedtime and harveſt; remarkable inſtances of good and bad ſeaſons; quantity and value of each ſpecies of crop; total value of the whole produce of the diſtrict; total quantity of grain and other articles conſumed in the pariſh; wages and price of labour; ſervices, whether exacted or aboliſhed; commerce; manufactures; manufacture of kelp, its amount, and the number of people employed in it; fiſheries; towns and villages; police; inns and alehouſes; roads and bridges; harbours, ferries, and their ſtate; number of ſhips and veſſels; number of ſeamen; ſtate of the church; ſtipend, manſe, glebe, and patron; number of poor; parochial funds, and the management of them; ſtate of the ſchools, and number of ſcholars; ancient ſtate of population; cauſes of its increaſe or decreaſe; number of families; exact amount of the number of ſouls now living; diviſion of the inhabitants; 1. By the place of their birth; 2. By their ages; 3. By their religious perſuaſions; 4. By their occupations and ſituation in life; 5. By their reſidence, whether in town, village, or in the country; number of houſes; number of uninhabited houſes; number of dove-cots, and to what extent they are deſtructive to the crops; number of horſes, their nature and value; number of cattle, their nature and value; number of ſheep, their nature and value; number of ſwine, their nature and value; minerals in general; mineral ſprings; coal and fuel; eminent men; antiquities; parochial records; miſcellaneous obſervations; character of the people; their manners, cuſtoms, ſtature, &c.; advantages and diſadvantages; means by which their ſituation could be meliorated.

If ſimilar ſurveys (ſays the public-ſpirited editor of this work) were inſtituted in the other kingdoms of Europe, it might be the means of eſtabliſhing, on ſure foundations, the principles of that moſt important of all ſciences, viz. political or ſtatiſtical philoſophy; that is, the ſcience, which, in preference to every other, ought to be held in reverence. No ſcience can furniſh, to any mind capable of receiving uſeful information, ſo much real entertainment, none can yield ſuch important hints for the improvement of agriculture, for the extenſion of commercial induſtry, for regulating the conduct of individuals, or for extending the proſperity of the ſtate; none can tend ſo much to promote the general happineſs of the ſpecies.

STATIUS, Publius Papinius, a celebrated Latin poet of the firſt century, was born at Naples, and was the ſon of Statius, a native of Epirus, who went to Rome to teach poetry and eloquence, and had Domitian for his ſcholar. Statius the poet alſo obtained the favour and friendſhip of that prince; and dedicated to him his Thebais and Achilleis; the firſt in twelve books, and the laſt in two. He died at Naples about the year 100. Beſides the above poems, there are alſo ſtill extant his *Sylvæ*, in five books; the ſtyle of which is purer, more agreeable, and more natural, than that of his Thebais and Achilleis.

STATUARY, a branch of ſculpture, employed in the making of ſtatues. See Sculpture and the next article.

Statuary is one of thoſe arts wherein the ancients ſurpaſſed the moderns; and indeed it was much more popular, and more cultivated, among the former than the latter. It is diſputed between ſtatuary and painting, which of the two is the moſt difficult and the moſt artful.

Statue.

Statuary is alſo uſed for the artificer who makes ſtatues. Phidias was the greateſt ſtatuary among the ancients, and Michael Angelo among the moderns.

STATUE, is defined to be a piece of ſculpture in full relievo, repreſenting a human figure. Daviler more ſcientifically defines ſtatue a repreſentation, in high relievo and inſulate, of ſome perſon diſtinguiſhed by his birth, merit, or great actions, placed as an ornament in a fine building, or expoſed in a public place, to preſerve the memory of his worth. In Greece one of the higheſt honours to which a citizen could aſpire was to obtain a ſtatue.

Statues are formed with the chiſel, of ſeveral matters, as ſtone, marble, plaſter, &c. They are alſo caſt of various kinds of metal, particularly gold, ſilver, braſs, and lead. For the method of caſting ſtatues, ſee the article *FOUNDERY of Statues*.

Statues are uſually diſtinguiſhed into four general kinds. The firſt are thoſe leſs than the life; of which kind we have ſeveral ſtatues of great men, of kings, and of gods themſelves. The ſecond are thoſe equal to the life; in which manner it was that the ancients, at the public expence, uſed to make ſtatues of perſons eminent for virtue, learning, or the ſervices they had done. The third are thoſe that exceed the life; among which thoſe that ſurpaſſed the life once and a half were for kings and emperors; and thoſe double the life, for heroes. The fourth kind were thoſe that exceeded the life twice, thrice, and even more, and were called *coloſſuſes*. See COLOSSUS.

Every ſtatue reſembling the perſon whom it is intended to repreſent, is called *ſtatua iconica*. Statues acquire various other denominations. 1. Thus, allegorical ſtatue is that which, under a human figure, or other ſymbol, repreſents ſomething of another kind; as a part of the earth, a ſeaſon, age, element, temperament, hour, &c. 2. Curule ſtatues, are thoſe which are repreſented in chariots drawn by bigæ or quadrigæ, that is, by two or four horſes; of which kind there were ſeveral in the circuſes, hippodromes, &c. or in cars, as we ſee ſome, with triumphal arches on antique medals. 3. Equeſtrian ſtatue, that which repreſents ſome illuſtrious perſon on horſeback, as that famous one of Marcus Aurelius at Rome; that of King Charles I. at Charing-croſs; King George II. in Leiceſter Square, &c. 4. Greek ſtatue, denotes a figure that is naked and antique; it being in this manner the Greeks repreſented their deities, athletæ of the olympic games, and heroes; the ſtatues of heroes were particularly called *Achillean ſtatues*, by reaſon of the great number of figures of Achilles in moſt of the cities of Greece. 5. Hydraulic ſtatue, is any figure placed as an ornament of a fountain or grotto, or that does the office of a *jet d'eau*, a cock, ſpout, or the like, by any of its parts, or by any attribute it holds: the like is to be underſtood of any animal ſerving for the ſame uſe. 6. Pedeſtrian ſtatue, a ſtatue ſtanding on foot; as that of King Charles II. in the Royal Exchange, and of King James II. in the Privy-Gardens. 7. Roman ſtatue, is an appellation given to ſuch as are clothed, and which receive various names from their various dreſſes. Thoſe of emperors, with long gowns over their armour, were called *ſtatuæ paludatæ*: thoſe of captains and cavaliers, with coats of arms, *thoracatæ*; thoſe of ſoldiers with cuiraſſes, *loricatæ*, thoſe of ſenators and augurs, *trabeatæ*; thoſe of magiſtrates with long robes, *togatæ*; thoſe of the people with a plain tunica, *tunicatæ*; and, laſtly, thoſe of women with long trains, *ſtolatæ*.

Statue || Steam.

In repairing a ſtatue caſt in a mould, they touch it up with a chiſel, graver, or other inſtrument, to finiſh the places which have not come well off: they alſo clear off the barb, and what is redundant in the joints and projectures.

STATURE. See DWARF and GIANT.

STATUTE, in its general ſenſe, ſignifies a law, ordinance, decree, &c. See LAW, &c.

STATUTE, in our laws and cuſtoms, more immediately ſignifies an act of parliament made by the three eſtates of the realm; and ſuch ſtatutes are either general, of which the courts at Weſtminſter muſt take notice without pleading them; or they are ſpecial and private, which laſt muſt be pleaded.

STAVESACRE, a ſpecies of DELPHINIUM, which ſee, BOTANY *Index*.

STAY, a large ſtrong rope employed to ſupport the maſt on the fore part, by extending from its upper end towards the fore part of the ſhip, as the ſhrouds are extended to the right and left, and behind it. See MAST, RIGGING, and SHROUD.

The ſtay of the fore-maſt, which is called the *fore-ſtay*, reaches from the maſt-head towards the bowſpirit end: the main ſtay extends over the forecaſtle to the ſhip's ſtem; and the mizen-ſtay is ſtretched down to that part of the main-maſt which lies immediately above the quarter-deck: the fore-top-maſt-ſtay comes alſo to the end of the bowſpirit, a little beyond the fore-ſtay: the main-top-maſt ſtay is attached to the head or hounds of the fore-maſt; and the mizen-top-maſt ſtay comes alſo to the hounds of the main-maſt: the fore-top-gallant ſtay comes to the outer end of the jib-boom; and the main-top-gallant ſtay is extended to the head of the fore-top-maſt.

STAY-Sail, a ſort of triangular ſail extended upon a ſtay. See SAIL.

STEAM, is the name given in our language to the viſible moiſt vapour which ariſes from all bodies which contain juices eaſily expelled from them by heats not ſufficient for their combuſtion. Thus we ſay, the ſteam of boiling water, of malt, of a tan-bed, &c. It is diſtinguiſhed from ſmoke by its not having been produced by combuſtion, by not containing any ſoot, and by its being condenſible by cold into water, oil, inflammable ſpirits, or liquids compoſed of theſe. 1 Definition.

We ſee it riſe in great abundance from bodies when they are heated, forming a white cloud, which diffuſes itſelf and diſappears at no very great diſtance from the body from which it was produced. In this caſe the ſurrounding air is found loaded with the water or other juices which ſeem to have produced it, and the ſteam ſeems to be completely ſoluble in air, as ſalt is in water, compoſing while thus united a tranſparent elaſtic fluid. 2 Appears like a white cloud

But in order to its appearance in the form of an opaque white cloud, the mixture with or diſſemination in air ſeems abſolutely neceſſary. If a tea-kettle boils violently, ſo that the ſteam is formed at the ſpout in great abundance, it may be obſerved, that the viſible cloud is not formed at the very mouth of the ſpout, but at a ſmall diſtance before it, and that the vapour is perfectly tranſparent at its firſt emiſſion. This is rendered ſtill more evident by fitting to the ſpout of the tea-kettle 3 when diſſeminated in air.

Steam. tea-kettle a glass pipe of any length, and of as large a diameter as we please. The steam is produced as copiously as without this pipe, but the vapour is transparent through the whole length of the pipe. Nay, if this pipe communicate with a glass vessel terminating in another pipe, and if the vessel be kept sufficiently hot, the steam will be as abundantly produced at the mouth of this second pipe as before, and the vessel will be quite transparent. The visibility therefore of the matter which constitutes the steam is an accidental or extraneous circumstance, and requires the admixture with air; yet this quality again leaves it when united with air by solution. It appears therefore to require a *dissemination* in the air. The appearances are quite agreeable to this notion: for we know that one perfectly transparent body, when minutely divided and diffused among the parts of another transparent body, but not dissolved in it, makes a mass which is visible. Thus oil beaten up with water makes a white opaque mass.

4 Is again converted into water by cold.

In the mean time, as steam is produced, the water gradually wastes in the tea kettle, and will soon be totally expended, if we continue it on the fire. It is reasonable therefore to suppose, that this steam is nothing but water changed by heat into an aerial or elastic form. If so, we should expect that the privation of this heat would leave it in the form of water again. Accordingly this is fully verified by experiment; for if the pipe fitted to the spout of the tea kettle be surrounded with cold water, no steam will issue, but water will continually trickle from it in drops: and if the process be conducted with the proper precautions, the water which we thus obtain from the pipe will be found equal in quantity to that which disappears from the tea-kettle.

5 Its appearances explained,

This is evidently the common process for distilling; and the whole appearances may be explained by saying, that the water is converted by heat into an elastic vapour, and that this, meeting with colder air, imparts to it the heat which it carried off as it arose from the heated water, and being deprived of its heat it is again water. The particles of this water being vastly more remote from each other than when they were in the tea-kettle, and thus being disseminated in the air, become visible, by reflecting light from their anterior and posterior surfaces, in the same manner as a transparent salt becomes visible when reduced to a fine powder. This disseminated water being presented to the air in a very extended surface, is quickly dissolved by it, as pounded salt is in water, and again becomes a transparent fluid, but of a different nature from what it was before, being no longer convertible into water by depriving it of its heat.

6 and the cause of its conversion, by Dr Black's discovery of latent heat.

Accordingly this opinion, or something very like it, has been long entertained. Muschenbroeck expresly says, that the water in the form of vapour carries off with it all the heat which is continually thrown in by the fuel. But Dr Black was the first who attended minutely to the whole phenomena, and enabled us to form distinct notions of the subject. He had discovered that it was not sufficient for converting ice into water that it be raised to that temperature in which it can no longer remain in the form of ice. A piece of ice of the temperature 32° of Fahrenheit's thermometer will remain a very long while in air of the temperature 50° before it be all melted, remaining all the while of the temperature 32°, and therefore continually absorbing heat from the surrounding air. By comparing the time in which the ice had its temperature changed from 28° to 32° with the subsequent time of its complete liquefaction, he found that it absorbed about 130 or 140 times as much heat as would raise its temperature one degree; and he found that one pound of ice, when mixed with one pound of water 140 degrees warmer, was just melted, but without rising in its temperature above 32°. Hence he justly concluded, that water differed from ice of the same temperature by containing, as a constituent ingredient, a great quantity of fire, or of the cause of heat, united with it in such a way as not to quit it for another colder body, and therefore so as not to go into the liquor of the thermometer and expand it. Considered therefore as the possible cause of heat, it was latent, which Dr Black expressed by the abbreviated term LATENT HEAT. If any more heat was added to the water it was not latent, but would readily quit it for the thermometer, and, by expanding the thermometer, would show what is the degree of this *redundant* heat, while fluidity alone is the indication of the *combined* and latent heat.

Dr Black, in like manner, concluded, that in order to convert water into an elastic vapour, it was necessary, not only to increase its uncombined heat till its temperature is 212°, in which state it is just ready to become elastic; but also to pour into it a great quantity of fire, or the cause of heat, which combines with every particle of it, so as to make it repel, or to recede from, its adjoining particles, and thus to make it a particle of an elastic fluid. He supposed that this additional heat might be combined with it so as not to quit it for the thermometer; and therefore so as to be in a latent state, having elastic fluidity for its sole indication.

7 The temperature at which it is produced, and the quantity of heat which it absorbs.

This opinion was very consistent with the phenomenon of boiling off a quantity of water. The application of heat to it causes it gradually to rise in its temperature till it reaches the temperature 212°. It then begins to send off elastic vapour, and is slowly expended in this way, continuing all the while of the same temperature. The steam also is of no higher temperature, as appears by holding a thermometer in it. We must conclude that this steam contains all the heat which is expended in its formation. Accordingly the scalding power of steam is well known; but it is extremely difficult to obtain precise measures of the quantity of heat absorbed by water during its conversion into steam. Dr Black endeavoured to ascertain this point, by comparing the time of raising its temperature a certain number of degrees with the time of boiling it off by the same external heat; and he found that the heat latent in steam, which balanced the pressure of the atmosphere, was not less than 800 degrees. He also directed Dr Irvine of Glasgow to the form of an experiment for measuring the heat actually extricated from such steam during its condensation in the refrigeratory of a still, which was found to be not less than 774 degrees. Dr Black was afterwards informed by Mr Watt, that a course of experiments, which he had made in each of these ways with great precision, determined the latent heat of steam under the ordinary pressure of the atmosphere to be about 948 or 950 degrees. Mr Watt also found that water would distil with great ease

in

Steam.

in vacuo when of the temperature 70°; and that in this case the latent heat of the steam is not less than 1200 or 1300 degrees: and a train of experiments, which he had made by distilling in different temperatures, made him conclude that the sum of the sensible and latent heats is a constant quantity. This is a curious and not an improbable circumstance; but we have no information of the particulars of these experiments. The conclusion evidently presupposes a knowledge of that particular temperature in which the water has no heat; but this is a point which is still *sub judice*.

8 Steam, by being combined with heat, becomes elastic and light,

This conversion of liquids (for it is not confined to water, but obtains also in ardent spirits, oils, mercury, &c.) is the cause of their boiling. The heat is applied to the bottom and sides of the vessel, and gradually accumulates in the fluid, in a sensible state, uncombined, and ready to quit it and to enter into any body that is colder, and to diffuse itself between them. Thus it enters into the fluid of a thermometer, expands it, and thus gives us the indication of the degree in which it has been accumulated in the water; for the thermometer swells as long as it continues to absorb sensible heat from the water: and when the sensible heat in both is in equilibrio, in a proportion depending on the nature of the two fluids, the thermometer rises no more, because it absorbs no more heat or fire from the water; for the particles of water which are in immediate contact with the bottom, are now (by this gradual expansion of liquidity) at such distance from each other, that their laws of attraction for each other and for heat are totally changed. Each particle either no longer attracts, or perhaps it repels its adjoining particle, and now accumulates round itself a great number of the particles of heat, and forms a particle of elastic fluid, so related to the adjoining new formed particles, as to repel them to a distance at least a hundred times greater than their distances in the state of water. Thus a mass of elastic vapour of sensible magnitude is formed. Being at least ten thousand times lighter than an equal bulk of water, it must rise up through it, as a cork would do, in form of a transparent ball or bubble, and getting to the top, it dissipates, filling the upper part of the vessel

9 and produces the phenomenon of boiling.

with vapour or steam. Thus, by tossing the liquid into bubbles, which are produced all over the bottom and sides of the vessel, it produces the phenomenon of ebullition or boiling. Observe, that during its passage up through the water, it is not changed or condensed; for the surrounding water is already so hot that the sensible or uncombined heat in it, is in equilibrio with that in the vapour, and therefore it is not disposed to absorb any of that heat which is combined as an ingredient of this vapour, and gives it its elasticity. For this reason, it happens that water will not boil till its whole mass be heated up to 212°; for if the upper part be colder, it robs the rising bubble of that heat which is necessary for its elasticity, so that it immediately collapses again, and the surface of the water remains still. This may be perceived by holding water in a Florence flask over a lamp or choffer. It will be observed, some time before the real ebullition, that some bubbles are formed at the bottom, and get up a very little way, and then disappear. The distances which they reach before collapsing increase as the water continues to warm farther up the mass, till at last it breaks out into boiling. If the handle of a tea-kettle be grasped with the hand, a tremor will be felt for some little time before boiling, arising from the little succussions which are produced by the collapsing of the bubbles of vapour. This is much more violent, and is really a remarkable phenomenon, if we suddenly plunge a lump of red hot iron into a vessel of cold water, taking care that no red part be near the surface. If the hand be now applied to the side of the vessel, a most violent tremor is felt, and sometimes strong thumps: these arise from the collapsing of very large bubbles. If the upper part of the iron be too hot, it warms the surrounding water so much, that the bubbles from below come up through it uncondensed, and produce ebullition without this succussion. The great resemblance of this tremor to the feeling which we have during the shock of an earthquake has led many to suppose that these last are produced in the same way, and their hypothesis, notwithstanding the objections which we have elsewhere stated to it, is by no means unfeasible.

10 The noise observed in the boiling of a tea-kettle explained.

It is owing to a similar cause that violent thumps are sometimes felt on the bottom of a tea-kettle, especially one which has been long in use. Such are frequently crusted on the bottom with a stony concretion. This sometimes is detached in little scales. When one of these is adhering by one end to the bottom, the water gets between them in a thin film. Hence it may be heated considerably above the boiling temperature, and it suddenly rises up in a large bubble, which collapses immediately. A smooth shilling lying on the bottom will produce this appearance very violently, or a thimble with the mouth down.

11 Water will not boil unless the fire be applied to the bottom or sides of the vessel.

In order to make water boil, the fire must be applied to the bottom or sides of the vessel. If the heat be applied at the top of the water, it will waste away without boiling; for the very superficial particles are first supplied with the heat necessary for rendering them elastic, and they fly off without agitating the rest (A).

Since this disengagement of vapour is the effect of its

(A) We explained the opaque and cloudy appearance of steam, by saying that the vapour is condensed by coming into contact with the cooler air. There is something in the form of this cloud which is very inexplicable. The particles of it are sometimes very distinguishable by the eye; but they have not the smart star-like brilliancy of very small drops of water, but give the fainter reflection of a very thin film or vesicle like a soap bubble. If we attend also to their motion, we see them descending very slowly in comparison with the descent of a solid drop; and this vesicular constitution is established beyond a doubt by looking at a candle through a cloud of steam. It is seen surrounded by a faint halo with prismatical colours, precisely such as we can demonstrate by optical laws to belong to a collection of vesicles, but totally different from the halo which would be produced by a collection of solid drops. It is very difficult to conceive how these vesicles can be formed of watery particles, each of which was surrounded its elafticity, and fince this elafticity is a determined force when the temperature is given, it follows, that fluids cannot boil till the elafticity of the vapour overcomes the preffure of the incumbent fluid and of the atmofphere. Therefore, when this preffure is removed or diminifhed, the fluids muft fooner overcome what remains, and boil at a lower temperature. Accordingly it is obferved that water will boil in an exhaufted receiver when of the heat of the human body. If two glafs balls A and B (fig. 1.) be connected by a flender tube, and one of them A be filled with water (a fmall opening or pipe b being left at top of the other), and this be made to boil, the vapour produced from it will drive all the air out of the other, and will at laft come out itfelf, producing fteam at the mouth of the pipe. When the ball B is obferved to be occupied by tranfparent vapour, we may conclude that the air is completely expelled. Now fhut the pipe by fticking it into a piece of tallow or bees-wax; the vapour in B will foon condenfe, and there will be a vacuum. The flame of a lamp and blow-pipe being directed to the little pipe, will caufe it immediately to clofe and feal hermetically. We now have a pretty inftrument or toy called a PULSE GLASS. Grafp the ball A in the hollow of the hand; the heat of the hand will immediately expand the bubble of vapour which may be in it, and this vapour will drive the water into B, and then will blow up through it for a long while, keeping it in a ftate of violent ebullition, as long as there remains a drop or film of water in A. But care muft be taken that B is all the while kept cold, that it may condenfe the vapour as faft as it rifes through the water. Touching B with the hand, or breathing warm on it, will immediately ftop the ebullition in it. When the water in A has thus been diffipated, grafp B in the hand; the water will be driven into A, and the ebullition will take place there as it did in B. Putting one of the balls into the mouth will make the ebullition more violent in the other, and the one in the mouth will feel very cold. This is a pretty illuftration of the rapid abforption of the heat by the particles of water which are thus converted into elaftic vapour. We have feen this little toy fufpended by the middle of the tube like a balance, and thus placed in the infide of a window, having two holes a and b cut in the pane, in fuch a fituation that when A is full of water and preponderates, B is oppofite to the hole b. Whenever the room became fufficiently warm, the vapour was formed in A, and immediately drove the water into B, which was kept cool by the air coming into the room through the hole b. By this means B was made to proponderate in its turn, and A was then oppofite to the hole a, and the procefs was now repeated in the oppofite direction; and this amufement continued as long as the room was warm enough.

12 No fluid can boil till the elafticity of the vapour overcome the preffure of the incumbent bodies. Plate DI. Fig. 1.

13 Liquors differ much in the temperature neceffary for their ebullition.

We know that liquors differ exceedingly in the temperatures neceffary for their ebullition. This forms the great chemical diftinction between volatile and fixed bodies. But the difference of temperature in which they boil, or are converted into permanently elaftic vapour, under the preffure of the atmofphere, is not a certain meafure of their differences of volatility. The natural boiling point of a body is that in which it will be converted into elaftic vapour under no preffure, or *in vacuo*. The boiling point in the open air depends on the law of the elafticity of the vapour in relation to its heat. A fluid A may be lefs volatile, that is, may require more heat to make it boil *in vacuo*, than a fluid B: But if the elafticity of the vapour of A be more increafed by an increafe of temperature than that of the vapour of B, A may boil at as low, or even at a lower temperature, in the open air, than B does; for the increafed elafticity of the vapour of A may fooner overcome the preffure of the atmofphere. Few experiments have been made on the relation between the temperature and the elafticity of different vapours. So long ago as the year 1765, we had occafion to examine the boiling points of all fuch liquors as we could manage in an air-pump; that is, fuch as did not produce vapours which deftroyed the valves and the leathers of the piftons: and we thought that the experiments gave us reafon to conclude, that the elafticity of all the vapours was affected by heat nearly in the fame degree. For we found that the difference between their boiling points in the air and *in vacuo* was nearly the fame in all, namely, about 120 degrees of Fahrenheit's thermometer. It is exceedingly difficult to make experiments of this kind: The vapours are fo condenfible, and change their elafticity fo prodigioufly by a trifling change of temperature, that it is almoft impoffible to examine this point with precifion. It is, however, as we fhall fee by and bye, a fubject of confiderable practical importance in the mechanic arts; and an accurate knowledge of the relation would be of great ufe alfo to the diftiller: and it would be no lefs important to difcover the relation of their elafticity and denfity, by examining their compreffibility, in the fame manner as we have afcertained the relation in the cafe of what we call *aerial fluids*, that is, fuch as we have never obferved in the form of liquids or folids, except in confequence of their union with each other or with other bodies. In the article PNEUMATICS we took notice of it as fomething like a natural law, that all thefe airs, or gafes as they are now called, had their elafticity very nearly, if not exactly proportional to their denfity. This appears from the experiments of Achard, of Fontana, and others, on vital air, inflammable air, fixed air, and fome others. It gives us fome prefumption to fuppofe that it holds in all elaftic vapours whatever, and that it is connected with their elafticity; and it renders it fomewhat probable that they are all elaftic, only becaufe the caufe of heat (the matter of fire if you will) is elaftic, and that their law of elafticity, in refpect of denfity, is the fame with that of fire. But it muft be

14 Difference between their boiling points in air and *in vacuo* about 120°.

rounded with many particles of fire, now communicated to the air, and how each of thefe veficles fhall include within it a ball of air; but we cannot refufe the fact. We know, that if, while linfeed oil is boiling or nearly boiling, the furface be obliquely ftruck with the ladle, it will be dafhed into a prodigious number of exceedingly fmall veficles, which will float about in the air for a long while. Mr Sauffure was (we think) the firft who diftinctly obferved this veficular form of mifts and clouds; and he makes confiderable ufe of it in explaining feveral phenomena of the atmofphere.

Steam.

15 To what the elaſticity of fluids may be owing.

be obſerved, that although we thus aſſign the elaſticity of fire as the immediate cauſe of the elaſticity of vapour, in the ſame way, and on the ſame grounds, that we aſcribe the fluidity of brine to the fluidity of the water which holds the ſolid ſalt in ſolution, it does not follow that this is owing, as is commonly ſuppoſed, to a repulſion or tendency to recede from each other exerted by the particles of fire. We are as much entitled to infer a repulſion of unlimited extent between the particles of water; for we ſee that by its means a ſingle particle of ſea-ſalt becomes diſſeminated through the whole of a very large veſſel. If water had not been a viſible and palpable ſubſtance, and the ſalt only had been viſible and palpable, we might have formed a ſimilar notion of chemical ſolution. But we, on the contrary, have conſidered the *quaquaverſum* motion or expanſion of the ſalt as a diſſemination among the particles of water; and we have aſcribed it to the ſtrong attraction of the atoms of ſalt for the atoms of water, and the attraction of theſe laſt for each other, thinking that each atom of ſalt accumulates round itſelf a multitude of watery atoms, and by ſo doing muſt recede from the other ſaline atoms. Nay, we farther ſee, that by forces which we naturally conſider as attractions, an expanſion may be produced of the whole maſs, which will act againſt external mechanical forces. It is thus that wood ſwells with almoſt inſuperable force by imbibing moiſture; it is thus that a ſponge immerſed in water becomes really an elaſtic compreſſible body; reſembling a blown bladder; and there are appearances which warrant us to apply this mode of conception to elaſtic fluids.—When air is ſuddenly compreſſed, a thermometer included in it ſhows a riſe of temperature; that is, an appearance of heat now redundant which was formerly combined. The heat ſeems to be ſqueezed out as the water from the ſponge.

16 Aſcribed by ſome to attraction, but improperly.

Accordingly this opinion, that the elaſticity of ſteam and other vapours is owing merely to the attraction for fire, and the conſequent diſſemination of their particles through the whole maſs of fire, has been entertained by many naturaliſts, and it has been aſcribed entirely to attraction. We by no means pretend to decide; but we think the analogy by far too ſlight to found any confident opinion on it. The aim is to ſolve phenomena by attraction only, as if it were of more eaſy conception than repulſion. Conſidered merely as facts, they are quite on a par. The appearances of nature in which we obſerve actual receſſes of the parts of body from each other, are as diſtinct, and as frequent and familiar, as the appearances of actual reproach. And if we attempt to go farther in our contemplation, and to conceive the way and the forces by which either the approximation or receſſes of the atoms are produced, we muſt acknowledge that we have no conception of the matter; and we can only ſay, that there is a cauſe of theſe motions, and we call it a force, as in every caſe of the production of motion. We call it attraction or repulſion juſt as we happen to contemplate an acceſs or a receſs. But the analogy here is not only ſlight, but imperfect, and fails moſt in thoſe caſes which are moſt ſimple, and where we ſhould expect it to be moſt complete. We can ſqueeze water out of a ſponge, it is true, or out of a piece of green wood; but when the white of an egg, the tremella, or ſome gums, ſwell to a hundred times their dry dimenſions by imbibing water, we cannot ſqueeze out a particle. If fluidity (for the reaſoning muſt equally apply to this as to vapourouſneſs) be owing to an accumulation of the extended matter of fire, which gradually expanded the ſolid by its very minute additions; and if the accumulation round a particle of ice, which is neceſſary for making it a particle of water, be ſo great in compariſon of what gives it the expanſion of one degree, as experiment obliges us to conclude—it ſeems an inevitable conſequence that all fluids ſhould be many times rarer than the ſolids from which they are produced. But we know that the difference is trifling in all caſes, and in ſome (water, for inſtance, and iron) the ſolid is rarer than the fluid.

17 More probably owing to a mutual repulſion between the particles of fire.

Many other arguments, (each of them perhaps of little weight when taken alone, but which are all ſyſtematically connected) concur in rendering it much more probable that the matter of fire, in cauſing elaſticity, acts immediately by its own elaſticity, which we cannot conceive in any other way than as a mutual tendency in its particles to receive from each other; and we doubt not but that, if it could be obtained alone, we ſhould find it an elaſtic fluid like air. We even think that there are caſes in which it is obſerved in this ſtate. The elaſtic force of gunpowder is very much beyond the elaſticity of all the vapours which are produced in its deflagration, each of them being expanded as much as we can reaſonably ſuppoſe by the great heat to which they are expoſed. The writer of this article exploded ſome gunpowder mixed with a conſiderable portion of finely powdered quartz, and another parcel mixed with fine filings of copper. The elaſticity was meaſured by the penetration of the ball which was diſcharged, and was great in the degree now mentioned. The experiment was ſo conducted, that much of the quartz and copper was collected; none of the quartz had been melted, and ſome of the copper was not melted. The heat, therefore, could not be ſuch as to explain the elaſticity by expanſion of the vapours; and it became not improbable that fire was acting here as a detached chemical fluid by its own elaſticity. But to return to our ſubject.

18 Probably a great difference between condenſible and inconденſible vapours;

There is one circumſtance in which we think our own experiments ſhow a remarkable difference (at leaſt in degree) between the condenſible and incondenſible vapours. It is well known, that when air is very ſuddenly expanded, cold is produced, and heat when it is ſuddenly condenſed. When making experiments with the hopes of diſcovering the connection between the elaſticity and denſity of the vapours of boiling water, and alſo of boiling ſpirits of turpentine, we found the change of denſity accompanied by a change of temperature vaſtly greater than in the caſe of incoercible gaſes. When the vapour of boiling water was ſuddenly allowed to expand into five times its bulk, we obſerved the depreſſion of a large and ſenſible air thermometer to be at leaſt four or five times greater than in a ſimilar expanſion of common air of the ſame temperature. The chemical reader will readily ſee reaſons for expecting, on the contrary, a ſmaller alteration of temperature, both on account of the much greater rarity of the fluid, and on account of a partial condenſation of its water and the conſequent diſengagement of combined heat.

19 and alſo ſome difference in the chemical conſtitution of vapour.

This difference in the quantity of fire which is combined in vapours and gaſes is ſo conſiderable, as to authorize us to ſuppoſe that there is ſome difference in the chemical conſtitution of vapours and gaſes, and that the connection

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connection between the ſpecific baſes of the vapour and the fire which it contains is not the ſame in air, for inſtance, as in the vapour of boiling water; and this difference may be the reaſon why the one is eaſily condenſible by cold, while the other has never been exhibited in a liquid or ſolid form, except by means of its chemical union with other ſubſtances. In this particular inſtance we know that there is an eſſential difference—that in vital or atmoſpheric air there is not only a prodigious quantity of fire which is not in the vapour of water, but that it alſo contains light, or the cauſe of light, in a combined ſtate. This is fully evinced by the great diſcovery of Mr Cavendiſh of the compoſition of water. Here we are taught that water (and conſequently its vapour) conſiſts of air from which the light and greateſt part of the fire have been ſeparated. And the ſubſequent diſcoveries of the celebrated Lavoiſier ſhow, that almoſt all the condenſible gaſes with which we are acquainted conſiſt either of airs which have already loſt much of their fire (and perhaps light too), or of matters in which we have no evidence of fire or light being combined in this manner.

This conſideration may go far in explaining this difference in the condenſibility of theſe different ſpecies of aerial fluids, the gaſes and the vapours; and it is with this qualification only that we are diſpoſed to allow that all bodies are condenſible into liquids or ſolids by abſtracting the heat. In order that vital air may become liquid or ſolid, we hold that it is not ſufficient that a body be preſented to it which ſhall ſimply abſtract its heat. This would only abſtract its uncombined fire. But another and much larger portion remains chemically combined by means of light. A chemical affinity muſt be brought into action which may abſtract, not the fire from the oxygen (to ſpeak the language of Mr Lavoiſier), but the oxygen from the fire and light. And our production is not the detached baſis of air, but detached heat and light, and the formation of an oxide of ſome kind.

General Observations.

To proſecute the chemical conſideration of STEAMS farther than theſe general obſervations, which are applicable to all, would be almoſt to write a treatiſe of chemiſtry, and would be a repetition of many things which have been treated of in ſufficient detail in other articles of this work. We ſhall therefore conclude this article with ſome other obſervations, which are alſo general, with reſpect to the different kinds of coercible vapours, but which have a particular relation to the following article.

20 Steam riſes at different temperatures, according as the air is heavy or light.

Steam or vapour is an elaſtic fluid, whoſe elaſticity balances the preſſure of the atmoſphere; and it has been produced from a ſolid or liquid body raiſed to a ſufficient temperature for giving it this elaſticity; that is, for cauſing the fluid to boil. This temperature muſt vary with the preſſure of the air. Accordingly it is found, that when the air is light (indicated by the barometer being low), the fluid will boil ſooner. When the barometer ſtands at 30 inches, water boils at the temperature 212°. If it ſtands ſo low as 28 inches, water will boil at 208½. In the plains of Quito, or at Gondar in Abyſſinia, where the barometer ſtands at about 21 inches, water will boil at 195°. Highly rectified alcohol will boil at 160°, and vitriolic ether will boil at 88° or 89°. This is a temperature by no means uncommon in theſe places; nay, the air is frequently warmer. Vitriolic ether, therefore, is a liquor which can hardly be known in thoſe countries. It is hardly poſſible to preſerve it in that form. If a phial have not its ſtopper firmly tied down, it will be blown out, and the liquor will boil and be diſſipated in ſteam. On the top of Chimboraçao, the human blood muſt be diſpoſed to give out air-bubbles.

21 As fluids boil under the preſſure of the vapour which aſcends from them, the concluſion mentioned in n° 14. is only a groſs approximation.

We ſaid ſome time ago, that we had concluded, from ſome experiments made in the receiver of an air-pump, that fluids boil *in vacuo* at a temperature nearly 120 degrees lower than that neceſſary for their boiling in the open air. But we now ſee that this muſt have been but a groſs approximation; for in theſe experiments the fluids were boiling under the preſſure of the vapour which they produced, and which could not be abſtracted by working the pump. It appears from the experiments of Lord Charles Cavendiſh, mentioned in the article PNEUMATICS, that water of the temperature 72° was converted into elaſtic vapour, which balanced a preſſure of ¾ths of an inch of mercury, and in this ſtate it occupied the receiver, and did not allow the mercury in the gauge to ſink to the level. As faſt as this was abſtracted by working the air-pump, more of it was produced from the ſurface of the water, ſo that the preſſure continued the ſame, and the water did not boil. Had it been poſſible to produce a vacuum above this water, it would have boiled for a moment, and would even have continued to boil, if the receiver could have been kept very cold.

22 Account of experiments to determine the relation between the temperature of vapour and its elaſticity. Fig. 2.

Upon reading theſe experiments, and ſome very curious ones of Mr Nairne, in the Phil. Tranſ. vol. lxvii. the writer of this article was induced to examine more particularly the relation between the temperature of the vapour and its elaſticity, in the following manner:

ABCD (fig. 2.) is the ſection of a ſmall digeſter made of copper. Its lid, which is faſtened to the body with ſcrews, is pierced with three holes, each of which had a ſmall pipe ſoldered into it. The firſt hole was furniſhed with a braſs ſafety-valve V, nicely fitted to it by grinding. The area of this valve was exactly ¼th of an inch. There reſted on the ſtalk at top of this valve the arm of a ſteelyard carrying a ſliding weight. This arm had a ſcale of equal parts, ſo adjuſted to the weight that the number on the ſcale correſponded to the inches of mercury, whoſe preſſure on the under ſurface of the valve is equal to that of the ſteelyard on its top; ſo that when the weight was at the diviſion 10, the preſſure of the ſteelyard on the valve was juſt equal to that of a column of mercury 10 inches high, and ¼th of an inch baſe. The middle hole contained a thermometer T firmly fixed into it, ſo that no vapour could eſcape by its ſides. The ball of this thermometer was but a little way below the lid. The third hole received occaſionally the end of a glaſs-pipe SGF, whoſe deſcending leg was about 36 inches long. When this ſyphon was not uſed, the hole was properly ſhut with a plug.

The veſſel was half filled with diſtilled water which had been purged of air by boiling. The lid was then fixed on, having the third hole S plugged up. A lamp being placed under the veſſel, the water boiled, and the ſteam iſſued copiouſly by the ſafety-valve. The thermometer ſtood at 213, and a barometer in the room at 29.9 inches. The weight was then put on the fifth diviſion. The thermometer immediately began to riſe; and when it was at 220, the ſteam iſſued by the ſides of

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of the valve. The weight was removed to the 10th division; but before the thermometer could be distinctly observed, the steam was issuing at the valve. The lamp was removed farther from the bottom of the vessel, that the progress of heating might be more moderate; and when the steam ceased to issue from the valve, the thermometer was at 227. The weight was now shifted to 15; and by gradually approaching the lamp, the steam again issued, and the thermometer was at 132½. This mode of trial was continued all the way to the 75th division of the scale. The experiments were then repeated in the contrary order; that is, the weight being suspended at the 75th division, and the steam issuing strongly at the valve, the lamp was withdrawn, and the moment the steam ceased to come out, the thermometer was observed. The same was done at the 70th, 65th, division, &c. These experiments were several times repeated both ways; and the means of all the results for each division are expressed in the following table, where column 1st expresses the elasticity of the steam, being the sum of 29.9, and the division of the steelyard; column 2d expresses the temperature of the steam corresponding to this elasticity.

I.	II.
35 inches.	219°
40	226
45	232
50	237
55	242
60	247
65	251
70	255
75	259
80	263
85	267
90	270½
95	274½
100	278
105	281

A very different process was necessary for ascertaining the elasticity of the steam in lower temperatures, and consequently under smaller pressures than that of the atmosphere. The glass syphon SGF was now fixed into its hole in the lid of the digester. The water was made to boil smartly for some time, and the steam issued copiously both at the valve and at the syphon. The lower end of the syphon was now immersed into a broad saucer of mercury, and the lamp instantly removed, and every thing was allowed to grow cold. By this the steam was gradually condensed, and the mercury rose in the syphon, without sensibly sinking in the saucer. The valve and all the joints were smeared with a thick clammy cement, composed of oil, tallow, and rosin, which effectually prevented all ingress of air. The weather was clear and frosty, and the barometer standing at 29.84, and the thermometer in the vessel at 42°. The mercury in the syphon stood at 29.7, or somewhat higher, thus showing a very complete condensation. The whole vessel was surrounded with pounded ice, of the temperature 32°. This made no sensible change in the height of the mercury. A mark was now made at the surface of the mercury. One observer was stationed at the thermometer, with instructions to call out as the thermometer reached the divisions 42, 47, 52, 57, and so on by every five degrees till it should attain the boiling heat. Another observer noted the corresponding descents of the mercury by a scale of inches, which had its beginning placed at 29.84 from the surface of the mercury in the saucer.

The pounded ice was now removed, and the lamp placed at a considerable distance below the vessel, so as to warm its contents very slowly. These observations being very easily made, were several times repeated, and their mean results are set down in the following table: Only observe, that it was found difficult to note down the descents for every fifth degree, because they succeeded each other so fast. Every 10th was judged sufficient for establishing the law of variation. The first column of the table contains the temperature, and the second the descent (in inches) of the mercury from the mark 29.84.

32°	☿
40	0.1
50	0.2
60	0.35
70	0.55
80	0.82
90	1.18
100	1.61
110	2.25
120	3.00
130	3.95
140	5.15
150	6.72
160	8.65
170	11.05
180	14.05
190	17.85
200	22.62
210	28.65

Four or five numbers at the top of the column of elasticities are not so accurate as the others, because the mercury passed pretty quickly through these points. But the progress was extremely regular through the remaining points; so that the elasticities corresponding to temperatures above 70° may be considered as very accurately ascertained.

Not being altogether satisfied with the method employed for measuring the elasticity in temperatures above that of boiling water, a better form of experiment was adopted. (Indeed it was the want of other apparatus which made it necessary to employ the former). A glass tube was procured of the form represented in fig. 3. having a little cistern L, from the top and bottom of which proceeded the syphons K and MN. The cistern contained mercury, and the tube MN was of a slender bore, and was about six feet two inches long. The end K was firmly fixed in the third hole of the lid, and the long leg of the syphon was furnished with a scale of inches, and firmly fastened to an upright post. Fig. 3.

The lamp was now applied at such a distance from the vessel as to warm it slowly, and make the water boil, the steam escaping for some time through the safety-valve. A heavy weight was then suspended on the steelyard; such as it was known that the vessel would support, and at the same time, such as would not allow the steam to force the mercury out of the long tube. The thermometer began immediately to rise, as also the mercury

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mercury in the tube MN. Their correfpondent ftations are marked in the following table :

Temperature.	*Elafticity.*
212°	0.0
220	5.9
230	14.6
240	25.0
250	36.9
260	50.4
270	64.2
280	106.0

This form of the experiment is much more fufceptible of accuracy than the other, and the meafures of elafticity are more to be depended on. In repeating the experiment, they were found much more conftant; whereas, in the former method, differences occurred of two inches and upwards.

We may now connect the two fets of experiments into one table, by adding to the numbers in this laft table the conftant height 29.9, which was the height of the mercury in the barometer during the laft fet of obfervations.

Temperature.	*Elafticity.*
32°	0.0
40	0.1
50	0.1
60	0.35
70	0.55
80	0.82
90	1.25
100	1.6
110	2.25
120	3.0
130	3.95
140	5.15
150	6.72
160	8.65
170	11.05
180	14.05
190	17.85
200	22.62
210	28.65
220	35.8
230	44.7
240	54.9
250	66.8
260	80.3
270	94.1
280	105.9

23
Which agree well with thofe of Mr Achard.

In the memoirs of the Royal Academy of Berlin for 1782, there is an account of fome experiments made by Mr Achard on the elaftic force of fteam, from the temperature 32° to 212°. They agree extremely well with thofe mentioned here, rarely differing more than two or three tenths of an inch. He alfo examined the elafticity of the vapour produced from alcohol, and found, that when the elafticity was equal to that of the vapour of water, the temperature was about 35° lower. Thus, when the elafticity of both was meafured by 28.1 inches of mercury, the temperature of the watery vapour was 209°, and that of the fpirituous vapour was 173°. When the elafticity was 18.5, the temperature of the water was 189.5, and that of the alcohol 154.6. When the elafticity was 11.05, the water was 168°, and the alcohol 134°.4. Obferving the difference between the temperatures of equally elaftic vapours of water and alcohol not to be conftant, but gradually to diminifh, in Mr Achard's experiments, along with the elafticity, it became interefting to difcover whether and at what temperature this difference would vanifh altogether. Experiments were accordingly made by the writer of this article, fimilar to thofe made with water. They were not made with the fame fcrupulous care, nor repeated as they deferved, but they furnifhed rather an unexpected refult. The following table will give the reader a diftinct notion of them :

Temperature.	*Elafticity.*
32°	0.0
40	0.1
60	0.8
80	0.8
100	3.9
120	6.9
140	12.2
160	21.3
180	34.
200	52.4
220	78.5
240	115.

24
An unexpected refult in comparing the temperatures of equally elaftic vapours of water and alcohol.

We fay that the refult was unexpected ; for as the natural boiling point feemed by former experiments to be in all fluids about 120° or more below their boiling point in the ordinary preffure of the atmofphere, it was reafonable to expect that the temperature at which they ceafed to emit fenfibly elaftic fteam would have fome relation to their temperatures when emitting fteam of any determinate elafticity. Now as the vapour of alcohol of elafticity 30 has its temperature about 36° lower than the temperature of water equally elaftic, it was to be expected that the temperature at which it ceafed to be fenfibly affected would be feveral degrees lower than 32°. It is evident, however, that this is not the cafe. But this is a point that deferves more attention, becaufe it is clofely connected with the chemical relation between the element (if fuch there be) of fire and the bodies into whofe compofition it feems to enter as a conftituent part. What is the temperature 32°, to make it peculiarly connected with elafticity ? It is a temperature affumed by us for our own conveniency, on account of the familiarity of water in our experiments. Ether, we know, boils in a temperature far below this, as appears from Dr Cullen's experiments narrated in the Effays Phyfical and Literary of Edinburgh. On the faith of former experiments, we may be pretty certain that it will boil in vacuo at the temperature —14°, becaufe in the air it boils at +106°. Therefore we may be certain, that the fteam or vapour of ether, when of the temperature 32°, will be very fenfibly elaftic. Indeed Mr Lavoifier fays, that if it be expofed in an exhaufted receiver in winter, its vapour will fupport mercury at the height of 10 inches. A feries of experiments on this vapour fimilar to the above would be very inftructive. We even wifh that thofe on alcohol were more carefully repeated. If we draw a curve line, of which the abfciffa is the line of temperatures, and the ordinates are the correfponding heights of the mercury in thefe experiments on water and alcohol,

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we ſhall obſerve, that although they both ſenſibly coincide at 32°, and have the abſciſſa for their common tangent, a very ſmall error of obſervation may be the cauſe of this, and the curve which expreſſes the elaſticity of ſpirituous vapour may really interſect the other, and go backwards conſiderably beyond 32°.

25
Theſe experiments give riſe to important reflections.

This range of experiments gives riſe to ſome curious and important reflections. We now ſee that no particular temperature is neceſſary for water aſſuming the form of permanently elaſtic vapour; and that it is highly probable that it aſſumes this form even at the temperature 32°; only its elaſticity is too ſmall to afford us any ſenſible meaſure. It is well known that even ice evaporates (ſee experiments to this purpoſe by Mr Wilſon in the Philoſophical Tranſactions, when a piece of poliſhed metal covered with hoar-froſt became perfectly clear by expoſing it to a dry froſty wind).

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Even mercury evaporates, or is converted into elaſtic vapour, when all external preſſure is removed. The dim film which may frequently be obſerved in the upper part of a barometer which ſtands near a ſtream of air, is found to be ſmall globules of mercury ſticking to the inſide of the tube. They may be ſeen by the help of a magnifying glaſs, and are the beſt teſt of a well made barometer. They will be entirely removed by cauſing the mercury to riſe along the tube. It will lick them all up. They conſiſt of mercury which had evaporated in the void ſpace, and was afterwards condenſed by the cold glaſs. But the elaſticity is too ſmall to occaſion a ſenſible depreſſion of the column, even when conſiderably warmed by a candle.

26
Spontaneous evaporation procured by the diſſolving power of the air.

Many philoſophers accordingly imagine, that ſpontaneous evaporation in low temperatures is produced in this way. But we cannot be of this opinion, and muſt ſtill think that this kind of evaporation is produced by the diſſolving power of the air. When moiſt air is ſuddenly rarefied, there is always a precipitation of water. This is moſt diſtinctly ſeen when we work an air-pump briſkly. A miſt is produced, which we ſee plainly fall to the bottom of the receiver. But by this new doctrine the very contrary ſhould happen, becauſe the tendency of water to appear in the elaſtic form is promoted by removing the external preſſure; and we really imagine that more of it now actually becomes ſimple elaſtic watery vapour. But the miſt or precipitation ſhows incontrovertibly, that there had been a previous ſolution. Solution is performed by forces which act in the way of attraction; or, to expreſs it more ſafely, ſolutions are accompanied by the mutual approaches of the particles of the menſtruum and ſolved: all ſuch tendencies are *obſerved* to increaſe by a diminution of diſtance. Hence it *muſt* follow, that air of double denſity will diſſolve more than twice as much water. Therefore when we ſuddenly rarefy ſaturated air (even though its heat ſhould not diminiſh) ſome water muſt be let go. What may be its quantity we know not; but it *may be more* than what would now become elaſtic by this diminution of ſurrounding preſſure; and it is not unlikely but this may have ſome effect in producing the veſicles which we found ſo difficult to explain. Theſe may be filled with pure watery vapour, and be floating in a fluid compoſed of water diſſolved in air. An experiment of Fontana's ſeems to put this matter out of doubt. A diſtilling apparatus AB (fig. 4.) was ſo contrived, that the heat was applied above the ſurface of the water in the alembic A. This was done by incloſing it in another veſſel CC, filled with hot water. In the receiver B there was a ſort of barometer D, with an open ciſtern, in order to ſee what preſſure there was on the ſurface of the fluid. While the receiver and alembic contained air, the heat applied at A produced no ſenſible diſtillation during ſeveral hours: But on opening a cock E in the receiver at its bottom, and making the water in the alembic to boil, ſteam was produced which ſoon expelled all the air, and followed it through the cock. The cock was now ſhut, and the whole allowed to grow cold by removing the fire, and applying cold water to the alembic. The barometer fell to a level nearly. Then warm water was allowed to get into the outer veſſel CC. The barometer roſe a little, and the diſtillation went on briſkly without the ſmalleſt ebullition in the alembic. The concluſion is obvious: while there was air in the receiver and communicating pipe, the diſtillation proceeded entirely by the diſſolving power of this air. Above the water in the alembic it was quickly ſaturated; and this ſaturation proceeded ſlowly along the ſtill air in the communicating pipe, and at laſt might take place through the whole of the receiver. The ſides of the receiver being kept cold, ſhould condenſe part of the water diſſolved in the air in contact with them, and this ſhould trickle down the ſides and be collected. But any perſon who has obſerved how long a cryſtal of blue vitriol will lie at the bottom of a glaſs of ſtill water before the tinge will reach the ſurface, will ſee that it muſt be next to impoſſible for diſtillation to go on in theſe circumſtances; and accordingly none was obſerved. But when the upper part of the apparatus was filled with pure watery vapour, it was ſupplied from the alembic as faſt as it was condenſed in the receiver, juſt as in the pulſe glaſs.

Fig. 4.

27
A certain law in the dilatation of aeriform fluids by heat.

Another inference which may be drawn from theſe experiments is, that Nature ſeems to affect a certain law in the dilatation of aeriform fluids by heat. They ſeem to be dilatable nearly in proportion of their preſent dilatation. For if we ſuppoſe that the vapours reſemble air, in having their elaſticity in any given temperature proportional to their denſity, we muſt ſuppoſe that if ſteam of the elaſticity 60, that is, ſupporting 60 inches of mercury, were ſubjected to a preſſure of 30 inches, it would expand into twice its preſent bulk. The augmentation of elaſticity therefore is the meaſure of the bulk into which it would expand in order to acquire its former elaſticity. Taking the increaſe of elaſticity therefore as a meaſure of the bulk into which it would expand under one conſtant preſſure, we ſee that equal increments of temperature produce nearly equal multiplications of bulk. Thus if a certain diminution of temperature diminiſhes its bulk $\frac{1}{4}$th, another equal diminution of temperature will diminiſh this new bulk $\frac{1}{4}$th very nearly. Thus, in our experiments, the temperatures 110°, 140°, 170°, 200°, 230°, are in arithmetical progreſſion, having equal differences; and we ſee that the correſponding elaſticities 2.25, 5.15, 11.05, 22.62, 44.7, are very nearly in the continued proportion of 1 to 2. The elaſticity correſponding to the temperature 260 deviates conſiderably from this law, which would give 88 or 89 inſtead of 80; and the deviation

deviation increaſes in the higher temperatures. But ſtill we ſee that there is a conſiderable approximation to this law; and it will frequently aſſiſt us to recollect, that whatever be the preſent temperature, an increaſe of 30 degrees doubles the elaſticity and the bulk of watery vapour.

That 4° will increaſe the elaſticity from			1 to $1\frac{1}{10}$
8	-	-	1 to $1\frac{1}{5}$
10	-	-	1 to $1\frac{1}{4}$
$12\frac{1}{2}$	-	-	1 to $1\frac{1}{3}$
18	-	-	1 to $1\frac{1}{2}$
22	-	-	1 to $1\frac{2}{3}$
24	-	-	1 to $1\frac{3}{4}$
26	-	-	1 to $1\frac{4}{5}$

This is ſufficiently exact for moſt practical purpoſes. Thus an engineer finds that the injection cools the cylinder of a ſteam-engine to 192°. It therefore leaves a ſteam whoſe elaſticity is three-fifths of its full elaſticity, = 18 inches ☿. But it is better at all times to have recourſe to the table. Obſerve, too, that in the lower temperatures, i. e. below 110°, this increment of temperature does more than double the elaſticity.

28 Obtains more remarkably in the incoercible vapours.

This law obtains more remarkably in the incoercible vapours; ſuch as vital air, atmoſpheric air, fixed air, &c. all of which have alſo their elaſticity proportional to their bulk inverſely: and perhaps the deviation from the law in ſteams is connected with their chemical difference of conſtitution. If the bulk were always augmented in the ſame proportion by equal augmentations of temperature, the elaſticities would be accurately repreſented by the ordinates of a logarithmic curve, of which the temperatures are the correſponding abſciſſæ; and we might contrive ſuch a ſcale for our thermometer, that the temperatures would be the common logarithms of the elaſticities, or of the bulks having equal elaſticity; or, with our preſent ſcale, we may find ſuch a multiplier m for the number x of degrees of our thermometer (above that temperature where the elaſticity is equal to unity), that this multiple ſhall be the common logarithm of the elaſticity y; ſo that $mx = \log. y$.

But our experiments are not ſufficiently accurate for determining the temperature where the elaſticity is meaſured by 1 inch; becauſe in theſe temperatures the elaſticities vary by exceedingly ſmall quantities. But if we take 11.04 for the unit of elaſticity, and number our temperature from 170°, and make $m = 0.010035$, we ſhall find the product mx to be very nearly the logarithm of the elaſticity. The deviations, however, from this law, are too great to make this equation of any uſe. But it is very practicable to frame an equation which ſhall correſpond with the experiments to any degree of accuracy; and it has been done for air in a tranſlation of General Roy's Meaſurement of the Baſe at Hounſlow Heath into French by Mr Prony. It is as follows: Let x be the degrees of Reaumur's thermometer; let y be the expanſion of 10,000 parts of air; let e be $= 10$, $m = 2.7979$, $n = 0.01768$: then $y = e^{m+nx} - 627.5$. Now e being $= 10$, it is plain that e^{m+nx} is the number, of which $m+nx$ is the common logarithm. This formula is very exact as far as the temperature 60°: but beyond this it needs a correction; becauſe air, like the vapour of water, does not expand in the exact proportion of its bulk.

29 And is conſiderably approximated to in the augmentation of the bulk or elaſticity of elaſtic vapours.

We obſerve this law conſiderably approximated to in the augmentation of the bulk or elaſticity of elaſtic vapours; that is, it is a fact that a given increment of temperature makes very nearly the ſame proportional augmentation of bulk and elaſticity. This gives us ſome notion of the manner in which the ſuppoſed expanding cauſe produces the effect. When vapour of the bulk 4 is expanded into a bulk 5 by an addition of 10 degrees of ſenſible heat, a certain quantity of fire goes into it, and is accumulated round each particle, in ſuch a manner that the temperature of each, which formerly was m, is now $m+10$. Let it now receive another equal augmentation of temperature. This is now $m+20$, and the bulk is $\frac{5\times5}{4}$ or $6\frac{1}{4}$, and the arithmetical increaſe of bulk is $1\frac{1}{4}$. The abſolute quantity of fire which has entered it is greater than the former, both on account of the greater augmentation of ſpace and the greater temperature. Conſequently if this vapour be compreſſed into the bulk 5, there muſt be heat or fire in it which is not neceſſary for the temperature $m+20$, far leſs for the temperature $m+10$. It muſt therefore emerge, and be diſpoſed to enter a thermometer which has already the temperature $m+20$: that is, the vapour muſt grow hotter by compreſſion; not by ſqueezing out the heat, like water out of a ſponge, but becauſe the law of attraction for heat is deranged. It would be a very valuable acquiſition to our knowledge to learn with preciſion the quantity of ſenſible heat produced in this way; but no ſatisfactory experiments have yet been made. M. Lavoiſier, with his chemical friends and colleagues, were buſily employed in this inquiry: but the wickedneſs of their countrymen deprived the world of this and many other important additions which we might have expected from this celebrated and unfortunate philoſopher. He had made, in conjunction with M. de la Place, a numerous train of accurate and expenſive experiments for meaſuring the quantity of latent or combined heat in elaſtic vapours. This is evidently a very important point to the diſtiller and practical chemiſt. This heat muſt all come from the fuel; and it is greatly worth while to know whether any ſaving may be made of this article. Thus we know that diſtillation will go on either under the preſſure of the air, or in an alembic and receiver from which the air has been expelled by ſteam; and we know that this laſt may be conducted in a very low temperature, even not exceeding that of the human body. But it is uncertain whether this may not employ even a greater quantity of fuel, as well as occaſion a great expence of time. We are diſpoſed to think, that when there is no air in the apparatus, and when the condenſation can be ſpeedily performed, the proportion of fuel expended to the fluid which comes over will diminiſh continually as the heat, and conſequently the denſity of the ſteam, is augmented; becauſe in this caſe the quantity of combined heat muſt be leſs. In the mean time, we earneſtly recommend the trial of this mode of diſtillation in veſſels cleared of air. It is undoubtedly of great advantage to be able to work with ſmaller fires; and it would ſecure us againſt all accidents of blowing off the

Steam.

the head of the ſtill, often attended with terrible conſequences (B).

We muſt not conclude this article without taking notice of ſome natural phenomena which ſeem to owe their origin to the action of elaſtic ſteam.

We have already taken notice of the reſemblance of the tremor and ſucceſſions obſerved in the ſhocks of many earthquakes to thoſe which may be felt in a veſſel where water is made to boil internally, while the breaking out of the ebullition is ſtifled by the cold of the upper parts; and we have likewiſe ſtated the objections which are uſually made to this theory of earthquakes. We may perhaps reſume the ſubject under the article VOLCANO; but in the mean time we do not heſitate to ſay, that the wonderful appearances of the Geyzer ſpring in Iceland (ſee HUER; and ICELAND, N° 3—5.) are undoubtedly produced by the expanſion of ſteam in ignited caverns. Of theſe appearances we ſuppoſe the whole train to be produced as follows.

30 Explanation of the phenomena of the Geyzer ſpring in Iceland by the force of ſteam. Fig. 5.

A cavern may be ſuppoſed of a ſhape analogous to CBDEF (fig. 5.), having a perpendicular funnel AB iſſuing from a depreſſed part of the roof. The part F may be lower than the reſt, remote, and red-hot. Such places we know to be frequent in Iceland. Water may be continually trickling into the part CD. It will fill it up to B, and even up to E *e*, and then trickle ſlowly along into F. As ſoon as any gets into contact with an ignited part, it expands into elaſtic ſteam, and is partly condenſed by the cold ſides of the cavern, which it gradually warms, till it condenſes no more. This production of ſteam hinders not in the ſmalleſt degree the trickling of more water into F, and the continual production of more ſteam. This now preſſes on the ſurface of the water in CD, and cauſes it to riſe gradually in the funnel BA; but ſlowly, becauſe its cold ſurface is condenſing an immenſe quantity of ſteam. We may eaſily ſuppoſe that the water trickles faſter into F than it is expended in the production of ſteam; ſo that it reaches farther into the ignited part, and may even fall in a ſtream into ſome deeper pit highly ignited. It will now produce ſteam in vaſt abundance, and of prodigious elaſticity; and at once puſh up the water through the funnel in a ſolid jet, and to a great height. This muſt continue till the ſurface of the water ſinks to BD. If the lower end of the funnel have any inequalities or notches, as is moſt likely, the ſteam will get admiſſion along with the water, which in this particular place is boiling hot, being ſuperficial, and will get to the mouth of the funnel, while water is ſtill preſſed in below. At laſt the ſteam gets in at B on all ſides; and as it is converging to B, along the ſurface of the water, with prodigious velocity it ſweeps along with it much water, and blows it up through the funnel with great force. When this is over, the remaining ſteam blows out unmixed with water, growing weaker as it is expended, till the bottom of the funnel is again ſtopped by the water increaſing in the cavern CBD. All the phenomena above ground are perfectly conformable to the neceſſary conſequences of this very probable conſtruction of the cavern. The feeling of being lifted up, immediately before the jet, in all probability is owing to a real heaving up of the whole roof of the cavern by the firſt expanſion of the great body of ſteam. We had an accurate deſcription of the phenomena from perſons well qualified to judge of theſe matters who viſited theſe celebrated ſprings in 1789.

STEAM-Engine, is the name of a machine which derives its moving power from the elaſticity and condenſibility of the ſteam of boiling water. It is the moſt valuable preſent which the arts of life have ever received from the philoſopher. The mariner's compaſs, the teleſcope, gunpowder, and other moſt uſeful ſervants to human weakneſs and ingenuity, were the productions of chance, and we do not exactly know to whom we are indebted for them; but the ſteam-engine was, in the very beginning, the reſult of reflection, and the production of a very ingenious mind; and every improvement it has received, and every alteration in its conſtruction and principles, were alſo the reſults of philoſophical ſtudy.

1 Steam engine invented by the marquis of Worceſter.

The ſteam-engine was beyond all doubt invented by the marquis of Worceſter during the reign of Charles II. This nobleman publiſhed in 1663 a ſmall book entitled A CENTURY OF INVENTIONS; giving ſome obſcure and enigmatical account of an hundred diſcoveries or contrivances of his own, which he extols as of great importance to the public. He appears to have been a perſon of much knowledge and great ingenuity: but his deſcription or accounts of theſe inventions ſeem not ſo much intended to inſtruct the public, as to raiſe wonder; and his encomiums on their utility and importance

(B) We earneſtly recommend this ſubject to the conſideration of the philoſopher. The laws which regulate the formation of elaſtic vapour, or the general phenomena which it exhibits, give us that link which connects chemiſtry with mechanical philoſophy. Here we ſee chemical affinities and mechanical forces ſet in immediate oppoſition to each other, and the one made the indication, characteriſtic, and meaſure of the other. We have not the leaſt doubt that they make but one ſcience, the Science of Univerſal Mechanics; nor do we deſpair of ſeeing the phenomena of ſolution, precipitation, cryſtallization, fermentation, nay animal and vegetable ſecretion and aſſimilation, ſucceſsfully inveſtigated, as caſes of local motion, and explained by the agency of central forces. Some thing of this kind, and that not inconſiderable, was done when Dr Cullen firſt ſhowed how the double affinities might be illuſtrated by the aſſiſtance of numbers. Dr Black gave to this hint (for it was little more) that elegant preciſion which characterizes all his views. Mr Kirwan has greatly promoted this ſtudy by his numerous and ingenious examples of its application; and the moſt valuable paſſages of the writings of Mr Lavoiſier, are thoſe where he traces with logical preciſion the balancings of force which appear in the chemical phenomena. It is from the ſimilar balancings and conſequent meaſurements, which may be obſerved and obtained in the preſent caſe, that we are to hope for admiſſion into this almoſt unbounded ſcience of contemplation. We have another link equally intereſting and promiſing, viz. the production of heat by friction. This alſo highly deſerves the conſideration of the mathematical philoſopher.

ance are to a great degree extravagant, reſembling more the puff of an advertiſing tradeſman than the patriotic communications of a gentleman. The marquis of Worceſter was indeed a projector, and very importunate and myſterious withal in his applications for public encouragement. His account, however, of the ſteam-engine, although by no means fit to give us any diſtinct notions of its ſtructure and operation, is exact as far as it goes, agreeing preciſely with what we now know of the ſubject. It is N° 68. of his inventions. His words are as follow: "This admirable method which I propoſe of raiſing water by the force of fire has no bounds if the veſſels be ſtrong enough: for I have taken a cannon, and having filled it three-fourths full of water, and ſhut up its muzzle and touch-hole, and expoſed it to the fire for 24 hours, it burſt with a great exploſion. Having afterwards diſcovered a method of fortifying veſſels internally, and combined them in ſuch a way that they filled and acted alternately, I have made the water ſpout in an uninterrupted ſtream 40 feet high; and one veſſel of rarefied water raiſed 40 of cold water. The perſon who conducted the operation had nothing to do but turn two cocks; ſo that one veſſel of water being conſumed, another begins to force, and then to fill itſelf with cold water, and ſo on in ſucceſſion."

2 But firſt reduced to practice by Captain Savary.

It does not appear that the noble inventor could ever intereſt the public by theſe accounts. His character as a projector, and the many failures which perſons of this turn of mind daily experience, probably prejudiced people againſt him, and prevented all attention to his projects. It was not till towards the end of the century, when experimental philoſophy was proſecuted all over Europe with uncommon ardour, that theſe notions again engaged attention. Captain Savary, a perſon alſo of great ingenuity and ardent mind, ſaw the reality and practicability of the marquis of Worceſter's project. He knew the great expanſive power of ſteam, and had diſcovered the inconceivable rapidity with which it is reconverted into water by cold; and he ſoon contrived a machine for raiſing water, in which both of theſe properties were employed. He ſays, that it was entirely his own invention. Dr Deſaguiliers inſiſts that he only copied the marquis's invention, and charges him with groſs plagiariſm, and with having bought up and burned the copies of the marquis's book, in order to ſecure the honour of the diſcovery to himſelf. This is a very grievous charge, and ſhould have been ſubſtantiated by very diſtinct evidence. Deſaguiliers produces none ſuch; and he was much too late to know what happened at that time. The argument which he gives is a very fooliſh one, and gave him no title to conſider Savary's experiment as a falſehood; for it might have happened preciſely as Savary relates, and not as it happened to Deſaguiliers. The fact is, that Savary obtained his patent of invention after a hearing of objections, among which the diſcovery of the marquis of Worceſter was not mentioned; and it is certain that the account given in the Century of Inventions could inſtruct no perſon who was not ſufficiently acquainted with the properties of ſteam to be able to invent the machine himſelf.

3 Papin has no claim to the invention as the French pretend.

Captain Savary obtained his patent *after having actually erected* ſeveral machines, of which he gave a deſcription in a book intitled THE MINER'S FRIEND, publiſhed in 1696, and in another work publiſhed in 1699. Much about this time Dr Papin, a Frenchman and fellow of the Royal Society, invented a method of diſſolving bones and other animal ſolids in water, by confining them in cloſe veſſels, which he called DIGESTERS, ſo as to acquire a great degree of heat. For it muſt be obſerved in this place, that it had been diſcovered long before (in 1684) by Dr Hooke, the moſt inquiſitive experimental philoſopher of that inquiſitive age, that water could not be made to acquire above a certain temperature in the open air; and that as ſoon as it begins to boil, its temperature remains fixed, and an increaſe of heat only produces a more violent ebullition, and a more rapid waſte. But Papin's experiments made the elaſtic power of ſteam very familiar to him: and when he left England and ſettled as profeſſor of mathematics at Marpurgh, he made many aukward attempts to employ this force in mechanics, and even for raiſing water. It appears that he had made experiments with this view in 1698, by order of Charles, landgrave of Heſſe. For this reaſon the French affect to conſider him as the inventor of the ſteam-engine. He indeed publiſhed ſome account of his invention in 1707; but he acknowledges that Captain Savary had alſo, and without any communication with him, invented the ſame thing. Whoever will take the trouble of looking at the deſcription which he has given of theſe inventions, which are to be ſeen in the *Acta Eruditorum Lipſiæ*, and in Leupold's *Theatrum Machinarum*, will ſee that they are moſt aukward, abſurd, and impracticable. His conceptions of natural operations were always vague and imperfect, and he was neither philoſopher nor mechanician.

We are thus anxious about the claim of thoſe gentlemen, becauſe a moſt reſpectable French author, Mr Boſſut, ſays in his *Hydrodynamique*, that the firſt notion of the ſteam-engine was *certainly* owing to Dr Papin, who had not only invented the digeſter, but had in 1695 publiſhed a little performance deſcribing a machine for raiſing water, in which the piſtons are moved by the vapour of boiling water alternately dilated and condenſed. Now the fact is, that Papin's firſt publication was in 1707, and his piſton is nothing more than a floater on the ſurface of the water, to prevent the waſte of ſteam by condenſation; and the return of the piſton is not produced, as in the ſteam-engine, by the condenſation of the ſteam, but by admitting the air and a column of water to preſs it back into its place. The whole contrivance is ſo aukward, and ſo unlike any diſtinct notions of the ſubject, that it cannot do credit to any perſon. We may add, that much about the ſame time Mr Amontons contrived a very ingenious but intricate machine, which he called a *fire-wheel*. It conſiſted of a number of buckets placed in the circumference of a wheel, and communicating with each other by very intricate circuitous paſſages. One part of this circumference was expoſed to the heat of a furnace, and another to a ſtream or ciſtern of cold water. The communications were ſo diſpoſed, that the ſteam produced in the buckets on one ſide of the wheel drove the water into buckets on the other ſide, ſo that one ſide of the wheel was always much heavier than the other; and it muſt therefore turn round, and may execute ſome work. The death of the inventor, and the intricacy of the machine, cauſed it to be neglected. Another member of the Pariſian academy of ſciences (Mr Deſlandes) alſo preſented to the academy a project of a ſteam-wheel, where the impulſive force of the vapour 4 Mr Amontons's fire-wheel.

Steam-Engine.

pour was employed; but it met with no encouragement. The English engineers had by this time so much improved Savary's first invention, that it supplanted all others. We have therefore no hesitation in giving the honour of the first and complete invention to the marquis of Worcester; and we are not disposed to refuse Captain Savary's claim to originality as to the construction of the machine, and even think it probable that his own experiments made him see the whole, independent of the marquis's account.

Captain Savary's engine, as improved and simplified by himself, is as follows.

5 Captain Savary's steam-engine described.

Fig. 6.

A (fig. 6.) represents a strong copper boiler properly built up in a furnace. There proceeds from its top a large steam-pipe B, which enters into the top of another strong vessel R called the RECEIVER. This pipe has a cock at C called the STEAM-COCK. In the bottom of the receiver is a pipe F, which communicates sidewise with the rising pipe KGH. The lower end H of this pipe is immersed in the water of the pit or well, and its upper part K opens into the cistern into which the water is to be delivered. Immediately below the pipe of communication F there is a valve G, opening when pressed from below, and shutting when pressed downwards. A similar valve is placed at I, immediately above the pipe of communication. Lastly, there is a pipe ED which branches off from the rising pipe, and enters into the top of the receiver. This pipe has a cock D called the INJECTION-COCK. The mouth of the pipe ED has a nozzle *f* pierced with small holes, pointing from a centre in every direction. The keys of the two cocks C and D are united, and the handle *g h* is called the REGULATOR.

Let the regulator be so placed that the steam-cock C is open and the injection-cock D is shut; put water into the boiler A, and make it boil strongly. The steam coming from it will enter the receiver, and gradually warm it, much steam being condensed in producing this effect. When it has been warmed so as to condense no more, the steam proceeds into the rising pipe; the valve G remains shut by its weight; the steam lifts the valve I, and gets into the rising pipe, and gradually warms it. When the workman feels this to be the case, or hears the rattling of the valve I, he immediately turns the steam-cock so as to shut it, the injection-cock still remaining shut (at least we may suppose this for the present.) The apparatus must now cool, and the steam in the receiver collapses into water. There is nothing now to balance the pressure of the atmosphere; the valve I remains shut by its weight; but the air incumbent on the water in the pit presses up this water through the suction-pipe HG, and causes it to lift the valve G, and flow into the receiver R, and fill it to the top, if not more than 20 or 25 feet above the surface of the pit water.

The steam-cock is now opened. The steam which, during the cooling of the receiver, has been accumulating in the boiler, and acquiring a great elasticity by the action of the fire, now rushes in with great violence, and, pressing on the surface of the water in the receiver, causes it to shut the valve G and open the valve I by its weight alone, and it now flows into the rising pipe, and would stand on a level if the elasticity of the steam were no more than what would balance the atmospherical pressure. But it is much more than this, and therefore it *presses* the water out of the receiver into the rising pipe, and will even cause it to come out at K, if the elasticity of the steam is sufficiently great. In order to ensure this, the boiler has another pipe in its top, covered with a *safety*-valve V, which is kept down by a weight W suspended on a steelyard LM. This weight is so adjusted that its pressure on the safety-valve is somewhat greater than the pressure of a column of water V*k* as high as the point of discharge K. The fire is so regulated that the steam is always issuing a little by the loaded valve V. The workman keeps the steam-valve open till he hears the valve I rattle. This tells him that the water is all forced out of the receiver, and that the steam is now following it. He immediately turns the regulator which shuts the steam-cock, and now, for the first time, opens the injection-cock. The cold water trickles at first through the holes of the nozzle *f*, and falling down through the steam, begins to condense it; and then its elasticity being less than the pressure of the water in the pipe KED*f*, the cold water spouts in all directions through the nozzle, and, quick as thought, produces a complete condensation. The valve G now opens again by the pressure of the atmosphere on the water of the pit, and the receiver is soon filled with cold water. The injection-cock is now shut, and the steam-cock opened, and the whole operation is now repeated; and so on continually.

This is the simple account of the process, and will serve to give the reader an introductory notion of the operation; but a more minute attention must be paid to many particulars before we can see the properties and defects of this ingenious machine.

6 Defects of this machine such,

The water is driven along the rising pipe by the elasticity of the steam. This must in the boiler, and every part of the machine, exert a pressure on every square inch of the vessels equal to that of the upright column of water. Suppose the water to be raised 100 feet, about 25 of this may be done in the suction-pipe; that is, the upper part of the receiver may be about 25 feet above the surface of the pit-water. The remaining 75 must be done by forcing, and every square inch of the boiler will be squeezed out by a pressure of more than 30 pounds. This very moderate height therefore requires very strong vessels; and the marquis of Worcester was well aware of the danger of their bursting. A copper boiler of six feet diameter must be nine-tenths of an inch thick to be just in equilibrio with this pressure: and the soldered joint will not be able to withstand it, especially in the high temperature to which the water must be heated in order to produce steam of sufficient elasticity. By consulting the table of the elasticity of steam deduced from our experiments mentioned in the preceding article, we see that this temperature must be at least 280° of Fahrenheit's thermometer. In this heat soft solder is just ready to melt, and has no tenacity; even spelter solder is considerably weakened by it. Accordingly, in a machine erected by Dr Desaguiliers, the workman having loaded the safety-valve a little more than usual to make the engine work more briskly, the boiler burst with a dreadful explosion, and blew up the furnace and adjoining parts of the building as if it had been gunpowder. Mr Savary succeeded pretty well in raising moderate quantities of water to small heights, but could make nothing of deep mines. Many attempts were made, on the marquis's

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quis's principle, to ſtrengthen the veſſels from within by radiated bars and by hoops, but in vain. Very ſmall boilers or evaporators were then tried, kept red hot, or nearly ſo, and ſupplied with a ſlender ſtream of water trickling into them; but this afforded no opportunity of making a collection of ſteam during the refrigeration of the receiver, ſo as to have a magazine of ſteam in readineſs for the next forcing operation; and the working of ſuch machines was always an employment of great danger and anxiety.

7
that it can be employed with advantage only in certain ſituations.

The only ſituation in which this machine could be employed with perfect ſafety, and with ſome effect, was where the whole lift did not exceed 30 or 35 feet. In this caſe the greateſt part of it was performed by the ſuction-pipe, and a very manageable preſſure was ſufficient for the reſt. Several machines of this kind were erected in England about the beginning of this century. A very large one was erected at a ſalt-work in the ſouth of France. Here the water was to be raiſed no more than 18 feet. The receiver was capacious, and it was occaſionally ſupplied with ſteam from a ſmall ſalt-pan conſtructed on purpoſe with a cover. The entry of the ſteam into the receiver merely allowed the water to run out of it by a large valve, which was opened by the hand, and the condenſation was produced by the help of a ſmall forcing pump alſo worked by the hand. In ſo particular a ſituation as this (and many ſuch may occur in the endleſs variety of human wants), this is a very powerful engine; and having few moving and rubbing parts, it muſt be of great durability. This circumſtance has occaſioned much attention to be given to this firſt form of the engine, even long after it was ſupplanted by thoſe of a much better conſtruction. A very ingenious attempt was made very lately to adapt this conſtruction to the uſes of the miners. The whole depth of the pit was divided into lifts of 15 feet, in the ſame manner as is frequently done in pump-machines. In each of theſe was a ſuction-pipe 14 feet long, having above it a ſmall receiver like R, about a foot high, and its capacity ſomewhat greater than that of the pipe. This receiver had a valve at the head of the ſuction-pipe, and another opening outwards into the little ciſtern, into which the next ſuction-pipe above dipped to take in water. Each of theſe receivers ſent up a pipe from its top, which all met in the cover of a large veſſel above ground, which was of double the capacity of all the receivers and pipes. This veſſel was cloſe on all ſides. Another veſſel of equal capacity was placed immediately above it, with a pipe from its bottom paſſing through the cover of the lower veſſel and reaching near to its bottom. This upper veſſel communicates with the boiler, and conſtitutes the receiver of the ſteam-engine. The operation is as follows: The lower veſſel is full of water. Steam is admitted into the upper veſſel, which expels the air by a valve, and fills the veſſel. It is then condenſed by cold water. The preſſure of the atmoſphere would cauſe it to enter by all the ſuction-pipes of the different lifts, and preſs on the ſurface of the water in the lower receiver, and force it into the upper one. But becauſe each ſuction-pipe dips in a ciſtern of water, the air preſſes this water before it, raiſes it into each of the little receivers which it fills, and allows the ſpring of the air (which was formerly in them, but which now paſſes up into the lower receiver) to force the water out of the lower receiver into the upper one. When this has been completed, the ſteam is again admitted into the upper receiver. This allows the water to run back into the lower receiver, and the air returns into the ſmall receivers in the pit, and allows the water to run out of each into its proper ciſtern. By this means the water of each pipe has been raiſed 15 feet. The operation may thus be repeated continually.

The contrivance is ingenious, and ſimilar to thoſe which are to be met with in the hydraulics of Schottus, Sturmius, and other German writers. But the operation muſt be exceedingly ſlow; and we imagine that the expence of ſteam muſt be great, becauſe it muſt fill a very large and very cold veſſel, which muſt waſte a great portion of it by condenſation. We ſee by ſome late publications of the very ingenious Mr Blackey, that he is ſtill attempting to maintain the reputation of this machine by ſome contrivances of this kind; but we imagine that they will be ineffectual, except in ſome very particular ſituations.

8
Occaſions great waſte of ſteam and fuel.

For the great defect of the machine, even when we can ſecure it againſt all riſk of burſting, is the prodigious waſte of ſteam, and conſequently of fuel. Daily experience ſhows, that a few ſcattered drops of cold water are ſufficient for producing an almoſt inſtantaneous condenſation of a great quantity of ſteam. Therefore when the ſteam is admitted into the receiver of Savary's engine, and comes into contact with the cold top and cold water, it is condenſed with great rapidity; and the water does not *begin* to ſubſide till its ſurface has become ſo hot that it condenſes no more ſteam. It may now begin to yield to the preſſure of the incumbent ſteam; but as ſoon as it deſcends a little, more of the cold ſurface of the receiver comes into contact with the ſteam, and condenſes more of it, and the water can deſcend no farther till this addition of cold ſurface is heated up to the ſtate of evaporation. This rapid condenſation goes on all the while the water is deſcending. By ſome experiments frequently repeated by the writer of this article, it appears that no leſs than $\frac{11}{12}$ths of the whole ſteam is uſeleſsly condenſed in this manner, and not more than $\frac{1}{12}$th is employed in allowing the water to deſcend by its own weight; and he has reaſon to think that the portion thus waſted will be conſiderably greater, if the ſteam be employed to *force* the water out of the receiver to any conſiderable height.

Obſerve, too, that all this waſte muſt be repeated in every ſucceeding ſtroke; for the whole receiver muſt be cooled again in order to fill itſelf with water.

9
The attempts made to diminiſh this waſte unſucceſsful.

Many attempts have been made to diminiſh this waſte; but all to little purpoſe, becauſe the very filling of the receiver with cold water occaſions its ſides to condenſe a prodigious quantity of ſteam in the ſucceeding ſtroke. Mr Blackey has attempted to leſſen this by uſing two receivers. In the firſt was oil; and into this only the ſteam was admitted. This oil paſſed to and fro between the two receivers, and never touched the water except in a ſmall ſurface. But this hardly produced a ſenſible diminution of the waſte: for it muſt now be obſerved, that there is a neceſſity for the firſt cylinder's being cooled to a conſiderable degree below the boiling point; otherwiſe, though it will condenſe much ſteam, and allow the water to riſe into the receiver, there will be a great diminution of the height of ſuction, unleſs the veſſel be much cooled. This appears plainly by

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by inſpecting the table of elaſticity. Thus, if the veſſel be cooled no lower than 180°, we ſhould loſe one half of the preſſure of the atmoſphere; if cooled to 120, we ſhould ſtill loſe $\frac{1}{10}$th. The inſpection of this table is of great uſe for underſtanding and improving this noble machine; and without a conſtant recollection of the elaſticity of ſteam correſponding to its actual heat, we ſhall never have a notion of the niceties of its operation.

10
The aſtoniſhing rapidity with which ſteam is condenſed.

The rapidity with which the ſteam is condenſed is really aſtoniſhing. Experiments have been made on ſteam-veſſels of ſix feet in diameter and ſeven feet high; and it has been found, that about four ounces of water, as warm as the human blood, will produce a complete condenſation in leſs than a ſecond; that is, will produce all the condenſation that it is capable of producing, leaving an elaſticity about one-fifth of the elaſticity of the air. In another experiment with the ſame ſteam-veſſel, no cold water was allowed to get into it, but it was made to communicate by a long pipe four inches in diameter with another veſſel immerſed in cold water. The condenſation was ſo rapid that the time could not be meaſured: it certainly did not exceed half a ſecond. Now this condenſation was performed by a very trifling ſurface of contact. Perhaps we may explain it a little in this way: When a maſs of ſteam, in immediate contact with the cold water, is condenſed, it leaves a void, into which the adjoining ſteam inſtantly expands; and by this very expanſion its capacity for heat is increaſed, or it grows cold, that is, abſtracts the heat from the ſteam ſituated immediately beyond it. And in this expanſion and refrigeration it is itſelf partly condenſed or converted into water, and leaves a void, into which the circumjacent ſteam immediately expands, and produces the ſame effect on the ſteam beyond it. And thus it may happen that the abſtraction of a ſmall quantity of heat from an inconſiderable maſs of ſteam may produce a condenſation which may be very extenſive. Did we know the change made in the capacity of ſteam for heat by a given change of bulk, we ſhould be able to tell exactly what would be the effect of this local actual condenſation. But experiment has not as yet given us any preciſe notions on this ſubject. We think that this rapid condenſation to a great diſtance by a very moderate actual abſtraction of heat is a proof that the capacity of ſteam for heat is prodigiouſly increaſed by expanſion. We ſay a *very moderate actual abſtraction* of heat, becauſe very little heat is neceſſary to raiſe four ounces of blood-warm water to a boiling temperature, which will unfit it for condenſing ſteam. The remarkable phenomenon of ſnow and ice produced in the Hungarian machine, when the air condenſed in the receiver is allowed to blow through the cock (ſee PNEUMATICS), ſhows this to be the caſe in moiſt air, that is, in air holding water in a ſtate of chemical ſolution. We ſee ſomething very like it in a thunder-ſtorm. A ſmall black cloud ſometimes appears in a particular ſpot, and in a very few ſeconds ſpreads over many hundred acres of ſky, that is, a precipitation of water goes on with that rapid diffuſion. We imagine that this increaſe of capacity or demand for heat, and the condenſation that muſt enſue if this demand is not ſupplied, is much more remarkable in pure watery vapours, and that this is a capital diſtinction of their conſtitution from vapours diſſolved in air (A).

The reader muſt now be ſo well acquainted with what paſſes in the ſteam-veſſel, and with the exterior reſults from it, as readily to comprehend the propriety of the changes which we ſhall now deſcribe as having been made in the conſtruction and principle of the ſteam engine. 11

Attempts to improve the ſteam-engine.

Of all places in England the tin-mines of Cornwall ſtood moſt in need of hydraulic aſſiſtance; and Mr Savary was much engaged in projects for draining them by his ſteam-engine. This made its conſtruction and principles well known among the machiniſts and engineers of that neighbourhood. Among theſe were a Mr Newcomen, an ironmonger or blackſmith, and Mr Cawley a glazier at Dartmouth in Devonſhire, who had dabbled much with this machine. Newcomen was a perſon of ſome reading, and was in particular acquainted with the perſon, writings, and projects of his countryman Dr Hooke. There are to be found among Hooke's papers, in the poſſeſſion of the Royal Society, ſome notes of obſervations, for the uſe of Newcomen his countryman, on Papin's boaſted method of tranſmitting to a great diſtance the action of a mill by means of pipes. Papin's project was to employ the mill to work two air-pumps of great diameter. The cylinders of theſe pumps were to communicate by means of pipes with equal cylinders furniſhed with piſtons, in the neighbourhood of a diſtant mine. Theſe piſtons were to be connected, by means of levers, with the piſton-rods of the mine. Therefore, when the piſton of the air-pump at the mill was drawn up by the mill, the correſponding piſton at the ſide of the mine would be preſſed down by the atmoſphere, and thus would raiſe the piſton-rod in the mine, and draw the water. It would appear from theſe notes, that Dr Hooke had diſſuaded Mr Newcomen from erecting a machine on this principle, of which he had expoſed the fallacy in ſeveral diſcourſes before the Royal Society. One paſſage is remarkable. "Could he (meaning Papin) make a ſpeedy vacuum under your ſecond piſton, your work is done."

It is highly probable that, in the courſe of this ſpeculation, it occurred to Mr Newcomen that the vacuum he ſo much wanted might be produced by ſteam, and that this gave riſe to his new principle and conſtruction of the ſteam-engine. The ſpecific deſideratum was in Newcomen's mind; and therefore, when Savary's engine appeared, and became known in his neighbourhood many years after, he would readily catch at the help which it promiſed.

Savary, however, claims the invention as his own; but Switzer, who was perſonally acquainted with both, is poſitive that Newcomen was the inventor. By his principles (as a quaker) being averſe from contention, he was contented to ſhare the honour and the profits with Savary, whoſe acquaintance at court enabled him to procure the patent in 1705, in which all the three were aſſociated. Poſterity has done juſtice to the modeſt inventor, and the machine is univerſally called NEWCOMEN'S

(A) But if it has been found that the condenſation requires more cold water than what is allowed above, and it is ſuſpected that the rapidity of condenſing a large volume of ſteam by the cold ſurface of a veſſel is overrated.

Steam-Engine. MEN'S ENGINE. Its principle and mode of operation may be clearly conceived as follows.

12 Description of Newcomen's. Fig. 7. Let A (fig. 7.) reprefent a great boiler properly built in a furnace. At a fmall height above it is a cylinder CBBC of metal, bored very truly and fmoothly. The boiler communicates with this cylinder by means of the throat or fteam-pipe NQ. The lower aperture of this pipe is fhut by the plate N, which is ground very flat, fo as to apply very accurately to the whole circumference of the orifice. This plate is called the regulator or fteam-cock, and it turns horizontally round an axis *b a* which paffes through the top of the boiler, and is nicely fitted to the focket, like the key of a cock, by grinding. The upper end of this axis is furnifhed with a handle *b* T.

A pifton P is fufpended in this cylinder, and made air-tight by a packing of leather or foft rope, well filled with tallow; and, for greater fecurity, a fmall quantity of water is kept above the pifton. The pifton-rod PD is fufpended by a chain which is fixed to the upper extremity F of the arched head FD of the great lever or WORKING BEAM HK, which turns on the gudgeon O. There is a fimilar arched head EG at the other end of the beam. To its upper extremity E is fixed a chain carrying the pump-rod XL, which raifes the water from the mine. The load on this end of the beam is made to exceed confiderably the weight of the pifton P at the other extremity.

At fome fmall height above the top of the cylinder is a ciftern W called the INJECTION CISTERN. From this defcends the INJECTION PIPE ZSR, which enters the cylinder through its bottom, and terminates in a fmall hole R, or fometimes in a nozzle pierced with many fmaller holes diverging from a centre in all directions. This pipe has at S a cock called the INJECTION COCK, fitted with a handle V.

At the oppofite fide of the cylinder, a little above its bottom, there is a lateral pipe, turning upwards at the extremity, and there covered by a clack-valve *f*, called the SNIFTING VALVE, which has a little difh round it to hold water for keeping it air-tight.

There proceeds alfo from the bottom of the cylinder a pipe *d e g h* (paffing behind the boiler), of which the lower end is turned upwards, and is covered with a valve *h*. This part is immerfed in a ciftern of water Y, called the HOT WELL, and the pipe itfelf is called the EDUCTION PIPE. Laftly, the boiler is furnifhed with a fafety-valve called the PUPPET CLACK (which is not reprefented in this fketch for want of room), in the fame manner as Savary's engine. This valve is generally loaded with one or two pounds on the fquare inch, fo that it allows the fteam to efcape when its elafticity is one-tenth greater than that of common air. Thus all rifk of burfting the boiler is avoided, and the preffure outwards is very moderate; fo alfo is the heat. For, by infpecting the table of vaporous elafticity, we fee that the heat correfponding to 32 inches of elafticity is only about 216° of Fahrenheit's thermometer.

Thefe are all the effential parts of the engine, and are here drawn in the moft fimple form, till our knowledge of their particular offices fhall fhow the propriety of the peculiar forms which are given to them. Let us now fee how the machine is put in motion, and what is the nature of its work.

The water in the boiler being fuppofed to be in a ftate of ftrong ebullition, and the fteam iffuing by the fafety-valve, let us confider the machine in a ftate of reft, having both the fteam-cock and injection-cock fhut. 13 How the machine is put in motion, and the nature of the work. The refting pofition or attitude of the machine muft be fuch as appears in fketch, the pump rods preponderating, and the great pifton being drawn up to the top of the cylinder. Now open the fteam-cock by turning the handle T of the regulator. The fteam from the boiler will immediately rufh in, and flying all over the cylinder, will mix with the air. Much of it will be condenfed by the cold furface of the cylinder and pifton, and the water produced from it will trickle down the fides, and run off by the eduction-pipe. This condenfation and wafte of fteam will continue till the whole cylinder and pifton are made as hot as boiling water. When this happens, the fteam will begin to open the fnifting valve *f*, and iffue through the pipe; flowly at firft and very cloudy, being mixed with much air. The blaft at *f* will grow ftronger by degrees, and more tranfparent, having already carried off the greateft part of the common air which filled the cylinder. We fuppofed that the water was boiling brifkly, fo that the fteam was iffuing by the fafety-valve which is in the top of the boiler, and through every crevice. The opening of the fteam-cock puts an end to this at once, and it has fometimes happened that the cold cylinder abftracts the fteam from the boiler with fuch aftonifhing rapidity, that the preffure of the atmofphere has burft up the bottom of the boiler. We may here mention an accident of which we were witneffes, which alfo fhows the the immenfe rapidity of the condenfation. The boiler was in a frail fhed at the fide of the engine-houfe; a fhoot of fnow from the top of the houfe fell down and broke through the roof of the fhed, and was fcattered over the head of the boiler, which was of an oblong or oval fhape. In an inftant the fides of it were fqueezed together by the preffure of the atmofphere.

When the manager of the engine perceives that not only the blaft at the fnifting valve is ftrong and fteady, but that the boiler is now fully fupplied with fteam of a proper ftrength, appearing by the renewal of the difcharge at the fafety-valve, he fhuts the fteam-cock, and opens the injection-cock S by turning its handle V. The preffure of the column of water in the injection-pipe ZS immediately forces fome water through the fpout R. This coming in contact with the pure vapour which now fills the cylinder, condenfes it, and thus makes a partial void, into which the more diftant fteam immediately expands, and by expanding collapfes (as has been already obferved). What remains in the cylinder no longer balances the atmofpherical preffure on the furface of the water in the injection ciftern, and therefore the water fpouts rapidly through the hole R by the joint action of the column ZS, and the unbalanced preffure of the atmofphere; at the fame time the fnifting-valve *f*, and the eduction-valve *h*, are fhut by the unbalanced preffure of the atmofphere. The velocity of the injection water muft therefore rapidly increafe, and the jet will dafh (if fingle) againft the bottom of the pifton, and be fcattered through the whole capacity of the cylinder. In a very fhort fpace of time, therefore, the condenfation of the fteam becomes univerfal, and the elafticity of what remains is almoft nothing. The whole preffure preſſure of the atmoſphere is exerted in the upper ſurface of the piſton, while there is hardly any on its under ſide. Therefore, if the load on the outer end E of the working beam is inferior to this preſſure, it muſt yield to it. The piſton P muſt deſcend, and the pump piſton L muſt aſcend, bringing along with it the water of the mine, and the motion muſt continue till the great piſton reaches the bottom of the cylinder; for it is not like the motion which would take place in a cylinder of air rarefied to the ſame degree. In this laſt caſe, the impelling force would be continually diminiſhed, becauſe the capacity of the cylinder is diminiſhed by the deſcent of the piſton, and the air in it is continually becoming more denſe and elaſtic. The piſton would ſtop at a certain height, where the elaſticity of the included air, together with the load at E, would balance the atmoſpherical preſſure on the piſton. But when the contents of the cylinder are pure vapour, and the continued ſtream of injected cold water keeps down its temperature to the ſame pitch as at the beginning, the elaſticity of the remaining ſteam can never increaſe by the deſcent of the piſton, nor exceed what correſponds to this temperature. The impelling or accelerating force therefore remains the ſame, and the deſcent of the piſton will be uniformly accelerated, if there is not an increaſe of reſiſtance ariſing from the nature of the work performed by the other end of the beam. This circumſtance will come under conſideration afterwards, and we need not attend to it at preſent. It is enough for our preſent purpoſe to ſee, that if the cylinder has been completely purged of common air before the ſteam-cock was ſhut, and if none has entered ſince, the piſton will deſcend to the very bottom of the cylinder. And this may be frequently obſerved in a good ſteam-engine, where every part is air-tight. It ſometimes happens, by the pit-pump drawing air, or ſome part of the communication between the two ſtrains giving way, that the piſton comes down with ſuch violence as to knock out the bottom of the cylinder with the blow.

14
The piſton does not begin to deſcend the moment the injection is made.

The only obſervation which remains to be made on the motion of the piſton in deſcending is, that it does not begin at the inſtant the injection is made. The piſton was kept at the top by the preponderancy of the outer end of the working beam, and it muſt remain there till the difference between the elaſticity of the ſteam below it and the preſſure of the atmoſphere exceeds this preponderancy. There muſt therefore be a ſmall ſpace of time between the beginning of the condenſation and the beginning of the motion. This is very ſmall, not exceeding the third or the fourth part of a ſecond; but it may be very diſtinctly obſerved by an attentive ſpectator. He will ſee, that the inſtant the injection cock is opened, the cylinder will ſenſibly riſe upwards a little by the preſſure of the air on its bottom. Its whole weight is not nearly equal to this preſſure; and inſtead of its being neceſſary to *ſupport* it by a ſtrong floor, we muſt *keep it down* by ſtrong joiſts loaded by heavy walls. It is uſual to frame theſe joints into the poſts which carry the axis of the working-beam, and are therefore loaded with the whole ſtrain of the machine. This riſing of the cylinder ſhows the inſtantaneous commencement of the condenſation; and it is not till *after* this has been diſtinctly obſerved that the piſton is ſeen to ſtart, and begin to deſcend.

When the manager ſees the piſton as low as he thinks proper, he ſhuts the injection-cock, and opens the ſteam-cock. The ſteam has been accumulating above the water in the boiler during the whole time of the piſton's deſcent, and is now ruſhing violently through the puppet clack. The moment, therefore, that the ſteam-cock is opened, it ruſhes violently into the cylinder, having an elaſticity greater than that of the air. It therefore immediately blows open the ſnifting valve, and allows (at leaſt) the water which had come in by the former injection, and what aroſe from the condenſed ſteam, to deſcend by its own weight through the eduction pipe *d e g h* to open the valve *h*, and to run out into the hot well. And we muſt eaſily ſee that this water is boiling hot; for while lying in the bottom of the cylinder, it will condenſe ſteam till it acquires this temperature, and therefore cannot run down till it condenſes no more. There is ſtill a waſte of ſteam at its firſt admiſſion, in order to heat the inſide of the cylinder and the injected water to the boiling temperature: but the ſpace being ſmall, and the whole being already very warm, this is very ſoon done; and when things are properly conſtructed, little more ſteam is wanted than what will warm the cylinder; for the eduction pipe receives the injection water even during the deſcent of the piſton, and it is therefore removed pretty much out of the way of the ſteam.

15
The circumſtances that ſucceed the deſcent of the piſton.

16
Effects of the firſt puff of entering ſteam

This firſt puff of the entering ſteam is of great ſervice; it drives out of the cylinder the vapour which it finds there. This is ſeldom pure watery vapour: all water contains a quantity of air in a ſtate of chemical union. The union is but feeble, and a boiling heat is ſufficient for diſengaging the greateſt part of it by increaſing its elaſticity. It may alſo be diſengaged by ſimply removing the external preſſure of the atmoſphere. This is clearly ſeen when we expoſe a glaſs of water in an exhauſted receiver. Therefore the ſmall ſpace below the piſton contains watery vapour mixed with all the air which had been diſengaged from the water in the boiler by ebullition, and all that was ſeparated from the injection water by the diminution of external preſſures. All this is blown out of the cylinder by the firſt puff of ſteam. We may obſerve in this place, that waters differ exceedingly in the quantity of air which they hold in a ſtate of ſolution. All ſpring water contains much of it: and water newly brought up from deep mines contains a great deal more, becauſe the ſolution was aided in theſe ſituations by great preſſures. Such waters ſparkle when poured into a glaſs. It is therefore of great conſequence to the good performance of a ſteam-engine to uſe water containing little air, both in the boiler and in the injection-ciſtern. The water of running brooks is preferable to all others, and the freer it is from any ſaline impregnation it generally contains leſs air. Such engines as are ſo unfortunately ſituated that they are obliged to employ the very water which they have brought up from great depths, are found greatly inferior in their performance to others. The air collected below the piſton greatly diminiſhes the accelerating force, and the expulſion of ſuch a quantity requires a long-continued blaſt of the beſt ſteam at the beginning of every ſtroke. It is adviſable to keep ſuch water in a large ſhallow pond for a long while before uſing it.

17
Of great conſequence to the good performance of a ſteam-engine, that the water employed contain little air.

18
How the piſton riſes.

Let us now conſider the ſtate of the piſton. It is evident that it will ſtart or begin to riſe the moment the

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the ſteam-cock is opened; for at that inſtant the exceſs of atmoſpherical preſſure, by which it was kept down in oppoſition to the preponderancy of the outer end of the beam, is diminiſhed. The piſton is therefore *dragged* upwards, and it will riſe even although the ſteam which is admitted be not ſo elaſtic as common air. Suppoſe the mercury in the barometer to ſtand at 30 inches, and that the preponderancy at the outer end of the beam is $\frac{1}{9}$th of the preſſure of the air on the piſton, the piſton will not riſe if the elaſticity of the ſteam is not equal to $30-\frac{30}{9}$, that is, to 26.7 inches nearly; but if it is juſt this quantity, the piſton will riſe as faſt as this ſteam can be ſupplied through the ſteam-pipe, and the velocity of its aſcent depends entirely on the velocity of this ſupply. This obſervation is of great importance; and it does not ſeem to have occurred to the mathematicians, who have paid moſt attention to the mechaniſm of the motion of this engine. In the mean time, we may clearly ſee that the entry of the ſteam depends chiefly on the counter weight at E: for ſuppoſe there was none, ſteam no ſtronger than air would not enter the cylinder at all; and if the ſteam be ſtronger, it will enter only by the exceſs of its ſtrength. Writers on the ſteam-engine (and even ſome of great reputation) familiarly ſpeak of the ſteam giving the piſton a puſh: But this is ſcarcely poſſible. During the riſe of the piſton the ſnifting valve is never obſerved to blow; and we have not heard any well-atteſted accounts of the piſton-chains ever being ſlackened by the upward preſſure of the ſteam, even at the very beginning of the ſtroke. During the riſing of the piſton the ſteam is (according to the common conception and manner of ſpeaking) *ſucked in*, in the ſame way that air is ſucked into a common ſyringe or pump when we draw up the piſton; for in the ſteam-engine the piſton is really drawn up by the counter weight. But it is ſtill more ſucked in, and requires a more copious ſupply, for another reaſon. As the piſton deſcended only in conſequence of the inſide of the cylinder's being ſufficiently cooled to condenſe the ſteam, this cooled ſurface muſt again be preſented to the ſteam during the riſe of the piſton, and muſt condenſe ſteam a ſecond time. The piſton cannot riſe another inch till the part of the cylinder which the piſton has already quitted has been warmed up to the boiling point, and ſteam muſt be expended in this warming. The inner ſurface of the cylinder is not only of the heat of boiling water while the piſton riſes, but is alſo perfectly dry; for the film of water left on it by the aſcending piſton muſt be completely evaporated, otherwiſe it will be condenſing ſteam. That the quantity thus waſted is conſiderable, appears by the experiments of Mr Beighton. He found that five pints of water were boiled off in a minute, and produced 16 ſtrokes of an engine whoſe cylinder contained 113 gallons of 282 inches each; and he thence concluded that ſteam was 2886 times rarer than water. But in no experiment made with ſcrupulous care on the expanſion of boiling water does it appear that the denſity of ſteam exceeds $\frac{1}{10,000}$th of the denſity of water. Deſaguiliers ſays that it is above 14,000 times rarer than water. We have frequently attempted to meaſure the weight of ſteam which filled a very light veſſel, which held 12,600 grains of water, and found it always leſs than one grain; ſo that we have no doubt of its being much more than 10,000 times rarer than water. This being the caſe, we may ſafely ſuppoſe that the number of gallons of ſteam, inſtead of being 16 times 113, were nearly five times as much; and that only $\frac{1}{5}$th was employed in allowing the piſton to riſe, and the remaining $\frac{4}{5}$ths were employed to warm the cylinder. But no diſtinct experiment ſhews ſo great an expanſion of water when converted into ſteam at 212°. Mr Watt never found it under the preſſure of the air more than 1800 times rarer than water.

19 Its aſcent chiefly owing to the weight of the pit piſton-rods.

The moving force during the aſcent of the piſton muſt be conſidered as reſulting chiefly, if not ſolely, from the preponderating weight of the pit piſton-rods. The office of this is to return the ſteam-piſton to the top of the cylinder, where it may again be preſſed down by the air, and make another working ſtroke by raiſing the pump rods. But the counter-weight at E has another ſervice to perform in this uſe of the engine; namely, to return the pump piſtons into their places at the bottom of their reſpective working barrels, in order that they alſo may make a working ſtroke. This requires force independent of the friction and inertia of the moving parts; for each piſton muſt be puſhed down through the water in the barrel, which muſt riſe through the piſton with a velocity whoſe proportion to the velocity of the piſton is the ſame with that of the bulk of the piſton to the bulk of the perforation through which the water riſes through the piſton. It is enough at preſent to mention this in general terms: we ſhall conſider it more particularly afterwards, when we come to calculate the performance of the engine, and to deduce from our acquired knowledge maxims of conſtruction and improvement.

20 The aſcent of the piſton differs greatly from the deſcent.

From this general conſideration of the aſcent of the piſton, we may ſee that the motion differs greatly from the deſcent. It can hardly be ſuppoſed to accelerate, even if the ſteam in the cylinder were in a moment annihilated. For the reſiſtance to the deſcent of the piſton is the ſame with the weight of the column of water, which would cauſe it to flow through the box of the pump piſton with the velocity with which it really riſes through it, and muſt therefore increaſe as the ſquare of that velocity increaſes; that is, as the ſquare of the velocity of the piſton increaſes. Independent of friction, therefore, the velocity of deſcent through the water muſt ſoon become a maximum, and the motion become uniform. We ſhall ſee by and by, that in ſuch a pump as is generally uſed this will happen in leſs than the 10th part of a ſecond. The friction of the pump will diminiſh this velocity a little, and retard the time of its attaining uniformity. But, on the other hand, the ſupply of ſteam which is neceſſary for this motion, being ſuſceptible of no acceleration from its previous motion, and depending entirely on the briſkneſs of the ebullition, an almoſt inſtantaneous ſtop is put to acceleration.

21 The counter weight is different during the two motions of the pump-rods.

Accordingly, any perſon who obſerves with attention the working of a ſteam-engine, will ſee that the riſe of the piſton and deſcent of the pump-rods is extremely uniform, whereas the working ſtroke is very ſenſibly accelerated. Before quitting this part of the ſubject, and leſt it ſhould afterwards eſcape our recollection, we may obſerve, that the counter-weight is different during the two motions of the pump-rods. While the machine is making a working ſtroke, it is lifting not only the column

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lumn of water in the pump, but the absolute weight of the pistons and piston-rods also: but while the pump-rods are descending, there is a diminution of the counter-weight by the whole weight lost by the immersion of the rod in water. The wooden rods which are generally used, soaked in water, and joined by iron straps, are heavier, and but a little heavier, than water, and they are generally about one-third of the bulk of the water in the pumps.

These two motions complete the period of the operation; and the whole may be repeated by shutting the steam-cock and opening the injection-cock whenever the piston has attained the proper height. We have been very minute in our attention to the different circumstances, that the reader may have a distinct notion of the state of the moving forces in every period of the operation. It is by no means sufficient that we know in general that the injection of cold water makes a void which allows the air to press down the piston, and that the readmission of the steam allows the piston to rise again. This lumping and slovenly way of viewing it has long prevented even the philosopher from seeing the defects of the construction, and the methods of removing them.

22 Difference between Savary's and Newcomen's machines.

We now see the great difference between Savary's and Newcomen's engine in respect of principle. Savary's was really an engine which raised water by the force of steam; but Newcomen's raises water entirely by the pressure of the atmosphere, and steam is employed merely as the most expeditious method of producing a void, into which the atmospherical pressure may impel the *first mover* of his machine. The elasticity of the steam is not the first mover.

23 Superiority of Newcomen's.

We see also the great superiority of this new machine. We have no need of steam of great and dangerous elasticity; and we operate by means of very moderate heats, and consequently with much smaller quantities of fuel; and there is no bounds to the power of this machine. How deep soever a mine may be, a cylinder may be employed of such dimensions that the pressure of the air on its piston may exceed in any degree the weight of the column of water to be raised. And lastly, this form of the machine renders it applicable to almost every mechanical purpose; because a skilful mechanic can readily find a method of converting the reciprocating motion of the working beam into a motion of any kind which may suit his purpose. Savary's engine could hardly admit of such an immediate application, and seems almost restricted to raising water.

24 Gradually improved

Inventions improve by degrees. This engine was first offered to the public in 1705. But many difficulties occurred in the execution, which were removed one by one; and it was not till 1712 that the engine seemed to give confidence in its efficacy. The most exact and unremitting attention of the manager was required to the precise moment of opening and shutting the cocks; and neglect might frequently be ruinous, by beating out the bottom of the cylinder, or allowing the piston to be wholly drawn out of it. Stops were contrived to prevent both of these accidents; then strings were used to connect the handles of the cocks with the

25 and simplified.

beam, so that they should be turned whenever it was in certain positions. These were gradually changed and improved into detents and catches of different shapes; at last, in 1717, Mr Beighton, a very ingenious and well-informed artist, simplified the whole of these subordinate movements, and brought the machine into the form in which it has continued, without the smallest material change, to the present day. We shall now describe one of these improved engines, copying almost exactly the drawings and description given by Bossut in his *Hydrodynamique*; these being by far the most accurate and perspicuous of any that have been published.

26 Description of Beighton's steam-engine. Plate DII. Fig. 8.

Fig. 8. N° 1. is a perspective view of the boiler cylinder, and all the parts necessary for turning the cocks. Fig. 8. N° 2. is a vertical section of the same; and the same pieces of both are marked with the same letters of reference.

The rod X of the piston P is suspended from the arch of the working-beam, as was represented in the preceding sketch (fig. 7.). An upright bar of timber FG is also seen hanging by a chain. This is suspended from a concentric arch of the beam, as may be seen also in the sketch at $\varphi\,\delta$. The bar is called the *plug-beam*; and it must rise and fall with the piston, but with a slower motion. The use of this plug-beam is to give motion to the different pieces which turn the cocks.

The steam-pipe K is of one piece with the bottom of the cylinder, and rises within it an inch or two, to prevent any of the cold injection water from falling into the boiler. The lower extremity Z of the steam-pipe penetrates the head of the boiler, projecting a little way. A flat plate of brass, in shape resembling a racket or battledore, called the *regulator*, applies itself exactly to the whole circumference of the steam-pipe, and completely excludes the steam from the cylinder. Being moveable round an upright axis, which is represented by the dotted lines at the side of the steam-pipe in the profile, it may be turned aside by the handle i, n° 1. The profile shows in the section of this plate a protuberance in the middle. This rests on a strong flat spring, which is fixed below it athwart the mouth of the steam-pipe. This spring presses it strongly towards the steam-pipe, causing it to apply very close; and this knob slides along the spring, while the regulator turns to the right or left.

We have said that the injection-water is furnished from a cistern placed above the cylinder. When the cistern cannot be supplied by pipes from some more elevated source, its water is raised by the machine itself. A small lifting pump $i\,k$ (fig. 7.), called the *jack-head* or *jaquette*, is worked by a rod $\gamma\,\iota$, suspended from a concentric arch $\epsilon\,\gamma$ near the outer end of the working beam. This forces a small portion of the pit water along the rising pipe i LM into the injection cistern.

In figure 8. N° 1. and 2. the letters QM 3′ represent the pipe which brings down the water from the injection cistern. This pipe has a cock at R to open or shut the passage of this water. It spouts through the jet 3′, and dashing against the bottom of the piston, it is dispersed into drops, and scattered through the whole capacity of the cylinder, so as to produce a rapid condensation of the steam.

An upright post A may be observed in the perspective view of the cylinder, &c. This supports one end B of a horizontal iron axis BC. The end C is supported by a similar post, of which the place only is marked by the dotted lines A, that the pieces connected

ted with this axis may not be hid by it. A kind of ſtirrup *a b c d* hangs from this axis, ſupported by the hooks *a* and *d*. This ſtirrup is croſſed near the bottom by a round bolt or bar *e*, which paſſes through the eyes or rings that are at the ends of the horizontal fork *h f g*, whoſe long tail *h* is double, receiving between its branches the handle *i* of the regulator. It is plain from this conſtruction, that when the ſtirrup is made to vibrate round the horizontal axis BC, on which it hangs freely by its hooks, the bolt *e* muſt pull or puſh the long fork *h f g* backwards and forwards horizontally, and by ſo doing will move the regulator round its axis by means of the handle *i*. Both the tail of the fork and the handle of the regulator are pierced with ſeveral holes, and a pin is put through them which unites them by a joint. The motion of the handle may be increaſed or diminiſhed by chooſing for the joint a hole near to the axis or remote from it; and the exact poſition at which the regulator is to ſtop on both ſides is determined by pins ſtuck in the horizontal bar on which the end of the handle appears to reſt.

This alternate motion of the regulator to the right and left is produced as follows: There is fixed to the axis BC a piece of iron *o k l*, called the Y, on account of its reſemblance to that letter of the alphabet inverted. The ſtalk *o* carries a heavy lump *p* of lead or iron; and a long leather ſtrap *q p r* is faſtened to *p* by the middle, and the two ends are faſtened to the beam above it, in ſuch a manner that the lump may be alternately catched and held up to the right and left of the perpendicular. By adjuſting the length of the two parts of the ſtrap, the Y may be ſtopped in any deſired poſition. The two claws *k* and *l* ſpread out from each other, and from the line of the ſtalk, and they are of ſuch length as to reach the horizontal bolt *e*, which croſſes the ſtirrup below, but not to reach the bottom of the fork *h f g*. Now ſuppoſe the ſtirrup hanging perpendicularly, and the ſtalk of the Y alſo held perpendicular; carry it a little outward from the cylinder, and then let it go. It will tumble farther out by its weight, without affecting the ſtirrup till the claw *l* ſtrikes on the horizontal bolt *e*, and then it puſhes the ſtirrup and the fork towards the cylinder, and opens the regulator. It ſets it in motion with a ſmart jerk, which is an effectual way of overcoming the coheſion and friction of the regulator with the mouth of the ſteam-pipe. This puſh is adjuſted to a proper length by the ſtrap *q p*, which ſtops the Y when it has gone far enough. If we now take hold of the ſtalk of the Y, and move it up to the perpendicular, the width between its claws is ſuch as to permit this motion, and ſomething more, without affecting the ſtirrup. But when puſhed ſtill nearer to the cylinder, it tumbles towards it by its own weight, and then the claw *k* ſtrikes the bolt *e*, and drives the ſtirrup and fork in the oppoſite direction, till the lump *p* is catched by the ſtrap *rp*, now ſtretched to its full length, while *q p* hangs ſlack. Thus by the motion of the Y the regulator is opened and ſhut. Let us now ſee how the motion of the Y is produced by the machine itſelf. To the horizontal axis BC are attached two ſpanners or handles *m* and *n*. The ſpanner *m* paſſes through a long ſlit in the plug-beam, and is at liberty to move upwards or downwards by its motion round the axis BC. A pin π which goes through the plug-beam catches hold of *m* when the beam riſes along with the piſton; and the pin is ſo placed, that when the beam is within an inch or two of its higheſt riſe, the pin has lifted *m* and thrown the ſtalk of the Y paſt the perpendicular. It therefore tumbles over with great force, and gives a ſmart blow to the fork, and immediately ſhuts the regulator. By this motion the ſpanner *m* is removed out of the neighbourhood of the plug-beam. But the ſpanner *n*, moving along with it in the ſame direction, now comes into the way of the pins of the plug-beam. Therefore, when the piſton deſcends again by the condenſation of the ſteam in the cylinder, a pin marked & in the ſide of the plug-beam catches hold of the tail of the ſpanner *n*, and by preſſing it down raiſes the lump on the ſtalk of the Y till it paſſes the perpendicular, and it then falls down, outwards from the cylinder, and the claw *l* again drives the fork in the direction *h i*, and opens the ſteam valve. This opening and ſhutting of the ſteam valve is executed in the preciſe moment that is proper, by placing the pins π and & at a proper height of the plug-beam. For this reaſon, it is pierced through with a great number of holes, that the places of theſe pins may be varied at pleaſure. This, and a proper curvature of the ſpinners *m* and *n*, make the adjuſtment as nice as we pleaſe.

The injection cock R is managed in a ſimilar manner. On its key may be obſerved a forked arm *s t*, like a crab's claw; at a little diſtance above it is the gudgeon or axis *u* of a piece *y u z*, called the hammer or the F, from its reſemblance to that letter. It has a lump of metal *y* at one end, and a ſpear *u s* projects from its middle, and paſſes between the claws *s* and *t* of the arm of the injection-cock. The hammer *y* is held up by a notch in the under ſide of a wooden lever DE, moveable round the center D, and ſupported at a proper height by a ſtring *r* E, made faſt to the joiſt above it.

Suppoſe the injection-cock ſhut, and the hammer in the poſition repreſented in the figure. A pin β of the plug-frame riſes along with the piſton, and catching hold of the detent DE, raiſes it, and diſengages the hammer *y* from its notch. This immediately falls down, and ſtrikes a board L put in the way to ſtop it. The ſpear *u s* takes hold of the claw *t*, and forces it aſide towards *x*, and opens the injection-cock. The piſton immediately deſcends, and along with it the plug-frame. During its deſcent the pin β meets with the tail *u z* of the hammer, which is now raiſed conſiderably above the level, and brings it down along with it, raiſing the lump *y*, and gradually ſhutting the injection-cock, becauſe the ſpear takes hold of the claw *s* of its arm. When the beam has come to its loweſt ſituation, the hammer is again engaged in the notch of the detent DE, and ſupported by it till the piſton again reaches the top of the cylinder.

In this manner the motions of the injection cock are alſo adjuſted to the preciſe moment that is proper for them. The different pins are ſo placed in the plug-frame, that the ſteam-cock may be completely ſhut before the injection-cock is opened. The inherent motion of the machine will give a ſmall addition to the aſcent of the piſton without expending ſteam all the while; and by leaving the ſteam rather leſs elaſtic than before, the ſubſequent deſcent of the piſton is promoted. There was a conſiderable propriety in the gradual ſhut-

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ting of the injection-cock. For after the firſt daſh of the cold water againſt the bottom of the piſton, the condenſation is nearly complete, and very little more water is needed; but a continual acceſſion of ſome is abſolutely neceſſary for completing the condenſation, as the capacity of the cylinder diminiſhes, and the water warms which is already injected.

In this manner the motion of the machine will be repeated as long as there is a ſupply of ſteam from the boiler, and of water from the injection ciſtern, and a diſcharge procured for what has been injected. We proceed to conſider how far theſe conditions alſo are provided by the machine itſelf.

The injection ciſtern is ſupplied with water by the jackhead pump, as we have already obſerved. From this ſource all the parts of the machine receive their reſpective ſupplies. In the firſt place, a ſmall branch 13, 13, is taken off from the injection-pipe immediately below the ciſtern, and conducted to the top of the cylinder, where it is furniſhed with a cock. The ſpout is ſo adjuſted, that no more runs from it than what will keep a conſtant ſupply of a foot of water above the piſton to keep it tight. Every time the piſton comes to the top of the cylinder, it brings this water along with it, and the ſurplus of its evaporation and leakage runs off by a waſte-pipe 14, 14. This water neceſſarily becomes almoſt boiling hot, and it was thought proper to employ its overplus for ſupplying the waſte of the boiler. This was accordingly practiſed for ſome time. But Mr Beighton improved this economical thought, by ſupplying the boiler from the eduction-pipe, 2, 2, the water of which muſt be ſtill hotter than that above the piſton. This contrivance required attention to many circumſtances, which the reader will underſtand by conſidering the perſpective and profile. The eduction-pipe comes out of the bottom of the cylinder at 1 with a perpendicular part, which bends ſidewiſe below, and is ſhut at the extremity 1. A deep cup 5 communicates with it, holding a metal valve nicely fitted to it by grinding, like the key of a cock. To ſecure its being always air-tight, a ſlender ſtream of water trickles into it from a branch 6 of the waſte-pipe from the top of the cylinder. The eduction-pipe branches off at 2, and goes down to the hot well, where it turns up, and is covered with a valve. In the perſpective view may be obſerved an upright pipe 4, 4, which goes through the head of the boiler, and reaches to within a few inches of its bottom. This pipe is called the *feeder*, and riſes about three or four feet above the boiler. It is open at both ends, and has a branch 3, 3, communicating with the bottom of the cup 5, immediately above the metal valve, and alſo a few inches below the level of the entry 2 of the eduction-pipe. This communicating branch has a cock by which its paſſage may be diminiſhed at pleaſure. Now ſuppoſe the ſteam in the boiler to be very ſtrong, it will cauſe the boiling water to riſe in the feeding pipe above 3, and coming along this branch, to riſe alſo in the cup 5, and run over. But the height of this cup above the ſurface of the water in the boiler is ſuch, that the ſteam is never ſtrong enough to produce this effect. Therefore, on the contrary, any water that may be in the cup 5 will run off by the branch 3, 3, and go down into the boiler by the feeding pipe.

Theſe things being underſtood, let us ſuppoſe a quantity of injected water lying at the bottom of the cylinder. It will run into the eduction-pipe, fill the crooked branch 1, 1, and open the valve in the bottom of the cup (its weight being ſupported by a wire hanging from a ſlender ſpring), and it will fill the cup to the level of the entry 2 of the eduction-pipe, and will then flow along 3, 3, and ſupply the boiler by the feeder 4, 4. What more water runs in at 1 will now go along the eduction pipe 2, 2, to the hot well. By properly adjuſting the cock on the branch 3, 3, the boiler may be ſupplied as faſt as the waſte in ſteam requires. This is a moſt ingenious contrivance, and does great honour to Mr Beighton. It is not, however, of much importance. The ſmall quantity which the boiler requires may be immediately taken even from a cold ciſtern, without ſenſibly diminiſhing the production of ſteam: for the quantity of heat neceſſary for raiſing the ſenſible heat of cold water to the boiling temperature is ſmall, when compared with the quantity of heat which muſt then be combined with it in order to convert the water into ſteam. For the heat expended in boiling off a cubic foot of water is about ſix times as much as would bring it to a boiling heat from the temperature of 55°. No difference can be obſerved in the performance of ſuch engines, and of thoſe which have their boilers ſupplied from a brook. It has, however, the advantage of being purged of air; and when an engine muſt derive all its ſupplies from pit water, the water from the eduction-pipe is vaſtly preferable to that from the top of the cylinder.

27
An ingenious contrivance.

We may here obſerve, that many writers (among them the Abbé Boſſut), in their deſcriptions of the ſteam-engine, have drawn the branch of communication 3, 3, from the feeding-pipe to a part of the crooked pipe 1, 1, lying below the valve in the cup 5. But this is quite erroneous; for, in this caſe, when the injection is made into the cylinder, and a vacuum produced, the water from the boiler would immediately ruſh up through the pipes 4, 3, and ſpout up into the cylinder: ſo would the external air coming in at the top of the feeder.

28
Which enables us to form ſome judgement of the internal ſtate of the engine during the performance.

This contrivance has alſo enabled us to form ſome judgement of the internal ſtate of the engine during the performance. Mr Beighton paid a minute attention to the ſituation of the water in the feeders and eduction-pipe of an engine, which ſeems to have been one of the beſt which has yet been erected. It was lifting a column of water whoſe weight was four-ſevenths of the preſſure of the air on its piſton, and made 16 ſtrokes, of ſix feet each, in a minute. This is acknowledged by all to be a very great performance of an engine of this form. He concluded that the elaſticity of the ſteam in the cylinder was never more than one-tenth greater or leſs than the elaſticity of the air. The water in the feeder never roſe more than three feet and a half above the ſurface of the boiling water, even though it was now lighter by $\frac{1}{27}$th than cold water. The eduction-pipe was only four feet and a half long (vertically), and yet it always diſcharged the injection water completely, and allowed ſome to paſs into the feeder. This could not be if the ſteam was much more than one-tenth weaker than air. By graſping this pipe in his hand during the riſe of the piſton, he could gueſs very well whereabouts the ſurface of the hot water in it reſted during the motion, and he never found it ſupported ſo high as four feet. Therefore the ſteam in the cylinder had at leaſt eight-ninths of of the elaſticity of the air. Mr Buat, in his examination of an engine which is erected at Montrelaix, in France, by an Engliſh engineer, and has always been conſidered as the pattern in that country, finds it neceſſary to ſuppoſe a much greater variation in the ſtrength of the ſteam, and ſays, that it muſt have been one-fifth ſtronger and one-fifth weaker than common air. But this engine has not been nearly ſo perfect. Its lift was not more than one-half of the preſſure of the atmoſphere, and it made but nine ſtrokes in a minute.—At W is a valve covering the mouth of a ſmall pipe, and ſurrounded with a cup containing water to keep it air-tight. This allows the air to eſcape which had been extricated from the water of laſt injection. It is driven out by the firſt ſtrong puff of ſteam which is admitted into the cylinder, and makes a noiſe in its exit. The valve is therefore called the ſnifting-valve.

To finiſh our deſcription, we obſerve, that beſides the ſafety valve 9 (called the PUPPET CLACK), which is loaded with about 3 pounds on the ſquare inch (though the engine will work very well with a load of 1 or 2 pounds), there is another DISCHARGER 10,10, having a clack at its extremity ſupported by a cord. Its uſe is to diſcharge the ſteam without doors, when the machine gives over working. There is alſo a pipe SI near the bottom of the boiler, by which it may be emptied when it needs repairs or cleanſing.

There are two ſmall pipes 11,11, and 12,12, with cocks called GAGE-PIPES. The firſt deſcends to within two inches of the ſurface of the water in the boiler, and the ſecond goes about 2 inches below that ſurface. If both cocks emit ſteam, the water is too low, and requires a recruit. If neither give ſteam, it is too high, and there is not ſufficient room above it for a collection of ſteam. Laſtly, there is a filling pipe Q, by which the boiler may be filled when the machine is to be ſet to work.

29 This form of the engine has been continued for many years, the only change being the poſition of the boiler.

The engine has continued in this form for many years. The only remarkable change introduced has been the manner of placing the boiler. It is no longer placed below the cylinder, but at one ſide, and the ſteam is introduced by a pipe from the top of the boiler into a flat box immediately below the cylinder. The uſe of this box is merely to lodge the regulator, and give room for its motions. This has been a very conſiderable improvement. It has greatly reduced the height of the building. This was formerly a tower. The wall which ſupported the beam could hardly be built with ſufficient ſtrength for withſtanding the violent ſhocks which were repeated without ceaſing; and the buildings ſeldom laſted more than a very few years. But the boiler is now ſet up in an adjoining ſhed, and the gudgeons of the main beam reſt on the top of upright poſts, which are framed into the joiſts which ſupport the cylinder. Thus the whole moving parts of the machine are contained in one compact frame of carpentry, and have little or no connection with the ſlight walls of the building, which is merely a caſe to hold the machine, and protect it from the weather.

30 How to aſcertain the moſt advantageous proportion between the moving power and the load.

It is now time to inquire what is to be expected from this machine, and to aſcertain the moſt advantageous proportion between the moving power and the load that is to be laid on the machine.

It may be conſidered as a great pulley, and is indeed ſometimes ſo conſtructed, the arches at the ends of the working beam being completed to a circle. It muſt be unequally loaded that it may move. It is loaded, during the working ſtroke, by the preſſure of the atmoſphere on the piſton ſide, and by the column of water to be raiſed and the pump-gear on the pump ſide.—During the returning ſtroke it is loaded, on the piſton ſide, by a ſmall part of the atmoſpheric preſſure, and on the pump ſide by the pump gear acting as a counter weight. The load during the working ſtroke muſt therefore conſiſt of the column of water to be raiſed and this counter weight. The performance of the machine is to be meaſured only by the quantity of water raiſed in a given time to a given height. It varies, therefore, in the joint proportion of the weight of the column of water in the pumps, and the number of ſtrokes made by the machine in a minute. Each ſtroke conſiſts of two parts, which we have called the working and the returning ſtroke. It does not, therefore, depend ſimply on the velocity of the working ſtroke and the quantity of water raiſed by it. If this were all that is to be attended to, we know that the weight of the column of water ſhould be nearly $\frac{4}{9}$ths of the preſſure of the atmoſphere, this being the proportion which gives the maximum in the common pulley. But the time of the returning ſtroke is a neceſſary part of the whole time elapſed, and therefore the velocity of the returning ſtroke equally merits attention. This is regulated by the counter weight. The number of ſtrokes per minute does not give an immediate proof of the goodneſs of the engine. A ſmall load of water and a great counter weight will enſure this, becauſe theſe conditions will produce a briſk motion in both directions.—The proper adjuſtment of the preſſure of the atmoſphere on the piſton, the column of water to be raiſed, and the counter weight, is a problem of very great difficulty; and mathematicians have not turned much of their attention to the ſubject, although it is certainly the moſt intereſting queſtion that practical mechanics affords them.

31 Mr Boſſut's ſolution,

Mr Boſſut has ſolved it very ſhortly and ſimply, upon this ſuppoſition, that the working and returning ſtroke ſhould be made in equal times. This, indeed, is generally aimed at in the erection of theſe machines, and they are not reckoned to be well arranged if it be otherwiſe. We doubt of the propriety of the maxim. Suppoſing, however, this condition for the preſent, we may compute the loadings of the two ends of the beam as follows. Let a be the length of the inner arm of the working beam, or that by which the great piſton is ſupported. Let b be the outer arm carrying the pump rods, and let W be a weight equivalent to all the load which is laid on the machine. Let c^2 be the area of the piſton; let H be the height of a column of water having c^2 for its baſe, and being equal in weight to the preſſure exerted by the ſteam on the under ſide of the piſton; and let h be the preſſure of the atmoſphere on the ſame area, or the height of a column of water of equal weight. It is evident that both ſtrokes will be performed in equal times, if $h c^2 a - \mathrm{W} b$ be equal to $(h - \mathrm{H}) c^2 a + \mathrm{W} b$. The firſt of theſe quantities is the energy of the machine during the working ſtroke, and the ſecond expreſſes the ſimilar energy during the returning ſtroke. This equation gives us $\mathrm{W} = \frac{2 h c^2 a - \mathrm{H} c^2 a}{2 b} = \frac{(2h - \mathrm{H}) c^2 a}{2 b}$. If we

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we suppose the arms of the lever equal and $H=h$, we have $W=c^2\frac{h}{2}$; that is, the whole weight of the outer end of the beam should be half the pressure of the air on the great piston. This is nearly the usual practice; and the engineers express it by saying, that the engine is loaded with seven or eight pounds on the square inch.

32 founded on an erroneous maxim,

This has been found to be nearly the most advantageous load. This way of expressing the matter would do well enough, if the maxim were not founded on erroneous notions, which hinder us from seeing the state of the machine, and the circumstances on which its improvement depends. The piston bears a pressure of 15 pounds, it is said, on the square inch, if the vacuum below it be perfect; but as this is far from being the case, we must not load it above the power of its vacuum, which very little exceeds eight pounds. But this is very far from the truth. When the cylinder is tight, the vacuum is not more than $\frac{1}{20}$th deficient, when the cylinder is cooled by the injection to the degree that is every day practicable, and the piston really bears during its descent a pressure very near to 14 pounds on the inch. The load must be diminished, not on account of the imperfect vacuum, but to give the machine a reasonable motion. We must consider not only the moving force, but also the quantity of matter to be put in motion. This is so great in the steam-engine, that even if it were balanced, that is, if there were suspended on the piston arm a weight equal to the whole column of water and the counter weight, the full pressure of the atmosphere on the steam piston would not make it move twice as fast as it does.

33 and faulty in another respect.

This equation by Mr Bossut is moreover essentially faulty in another respect. The W in the first member is not the same with the W in the second. In the first it is the column of water to be raised, together with the counter weight. In the second it is the counter weight only. Nor is the quantity H the same in both cases, as is most evident. The proper equation for ensuring the equal duration of the two strokes may be had in the following manner. Let it be determined by experiment what portion of the atmospheric pressure is exerted on the great piston during its descent. This depends on the remaining elasticity of the steam. Suppose it $\frac{9}{10}$ths: this we may express by $a\,h$, a being $=\frac{9}{10}$ths. Let it also be determined by experiment what portion of the atmospheric pressure on the piston remains unbalanced by the steam below it during its ascent. Suppose this $\frac{1}{10}$th, we may express this by $b\,h$. Then let W be the weight of the column of water to be raised, and c the counter weight. Then, if the arms of the beam are equal, we have the energy during the working stroke $=a\,h-W-c$, and during the returning stroke it is $=c-b\,h$. Therefore $c-b\,h=a\,h-W-c$; and $c=\frac{h(a+b)-W}{2}$; which, on the above supposition of the values of a and b, gives us $c=\frac{h-W}{2}$. We shall make some use of this equation afterwards; but it affords us no information concerning the most advantageous proportion of h and W, which is the material point.

34 Another way of considering the matter.

We must consider this matter in another way: And that we may not involve ourselves in unnecessary difficulties, let us make the case as simple as possible, and suppose the arms of the working-beam to be of equal length.

We shall first consider the adjustment of things at the outer end of the beam.

35 Adjustment of things at the outer end of the beam considered.

Since the sole use of the steam is to give room for the action of the atmospheric pressure by its rapid condensibility, it is admitted into the cylinder only to allow the piston to rise again, but without giving it any impulse. The pump-rods must therefore be returned to the bottom of the working barrels by means of a preponderancy at the outer end of the beam. It may be the weight of the pump-rods themselves, or may be considered as making part of this weight. A weight at the end of the beam will not operate on the rods which are suspended there by chains, and it must therefore be attached to the rods themselves, but above their respective pump-barrels, so that it may not lose part of its efficacy by immersion in the water. We may consider the whole under the notion of the pump-gear, and call it p. Its office is to depress the pump-rods with sufficient velocity, by overcoming the resistances arising from the following causes.

1. From the inertia of the beams and all the parts of the apparatus which are in motion during the descent of the pump-rods.

2. From the loss of weight sustained by the immersion of the pump-rods in water.

3. From the friction of all the pistons and the weight of the plug-frame.

4. From the resistance to the piston's motion, arising from the velocity which must be generated in the water in passing through the descending pistons.

The sum of all these resistances is equal to the pressure of some weight (as yet unknown), which we may call m.

When the pump-rods are brought up again, they bring along with them a column of water, whose weight we may call w.

It is evident that the load which must be overcome by the pressure of the atmosphere on the steam piston consists of w and p. Let this load be called L, and the pressure of the air be called P.

If p be $=$ L, no water will be raised; if p be $=o$, the rods will not descend: therefore there is some intermediate value of p which will produce the greatest effect.

In order to discover this, let g be the fall of a heavy body in a second.

The descending mass is p: but it does not descend with its full weight; because it is overcoming a set of resistances which are equivalent to a weight m, and the moving force is $p-m$. In order to discover the space through which the rods will descend in a second, when urged by the force $p-m$ (supposed constant, notwithstanding the increase of velocity, and consequently of m), we must institute this proportion $p:p-m=g:\frac{g(p-m)}{p}$.

The fourth term of this analogy is the space required.

Let t be the whole time of the descent in seconds. Then $1^2:t^2=\frac{g(p-m)}{p}:\frac{t^2g(p-m)}{p}$. This last term is is the whole deſcent or length of the ſtroke accompliſhed in the time t.

The weight of the column of water, which has now got above the piſton, is w, $=L-p$. This muſt be lifted in the next working ſtroke through the ſpace $\frac{t^2 g(p-m)}{p}$. Therefore the performance of the engine muſt be $\frac{t^2 g(p-m)(L-p)}{p}$.

That this may be the greateſt poſſible, we muſt conſider p as the variable quantity, and make the fluxion of the fraction $\frac{\overline{p-m}\times\overline{L-p}}{p}=o$.

This will be found to give us $p=\sqrt{Lm}$; that is, the counter weight or preponderancy of the outer end of the beam is $=\sqrt{Lm}$.

This gives us a method of determining m experimentally. We can diſcover by actual meaſurement the quantity L in any engine, it being equal to the unbalanced weights on the beam and the weight of the water in the pumps. Then $m=\frac{p^2}{L}$.

Alſo we have the weight of the column of water $=L-p$, $=L-\sqrt{Lm}$.

When therefore we have determined the load which is to be on the outer end of the beam during the working ſtroke, it muſt be diſtributed into two parts, which have the proportion of $\sqrt{Lm}$ to $L-\sqrt{Lm}$. The firſt is the counter weight, and the ſecond is the weight of the column of water.

If m is a fraction of L, ſuch as an aliquot part of it; that is, if

$$m=\frac{L}{1},\ \frac{L}{4},\ \frac{L}{9},\ \frac{L}{16},\ \frac{L}{25},\ \&c.$$
$$p=\frac{L}{1},\ \frac{L}{2},\ \frac{L}{3},\ \frac{L}{4},\ \frac{L}{5},\ \&c.$$

The circumſtance which is commonly obtruded on us by local conſiderations is the quantity of water, and the depth from which it is to be raiſed; that is, w: and it will be convenient to determine every thing in conformity to this.

We ſaw that $w=L-\sqrt{Lm}$. This gives us $L=\pm\sqrt{wm+\frac{m^2}{4}}+\frac{m}{2}+w$, and the counter weight $p=\sqrt{wm+\frac{m^2}{4}}+\frac{m}{2}$.

36 What proportion of moving force may be applied to the greateſt advantage.

Having thus aſcertained that diſtribution of the load on the outer end of the beam which produces the greateſt effect, we come now to conſider what proportion of moving force we muſt apply, ſo that it may be employed to the beſt advantage, or ſo that any expence of power may produce the greateſt performance. It will be ſo much the greater as the work done is greater, and the power employed is leſs; and will therefore be properly meaſured by the quotient of the work done divided by the power employed.

The work immediately done is the lifting up the weight L. In order to accompliſh this, we muſt employ a preſſure P, which is greater than L. Let it be $=L+y$; alſo let s be the length of the ſtroke.

If the maſs L were urged along the ſpace s by the force $L+y$, it would acquire a certain velocity, which we may expreſs by $\sqrt{s}$; but it is impelled only by the force y, the reſt of P being employed in balancing L. The velocities which different forces generate by impelling a body along the ſame ſpace are as the ſquare roots of the forces. Therefore $\sqrt{L+y}:\sqrt{y}=\sqrt{s}:\frac{\sqrt{sy}}{\sqrt{L+y}}$. The fourth term of this analogy expreſſes the velocity of the piſton at the end of the ſtroke. The quantity of motion produced will be had by multiplying this velocity by the maſs L. This gives $\frac{L\times\sqrt{sy}}{\sqrt{L+y}}$; and this divided by the power expended, or by $L+y$, gives us the meaſure of the performance; namely, $\frac{L\sqrt{sy}}{\overline{L+y}\times\sqrt{L+y}}$.

That this may be a maximum, conſider y as the variable quantity, and make the fluxion of this formula $=o$. This will give us $y=\frac{L}{2}$.

Now $P=L+y$, $=L+\frac{L}{2}$, $=\frac{3}{2}L$. Therefore the *whole* load on the outer end of the beam, conſiſting of the water and the counter weight, muſt be two-thirds of the preſſure of the atmoſphere on the ſteam piſton.

We have here ſuppoſed that the expenditure is the atmoſpheric preſſure; and ſo it is if we conſider it mechanically. But the expenditure of which we are ſenſible, and which we are anxious to employ to the beſt advantage, is fuel. Suppoſing this to be employed with the ſame judgement in all caſes, we are almoſt intitled, by what we now know of the production of ſteam, to ſay that the ſteam produced is proportional to the fuel expended. But the ſteam requiſite for merely filling the cylinder is proportional to the area of the piſton, and therefore to the atmoſpheric preſſure. The reſult of our inveſtigation therefore is ſtill juſt; but the ſteam waſted by condenſation on the ſides of the cylinder does not follow this ratio, and this is more than what is neceſſary for merely filling it. This deranges our calculations, and is in favour of large cylinders; but this advantage muſt be in a great meaſure compenſated by a ſimilar variation in the production of the ſteam; for in ſimilar boilers of greater dimenſions the fuel is leſs advantageouſly employed, becauſe the ſurface to which the fuel is applied does not increaſe in the ratio of the capacity, juſt as the ſurface of the cylinder which waſtes the ſteam. The rule may therefore be confided in as pretty exact.

37 Theſe reſults agree with the moſt ſucceſsful practice.

It is a ſatisfactory thing to obſerve theſe reſults agree very well with the moſt ſucceſsful practice. By many changes and trials engineers have eſtabliſhed maxims of conſtruction, which are probably not very far from the beſt. It is a pretty general maxim, that the load of water ſhould be one-half of the atmoſpheric preſſure. They call this loading the engine with $7\frac{1}{2}$ pounds on the inch, and they ſay that ſo ſmall a load is neceſſary on account of the imperfect vacuum. But we have now ſeen that it is neceſſary for giving a reaſonable velocity of motion. Since, in this practice, w is made $\frac{1}{2}$ or $\frac{6}{12}$ths of P, and L ſhould be $\frac{8}{12}$ths of P, and L is $=w+p$; it follows, that the counter weight ſhould be

$\frac{1}{6}$th

$\frac{1}{6}$th of P; and we have found this to be nearly the caſe in ſeveral very good engines.

It muſt be remarked, that in the preceding inveſtigation we introduced a quantity M to expreſs the reſiſtances to the motion of the engine. This was done in order to avoid a very troubleſome inveſtigation. The reſiſtances are of ſuch a nature as to vary with the velocity, and moſt of them as the ſquare of the velocity. This is the caſe with the reſiſtance ariſing from the motion of the water through the piſtons of the pumps, and that ariſing from the friction in the long lift during the working ſtroke. Had we taken the direct method, which is ſimilar to the determination of the motion through a medium which reſiſts in the duplicate ratio of the velocity, we muſt have uſed a very intricate exponential calculus, which few of our readers would have the patience to look at.

But the greateſt part of the quantity m ſuppoſes a motion already known, and its determination depends on this motion. We muſt now ſhow how its different component parts may be computed.

38 Reſiſtance to the motion of the engine computed.

1. What ariſes from the inertia of the moving parts is by far the moſt conſiderable portion of it. To obtain it, we muſt find a quantity of matter which, when placed at the end of the beam, will have the ſame momentum of inertia with that of the whole moving parts in their natural places. Therefore (in the returning ſtroke) add together the weight of the great piſton with its rod and chains; the pit pump-rods, chains, and any weight that is attached to them; the arch-heads and iron-work at the ends of the beam, and $\frac{4}{9}$ths of the weight of the beam itſelf; alſo the plug-beam with its arch-head and chain, multiplied by the ſquare of its diſtance from the axis, and divided by the ſquare of half the length of the beam; alſo the jack-head pump-rod, chain, and arch-head, multiplied by the ſquare of its diſtance from the axis, and divided by the ſquare of the half length of the beam. Theſe articles added into one ſum may be called M, and may be ſuppoſed to move with the velocity of the end of the beam. Suppoſe this beam to have made a ſix-foot ſtroke in two ſeconds, with an uniformly accelerated motion. In one ſecond it would have moved $1\frac{1}{2}$ feet, and would have acquired the velocity of three feet per ſecond. But in one ſecond gravity would have produced a velocity of 32 feet in the ſame maſs. Therefore the accelerating force, which has produced the velocity of three feet, is nearly $\frac{1}{11}$th of the weight. Therefore $\frac{M}{11}$ is the firſt conſtituent of m in the above inveſtigation. If the obſerved velocity is greater or leſs than three feet per ſecond, this value muſt be increaſed or diminiſhed in the ſame proportion.

The ſecond cauſe of reſiſtance, viz. the immerſion of the pump rods in water, is eaſily computed, being the weight of the water which they diſplace.

The third cauſe, the friction of the piſtons, &c. is almoſt inſignificant, and muſt be diſcovered by experiment.

The fourth cauſe depends on the ſtructure of the pumps. Theſe pumps, when made of a proper ſtrength, can hardly have the perforation of the piſton more than a fourth part of the area of the working-barrel; and the velocity with which the water paſſes through it is increaſed at leaſt $\frac{1}{4}$th by the contraction (ſee PUMP). The velocity of the water is therefore five times greater than that of the piſton. A piſton 12 inches diameter, and moving one foot per ſecond, meets with a reſiſtance equal to 20 pounds; and this increaſes as the ſquare of the diameter and as the ſquare of the velocity. If the whole depth of the pit be divided into ſeveral lifts, this reſiſtance muſt be multiplied by the number of lifts, becauſe it obtains in each pump.

Thus we make up the value of m; and we muſt acknowledge that the method is ſtill indirect, becauſe it ſuppoſes the velocity to be known.

We may obtain it more eaſily in another way, but ſtill with this circumſtance of being indirect. We found that p was equal to $\sqrt{L\,m}$, and conſequently $m = \frac{p^2}{L}$. Now in any engine L and p can always be had; and unleſs p deviates greatly from the proportion which we determined to be the beſt, the value of m thus obtained will not be very erroneous.

39 Obſervations concerning ſomething preſumed in the inveſtigation.

It was farther preſumed in this inveſtigation, that the motions both up and down were uniformly accelerated; but this cannot be the caſe when the reſiſtances increaſe with the velocity. This circumſtance makes very little change in the working-ſtroke, and therefore the theorem which determines the beſt relation of P to L may be confided in. The reſiſtances which vary with the velocity in this caſe are a mere trifle when compared with the moving power y. Theſe reſiſtances are, 1ſt, The ſtrangling of the water at the entry and at the ſtanding valve of each pump: This is about 37 pounds for a pump 12 inches diameter, and the velocity one foot per ſecond, increaſing in the duplicate ratio of the diameter and velocity. And, 2d, The friction of the water along the whole lift: This for a pump of the ſame ſize and with the ſame velocity, lifting 20 fathoms, is only about $2\frac{1}{3}$ pounds, and varies in the ſimple proportion of the diameter and the depth, and in the duplicate proportion of the velocity. The reſiſtance ariſing from inertia is greater than in the returning ſtroke; becauſe the M in this caſe muſt contain the momentum of the water both of the pit-pumps and the jackhead-pump: but this part of the reſiſtance does not affect the uniform acceleration. We may therefore confide in the propriety of the formula $y = \frac{L}{2}$. And we may obtain the velocity of this ſtroke at the end of a ſecond with great accuracy as follows. Let $2g$ be the velocity communicated by gravity in a ſecond, and the velocity at the end of the firſt ſecond of the ſteam piſton's deſcent will be ſomewhat leſs than $\frac{y}{M}\,2g$; where M expreſſes the inertia of all the parts which are in motion during the deſcent of the ſteam piſton, and therefore includes L. Compute the two reſiſtances juſt mentioned for this velocity. Call this r. Then $\frac{y - \frac{1}{2}r}{M}\,2g$ will give another velocity infinitely near the truth.

But the caſe is very different in the returning ſtroke, and the proper ratio of p to L is not aſcertained with the ſame certainty: for the moving force p is not ſo great in proportion to the reſiſtance m; and therefore the acceleration of the motion is conſiderably affected by it, and the motion itſelf is conſiderably retarded, and in a very moderate time it becomes ſenſibly uniform: for it is preciſely ſimilar to the motion of a heavy body falling

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falling through the air, and may be determined in the manner laid down in the article *RESISTANCE of Fluids*, viz. by an exponential calculus. We fhall content ourfelves here with faying, that the refiftances in the prefent cafe are fo great that the motion would be to all fenfe uniform before the piftons have defcended one-third of their ftroke, even although there were no other circumftance to affect it.

40
The motion affected by a circumftance that deferves particular confideration.

But this motion is affected by a circumftance quite unconnected with any thing yet confidered, depending on conditions not mechanical, and fo uncertain, that we are not yet able to afcertain them with any precifion; yet they are of the utmoft importance to the good performance and improvement of the engine, and therefore deferve a particular confideration.

The counter weight has not only to pufh down the pump rods, but alfo to *drag* up the great pifton. This it cannot do unlefs the fteam be admitted into the cylinder. If the fteam be no ftronger than common air, it cannot enter the cylinder except *in confequence* of the pifton's being dragged up. If common air were admitted into the cylinder, fome force would be required to drag up the pifton, in the fame manner as it is required to draw up the pifton of a common fyringe; for the air would rufh through the fmall entry of the cylinder in the fame manner as through the fmall nozzle of the fyringe. Some part of the atmofpheric preffure is employed in driving in the air with fufficient velocity to fill the fyringe, and it is only with the remainder that the admitted air preffes on the under furface of the fyringe. Therefore fome of the atmofpheric preffure on its upper furface is not balanced. This is felt by the hand which draws it up. The fame thing muft happen in the fteam-engine, and fome part of the counter weight is expended in drawing up the fteam-pifton. We could tell how much is thus expended if we knew the denfity of the fteam; for this would tell us the velocity with which its elafticity would caufe it to fill the cylinder. If we fuppofe it 12 times rarer than air, which it certainly is, and the pifton rifes to the top of the cylinder in two feconds, we can demonftrate that it will enter with a velocity not lefs than 1400 feet per fecond, whereas 500 feet is enough to make it maintain a denfity $\frac{9}{10}$ths of that of fteam in equilibrio with the air. Hence it follows, that its elafticity will not be lefs than $\frac{29}{30}$ths of the elafticity of the air, and therefore not more than $\frac{1}{30}$th of counter weight will be expended in drawing up the fteam-pifton.

But all this is on the fuppofition that there is an unbounded fupply of fteam of undiminifhed elafticity. This is by no means the cafe. Immediately before opening the fteam-cock, the fteam was iffuing through the fafety-valve and all the crevices in the top of the boiler, and (in good engines) was about $\frac{1}{10}$th ftronger or more elaftic than air. This had been gathering during fomething more than the defcent of the pifton, viz. in about three feconds. The pifton rifes to the top in about two feconds; therefore about twice and a half as much fteam as fills the dome of the boiler is now fhared between the boiler and cylinder. The dome is commonly about fix times more capacious than the cylinder. If therefore no fteam is condenfed in the cylinder, the denfity of the fteam, when the pifton has reached the top, muft be about $\frac{15}{16}$ths of its former denfity, and ftill more elaftic than air. But as much fteam is condenfed by the cold cylinder, its elafticity muft be lefs than this. We cannot tell how much lefs, both becaufe we do not know how much is thus condenfed, and becaufe by this diminution of its preffure on the furface of the boiling water, it muft be more copioufly produced in the boiler; but an attentive obfervation of the engine will give us fome information. The moment the fteam-cock is opened we have a ftrong puff of fteam through the fnifting valve. At this time, therefore, it is ftill more elaftic than air; but after this, the fnifting valve remains fhut during the whole rife of the pifton, and no fteam any longer iffues through the fafety-valve or crevices; nay, the whole dome of the boiler may be obferved to fink.

41
The elafticity of the fteam during the afcent of the pifton greatly diminifhed.

Thefe facts give abundant proof that the elafticity of the fteam during the afcent of the pifton is greatly diminifhed, and therefore much of the counter weight is expended in dragging up the fteam-pifton in oppofition to the unbalanced part of the atmofpheric preffure. The motion of the returning ftroke is therefore fo much deranged by this foreign and inappreciated circumftance, that it would have been quite ufelefs to engage in the intricate exponential inveftigation, and we muft fit down contented with a lefs perfect adjuftment of the counter weight and weight of water.—Any perfon who attends to the motion of a fteam-engine will perceive that the defcent of the pump-rods is fo far from being accelerated, that it is nearly uniform, and frequently it is fenfibly retarded towards the end. We learn by the way, that it is of the utmoft importance not only to have a quick production of fteam, but alfo a very capacious dome, or empty fpace above the water in the boiler. In engines where this fpace was but four or five times the capacity of the cylinder, we have always obferved a very fenfible check given to the defcent of the pump-rods after having made half their ftroke. This obliges us to employ a greater counter weight, which diminifhes the column of water, or retards the working ftroke; it alfo obliges us to employ a ftronger fteam, at the rifk of burfting the boiler, and increafes the expence of fuel.

42
How to know the elafticity of the fteam in the cylinder.

It would be a moft defirable thing to get an exact knowledge of the elafticity of the fteam in the cylinder; and this is by no means difficult. Take a long glafs tube exactly calibered, and clofe at the farther end. Put a fmall drop of fome coloured fluid into it, fo as to ftand at the middle nearly.—Let it be placed in a long box filled with water to keep it of a conftant temperature. Let the open end communicate with the cylinder, with a cock between. The moment the fteam-cock is opened, open the cock of this inftrument. The drop will be pufhed towards the clofe end of the tube, while the fteam in the cylinder is more elaftic than the air, and it will be drawn the other way while it is lefs elaftic, and, by a fcale properly adapted to it, the elafticity of the fteam correfponding to every pofition of the pifton may be difcovered. The fame thing may be done more accurately by a barometer properly conftructed, fo as to prevent the ofcillations of the mercury.

43
Neceffary alfo to know the ftate of the cylinder during the defcent of the pifton.

It is equally neceffary to know the ftate of the cylinder during the defcent of the fteam-pifton. We have hitherto fuppofed P to be the full preffure of the atmofphere on the area of the pifton, fuppofing the vacuum below it to be complete. But the infpection of our table of elafticity fhows that this can never be the cafe, becaufe the cylinder is always of a temperature far above 32°. We have made many attempts to difcover its temperature.

perature. We have employed a thermometer in close contact with the side of the cylinder, which soon acquired a steady temperature: this was never less than 145°. We have kept a thermometer in the water which lies on the piston: this never sunk below 135°. It is probable that the cylinder within may be cooled somewhat lower; but for this opinion we cannot give any very satisfactory reason. Suppose it cooled down to 120°; this will leave an elasticity which would support three inches of mercury. We cannot think therefore that the unbalanced pressure of the atmosphere exceeds that of 27 inches of mercury, which is about $13\frac{1}{3}$d pounds on a square inch, or $10\frac{1}{2}$ on a circular inch. And this is the value which we should employ in the equation $P=L+y$. This question may be decided in the same way as the other, by a barometer connected with the inside of the cylinder.

And thus we shall learn the state of the moving forces in every moment of the performance, and the machine will then be as open to our examination as any water or horse mill; and till this be done, or something equivalent, we can only guess at what the machine is actually performing, and we cannot tell in what particulars we can lend it a helping hand. We are informed that Messrs Watt and Boulton have made this addition to some of their engines; and we are persuaded that, from the information which they have derived from it, they have been enabled to make the curious improvements from which they have acquired so much reputation and profit.

44 Quantity of cold water to be injected.

There is a circumstance of which we have as yet taken no notice, viz. the quantity of cold water injected. Here we confess ourselves unable to give any precise instructions. It is clear at first sight that no more than is absolutely necessary should be injected. It must generally be supplied by the engine, and this expends part of its power. An excess is much more hurtful by cooling the cylinder and piston too much, and therefore wasting steam during the next rise of the piston. But the determination of the proper quantity requires a knowledge, which we have not yet acquired, of the quantity of heat contained in the steam in a latent form. As much water must be injected as will absorb all this without rising near to the boiling temperature. But it is of much more importance to know how far we may cool the cylinder with advantage; that is, when will the loss of steam, during the next rise of the piston, compensate for the diminution of its elasticity during its present descent? Our table of elasticities shows us, that by cooling the cylinder to 120°, we still leave an elasticity equal to one-tenth of the whole power of the engine; if we cool it only to 140, we leave an elasticity of one-fifth; if we cool it to a blood-heat, we leave an elasticity of one-twentieth. It is extremely difficult to choose among these varieties. Experience, however, informs us, that the best engines are those which use the smallest quantities of injection water. We know an exceedingly good engine having a cylinder of 30 inches and a six feet stroke, which works with something less than one-fifth of a cubic foot of water at each injection; and we imagine that the quantity should be nearly in the proportion of the capacity of the cylinder. Desaguliers observed, that a very good engine, with a cylinder of 32 inches, worked with 300 inches of water at each injection, which does not much exceed one-sixth of a cubic foot. Mr Watt's observations, by means of the barometer, must have given him much valuable information in this particular, and we hope that he will not always withhold them from the public.

45 This examination, though not satisfactory, may direct the attention to the principal circumstances.

We have gone thus far in the examination, in order seemingly to ascertain the motion of the engine when loaded and balanced in any known manner, and in order to discover that proportion between the moving power and the load which will produce the greatest quantity of work. The result has been very unsatisfactory, because the computation of the returning stroke is acknowledged to be beyond our abilities. But it has given us the opportunity of directing the reader's attention to the leading circumstances in this inquiry. By knowing the internal state of the cylinder in machines of very different goodness, we learn the connection between the state of the steam and the performance of the machine; and it is very possible that the result of a full examination may be, that in situations where fuel is expensive, it may be proper to employ a weak steam which will expend less fuel, although less work is performed by it. We shall see this confirmed in the clearest manner in some particular employments of the new engines invented by Watt and Boulton.

In the mean time, we see that the equation which we gave from the celebrated Abbé Bossut, is in every respect erroneous even for the purpose which he had in view. We also see that the equation which we substituted in its place, and which was intended for determining that proportion between the counter-weight and the moving force, and the load which would render the working stroke and returning stroke of equal duration, is also erroneous, because these two motions are extremely different in kind, the one being nearly uniform, and the other nearly uniformly accelerated. This being supposed true, it should follow that the counter-weight should be reduced to one half; and we have found this to be very nearly true in some good engines which we have examined.

46 An erroneous maxim that the two motions are of equal duration.

We shall add but one observation more on this head. The practical engineers have almost made it a maxim, that the two motions are of equal duration. But the only reason which we have heard for the maxim, is, that it is aukward to see an engine go otherwise. But we doubt exceedingly the truth of this maxim, and, without being able to give any accurate determination, we think that the engine will do more work if the working stroke be made slower than the returning stroke. Suppose the engine so constructed that they are made in equal times; an addition to the counter-weight will accelerate the returning stroke and retard the working stroke. But as the counter-weight is but small in proportion to the unbalanced portion of the atmospheric pressure, which is the moving force of the machine, it is evident that this addition to the counter-weight must bear a much greater proportion to the counter-weight than it does to the moving force, and must therefore accelerate the returning stroke much more than it retards the working stroke, and the time of both strokes taken together must be diminished by this addition and the performance of the machine improved; and this must be the case as long as the machine is not extravagantly loaded. The best machine which we have seen, in respect of performance, raises a column of water whose weight is very nearly two-thirds of the pressure of the atmosphere

atmoſphere on the piſton, making 11 ſtrokes of ſix feet each per minute, and the working ſtroke was almoſt twice as ſlow as the other. This engine had worked pumps of 12 inches, which were changed for pumps of 14 inches, all other things remaining the ſame. In its former ſtate it made from 12 and a half to 13 and a half ſtrokes per minute, the working ſtroke being conſiderably ſlower than the returning ſtroke. The load was increaſed, by the change of the pumps, nearly in the proportion to three to four. This had retarded the working ſtroke; but the performance was evidently increaſed in the proportion of 3×13 to 4×11, or of 39 to 44. About 300 pounds were added to the counterweight, which increaſed the number of ſtrokes to more than 12 per minute. No ſenſible change could be obſerved in the time of the working ſtroke. The performance was therefore increaſed in the proportion of 39 to 48. We have therefore no heſitation in ſaying, that the ſeemly equality of the two ſtrokes is a ſacrifice to fancy. The engineer who obſerves the working ſtroke to be ſlow, fears that his engine may be thought feeble and unequal to its work; a ſimilar notion has long miſled him in the conſtruction of water-mills, eſpecially of overſhot mills; and, even now, he is ſubmitting with heſitation and fear to the daily correction of experience.

It is needleſs to engage more deeply in ſcientific calculations in a ſubject where ſo many of the data are ſo very imperfectly underſtood.

47 The load of work ſhould not be leſs than 10 pounds for every ſquare inch of the piſton.

We venture to recommend as a maxim of conſtruction (ſuppoſing always a large boiler and plentiful ſupply of pure ſteam unmixed with air), that the load of work be not leſs than 10 pounds for every ſquare inch of the piſton, and the counter-weight ſo proportioned that the time of the returning ſtroke may not exceed two-thirds of that of the working ſtroke. A ſerious objection may be made to this maxim, and it deſerves mature conſideration. Such a load requires the utmoſt care of the machine, that no admiſſion be given to the common air; and it precludes the poſſibility of its working, in caſe the growth of water, or deepening the pit, ſhould make a greater load abſolutely neceſſary. Theſe conſiderations muſt be left to the prudence of the engineer. The maxim now recommended relates only to the beſt actual performance of the engine.

48 Rules for computing the performance of the ſteam-engine.

Before quitting this machine, it will not be amiſs to give ſome eaſy rules, ſanctioned by ſucceſsful practice, for computing its performance. Theſe will enable any artiſt, who can go through ſimple calculations, to ſuit the ſize of his engine to the taſk which it is to perform.

The circumſtance on which the whole computation muſt be founded is the quantity of water which muſt be drawn in a minute, and the depth of the mine; and the performance which may be expected from a good engine is at leaſt 12 ſtrokes per minute of ſix feet each, working againſt a column of water whoſe weight is equal to half of the atmoſpheric preſſure on the ſteam-piſton, or rather to 7.64 pounds on every ſquare inch of its ſurface.

It is moſt convenient to eſtimate the quantity of water in cubic feet, or its weight in pounds, recollecting that a cubic foot of water weighs $62\frac{1}{2}$ pounds. The depth of the pit is uſually reckoned in fathoms of ſix feet, and the diameter of the cylinder and pump is uſually reckoned in inches.

Let Q be the quantity of water to be drawn per minute in cubical feet, and f the depth of the mine in fathoms; let c be the diameter of the cylinder, and p that of the pump; and let us ſuppoſe the arms of the beam to be of equal length.

1ſt, To find the diameter of the pump, the area of the piſton in ſquare feet is $p^2\times\frac{0.7854}{144}$. The length of the column drawn in one minute is 12 times 6 or 72 feet, and therefore its ſolid contents is $p^2\times\frac{72\times 0.7854}{144}$ cubical feet, or $p^2\times 0.3927$ cubical feet. This muſt be equal to Q; therefore p^2 muſt be $\frac{Q}{0.3927}$ or nearly $Q\times 2\frac{1}{2}$. Hence this practical rule: Multiply the cubic feet of water which muſt be drawn in a minute by $2\frac{1}{2}$, and extract the ſquare root of the product: this will be the diameter of the pump in inches.

Thus ſuppoſe that 58 cubic feet muſt be drawn every minute; 58 multiplied by $2\frac{1}{2}$ gives 145, of which the ſquare root is 12, which is the required diameter of the pump.

2. To find the proper diameter of the cylinder.

The piſton is to be loaded with 7.64 pounds on every ſquare inch. This is equivalent to ſix pounds on a circular inch very nearly. The weight of a cylinder of water an inch in diameter and a fathom in height is $2\frac{1}{24}$ pounds, or nearly two pounds. Hence it follows that $6c^2$ muſt be made equal to $2fp^2$, and that c^2 is equal to $\frac{2fp^2}{6}$, or to $\frac{fp^2}{3}$.

Hence the following rule: Multiply the ſquare of the diameter of the pump piſton (found as above) by the fathoms of lift, and divide the product by 3; the ſquare root of the quotient is the diameter of the cylinder.

Suppoſe the pit to which the foregoing pump is to be applied is 24 fathoms deep; then $\frac{24\times 144}{3}$ gives 1152, of which the ſquare root is 34 inches very nearly.

This engine conſtructed with care will certainly do the work.

Whatever is the load of *water* propoſed for the engine, let 10 be the pounds on every circular inch of the ſteam piſton, and make $c^2=p^2\times\frac{2f}{m}$, and the ſquare root will be the diameter of the ſteam piſton in inches.

To free the practical engineer as much as poſſible from all trouble of calculation, we ſubjoin the following *TABLE of the Dimenſions and Power of the Steam Engine*, drawn up by Mr Beighton in 1717, and fully verified by practice ſince that time. The meaſure is in Engliſh ale gallons of 282 cubic inches.

49 Mr Beighton's table of the dimensions and power of the steam-engine.

Diam of pump.	Holds in one yard.	Draws by a six feet stroke.	Weighs in one yard.	At 16 strokes per min.	Ditto in hogsheads.	Ditto per hour.	Diameter of cylinder in inches. The depth to be drawn in yards. 15	20	25	30	35	40	45	50	60	70	80	90
Inch.	Gall.	Gall.	Lb. avoir.	Gall.	Hd. Gal	Hd. Gal												
12	14.4	28.8	146	462	7.21	440.	18½	21¾	24	26½	28½	30½	32½	34¼	37¼	40	43½	
11	12.13	24.26	123.5	338	6.20	369.33	17	19¾	22	25	26¼	28	29¼	31¼	34½	37	39½	
10	10.02	20.04	102	320	5.5	304.48	15½	18	20	22	23¾	25¼	27	28¾	31¼	34	36	38½
9	8.12	16.24	82.7	259.8	4.7	247.7	14	16¼	18	20	21½	23	24¼	25	28	30½	33	35
8½	7.26	14.52	73.9	232.3	3.43	221.15	13½	15¼	17¼	19	20¼	21¾	23	24	26¼	28½	31	32½
8	6.41	12.82	65.3	205.2	3.16	195.22	12½	14½	16½	18½	19	20½	21½	23	25	27	29	30½
7¾	6.01	12.02	61.2	192.3	3.2	182.13	12	14	15½	17½	18¾	19¾	21	22	24¼	26	28	29½
7½	5.66	11.32	57.6	181.1	2.55	172.30	11	13¾	15	16½	18	19	20	21¼	23¼	25	27	28½
7	4.91	9.82	50.0	157.1	2.31	149.40	10¾	13	14	15½	16¾	18¾	19	20½	22	24	25½	27
6½	4.23	8.46	43	135.3	2.9	128.54	10	12	13	14	15½	16¼	18	19	20	22	23	24½
6	3.61	7.2	36.7	115.5	1.52	110.1	9½	11	12	13	14	15½	16	17	19	20½	22	23
5½	3.13	6.2	31.8	99.2	1.36	94.30		10	11	12	13	14	15	15¾	17	19	20	21
5	2.51	5.0	25.5	80.3	1.7	66.61			10	11	11¾	13	13¾	14	15½	16¾	18½	19½
4½	2.02	4.04	20.5	64.6	1.1	60.60				10	11	11¾	12	13½	14	15	16	17
4	1.6	3.2	16.2	51.2	0.51	48.51					9	10	11	11½	12	13½	14	15

The first part of the table gives the size of the pump suited to the growth of water. The second gives the size of the cylinder suited to the load of water. If the depth is greater than any in this table, take its fourth part, and double the diameter of the cylinder. Thus if 150 hogsheads are to be drawn in an hour from the depth of 100 fathoms, the last column of part first gives for 149.40 a pump of seven inches bore. In a line with this, under the depth of 50 yards, which is one-fourth of 100 fathoms, we find 20½, the double of which is 41 inches for the diameter of the cylinder.

It is almost impossible to give a general rule for strokes of different lengths, &c. but any one who professes the ability to erect an engine, should surely know as much arithmetic as will accommodate the rule now given to any length of stroke.

We venture to say, that no ordinary engineer can tell *à priori* the number per minute which an engine will give. We took 12 strokes of six feet each for a standard, which a careful engineer may easily accomplish, and which an employer has a right to expect, the engine being loaded with water to half the pressure of the atmosphere: if the load be less, there is some fault—an improper counter weight, or too little boiler, or leaks, &c. &c.

50 Mr Fitzgerald's method of converting its reciprocating motion into a continued rotatory motion.

Such is the state in which Newcomen's steam-engine had continued in use for 60 years, neglected by the philosopher, although it is the most curious object which human ingenuity has yet offered to his contemplation, and abandoned to the efforts of the unlettered artist. Its use has been entirely confined to the raising of water. Mr Keane Fitzgerald indeed published in the Philosophical Transactions a method of converting its reciprocating motion into a continued rotatory motion by employing the great beam to work a crank or a train of wheel-work. As the real action of the machine is confined to its working stroke, to accomplish this, it became necessary to connect with the crank or wheeled work a very large and heavy fly, which should accumulate in itself the whole pressure of the machine during its time of action, and therefore continue in motion, and urge forward the working machinery, while the steam engine was going through its inactive returning stroke. This will be the case, provided that the resistance exerted by the working machine during the whole period of the working and returning stroke of the steam-engine, together with the friction of both, does not exceed the whole pressure exerted by the steam-engine during its working stroke; and provided that the momentum of the fly, arising from its great weight and velocity, be very great, so that the resistance of the work during one returning stroke of the steam-engine do not make any very sensible dimunition of the velocity of the fly. This is evidently possible and easy. The fly may be made of any magnitude; and being exactly balanced round its axis, it will soon acquire any velocity consistent with the motion of the steam-engine. During the working stroke of the engine it is uniformly accelerated, and by its acquired momentum it produces in the beam the movement of the returning stroke; but in doing this, its momentum is shared with the inert matter of the steam-engine, and consequently its velocity diminished, but not entirely taken away. The next working stroke therefore, by pressing on it afresh, increases its remaining velocity by a quantity nearly equal to the whole that it acquired during the first stroke. We say *nearly*, but not quite equal, because the time of the second working stroke must be shorter than that of the first, on account of the velocity already in the machine. In this manner the fly will be more and more accelerated every succeeding stroke, because the pressure of the engine during the working stroke does more than restore to the fly the momentum which it lost in producing the returning movement of the steam-engine. Now suppose the working part of the machine to be added. The acceleration of the fly during each working stroke of the steam-engine will be less than it was before, because the impelling pressure is now partly employed in driving the working machine, and because the fly will lose more of its momentum during the returning stroke of the steam-engine, part of it being expended in driving the working machine. It is evident, therefore, that a time will come

Steam-Engine. come when the ſucceſſive augmentation of the fly's velocity will ceaſe; for, on the one hand, the continual acceleration diminiſhes the time of the next working ſtroke, and therefore the time of action of the accelerating power. The acceleration muſt diminiſh in the ſame proportion; and on the other hand, the reſiſtance of the working machine generally, though not always, increaſes with its velocity. The acceleration ceaſes whenever the addition made to the momentum of the fly during a working ſtroke of the ſteam-engine is juſt equal to what it loſes by driving the machine, and by producing the returning movement of the ſteam-engine.

51 An important addition;

This muſt be acknowledged to be a very important addition to the engine, and though ſufficiently obvious, it is ingenious, and requires conſiderable ſkill and addreſs to make it effective (B).

The movement of the working machine, or mill of whatever kind, muſt be in ſome degree hobbling or unequal. But this may be made quite inſenſible, by making the fly exceedingly large, and diſpoſing the greateſt part of its weight in the rim. By theſe means its momentum may be made ſo great, that the whole force required for driving the mill and producing the returning movement of the engine may bear a very ſmall proportion to it. The diminution of its velocity will then be very trifling.

No counter weight is neceſſary here, becauſe the returning movement is produced by the inertia of the fly. A counter weight may, however, be employed, and ſhould be employed, viz. as much as will produce the returning movement of the ſteam-engine. It will do this better than the ſame force accumulated in the fly; for this force muſt be accumulated in the fly by the intervention of rubbing parts, by which ſome of it is loſt; and it muſt be afterwards returned to the engine with a ſimilar loſs. But, for the ſame reaſon, it would be improper to make the counter weight alſo able to drive the mill during the returning ſtroke.

52 but ſeldom or never adopted.

By this contrivance Mr Fitzgerald hoped to render the ſteam-engine of moſt extenſive uſe; and he, or others aſſociated with him, obtained a patent excluding all others from employing the ſteam-engine for turning a crank. They alſo publiſhed propoſals for erecting mills of all kinds driven by ſteam engines, and ſtated very fairly their powers and their advantages. But their propoſals do not ſeem to have acquired the confidence of the public; for we do not know of any mill ever having been erected under this patent.

53 The great expenſe of fuel

The great obſtacle to this extenſive uſe of the ſteam-engine is the prodigious expenſe of fuel. An engine having a cylinder of four feet diameter, working night and day, conſumes about 3400 chaldron (London) of good coals in a year.

Steam-Engine. This circumſtance limits the uſe of ſteam-engines exceedingly. To draw water from coal-pits, where they can be ſtocked with unſaleable ſmall coal, they are of univerſal employment: alſo for valuable mines, for ſupplying a great and wealthy city with water, and a few other purpoſes where a great expence can be borne, they are very proper engines; but in a thouſand caſes where their unlimited powers might be vaſtly ſerviceable, the enormous expenſe of fuel completely excludes them. We cannot doubt but that the attention of engineers was much directed to every thing that could promiſe a diminution of this expenſe. Every one had his particular noſtrum for the conſtruction of his furnace, and ſome were undoubtedly more ſucceſsful than others. But ſcience was not yet ſufficiently advanced: It was not till Dr Black had made his beautiful diſcovery of latent heat, that we could know the intimate relation between the heat expended in boiling off a quantity of water and the quantity of ſteam that is produced.

54 limits the uſe of ſteam-engines.

Much about the time of this diſcovery, viz. 1763, Mr James Watt, eſtabliſhed in Glaſgow in the commercial line, was amuſing himſelf with repairing a working model of the ſteam engine which belonged to the philoſophical apparatus of the univerſity. Mr Watt was a perſon of a truly philoſophical mind, eminently converſant in all branches of natural knowledge, and the pupil and intimate friend of Dr Black. In the courſe of the above-mentioned amuſement many curious facts in the production and condenſation of ſteam occurred to him; and among others, that remarkable fact which is always appealed to by Dr Black as the proof of the immenſe quantity of heat which is contained in a very minute quantity of water in the form of elaſtic ſteam. When a quantity of water is heated ſeveral degrees above the boiling point in a cloſe digeſter, if a hole be opened, the ſteam ruſhes out with prodigious violence, and the heat of the remaining water is reduced, in the courſe of three or four ſeconds, to the boiling temperature. The water of the ſteam which has iſſued amounts only to a very few drops; and yet theſe have carried off with them the whole exceſs of heat from the water in the digeſter.

55 Mr Watt diſcovers that ſteam contains an immenſe quantity of heat

Since then a certain quantity of ſteam contains ſo great a quantity of heat, it muſt expend a great quantity of fuel; and no conſtruction of furnace can prevent this. Mr Watt therefore ſet his invention to work to diſcover methods of huſbanding this heat. The cylinder of his little model was heated almoſt in an inſtant, ſo that it could not be touched by the hand. It could not be otherwiſe, becauſe it condenſed the vapour by abſtracting its heat. But all the heat thus communicated to the cylinder, and waſted by it on ſurrounding bodies, contributed nothing to the performance of the engine,

56 in his attempts to find out a way to huſband this heat,

(B) We do not recollect at preſent the date of this propoſal of Mr Fitzgerald; but in 1781 the Abbé Arnal, canon of Alais in Languedoc, entertained a thought of the ſame kind, and propoſed it for working lighters in the inland navigations; a ſcheme which has been ſucceſsfully practiſed (we are told) in America. His brother, a major of engineers in the Auſtrian ſervice, has carried the thing much farther, and applied it to manufactures; and the Aulic Chamber of Mines at Vienna has patronized the project: (See *Journal Encyclopedique*, 1781). But theſe ſchemes are long poſterior to Mr Fitzgerald's patent, and are even later than the erection of ſeveral machines driven by ſteam-engines which have been erected by Meſſrs Watt and Boulton. We think it our duty to ſtate theſe particulars, becauſe it is very uſual for our neighbours on the continent to aſſume the credit of Britiſh inventions.

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engine, and muſt be taken away at every injection, and again communicated and waſted. Mr Watt quickly underſtood the whole proceſs which was going on within the cylinder, and which we have conſidered ſo minutely, and ſaw that a very conſiderable portion of the ſteam muſt be waſted in warming the cylinder. His firſt attempts were made to aſcertain how much was thus waſted, and he found that it was not leſs than three or four times as much as would fill the cylinder and work the engine. He attempted to diminiſh this waſte by uſing wooden cylinders. But though this produced a ſenſible diminution of the waſte, other reaſons forced him to give them up. He then caſed his metal cylinders in a wooden caſe with light wood aſhes between. By this, and uſing no more injection than was abſolutely neceſſary for the condenſation, he reduced the waſte almoſt one half. But by uſing ſo ſmall a quantity of cold water, the inſide of the cylinder was hardly brought below the boiling temperature; and there conſequently remained in it a ſteam of very conſiderable elaſticity, which robbed the engine of a proportional part of the atmoſpherical preſſure. He ſaw that this was unavoidable as long as the condenſation was performed in the cylinder. The thought ſtruck him to attempt the condenſation in another place. His firſt experiment was made in the ſimpleſt manner. A globular veſſel communicated by means of a long pipe of one inch diameter with the bottom of his little cylinder of four inches diameter and 30 inches long. This pipe had a ſtop-cock, and the globe was immerſed in a veſſel of cold water. When the piſton was at the top, and the cylinder filled with ſtrong ſteam, he turned the cock. It was ſcarcely turned, nay he did not think it completely turned, when the ſides of his cylinder (only ſtrong tin-plate) were cruſhed together like an empty bladder. This ſurpriſed and delighted him. A new cylinder was immediately made of braſs ſufficiently thick, and nicely bored. When the experiment was repeated with this cylinder, the condenſation was ſo rapid, that he could not ſay that any time was expended in it. But the moſt valuable diſcovery was, that the vacuum in the cylinder was, as he hoped, almoſt perfect. Mr Watt found, that when he uſed water in the boiler purged of air by long boiling, nothing that was very ſenſibly inferior to the preſſure of the atmoſphere on the piſton could hinder it from coming quite down to the bottom of the cylinder. This alone was gaining a great deal, for in moſt engines the remaining elaſticity of the ſteam was not leſs than one-eighth of the atmoſpherical preſſure, and therefore took away one-eighth of the power of the engine.

57 diſcovers a method of condenſing the ſteam at a little diſtance from the cylinder,

58 and removes the difficulties which attended this improvement by means of pumps.

Having gained this capital point, Mr Watt found many difficulties to ſtruggle with before he could get the machine to continue its motion. The water produced from the condenſed ſteam, and the air which was extricated from it, or which penetrated through unavoidable leaks, behoved to accumulate in the condenſing veſſel, and could not be voided in any way ſimilar to that adopted in Newcomen's engine. He took another method: He applied pumps to extract both, which were worked by the great beam. The contrivance is eaſy to any good mechanic; only we muſt obſerve, that the piſton of the water-pump muſt be under the ſurface of the water in the condenſer, that the water may enter the pump by its own weight, becauſe there is no atmoſpherical preſſure there to force it in. We muſt alſo obſerve, that a conſiderable force is neceſſarily expended here, becauſe, as there is but one ſtroke for rarefying the air, and this rarefaction muſt be nearly complete, the air-pump muſt be of large dimenſions, and its piſton muſt act againſt the whole preſſure of the atmoſphere. Mr Watt, however, found that this force could be eaſily ſpared from his machine, already ſo much improved in reſpect of power.

59 Obſervations on the advantages of theſe diſcoveries.

Thus has the ſteam-engine received a very conſiderable improvement. The cylinder may be allowed to remain very hot; nay, boiling hot, and yet the condenſation be completely performed. The only elaſtic ſteam that now remains is the ſmall quantity in the pipe of communication. Even this ſmall quantity Mr Watt at laſt got rid of, by admitting a ſmall jet of cold water up this pipe to meet the ſteam in its paſſage to the condenſer. This both cooled this part of the apparatus in a ſituation where it was not neceſſary to warm it again, and it quickened the condenſation. He found at laſt that the ſmall pipe of communication was of itſelf ſufficiently large for the condenſation, and that no ſeparate veſſel, under the name of condenſer, was neceſſary. This circumſtance ſhows the prodigious rapidity of the condenſation. We may add, that unleſs this had been the caſe, his improvement would have been vaſtly diminiſhed; for a large condenſer would have required a much larger air-pump, which would have expended much of the power of the engine. By theſe means the vacuum below the piſton is greatly improved: for it will appear clear to any perſon who underſtands the ſubject, that as long as any part of the condenſer is kept of a low temperature, it will abſtract and condenſe the vapour from the warmer parts, till the whole acquires the elaſticity correſponding to the coldeſt part. By the ſame means much of the waſte is prevented, becauſe the cylinder is never cooled much below the boiling temperature. Many engines have been erected by Mr Watt in this form, and their performance gave univerſal ſatisfaction.

We have contented ourſelves with giving a very ſlight deſcription without a figure of this improved engine, becauſe we imagine it to be of very eaſy comprehenſion, and becauſe it is only a preparation for ſtill greater improvements, which, when underſtood, will at the ſame time leave no part of this more ſimple form unexplained.

60 Mr Watt makes the piſton deſcend by the force of ſteam.

During the progreſs of theſe improvements Mr Watt made many experiments on the quantity and denſity of the ſteam of boiling water. Theſe fully convinced him, that although he had greatly diminiſhed the waſte of ſteam, a great deal yet remained, and that the ſteam expended during the riſe of the piſton was at leaſt three times more than what would fill the cylinder. The cauſe of this was very apparent. In the ſubſequent deſcent of the piſton, covered with water much below the boiling temperature, the whole cylinder was neceſſarily cooled and expoſed to the air. Mr Watt's fertile genius immediately ſuggeſted to him the expedient of employing the elaſticity of the ſteam from the boiler to impel the piſton down the cylinder, in place of the preſſure of the atmoſphere; and thus he reſtored the engine to its firſt principles, making it an engine *really moved by ſteam*. As this is a new epoch in its hiſtory, we ſhall be more particular in the deſcription; at the ſame

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fame time ftill reftricting ourfelves to the effential circumftances, and avoiding every peculiarity which is to be found in the prodigious varieties which Mr Watt has introduced into the machines which he has erected, every individual of which has been adapted to local circumftances, or diverfified by the progrefs of Mr Watt's improvements.

61 Defcription of the machine after thefe improvements were added.

Fig. 9

Let A (fig. 9.) reprefent the boiler. This has received great improvements from his complete acquaintance with the procedure of nature in the production of fteam. In fome of his engines the fuel has been placed in the midft of the water, furrounded by an iron or copper veffel, while the exterior boiler was made of wood, which tranfmits, and therefore waftes the heat very flowly. In others, the flame not only plays round the whole outfide, as in common boilers, but alfo runs along feveral flues which are conducted through the midft of the water. By fuch contrivances the fire is applied to the water in a moft extenfive furface, and for a long time, fo as to impart to it the greateft part of its heat. So fkilfully was it applied in the Albion mills, that although it was perhaps the largeft engine in the kingdom, its unconfumed fmoke was inferior to that of a very fmall brew-houfe, In this fecond engine of Mr Watt, the top of the cylinder is fhut up by a ftrong metal plate *g h*, in the middle of which is a collar or box of leathers *k l*, formed in the ufual manner of a jack-head pump, through which the pifton rod PD, nicely turned and polifhed, can move up and down, without allowing any air to pafs by its fides. From the dome of the boiler proceeds a large pipe BCIOQ, which, after reaching the cylinder with its horizontal part BC, defcends parallel to its fide, fending off two branches, viz. IM to the top of the cylinder, and ON to its bottom. At I is a puppet valve opening from below upwards. At L, immediately below this branch, there is a fimilar valve, alfo opening from below upwards. The pipe defcends to Q, near the bottom of a large ciftern *c d e f*, filled with cold water conftantly renewed. The pipe is then continued horizontally along the bottom of this ciftern (but not in contact), and terminates at R in a large pump ST. The pifton S has clack valves opening upwards, and its rod S *s*, paffing through a collar of leathers at T, is fufpended by a chain to a fmall arch head on the outer arm of the beam. There is a valve R in the bottom of this pump, as ufual, which opens when preffed in the direction QR, and fhuts againft a contrary preffure. This pump delivers its contents into another pump XY, by means of the fmall pipe *t* X, which proceeds from its top. This fecond pump has a valve at X, and a clack in its pifton Z as ufual, and the pifton rod Z *z* is fufpended from another arch head on the outer arm of the beam. The two valves I and L are opened and fhut by means of fpanners and handles, which are put in motion by a plug frame, in the fame manner as in Newcomen's engine.

Laftly, there may be obferved a crooked pipe *a b o*, which enters the upright pipe laterally a little above Q. This has a fmall jet hole at *o*; and the other end *a*, which is confiderably under the furface of the water of the condenfing ciftern, is covered with a puppet valve *v*, whofe long ftalk *v u* rifes above the water, and may be raifed or lowered by hand or by the plug beam. The valves R and X, and the clacks in the piftons S and Z, are opened or fhut by the preffures to which they are immediately expofed.

This figure is not an exact copy of any of Mr Watt's engines, but has its parts fo difpofed that all may come diftinctly into view, and exactly perform their various functions. It is drawn in its quiefcent pofition, the outer end of the beam preponderating by the counter weight, and the pifton P at the top of the cylinder, and the piftons S and Z in their loweft fituations.

In this fituation let us fuppofe that a vacuum is (by any means) produced in all the fpace below the pifton, the valve I being fhut. It is evident that the valve R will alfo be fhut, as alfo the valve *v*. Now let the valve I be opened. The fteam from the boiler, as elaftic as common air, will rufh into the fpace above the pifton, and will exert on it a preffure as great as that of the atmofphere. It will therefore prefs it down, raife the outer end of the beam, and caufe it to perform the fame work as an ordinary engine.

When the pifton P has reached the bottom of the cylinder, the plug frame fhuts the valve I, and opens L. By fo doing the communication is open between the top and bottom of the cylinder, and nothing hinders the fteam which is above the pifton from going along the paffage MLON. The pifton is now equally affected on both fides by the fteam, even though a part of it is continually condenfed by the cylinder, and in the pipe IOQ. Nothing therefore hinders the pifton from being dragged up by the counter weight, which acts with its whole force, undiminifhed by any remaining unbalanced elafticity of fteam. Here therefore this form of the engine has an advantage (and by no means a fmall one) over the common engines, in which a great part of the counter weight is expended in overcoming unbalanced atmofpheric preffure.

Whenever the pifton P arrives at the top of the cylinder, the valve L is fhut by the plug frame, and the valves I and *v* are opened. All the fpace below the pifton is at this time occupied by the fteam which came from the upper part of the cylinder. This being a little wafted by condenfation, is not quite a balance for the preffure of the atmofphere. Therefore, during the afcent of the pifton, the valve R was fhut, and it remains fo. When, therefore, the valve *v* is opened, the cold water of the ciftern muft fpout up through the hole *o*, and condenfe the fteam. To this muft be added the coldnefs of the whole pipe OQS. As faft as it is condenfed, its place is fupplied by fteam from the lower part of the cylinder. We have already remarked, that this fucceffive condenfation is accomplifhed with aftonifhing rapidity. In the mean time, fteam from the boiler preffes on the upper furface of the pifton. It muft therefore defcend as before, and the engine muft perform a fecond working ftroke.

But in the mean time the injection water lies in the bottom of the pipe OQR, heated to a confiderable degree by the condenfation of the fteam; alfo a quantity of air has been difengaged from it and from the water in the boiler. How is this to be difcharged?—This is the office of the pumps ST and XY. The capacity of ST is very great in proportion to the fpace in which the air and water are lodged. When, therefore, the pifton S has got to the top of its courfe, there muft be a vacuum in the barrel of this pump, and the water and air muft open the valve R and come into it. When the pifton piſton S comes down again in the next returning ſtroke, this water and air gets through the valve of the piſton; and in the next working ſtroke they are diſcharged by the piſton into the pump XY, and raiſed by its piſton. The air eſcapes at Y, and as much of the water as is neceſſary is delivered into the boiler by a ſmall pipe Y *g* to ſupply its waſte. It is a matter of indifference whether the piſtons S and Z riſe with the outer or inner end of the beam, but it is rather better that they riſe with the inner end. They are otherwiſe drawn here, in order to detach them from the reſt and ſhow them more diſtinctly.

Such is Mr Watt's ſecond engine. Let us examine its principles, that we may ſee the cauſes of its avowed and great ſuperiority over the common engines.

62 Cauſes of its ſuperiority over common engines are, the full operation of the counter-weight,

We have already ſeen one ground of ſuperiority, the full operation of the counter weight. We are authoriſed by careful examination to ſay, that in the common engines at leaſt one-half of the counter weight is expended in counteracting an unbalanced preſſure of the air on the piſton during its aſcent. In many engines, which are not the worſt, this extends to $\frac{4}{5}$th of the whole preſſure. This is evident from the examination of the engine at Montrelaix by Boſſut. This makes a very great counter weight neceſſary, which exhauſts a proportional part of the moving force.

63 and great ſaving of ſteam.

But the great advantage of Mr Watt's form is the almoſt total annihilation of the waſte of ſteam by condenſation in the cylinder. The cylinder is always boiling hot, and therefore perfectly dry. This muſt be evident to any perſon who underſtands the ſubject. By the time that Mr Watt had completed his improvements, his experiments on the production of ſteam had given him a pretty accurate knowledge of its denſity; and he found himſelf authorized to ſay, that the quantity of ſteam employed did not exceed twice as much as would fill the cylinder, ſo that not above one-half was unavoidably waſted. But before he could bring the engine to this degree of perfection, he had many difficulties to overcome: He incloſed the cylinder in an outer wooden caſe at a ſmall diſtance from it. This diminiſhed the expence of heat by communication to ſurrounding bodies. Sometimes he allowed the ſteam from the boiler to occupy this interval. This undoubtedly prevented all diſſipation from the inner cylinder; but in its turn it diſſipated much heat by the outer caſe, and a very ſenſible condenſation was obſerved between them. This has occaſioned him to omit this circumſtance in ſome of his beſt engines. We believe it was omitted in the Albion mills.

The greateſt difficulty was to make the great piſton tight. The old and effectual method, by water lying on it, was inadmiſſible. He was therefore obliged to have his cylinders moſt nicely bored, perfectly cylindrical, and finely poliſhed; and he made numberleſs trials of different ſoft ſubſtances for packing his piſton, which ſhould be tight without enormous friction, and which ſhould long remain ſo, in a ſituation perfectly dry, and hot almoſt to burning.

After all that Mr Watt has done in this reſpect, he thinks that the greateſt part of the waſte of ſteam which he ſtill perceives in his engines ariſes from the unavoidable eſcape by the ſides of the piſton during its deſcent.

But the fact is, that an engine of this conſtruction, of the ſame dimenſions with a common engine, making the ſame number of ſtrokes of the ſame extent, does not conſume above one-fourth part of the fuel that is conſumed by the beſt engines of the common form. It is alſo a very fortunate circumſtance, that the performance of the engine is not immediately deſtroyed, nor indeed ſenſibly diminiſhed, by a ſmall want of tightneſs in the piſton. In the common engine, if air get in, in this way, it immediately puts a ſtop to the work; but although even a conſiderable quantity of ſteam get paſt the piſton during its deſcent, the rapidity of condenſation is ſuch, that hardly any diminution of preſſure can be obſerved.

64 Another valuable property of it.

Mr Watt's penetration ſoon diſcovered another moſt valuable property of this engine. When an engine of the common form is erected, the engineer muſt make an accurate eſtimate of the work to be performed, and muſt proportion his engine accordingly. He muſt be careful that it be *fully* able to execute its taſk; but its power muſt not exceed its load in any extravagant degree. This would produce a motion which is too rapid, and which, being alternately in oppoſite directions, would occaſion jolts which no building or machinery could withſtand. Many engines have been ſhattered by the pumps drawing air, or a pump-rod breaking; by which accidents the ſteam-piſton deſcends with ſuch rapidity that every thing gives way. But in moſt operations of mining, the taſk of the engine increaſes, and it muſt be ſo conſtructed at firſt as to be able to bear this addition. It is very difficult to manage an engine that is much ſuperior to its taſk; and the eaſieſt way is, to have it almoſt full loaded, and to work it only during a few hours each day, and allow the pit water to accumulate during its repoſe. This increaſes the firſt coſt, and waſtes fuel during the inaction of the engine.

65 is, that it can always be exactly fitted to the load which happens to be on it.

But this new engine can at all times be exactly fitted (at leaſt during the working ſtroke) to the load of work that then happens to be on it. We have only to adminiſter ſteam of a proper elaſticity. At the firſt erection the engine may be equal to twice its taſk, if the ſteam admitted above the cylinder be equal to that of common boiling water; but when once the ebullition is fairly commenced, and the whole air expelled from all parts of the apparatus, it is evident, that by damping the fire, ſteam of half this elaſticity may be continually ſupplied, and the water will continue boiling although its temperature does not exceed 185° of Fahrenheit's thermometer. This appears by inſpecting our table of vaporous elaſticity, and affords another argument for rendering that table more accurate by new experiments. We hope that Mr Watt will not withhold from the public the knowledge which he has acquired on this ſubject. It may very poſſibly reſult from an accurate inveſtigation, that it would be adviſable to work our ſteam-engines with weak ſteams, and that the diminution of work may be more than compenſated by the diminution of fuel. It is more probable indeed, and it is Mr Watt's opinion, that the contrary is the caſe, and that it is much more economical to employ great heats. At any rate, the deciſion of this queſtion is of great importance for improving the engine; and we ſee, in the mean time, that the engine can at all times be fitted ſo as to perform its taſk with a moderate and manageable motion, and that as the taſk increaſes we can increaſe the power of the engine.

Steam-Engine.

66 One inconvenience

But the method now proposed has a great inconvenience. While the steam is weaker than the atmosphere, there is an external force tending to squeeze in the sides and bottom of the boiler. This could not be resisted when the difference is considerable, and common air would rush in through every crevice of the boiler and soon choke the engine: it must therefore be given up.

67 remedied in some degree.

But the same effect will be produced by diminishing the passage for the steam into the cylinder. For this purpose, the puppet valve by which the steam enters the cylinder was made in the form of a long taper spigot, and it was lodged in a cone of the same shape; consequently the passage could be enlarged or contracted at pleasure by the distance to which the inner cone was drawn up.

68 But the remedy attended with some difficulties;

In this way several engines were constructed, and the general purpose of suiting the power of the engine to its task was completely answered; but (as the mathematical reader will readily perceive) it was extremely difficult to make this adjustment precise and constant. In a great machine like this going by jerks, it was hardly possible that every successive motion of the valve should be precisely the same. This occasioned very sensible irregularities in the motion of the engine, which increased and became hazardous when the joints worked loose by long use.

69 which Mr Watt's fertile genius completely removed.

Mr Watt's genius, always fertile in resources, found out a complete remedy for all these inconveniences. Making the valve of the ordinary form of a puppet clack, he adjusted the button of its stalk or tail so that it should always open full to the same height. He then regulated the pins of the plug-frame, in such a manner that the valve should shut the moment that the piston had descended a certain proportion (suppose one-fourth, one-third, one-half, &c.) of the cylinder. So far the cylinder was occupied by steam as elastic as common air. In pressing the piston farther down, it behoved the steam to expand, and its elasticity to diminish. It is plain that this could be done in any degree we please, and that the adjustment can be varied in a minute, according to the exigency of the case, by moving the plug pins.

In the mean time, it must be observed, that the pressure on the piston is continually changing, and consequently the accelerating force. The motion therefore will no longer be uniformly accelerated: it will approach much faster to uniformity; nay, it may be retarded, because although the pressure on the piston at the beginning of the stroke may exceed the resistance of the load, yet when the piston is near the bottom the resistance may exceed the pressure. Whatever may be the law by which the pressure on the piston varies, an ingenious mechanic may contrive the connecting machinery in such a way that the chains or rods at the outer end of the beam shall continually exert the same pressure, or shall vary their pressure according to any law he finds most convenient. It is in this manner that the watchmaker, by the form of the fuzee, produces an equal pressure on the wheel-work by means of a very unequal action of the main-spring. In like manner, by making the outer arch heads portions of a proper spiral instead of a circle, we can regulate the force of the beam at pleasure.

Thus we see how much more manageable an engine is in this form than Newcomen's was, and also more easily investigated in respect of its power in its various positions. The knowledge of this last circumstance was of mighty consequence, and without it no notion could be formed of what it could perform. This suggested to Mr Watt the use of the barometer communicating with the cylinder; and by the knowledge acquired by these means has the machine been so much improved by its ingenious inventor.

We must not omit in this place one deduction made by Mr Watt from his observations, which may be called a discovery of great importance in the theory of the engine.

70 A discovery of Mr Watt of great importance in the theory of the engine. Fig. 10.

Let ABCD (fig. 10.) represent a section of the cylinder of a steam-engine, and EF the surface of its piston. Let us suppose that the steam was admitted while EF was in contact with AB, and that as soon as it had pressed it down to the situation EF the steam cock is shut. The steam will continue to press it down, and as the steam expands its pressure diminishes. We may express its pressure (exerted all the while the piston moves from the situation AB to the situation EF) by the line EF. If we suppose the elasticity of the steam proportional to its density, as is nearly the case with air, we may express the pressure on the piston in any other position, such as KL or DC, by Kl and Dc, the ordinates of a rectangular hyperbola Flc, of which AE, AB are the assymptotes, and A the centre. The accumulated pressure during the motion of the piston from EF to DC will be expressed by the area EFcDE, and the pressure during the whole motion by the area ABFcDA.

Now it is well known that the area EFcDE is equal to ABFE multiplied by the hyperbolic logarithm of $\frac{AD}{AE}, = L. \frac{AD}{AE}$, and the whole area ABF$c$DA is $= ABFE \times \left(1 + L.\frac{AD}{AE}\right)$.

Thus let the diameter of the piston be 24 inches, and the pressure of the atmosphere on a square inch be 14 pounds; the pressure on the piston is 6333 pounds. Let the whole stroke be 6 feet, and let the steam be stopped when the piston has descended 18 inches, or 1.5 feet. The hyperbolic logarithm of $\frac{6}{1.5}$ is 1.3862943. Therefore the accumulated pressure ABFcDA is $= 6333 \times 2.3862943, = 15114$ pounds.

As few professional engineers are possessed of a table of hyperbolic logarithms, while tables of common logarithms are or should be in the hands of every person who is much engaged in mechanical calculations, let the following method be practised. Take the common logarithm of $\frac{AD}{AE}$, and multiply it by 2.3026; the product is the hyperbolic logarithm of $\frac{AD}{AE}$.

The accumulated pressure while the piston moves from AB to EF is 6333×1, or simply 6333 pounds. Therefore the steam while it expands into the whole cylinder adds a pressure of 8781 pounds.

Suppose that the steam had got free admission during the whole descent of the piston, the accumulated pressure would have been 6333×4, or 25332 pounds.

Here Mr Watt observed a remarkable result. The steam expended in this case would have been four times

greater

greater than when it was ſtopped at one-fourth, and yet the accumulated preſſure is not twice as great, being nearly five-thirds. One-fourth of the ſteam performs nearly three-fifths of the work, and an equal quantity performs more than twice as much work when thus admitted during one-fourth of the motion.

This is a curious and an important information, and the advantage of this method of working a ſteam-engine increaſes in proportion as the ſteam is ſooner ſtopped; but the increaſe is not great after the ſteam is rarefied four times. The curve approaches near to the axis, and ſmall additions are made to the area. The expenſe of ſuch great cylinders is conſiderable, and may ſometimes compenſate this advantage.

Let the ſteam be ſtopped at	Its performance is mult.
$\frac{1}{2}$ - -	1.7
$\frac{1}{3}$ - -	2.1
$\frac{1}{4}$ - -	2.4
$\frac{1}{5}$ - -	2.6
$\frac{1}{6}$ - -	2.8
$\frac{1}{7}$ - -	3.
$\frac{1}{8}$ - -	3.2
&c.	&c.

It is very pleaſing to obſerve ſo many unlooked-for advantages reſulting from an improvement made with the ſole view of leſſening the waſte of ſteam by condenſation. While this purpoſe is gained, we learn how to huſband the ſteam which is not thus waſted. The engine becomes more manageable, and is more eaſily adapted to every variation in its taſk, and all its powers are more eaſily computed.

The active mind of its ingenious inventor did not ſtop here: It had always been matter of regret that one-half of the motion was unaccompanied by any work. It was a very obvious thing to Mr Watt, that as the ſteam admitted above the piſton preſſed it down, ſo ſteam admitted below the piſton preſſed it up with the ſame force, provided that a vacuum were made on its upper ſide. This was eaſily done, by connecting the lower end of the cylinder with the boiler and the upper end with the condenſer.

Plate DIII. Fig. 11.

71 Deſcription of Mr Watt's ſteam-engine in its moſt improved ſtate.

Fig. 11. is a repreſentation of this conſtruction exactly copied from Mr Watt's figure accompanying his ſpecification. Here BB is a ſection of the cylinder, ſurrounded at a ſmall diſtance by the caſe 1111. The ſection of the piſton A, and the collar of leathers which embraces the piſton rod, gives a diſtinct notion of its conſtruction, of the manner in which it is connected with the piſton-rod, and how the packing of the piſton and collar contributes to make all tight.

From the top of the cylinder proceeds the horizontal pipe. Above the letter D is obſerved the ſeat of the ſteam valve, communicating with the box above it. In the middle of this may be obſerved a dark ſhaded circle. This is the mouth of the upper branch of the ſteam pipe coming from the boiler. Beyond D, below the letter N, is the ſeat of the upper condenſing valve. The bottom of the cylinder is made ſpherical, fitting the piſton, ſo that they may come into entire contact. Another horizontal pipe proceeds from this bottom. Above the letter E is the ſeat of the lower ſteam valve, opening into the valve box. This box is at the extremity of another ſteam pipe marked C, which branches off from the upper horizontal part, and deſcends obliquely, coming forward to the eye. The lower part is repreſented as cut open, to ſhow its interior conformation. Beyond this ſteam valve, and below the letter F, may be obſerved the ſeat of the lower condenſing valve. A pipe deſcends from hence, and at a ſmall diſtance below unites with another pipe GG, which comes down from the upper condenſing valve N. Theſe two eduction-pipes thus united go downwards, and open at L into a rectangular box, of which the end is ſeen at L. This box goes backward from the eye, and at its farther extremity communicates with the air-pump K, whoſe piſton is here repreſented in ſection with its butterfly valves. The piſton delivers the water and air laterally into another rectangular box M, darkly ſhaded, which box communicates with the pump I. The piſton-rods of this and of the air pump are ſuſpended by chains from a ſmall arch head on the inner arm of the great beam. The lower part of the eduction-pipe, the horizontal box L, the air-pump K, with the communicating box M between it and the pump I, are all immerſed in the cold water of the condenſing ciſtern. The box L is made flat, broad, and ſhallow, in order to increaſe its ſurface and accelerate the condenſation. But that this may be performed with the greateſt expedition, a ſmall pipe H, open below (but occaſionally ſtopped by a plug valve), is inſerted laterally into the eduction-pipe G, and then divides into two branches; one of which reaches within a foot or two of the upper valve N, and the other approaches as near to the valve F.

As it is intended by this conſtruction to give the piſton a ſtrong impulſe in both directions, it will not be proper to ſuſpend its rod by a chain from the great beam; for it muſt not only pull down that end of the beam, but alſo puſh it upwards. It may indeed be ſuſpended by double chains like the piſtons of the engines for extinguiſhing fires; and Mr Watt has accordingly done ſo in ſome of his engines. But in his drawing from which this figure is copied, he has communicated the force of the piſton to the beam by means of a toothed rack OO, which engages or works in the toothed ſector QQ on the end of the beam. The reader will underſtand, without any farther explanation, how the impulſe given to the piſton in either direction is thus tranſmitted to the beam without diminution. The fly XX, with its pinion Y, which alſo works in the toothed arch QQ, may be ſuppoſed to be removed for the preſent, and will be conſidered afterwards.

We ſhall take the preſent opportunity of deſcribing Mr Watt's method of communicating the force of the ſteam-engine to any machine of the rotatory kind. VV repreſents the rim and arms of a very large and heavy metalline fly. On its axis is the concentric toothed wheel U. There is attached to the end of the great beam a ſtrong and ſtiff rod TT, to the lower end of which a toothed wheel W is firmly fixed by two bolts, ſo that it cannot turn round. This wheel is of the ſame ſize and in the ſame vertical plane with the wheel U; and an iron link or ſtrap (which cannot be ſeen here, becauſe it is on the other ſide of the two wheels) connects the centres of the two wheels, ſo that the one cannot quit the other. The engine being in the poſition repreſented in the figure, ſuppoſe the fly to be turned once round by any external force in the direction of the darts. It is plain, that ſince the toothed wheels cannot quit each other, being kept together by the

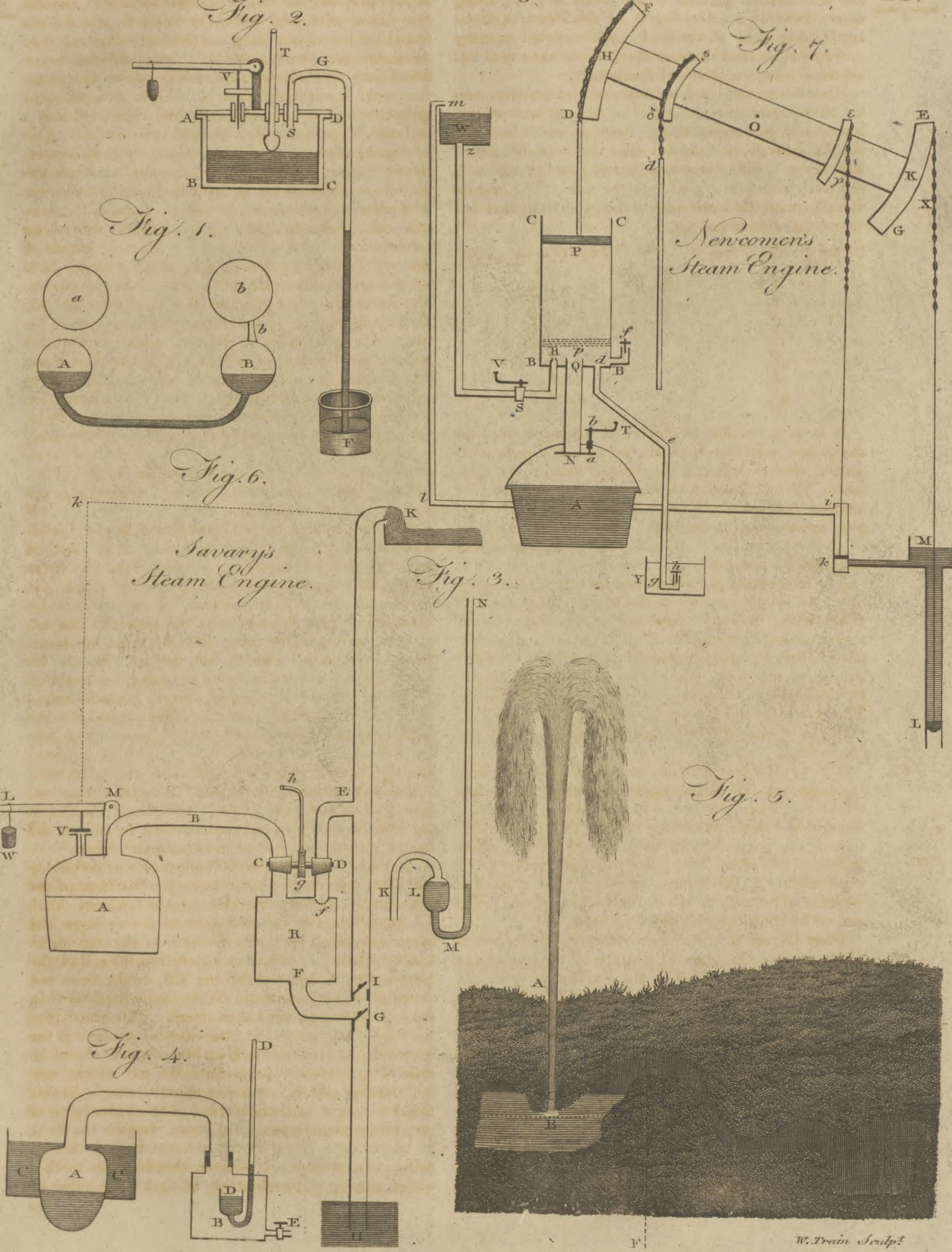


Fig. 2.
Fig. 7.
Fig. 1.
Newcomen's
Steam Engine.
Fig. 6.
Savary's
Steam Engine.
Fig. 3.
Fig. 5.
Fig. 4.
W. Train Sculpt.

BEIGHTON'S STEAM ENGINE.

Fig. 8.

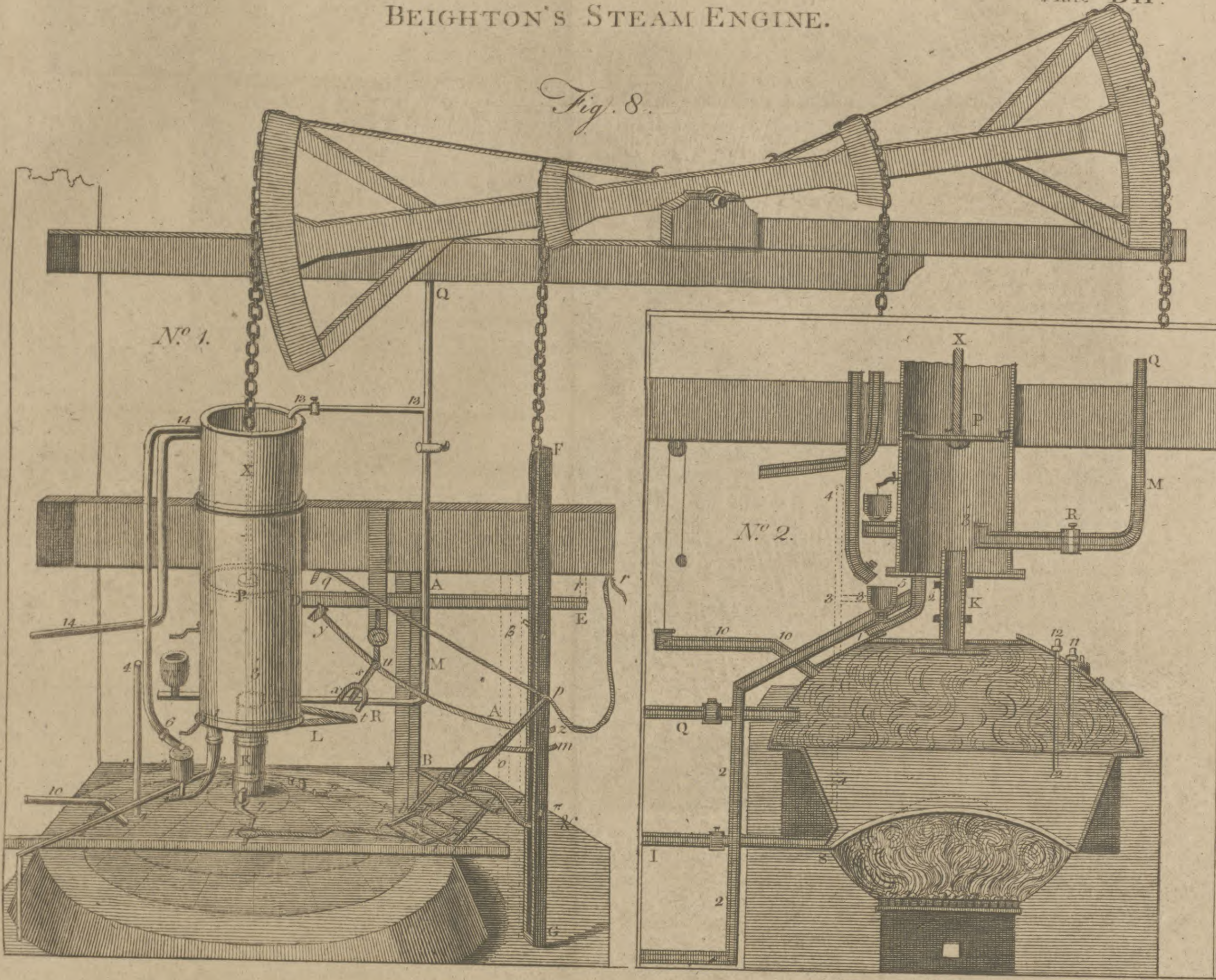


Fig. 9.

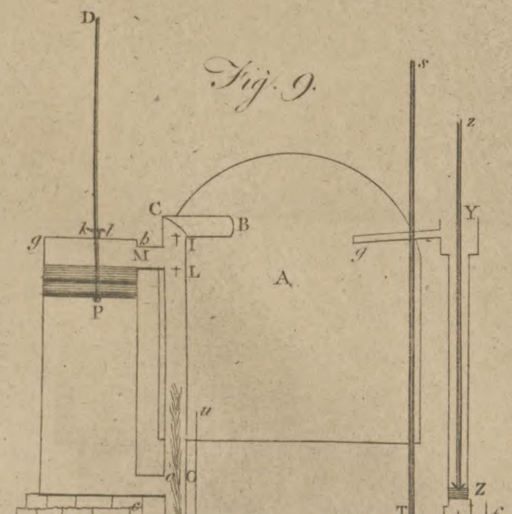
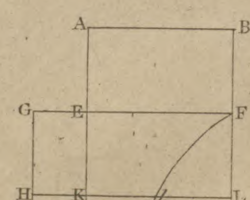


Fig. 10.



W. Archibald sculp^t.

Watt's

STEAM ENGINE.

Plate DIII.

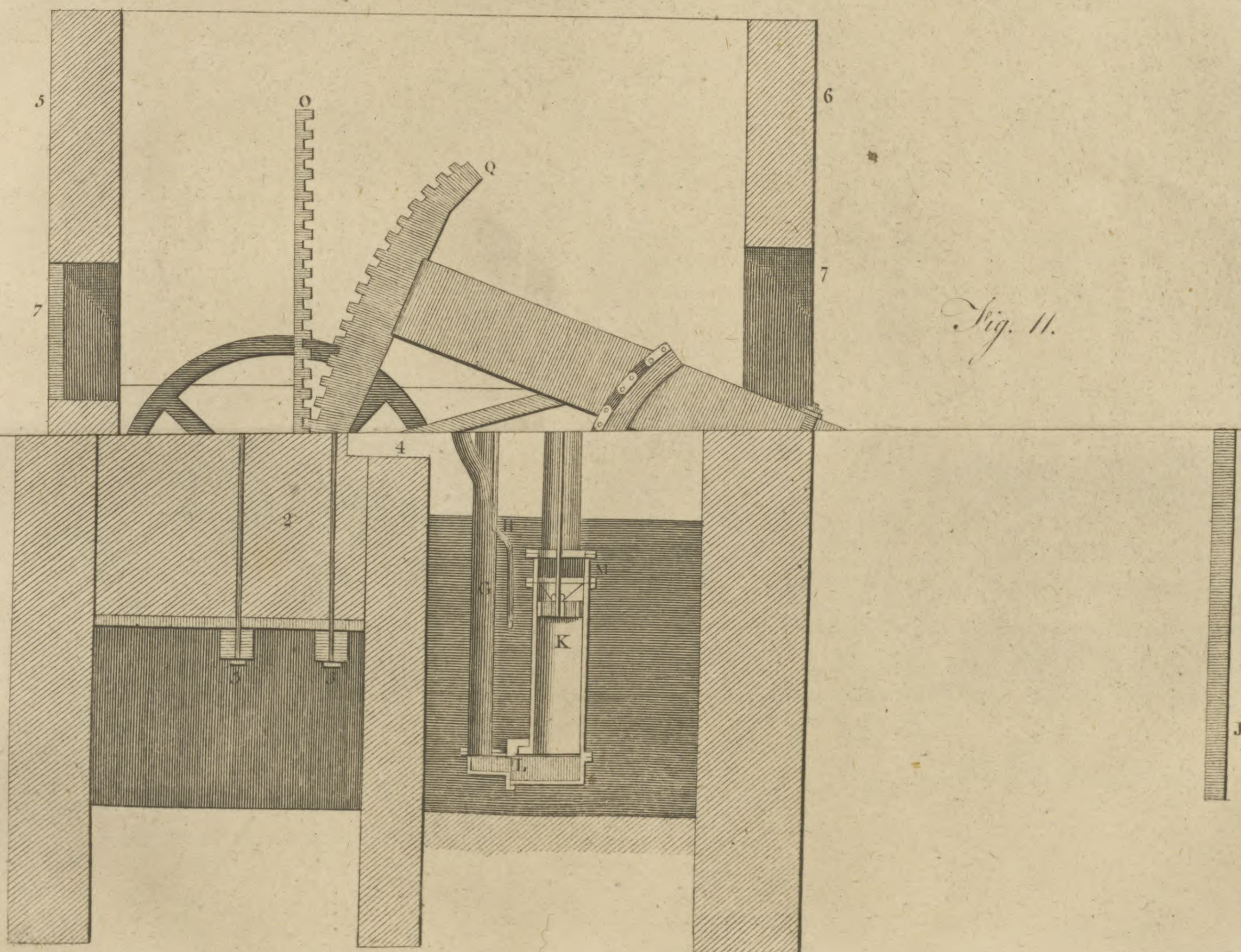


Fig. 11.

Fig. 12.

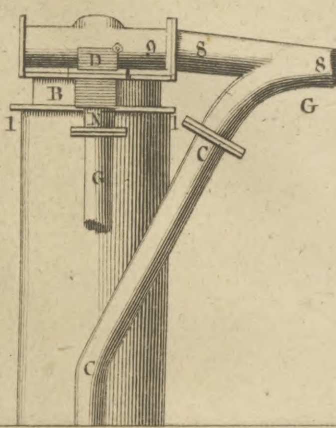
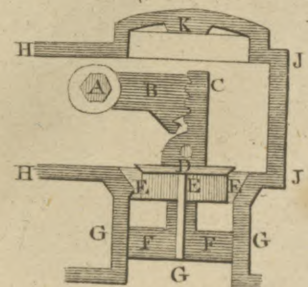


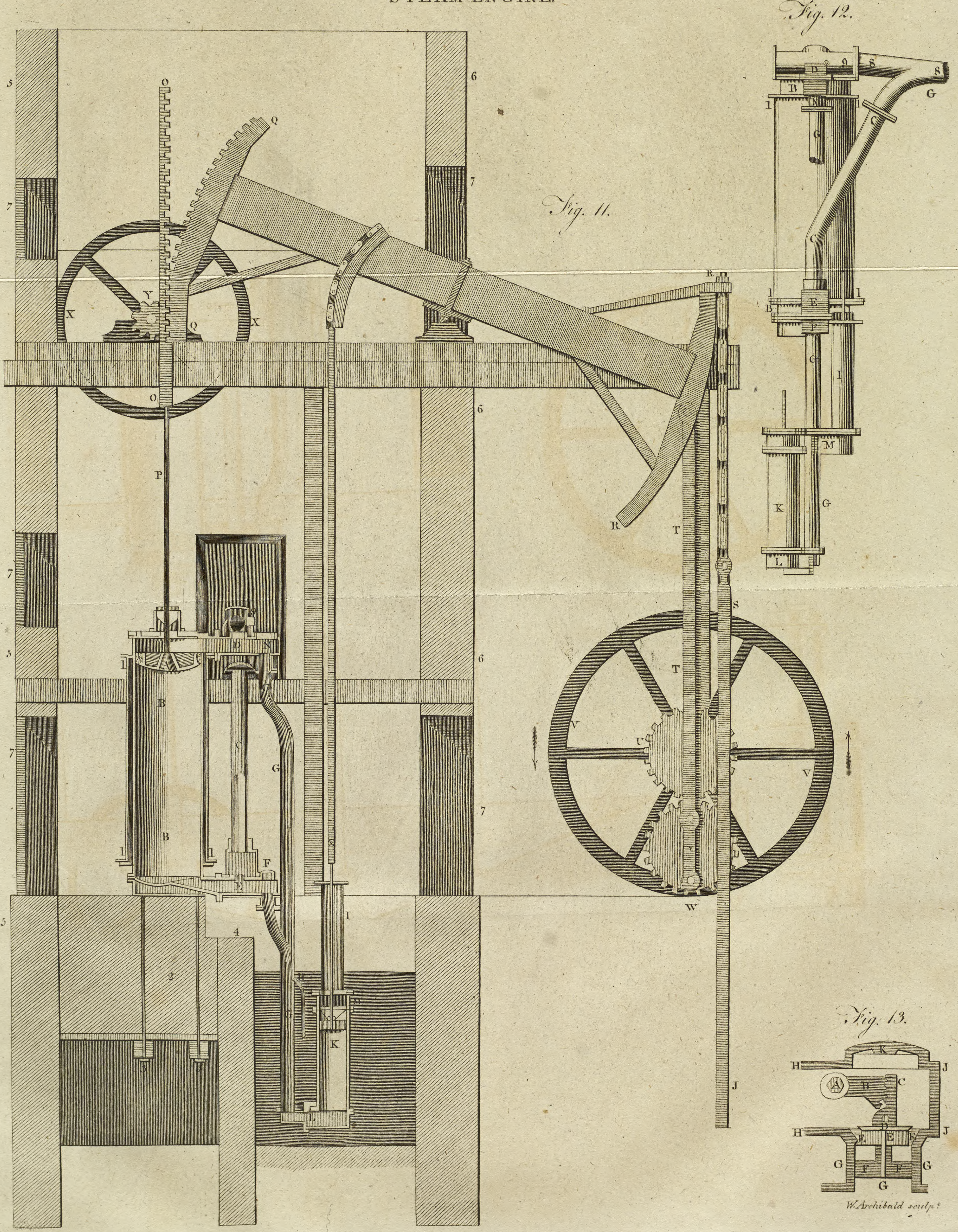
Fig. 13.



W. Archibald sculp.

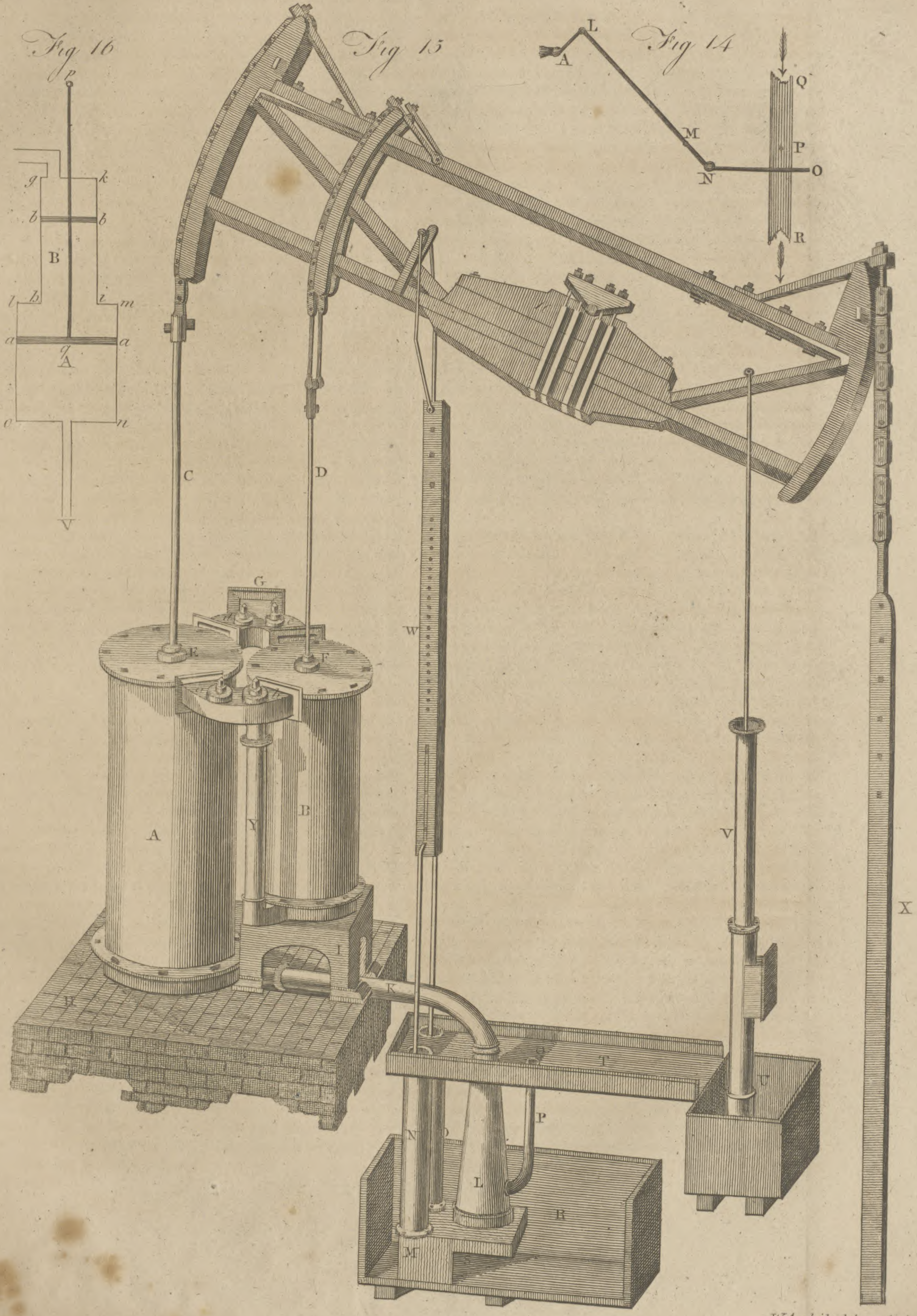
Watt's
STEAM ENGINE.

Plate DIII.



W. Archibald sculp.

Hornblower's
STEAM ENGINE.



W. Archibald sculp.

the link, the inner half (that is, the half next the cylinder) of the wheel U will work on the inner half of the wheel W, fo that at the end of the revolution of the fly the wheel W muft have got to the top of the wheel U, and the outer end of the beam muft be raifed to its higheft pofition. The next revolution of the fly will bring the wheel W and the beam connected with it to their firft pofitions; and thus every two revolutions of the fly will make a complete period of the beam's reciprocating movements. Now, inftead of fuppofing the fly to drive the beam, let the beam drive the fly. The motions muft be perfectly the fame, and the afcent or defcent of the pifton will produce one revolution of the fly.

Fig. 12. A fide view of this apparatus is given in fig. 12. marked by the fame letters of reference. This fhows the fituation of parts which were fore-fhortened in fig. 11. particularly the defcending branch C of the fteam-pipe, and the fituation and communications of the two pumps K and I. 8, 8 is the horizontal part of the fteam-pipe. 9 is a part of it whofe box is reprefented by the dark circle of fig. 11. D is the box of the fteam-clack; and the little circle at its corner reprefents the end of the axis which turns it, as will be defcribed afterwards. N is the place of the upper eduction valve. A part only of the upper eduction-pipe G is reprefented, the reft being cut off, becaufe it would have covered the defcending fteam-pipe CC. When continued down, it comes between the eye and the box E of the lower fteam-valve, and the box F of the lower eduction-valve.

Let us now trace the operation of this machine through all its fteps. Recurring to fig. 11. let us fuppofe that the lower part of the cylinder BB is exhaufted of all elaftic fluids; that the upper fteam-valve D and the lower eduction-valve F are open, and that the lower fteam-valve E and upper eduction-valve N are fhut. It is evident that the pifton muft be preffed toward the bottom of the cylinder, and muft pull down the end of the working beam by means of the toothed rack OO and fector QQ, caufing the other end of the beam to urge forward the machinery with which it is connected. When the pifton arrives at the bottom of the cylinder, the valves D and F are fhut by the plug frame, and E and N are opened. By this laft paffage the fteam gets into the eduction-pipe, where it meets with the injection water, and is rapidly condenfed. The fteam from the boiler enters at the fame time by E, and preffing on the lower fide of the pifton, forces it upwards, and by means of the toothed rack OO and toothed fector QQ forces up that end of the working beam, and caufes the other end to urge forward the machinery with which it is connected: and in this manner the operation of the engine may be continued for ever.

The injection water is continually running into the eduction-pipe, becaufe condenfation is continually going on, and therefore there is a continual atmofpheric preffure to produce a jet. The air which is difengaged from the water, or enters by leaks, is evacuated only during the rife of the pifton of the air-pump K. When this is very copious, it renders a very large air-pump neceffary; and in fome fituations Mr Watt has been obliged to employ two air-pumps, one worked by each arm of the beam. This in every cafe expends a very confiderable portion of the power, for the air-pump is always working againft the whole preffure of the atmofphere.

It is evident that this form of the engine, by maintaining an almoft conftant and uninterrupted impulfion, is much fitter for driving any machinery of continued motion than any of the former engines, which were inactive during half of their motion. It does not, however, feem to have this fuperiority when employed to draw water: But it is equally fitted for this tafk. Let the engine be loaded with twice as much as would be proper for it if a fingle-ftroke engine, and let a fly be connected with it. Then it is plain that the power of the engine during the rife of the fteam-pifton will be accumulated in the fly; and this, in conjunction with the power of the engine during the defcent of the fteam-pifton, will be equal to the whole load of water.

In fpeaking of the fteam and eduction-valves, we faid that they were all puppet-valves. Mr Watt employed cocks, and alfo fliding-valves, fuch as the regulator or fteam-valves in the old engines. But he found them always lofe their tightnefs after a fhort time. This is not furprifing, when we confider that they are always perfectly dry, and almoft burning hot. He was therefore obliged to change them all for puppet-clacks, which, when truly ground and nicely fitted in their motions at firft, are not found to go out of order by any length of time. Other engineers now univerfally ufe them in the old form of the fteam-engine, without the fame reafons, and merely by fervile and ignorant imitation.

The way in which Mr Watt opens and fhuts thefe valves is as follows. Fig. 13. reprefents a clack with its feat and box. Suppofe it one of the eduction-valves. HH is part of the pipe which introduces the fteam, and GG is the upper part of the pipe which communicates with the condenfer. At EE may be obferved a piece more faintly fhaded than the furrounding parts. This is the feat of the valve, and is a brafs or bell-metal ring turned conical on the outfide, fo as to fit exactly into a conical part of the pipe GG. Thefe two pieces are fitted by grinding; and the cone being of a long taper, the ring fticks firmly in it, efpecially after having been there for fome time and united by ruft. The clack itfelf is a ftrong brafs plate D, turned conical on the edge, fo as to fit the conical or floping inner edge of the feat. Thefe are very nicely ground on each other with emery. This conical joining is much more obtufe than the outer fide of the ring; fo that although the joint is air-tight, the two pieces do not ftick ftrongly together. The clack has a round tail DG, which is freely moveable up and down in the hole of a crofs piece FF. On the upper fide of the valve is a ftrong piece of metal DC firmly joined to it, one fide of which is formed into a toothed rack. A is the fection of an iron axle which turns in holes in the oppofite fides of the valve-box, where it is nicely fitted by grinding, fo as to be air-tight. Collets of thick leather, well foaked in melted tallow and rofin, are fcrewed on the outfide of thefe holes to prevent all ingrefs of air. One end of this axis projects a good way without the box, and carries a fpanner or handle, which is moved by the plug-frame. To this axis is fixed a ftrong piece of metal B, the edge of which is formed into an arch of a circle having the axis A in its centre, and is cut into teeth, which work in the teeth

Steam-Engine.

teeth of the rack DC. K is a cover which is fixed by ſcrews to the top of the box HJJH, and may be taken off in order to get at the valve when it needs repairs.

From this deſcription it is eaſy to ſee that by turning the handle which is on the axis A, the ſector B muſt lift up the valve by means of its toothed rack DC, till the upper end of the rack touch the knob or button K. Turning the handle in the oppoſite direction brings the valve down again to its ſeat.

This valve is extremely tight. But in order to open it for the paſſage of the ſteam, we muſt exert a force equal to the preſſure of the atmoſphere. This in a large engine is a very great weight. A valve of ſix inches diameter ſuſtains a preſſure not leſs that 400 pounds. But this force is quite momentary, and hardly impedes the motion of the engine; for the inſtant the valve is detached from its ſeat, although it has not moved the 100th part of an inch, the preſſure is over. Even this little inconvenience has been removed by a delicate thought of Mr Watt. He has put the ſpanner in ſuch a poſition when it *begins* to raiſe the valve, that its mechanical energy is almoſt infinitely great. Let QR (fig. 14.) be part of the plug-frame deſcending, and P one of its pins juſt going to lay hold of the ſpanner NO moveable round the axis N. On the ſame axis is another arm NM connected by a joint with the leader ML, which is connected alſo by a joint with the ſpanner LA that is on the axis A of the ſector within the valve-box. Therefore when the pin P puſhes down the ſpanner NO, the arm NM moves ſidewiſe and pulls down the ſpanner AL by means of the connecting rod. Things are ſo diſpoſed, that when the cock is ſhut, LM and MN are in one ſtraight line. The intelligent mechanic will perceive that, in this poſition, the force of the lever ONM is inſuperable. It has this further advantage, that if any thing ſhould tend to force open the valve, it would be ineffectual; for no force exerted at A, and tranſmitted by the rod LM, can poſſibly puſh the joint M out of its poſition. Of ſuch importance is it to practical mechanics, that its profeſſors ſhould be perſons of penetration as well as knowledge. Yet this circumſtance is unheeded by hundreds who have ſervilely copied from Mr Watt, as may be ſeen in every engine that is puffed on the public as a diſcovery and an improvement. When theſe puppet-valves have been introduced into the common engine, we have not ſeen one inſtance where this has been attended to; certainly becauſe its utility has not been obſerved: and there is one ſituation where it is of more conſequence than in Mr Watt's engine, viz. in the injection-cock. Here the valve is drawn back into a box, where the water is ſo aukwardly diſpoſed round it that it can hardly get out out of its way, and where the preſſure even exceeds that of the atmoſphere. Indeed this particular ſubſtitution of the button-valve for the cock is moſt injudicious.

We poſtponed any account of the office of the fly XX (fig. 11.), as it is not of uſe in an engine regulated by the fly VV. The fly XX is only for regulating the reciprocating motion of the beam when the ſteam is not admitted during the whole deſcent of the piſton. This it evidently muſt render more uniform, accumulating a momentum equal to the whole preſſure of the full ſupply of ſteam, and then ſharing it with the beam during the reſt of the deſcent of the piſton.

When a perſon properly ſkilled in mechanics and chemiſtry reviews theſe different forms of Mr Watt's ſteam-engine, he will eaſily perceive them ſuſceptible of many intermediate forms, in which any one or more of the diſtinguiſhing improvements may be employed. The firſt great improvement was the condenſation in a ſeparate veſſel. This increaſed the original powers of the engine, giving to the atmoſpheric preſſure and to the counter-weight their full energy; at the ſame time the waſte of ſteam is greatly diminiſhed. The next improvement, by employing the preſſure of the ſteam inſtead of that of the atmoſphere, aimed only at a ſtill farther diminution of the waſte; but was fertile in advantages, rendering the machine more manageable, and particularly enabling us at all times, and without trouble, to ſuit the power of the engine to its load of work, however variable and increaſing; and brought into view a very intereſting propoſition in the mechanical theory of the engine, viz. that the whole performance of a given quantity of ſteam may be augmented by admitting it into the cylinder only during a part of the piſton's motion. Mr Watt has varied the application of this propoſition in a thouſand ways; and there is nothing about the machine which gives more employment to the ſagacity and judgement of the engineer. The third improvement of the double impulſe may be conſidered as the finiſhing touch given to the engine, and renders it as uniform in its action as any water-wheel. In the engine in its moſt perfect form there does not ſeem to be above one-fourth of the ſteam waſted by warming the apparatus; ſo that *it is not poſſible* to make it one-fourth part more powerful than it is at preſent. The only thing that ſeems ſuſceptible of conſiderable improvement is the great beam. The enormous ſtrains exerted on its arms require a proportional ſtrength. This requires a vaſt maſs of matter, not leſs indeed in an engine with a cylinder of 54 inches than three tons and a half, moving with the velocity of three feet in a ſecond, which muſt be communicated in about half a ſecond. This maſs muſt be brought into motion from a ſtate of reſt, muſt again be brought to reſt, again into motion, and again to reſt, to complete the period of a ſtroke. This conſumes much power; and Mr Watt has not been able to load an engine with more than 10 or 11 pounds on the inch and preſerve a ſufficient quantity of motion, ſo as to make 12 or 15 ſix-feet ſtrokes in a ſecond. Many attempts have been made to leſſen this maſs by uſing a light framed wheel, or a light frame of carpentry, in place of a ſolid beam. Theſe have generally been conſtructed by perſons ignorant of the true ſcientific principles of carpentry, and have fared accordingly. Mr Watt has made ſimilar attempts; but found, that although at firſt they were abundantly ſtrong, yet after a ſhort time's employment the ſtraps and bolts with which the wooden parts were connected cut their way into the wood, and the framing grew looſe in the joints, and, without giving any warning, went to pieces in an inſtant. A ſolid maſſy ſimple beam, of ſufficient ſtrength, bends, and ſenſibly complains (as the carpenters expreſs it), before it breaks. In all great engines, therefore, ſuch only are employed, and in ſmaller engines he ſometimes uſes caſt-iron wheels or pulleys; nay, he frequently uſes no beam or equivalent whatever, but employs the ſteam-piſton rod to drive the machinery to which the engine is applied.

72
Review of Mr Watt's three great improvements.

73
The only improvement now wanting is to ſtrengthen the great beam.

We preſume that our thinking readers will not be diſpleaſed

Steam-Engine.

displeased with this rational history of the progress of this engine in the hands of its ingenious and worthy inventor. We owe it to the communications of a friend, well acquainted with him, and able to judge of his merits. The public see him always associated with the no less celebrated mechanic and philosopher Mr Boulton of Soho near Birmingham (see SOHO). They have shared the royal patent from the beginning; and the alliance is equally honourable to both.

74 Mr Watt associated with Mr Boulton.

75 Whence their profits are derived in erecting engines.

The advantages derived from the patent-right show both the superiority of the engine and the liberal minds of the proprietors. They erect the engines at the expence of the employers, or give working drafts of all the parts, with instructions, by which any resident engineer may execute the work. The employers select the best engine of the ordinary kind in the kingdom, compare the quantities of fuel expended by each, and pay to Messrs Watt and Boulton one-third of the annual savings for a certain term of years. By this the patentees are excited to do their utmost to make the engine perfect; and the employer pays in proportion to the advantage he derives from it.

It may not be here improper to state the actual performance of some of these engines, as they have been ascertained by experiment.

76 What the actual performance of some of these engines is.

An engine having a cylinder of 31 inches in diameter, and making 17 double strokes per minute, performs the work of forty horses working night and day (for which three relays or 120 horses must be kept), and burns 11,000 pounds of Staffordshire coal per day. A cylinder of 19 inches, making 25 strokes of 4 feet each per minute, performs the work of 12 horses working constantly, and burns 3700 pounds of coals per day. A cylinder of 24 inches, making 22 strokes of 5 feet, burns 5500 pounds of coals, and is equivalent to the constant work of 20 horses. And the patentees think themselves authorized by experience to say in general, that these engines will raise more than 20,000 cubic feet of water 24 feet high for every hundred weight of good pit-coal consumed by them.

In consequence of the great superiority of Mr Watt's engines, both with respect to economy and manageableness, they have become of most extensive use; and in every demand of manufacture on a great scale they offer us an indefatigable servant, whose strength has no bounds. The greatest mechanical project that ever engaged the attention of man was on the point of being executed by this machine. The States of Holland were treating with Messrs Watt and Boulton for draining the Haerlem Meer, and even reducing the Zuyder Zee: and we doubt not but that it will be accomplished whenever that unhappy nation has sufficiently felt the difference between liberty and foreign tyranny. Indeed such unlimited powers are afforded by this engine, that the engineer now thinks that no task can be proposed to him which he cannot execute with profit to his employer.

77 Proposed to drain the Haerlem Meer by the steam-engine.

78 The attempts to improve Mr Watt's engine in general of little advantage;

No wonder then that all classes of engineers have turned much of their attention to this engine; and seeing that it has done so much, that they try to make it do still more. Numberless attempts have been made to improve Mr Watt's engine; and it would occupy a volume to give an account of them, whilst that account would do no more than indulge curiosity. Our engineers by profession are in general miserably deficient in that accurate knowledge of mechanics and of chemistry which is necessary for understanding this machine; and we have not heard of one in this kingdom who can be put on a par with the present patentees in this respect. Most of the attempts of engineers have been made with the humbler view of availing themselves of Mr Watt's discoveries, so as to construct a steam-engine superior to Newcomen's, and yet of a form sufficiently different from Watt's to keep it without the reach of his patent. This they have in general accomplished by performing the condensation in a place which, with a little stretch of fancy, not unfrequent in a court of law, may be called *part of the cylinder*.

79 and the success of these has not injured the other.

The success of most of these attempts has interfered so little with the interest of the patentees, that they have not hindered the erection of many engines which the law would have deemed encroachments. We think it our duty to give our opinion on this subject without reserve. These are most expensive undertakings, and few employers are able to judge accurately of the merits of a project presented to them by an ingenious artist. They may see the practicability of the scheme, by having a general notion of the expansion and condensation of steam, and they may be misled by the ingenuity apparent in the construction. The engineer himself is frequently the dupe of his own ingenuity; and it is not always dishonesty, but frequently ignorance, which makes him prefer his own invention or (as he thinks it) improvement. It is a most delicate engine, and requires much knowledge to see what does and what does not improve its performance. We have gone into the preceding minute investigation of Mr Watt's progress with the express purpose of making our readers fully masters of its principles, and have more than once pointed out the real improvements, that they may be firmly fixed and always ready in the mind. By having recourse to them, the reader may pronounce with confidence on the merits of any new construction, and will not be deceived by the puffs of an ignorant or dishonest engineer.

80 Exception in favour of Mr Hornblower.

We must except from this general criticism a construction by Mr Jonathan Hornblower near Bristol, on account of its singularity, and the ingenuity and real skill which appears in some particulars of its construction. The following short description will sufficiently explain its principle, and enable our readers to appreciate its merit.

Plate DIV.

81 Description of his steam-engine.

A and B (fig. 15.) represent two cylinders, of which A is the largest. A piston moves in each, having their rods C and D moving through collars at E and F. These cylinders may be supplied with steam from the boiler by means of the square pipe G, which has a flanch to connect it with the rest of the steam-pipe. This square part is represented as branching off to both cylinders. *c* and *d* are two cocks, which have handles and tumblers as usual, worked by the plug-beam W. On the fore-side (that is, the side next the eye) of the cylinders is represented another communicating pipe, whole section is also square or rectangular, having also two cocks *a*, *b*. The pipe Y, immediately under the cock *b*, establishes a communication between the upper and lower parts of the small cylinder B, by opening the cock *b*. There is a similar pipe on the other side of the cylinder A, immediately under the cock *d*. When the cocks *c* and *a* are open, and the cocks *b* and *d* are shut, the steam from the boiler has free admission into the upper part of the cylinder B, and the steam from

from the lower part of B has free admiſſion into the upper part of A; but the upper part of each cylinder has no communication with its lower part.

From the bottom of the great cylinder proceeds the eduction-pipe K, having a valve at its opening into the cylinder, which bends downwards, and is connected with the conical condenſer L (c). The condenſer is fixed on a hollow box M, on which ſtand the pumps N and O for extracting the air and water; which laſt runs along the trough T into a ciſtern U, from which it is raiſed by the pump V for recruiting the boiler, being already nearly boiling hot. Immediately under the condenſer there is a ſpigot valve at S, over which is a ſmall jet pipe, reaching to the bend of the eduction-pipe. The whole of the condenſing apparatus is contained in a ciſtern R of cold water. A ſmall pipe P comes from the ſide of the condenſer, and terminates on the bottom of the trough T, and is there covered with a valve Q, which is kept tight by the water that is always running over it. Laſtly, the pump-rods X cauſe the outer end of the beam to preponderate, ſo that the quieſcent poſition of the beam is that repreſented in the figure, the piſtons being at the top of the cylinders.

Suppoſe all the cocks open, and ſteam coming in copiouſly from the boiler, and no condenſation going on in L; the ſteam muſt drive out all the air, and at laſt follow it through the valve Q. Now ſhut the valves b and d, and open the valve S of the condenſer. The condenſation will immediately commence. There is now no preſſure on the under ſide of the piſton of A, and it immediately deſcends. The communication between the lower part of B and the upper part of A being open, the ſteam will go from B into the ſpace left by the piſton of A. It muſt therefore expand, and its elaſticity muſt diminiſh, and will no longer balance the preſſure of the ſteam above the piſton of B. This piſton therefore, if not withheld by the beam, would deſcend till it is in equilibrio, having ſteam of equal denſity above and below it. But it cannot deſcend ſo far; for the cylinder A is wider than B, and the arm of the beam at which its piſton hangs is longer than the arm which ſupports the piſton of B: therefore when the piſton of B has deſcended as far as the beam will permit it, the ſteam between the two piſtons occupies a larger ſpace than it did when both piſtons were at the tops of their cylinders. Its denſity, therefore, and its elaſticity, diminiſh as its bulk increaſes. It is therefore not a balance; for the ſteam on the upper ſide of B, and the piſton B, *pulls* at the beam with all the difference of theſe preſſures. The ſlighteſt view of the ſubject muſt ſhow the reader, that as the piſtons deſcend, the ſteam that is between them will grow continually rarer and leſs elaſtic, and that both piſtons will pull the beam downwards.

Suppoſe now that each has reached the bottom of its cylinder. Shut the cock a and the eduction cock at the bottom of A, and open the cocks b and d. The communication being now eſtabliſhed between the upper and lower part of each cylinder, nothing hinders the counter weight from raiſing the piſtons to the top. Let them arrive there. The cylinder B is at this time filled with ſteam of the ordinary denſity, and the cylinder A with an equal abſolute quantity of ſteam, but expanded into a larger ſpace.

Shut the cocks b and d, and open the cock a, and the eduction cock at the bottom of A; the condenſation will again operate, and the piſtons deſcend. And thus the operation may be repeated as long as ſteam is ſupplied; and one full of the cylinder B of ordinary ſteam is expended during each working ſtroke.

Let us now examine the power of this engine. It is evident, that when both piſtons are at the top of their reſpective cylinders, the active preſſure (that is, the difference of the preſſure on its two ſides) on the piſton of B is nothing, while that on the piſton of A is equal to the full preſſure of the atmoſphere on its area. This, multiplied by the length of the arm by which it is ſupported, gives its mechanical energy. As the piſtons deſcend, the preſſure on the piſton of B increaſes, while that on the piſton of A diminiſhes. When both are at the bottom, the preſſure on the piſton of B is at its maximum, and that on the piſton of A at its minimum.

Mr Hornblower ſaw that this muſt be a beneficial employment of ſteam, and preferable to the practice of condenſing it while its full elaſticity remained; but he has not conſidered it with the attention neceſſary for aſcertaining the advantage with preciſion.

Let a and b repreſent the areas of the piſtons of A and B, and let α and β be the lengths of the arms by which they are ſupported. It is evident, that when both piſtons have arrived at the bottoms of their cylinders, the capacities of the cylinders are as $a\,\alpha$ and $b\,\beta$. Let this be the ratio of m to 1. Let $g\,h\,i\,k$ (fig. 16.) and $l\,m\,n\,o$ be two cylinders of equal length, communicating with each other, and fitted with a piſton-rod $p\,q$, on which are fixed two piſtons $a\,a$ and $b\,b$, whoſe areas are as m and 1. Let the diſtance between the piſtons be preciſely equal to the height of each cylinder, which height we ſhall call h. Let x be the ſpace $g\,b$ or $b\,a$, through which the piſtons have deſcended. Let the upper cylinder communicate with the boiler, and the lower cylinder with the condenſer or vacuum V.

Any perſon in the leaſt converſant in mechanics and pneumatics will clearly ſee that the ſtrain or preſſure on the piſton-rod $p\,q$ is preciſely the ſame with the united energies of the two piſton rods of Mr Hornblower's engine, by which they tend to turn the working beam round its axis.

The baſe of the upper cylinder being 1, and its height h, its capacity or bulk is $1\,h$ or h; and this expreſſes the natural bulk of the ſteam which formerly filled it, and is now expanded into the ſpace $b\,h\,l\,a\,a\,m\,i\,b$. The part $b\,h\,i\,b$ is plainly $=h-x$, and the part $l\,a\,a\,m$ is $=m\,x$. The whole ſpace therefore is $m\,x+h-x$, $=h+m\,x-x$, or $h+\overline{m-1}\,x$. Therefore the denſity of the ſteam between the piſtons is $\frac{h}{h+\overline{m-1}\,x}$.

Let p be the downward preſſure of the ſteam from the

(c) This, however, was ſtopped by Watt's patent; and the condenſation muſt be performed as in Newcomen's engine, or at leaſt in the cylinder A.

the boiler on the upper piſton $b\,b$. This piſton is alſo preſſed up with a force $=p\frac{h}{h+\overline{m-1}\,x}$ by the ſteam between the piſtons. It is therefore, on the whole, preſſed downward with a force $=p\left(1-\frac{h}{h+\overline{m-1}\,x}\right)$. The lower piſton $a\,a$, having a vacuum below it, is preſſed downwards with a force $=p\frac{m\,h}{h+\overline{m-1}\,x}$. Therefore the whole preſſure on the piſton rod downwards is $=p\left(1+\frac{m\,h}{h+\overline{m-1}\,x}-\frac{h}{h+\overline{m-1}\,x}\right)$, $=p\left(1+\frac{\overline{m-1}\,h}{h+\overline{m-1}\,x}\right)$, $=p+\frac{p\,h\,\overline{m-1}}{h+\overline{m-1}\,x}=p+\frac{p\,h}{\frac{h}{m-1}+x}$.

This then is the momentary preſſure on the piſton rod correſponding to its deſcent x from its higheſt poſition. When the piſtons are in their higheſt poſition, this preſſure is equal to $m\,p$. When they are in their loweſt poſition, it is $=p\frac{2m-1}{m}$. Here therefore is an acceſſion of power. In the beginning the preſſure is greater than on a ſingle piſton in the proportion of m to 1; and at the end of the ſtroke, where the preſſure is weakeſt, it is ſtill much greater than the preſſure on a ſingle piſton. Thus, if m be 4, the preſſure at the beginning of the ſtroke is $4p$, and at the end it is $\frac{7}{4}p$, almoſt double, and in all intermediate poſitions it is greater. It is worth while to obtain the ſum total of all the accumulated preſſures, that we may compare it with the conſtant preſſure on a ſingle piſton.

We may do this by conſidering the momentary preſſure $p+\frac{p\,h}{\frac{h}{m-1}+x}$, as equal to the ordinate GF, Hb, or Mc, of a curve F$b\,c$ (fig. 10.), which has for its axis the line GM equal to h the height of our cylinder. Call this ordinate y. We have $y=p+\frac{p\,h}{\frac{h}{m-1}-x}$, and $y-p=\frac{p\,h}{\frac{h}{m-1}+x}$. Now it is plain that $\frac{p\,h}{\frac{h}{m-1}+x}$ is the ordinate of an equilateral hyperbola, of which $p\,h$ is the power or rectangle of the ordinate and abſciſs, and of which the abſciſs reckoned from the centre is $\frac{h}{m-1}+x$. Therefore make GE $=p$, and draw DEA parallel to MG, and make EA$=\frac{\text{GM}}{m-1}$, $=\frac{h}{m-1}$. The curve F$b\,c$ is an equilateral hyperbola, having A for its centre and AD for its aſſymptote. Draw the other aſſymptote AB, and its ordinate FB. Since the power of the hyperbola is $=p\,h$, =GEDM (for GE$=p$, and GM$=h$); and ſince all the inſcribed rectangles, ſuch as AEFB, are equal to $p\,h$, it follows that AEFB is equal to GEDM, and that the area ABFcDA is equal to the area GFcMG, which expreſſes the accumulated preſſure in Hornblower's engine.

We can now compute the accumulated preſſure very eaſily. It is evidently $=p\,h\times\left(1+\text{L.}\frac{\text{AD}}{\text{AE}}\right)$.

82 The accumulated preſſure the ſame with that of Mr Watt's engine.

The intelligent reader cannot but obſerve that this is preciſely the ſame with the accumulated preſſure of a quantity of ſteam admitted in the beginning, and ſtopped in Mr Watt's method, when the piſton has deſcended through the mth part of the cylinder. In conſidering Mr Hornblower's engine, the thing was preſented in ſo different a form that we did not perceive the analogy at firſt, and we were ſurpriſed at the reſult. We could not help even regretting it, becauſe it had the appearance of a new principle and an improvement: and we doubt not but that it appeared ſo to the ingenious author; for we have had ſuch proofs of his liberality of mind as permit us not to ſuppoſe that he ſaw it from the beginning, and availed himſelf of the difficulty of tracing the analogy. And as the thing may miſlead others in the ſame way, we have done a ſervice to the public by ſhowing that this engine, ſo coſtly and ſo difficult in its conſtruction, is no way ſuperior in power to Mr Watt's ſimple method of ſtopping the ſteam. It is even inferior, becauſe there muſt be a condenſation in the communicating paſſages. We may add, that if the condenſation is performed in the cylinder A, which it muſt be unleſs with the permiſſion of Watt and Boulton, the engine cannot be much ſuperior to a common engine; for much of the ſteam from below B will be condenſed between the piſtons by the coldneſs of the cylinder A; and this diminiſhes the downward preſſure on A more than it increaſes the downward preſſure on B. We learn however that, by confining the condenſation to a ſmall *part of the cylinder* A, Mr Hornblower has erected engines clear of Mr Watt's patent, which are conſiderably ſuperior to Newcomen's: ſo has Mr Symington.

83 Still, however, the engine diſcovers ingenuity and ſkill.

We ſaid that there was much ingenuity and real ſkill obſervable in many particulars of this engine. The diſpoſition and connection of the cylinders, and the whole condenſing apparatus, are contrived with peculiar neatneſs. The cocks are very ingenious; they are compoſed of two flat circular plates ground very true to each other, and one of them turns round on a pin through their centres; each is pierced with three ſectoral apertures, exactly correſponding with each other, and occupying a little leſs than one-half of their ſurfaces. By turning the moveable plate ſo that the apertures coincide, a large paſſage is opened for the ſteam; and by turning it ſo that the ſolid of the one covers the aperture of the other, the cock is ſhut. Such regulators are now very common in the caſt iron ſtoves for warming rooms.

Mr Hornblower's contrivance for making the collars for the piſton rods air-tight is alſo uncommonly ingenious. This collar is in fact two, at a ſmall diſtance from each other. A ſmall pipe, branching off from the main ſteam-pipe, communicates with the ſpace between the collars. This ſteam, being a little ſtronger than the preſſure of the atmoſphere, effectually hinders the air from penetrating by the upper collar; and though a little ſteam ſhould get through the lower collar into the cylinder A, it can do no harm. We ſee many caſes in which this pretty contrivance may be of ſignal ſervice.

84 The greatest improvement is the framing of the working beam.

But it is in the framing of the great working beam that Mr Hornblower's ſcientific knowledge is moſt conſpicuous; and we have no heſitation in affirming that it is ſtronger than a beam of the common form, and containing twenty times its quantity of timber. There is hardly a part of it expoſed to a tranverſe ſtrain, if we except the ſtrain of the pump V on the ſtrutt by which it is worked. Every piece is either puſhed or pulled in the direction of its length. We only fear that the bolts which connect the upper beam with the two iron bars under its ends will work looſe in their holes, and tear out the wood which lies between them. We would propoſe to ſubſtitute an iron bar for the whole of this upper beam. This working beam highly deſerves the attention of all carpenters and engineers. We have that opinion of Mr Hornblower's knowledge and talents, that we are confident that he will ſee the fairneſs of our examination of his engine, and we truſt to his candour for an excuſe for our criticiſm.

85 The reciprocating motion of the ſteam-engine is a defect ſtill to be remedied.

The reciprocating motion of the ſteam-engine has always been conſidered as a great defect; for though it be now obviated by connecting it with a fly, yet, unleſs it is an engine of double ſtroke, this fly muſt be an enormous maſs of matter moving with great velocity. Any accident happening to it would produce dreadful effects: A part of the rim detaching itſelf would have the force of a bomb, and no building could withſtand it. Many attempts have been made to produce a circular motion at once by the ſteam. It has been made to blow on the vanes of a wheel of various forms. But the rarity of ſteam is ſuch, that even if none is condenſed by the cold of the vanes, the impulſe is exceedingly feeble, and the expence of ſteam, ſo as to produce any ſerviceable impulſe, is enormous.

86 Mr Watt's attempts to produce a circular motion by ſteam unſucceſsful.

Mr Watt, among his firſt ſpeculations on the ſteam-engine, made ſome attempts of this kind. One in particular was uncommonly ingenious. It conſiſted of a drum turning air-tight within another, with cavities ſo diſpoſed that there was a conſtant and great preſſure urging it in one direction. But no packing of the common kind could preſerve it air-tight with ſufficient mobility. He ſucceeded by immerſing it in mercury, or in an almagam which remained fluid in the heat of boiling water; but the continual trituration ſoon calcined the fluid and rendered it uſeleſs. He then tried Parent's or Dr Barker's mill, incloſing the arms in a metal drum, which was immerſed in cold water. The ſteam ruſhed rapidly along the pipe which was the axis, and it was hoped that a great reaction would have been exerted at the ends of the arms; but it was almoſt nothing. The reaſon ſeems to be, that the greateſt part of the ſteam was condenſed in the cold arms. It was then tried in a drum kept boiling hot; but the impulſe was now very ſmall in compariſon with the expence of ſteam. This muſt be the caſe.

Mr Watt has deſcribed in his ſpecification to the patent office ſome contrivances for producing a circular motion by the immediate action of the ſteam. Some of theſe produce alternate motions, and are perfectly analogous to his double-ſtroke engine. Others produce a continued motion. But he has not given ſuch a deſcription of his valves for this purpoſe as can enable an engineer to conſtruct one of them. From any gueſs that we can form, we think the machine very imperfect; and we do not find that Mr Watt has ever erected a continuous circular engine. He has doubtleſs found all his attempts inferior to the reciprocating engine with a fly. A very crude ſcheme of this kind may be ſeen in the Tranſactions of the Royal Society of Dublin 1787.

87 Still the caſe is not deſperate, for different principles may be employed.

But although our attempts have hitherto failed, we hope that the caſe is not yet deſperate: we ſee different principles which have not yet been employed.

88 Mr Watt's engine ſuggeſts the conſtruction of an excellent air pump.

We ſhall conclude our account of this noble engine with obſerving, that Mr Watt's form ſuggeſts the conſtruction of an excellent air-pump. A large veſſel may be made to communicate with a boiler at one ſide, and with the pump-receiver on the other, and alſo with a condenſer. Suppoſe this veſſel of ten times the capacity of the receiver; fill it with ſteam from the boiler, and drive out the air from it; then open its communication with the receiver and the condenſer. This will rarefy the air of the receiver ten times. Repeating the operation will rarefy it 100 times; the third operation will rarefy it 1000 times; the fourth 10,000 times, &c. All this may be done in half a minute.

STEAM-Kitchen. Ever ſince Dr Papin contrived his digeſter (about the year 1690), ſchemes have been propoſed for dreſſing victuals by the ſteam of boiling water. A philoſophical club uſed to dine at Saltero's coffee-houſe, Chelſea, about 40 years ago, and had their victuals dreſſed by hanging them in the boiler of the ſteam-engine which raiſes water for the ſupply of Picadilly and its neighbourhood. They were completely dreſſed, and both expeditiouſly and with high flavour.

A patent was obtained for an apparatus for this purpoſe by a tin-man in London; we think of the name of Tate. They were afterwards made on a much more effective plan by Mr Gregory, an ingenious tradeſman in Edinburgh, and are coming into very general uſe.

It is well known to the philoſopher that the ſteam of boiling water contains a prodigious quantity of heat, which it retains in a latent ſtate ready to be faithfully accounted for, and communicated to any colder body. Every cook knows the great ſcalding power of ſteam, and is diſpoſed to think that it is much hotter than boiling water. This, however, is a miſtake; for it will raiſe the thermometer no higher than the water from which it comes. But we can aſſure the cook, that if he make the ſteam from the ſpout of a tea-kettle paſs through a great body of cold water, it will be condenſed or changed into water; and when one pound of water has in this manner been boiled off, it will have heated the maſs of cold water as much as if we had thrown into it ſeven or eight hundred pounds of boiling hot water.

If, therefore, a boiler be properly fitted up in a furnace, and if the ſteam of the water boiling in it be conveyed by a pipe into a pan containing victuals to be dreſſed, every thing can be cooked that requires no higher degree of heat than that of boiling water: And this will be done without any riſk of ſcorching, or any kind of overheating, which frequently ſpoils our diſhes, and proceeds from the burning heat of air coming to thoſe parts of the pot or pan which is not filled with liquor, and is covered only with a film, which quickly burns and taints the whole diſh. Nor will the cook be ſcorched by the great heat of the open fire that is neceſſary for dreſſing at once a number of diſhes, nor have his perſon and clothes ſoiled by the ſmoke and ſoot unavoidable in the cooking on an open fire. Indeed the whole

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whole process is so neat, so managcable, so open to inspection, and so cleanly, that it need neither fatigue nor offend the delicacy of the nicest lady.

We had great doubts, when we first heard of this as a general mode of cookery, as to its economy; we had none as to its efficacy. We thought that the steam, and consequently the fuel expended, must be vastly greater than by the immediate use of an open fire; but we have seen a large tavern dinner expeditiously dressed in this manner, seemingly with much less fuel than in the common method. The following simple narration of facts will show the superiority. In a paper manufactory in this neighbourhood, the vats containing the pulp into which the frames are dipped are about six feet diameter, and contain above 200 gallons. This is brought to a proper heat by means of a small cockle or furnace in the middle of the liquor. This is heated by putting in about one hundred weight of coals about eight o'clock in the evening, and continuing this till four next morning, renewing the fuel as it burns away. This method was lately changed for a steam heater. A furnace, having a boiler of five or six feet diameter and three feet deep, is heated about one o'clock in the morning with two hundred weight of coals, and the water kept in brisk ebullition. Pipes go off from this boiler to six vats, some of which are at 90 feet distance. It is conveyed into a flat box or vessel in the midst of the pulp, where it condenses, imparting its heat to the sides of the box, and thus heats the surrounding pulp. These six vats are as completely heated in three hours, expending about three hundred weight of coals, as they were formerly in eight hours, expending near eighteen hundred weight of coals. Mr Gregory, the inventor of this steam-heater, has obtained (in company with Mr Scott, plumber, Edinburgh) a patent for the invention; and we are persuaded that it will come into very general use for many similar purposes. The dyers, hatmakers, and many other manufacturers, have occasion for large vats kept in a continual heat; and there seems no way so effectual.

Indeed when we reflect seriously on the subject, we see that this method has immense advantages considered merely as a mode of applying heat. The steam may be applied to the vessel containing the victuals in every part of its surface: it may even be made to enter the vessel, and apply itself immediately to the piece of meat that is to be dressed. and this without any risk of scorching or overdoing.—And it will give out about $\frac{799}{800}$ of the heat which it contains. and will do this only if it be wanted; so that no heat whatever is wasted except what is required for heating the apparatus. Experience shows that this is a mere trifle in comparison of what was supposed necessary. But with an open fire we only apply the flame and hot air to the bottom and part of the sides of our boiling vessels: and this application is hurried in the extreme; for to make a great heat, we must have a great fire, which requires a prodigious and most rapid current of air. This air touches our pans but for a moment, imparts to them but a small portion of its heat; and we are persuaded that three-fourths of the heat is carried up the chimney, and escapes in pure waste, while another great portion beams out into the kitchen to the great annoyance of the scorched cook. We think, therefore, that a page or two of this work will not be thrown away in the description of a contrivance by which a saving may be made to the entertainer, and the providing the pleasures of his table prove a less fatiguing task to this valuable corps of practical chemists.

Let A (fig. 1.) represent a kitchen-boiler, either properly fitted up in a furnace, with its proper fire-place, ash-pit, and flue, or set on a tripod on the open fire, or built up in the general fire-place. The steam-pipe BC rises from the cover of this boiler, and then is led away with a gentle ascent in any convenient direction. C represents the section of this conducting steam-pipe. Branches are taken off from the side at proper distances. One of these is represented at CDE, furnished with a cock D, and having a taper nozzle E, fitted by grinding into a conical piece F, which communicates with an upright pipe GH, which is soldered to the side of the stewing vessel PQRS, communicating with it by the short pipe I. The vessel is fitted with a cover OT, having a staple handle V. The piece of meat M is laid on a tin-plate grate KL, pierced with holes like a cullender, and standing on three short feet *n n n*. Plate DV. Fig. 1.

The steam from the boiler comes in by the pipe I, and is condensed by the meat and by the sides of the vessel, communicating to them all its heat. What is not so condensed escapes between the vessel and its cover. The condensed water lies on the bottom of the vessel, mixed with a very small quantity of gravy and fatty matter from the victuals. Frequently, instead of a cover, another stew-vessel with a cullender bottom is set on this one, the bottom of the one fitting the mouth of the other: and *it is observed*, that when this is done, the dish in the under vessel is more expeditiously and better dressed, and the upper dish is more slowly, but as completely stewed.

This description of one stewing vessel may serve to give a notion of the whole; only we must observe, that when broths, soups, and dishes with made sauces or containing liquids, are to be dressed, they must be put into a smaller vessel, which is set into the vessel PQRS, and is supported on three short feet, so that there may be a space all round it of about an inch or three quarters of an inch. It is observed, that dishes of this kind are not so expeditiously cooked as on an open fire, but as completely in the end, only requiring to be turned up now and then to mix the ingredients; because as the liquids in the inner vessel can never come into ebullition, unless the steam from the boiler be made of a dangerous heat, and every thing be close confined, there cannot be any of that tumbling motion that we observe in a boiling pot.

The performance of this apparatus is far beyond any expectation we had formed of it. In one which we examined, six pans were stewing together by means of a boiler $10\frac{1}{2}$ inches in diameter, standing on a brisk open fire. It boiled very briskly, and the steam puffed frequently through the chinks between the stew-pans and their covers. In one of them was a piece of meat considerably above 30 pounds weight. This required above four hours stewing, and was then very thoroughly and equally cooked; the outside being no more done than the heart, and it was near two pounds heavier than when put in, and greatly swelled. In the mean time, several dishes had been dressed in the other pans. As far

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far as we could judge, this cooking did not consume one-third part of the fuel which an open fire would have required for the same effect.

When we consider this apparatus with a little more knowledge of the mode of operation of fire than falls to the share of the cooks (we speak with deference), and consider the very injudicious manner in which the steam is applied, we think that it may be improved so as to surpass any thing that the cook can have a notion of.

When the steam enters the stew-pan, it is condensed on the meat and on the vessel; but we do not want it to be condensed on the vessel. And the surface of the vessel is much greater than that of the meat, and continues much colder; for the meat grows hot, and continues so, while the vessel, made of metal, which is a very perfect conductor of heat, is continually robbed of its heat by the air of the kitchen, and carried off by it. If the meat touch the side of the pan in any part, no steam can be applied to that part of the meat, while it is continually imparting heat to the air by the intermedium of the vessel. Nay, the meat can hardly be dressed unless there be a current of steam through it; and we think this confirmed by what is observed above, that when another stew-pan is set over the first, and thus gives occasion to a current of steam through its cullender bottom to be condensed by its sides and contents, the lower dish is more expeditiously dressed. We imagine, therefore, that not less than half of the steam is wasted on the sides of the different stew-pans. Our first attention is therefore called to this circumstance, and we wish to apply the steam more economically and effectually.

We would therefore construct the steam-kitchen in the following manner:

Fig. 2. We would make a wooden chest (which we shall call the STEW-CHEST) ABCD (fig. 2.). This should be made of deal, in very narrow slips, not exceeding an inch, that it may not shrink. This should be lined with very thin copper, lead, or even strong tinfoil. This will prevent it from becoming a conductor of heat by soaking with steam. For further security it might be set in another chest, with a space of an inch or two all round, and this space filled with a composition of powdered charcoal and clay. This should be made by first making a mixture of fine potter's clay and water about as thick as poor cream: then as much powdered charcoal must be beat up with this as can be made to stick together. When this is rammed in and dry, it may be hot enough on one side to melt glass, and will not discolour white paper on the other.

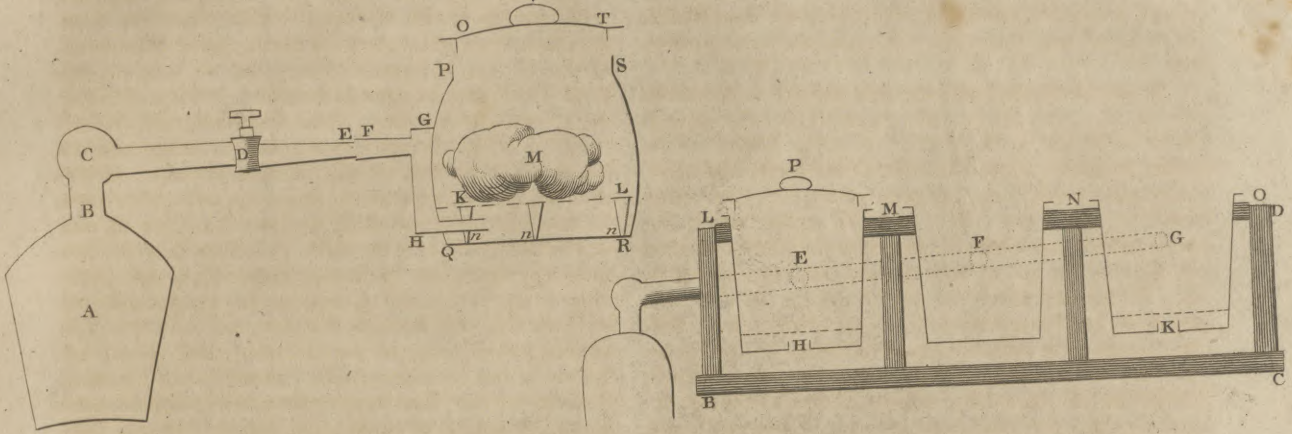
This chest must have a cover LMNO, also of wood, having holes in it to receive the stew-pans P, Q, R. Between each pan is a wooden partition, covered on both sides with milled lead or tinfoil. The whole top must be covered with very spongy leather or felt, and made very flat. Each stew-pan must have a bearing or shoulder all round it, by which it is supported, resting on the felt, and lying so true and close that no steam can escape. Some of the pans should be simple, like the pan F, for dressing broths and other liquid dishes. Others should be like E and G, having in the bottom a pretty wide hole H, K, which has a pipe in its upper side, rising about an inch or an inch and half into the stew-pan. The meat is laid on a cullender plate, as in the common way; only there must be no holes in the cullender immediately above the pipe.—These stew-pans must be fitted with covers, or they may have others fitted to their mouths, for warming sauces or other dishes, or stewing greens, and many other subordinate purposes for which they may be fitted.

The main-pipe from the boiler must have branches, (each furnished with a cock), which admit the steam into these divisions. At its first entry some will be condensed on the bottom and sides; but we imagine that these will in two minutes be heated so as to condense no more, or almost nothing. The steam will also quickly condense on the stew-pan, and in half a minute make it boiling hot, so that it will condense no more; all the rest will now apply itself to the meat and to the cover. It may perhaps be advisable to allow the cover to condense steam, and even to waste it. This may be promoted by laying on it flannel soaked in water. Our view in this is to create a demand for steam, and thus produce a current through the stew-pan, which will be applied in its passage to the victuals. But we are not certain of the necessity of this. Steam is not like common air of the same temperature, which would glide along the surfaces of bodies, and impart to them a small portion of its heat, and escape with the rest. To produce this effect there *must* be a current; for air hot enough to melt lead, will not boil water, if it be kept stagnant round the vessel. But steam imparts the *whole* of its latent heat to any body colder than boiling water, and goes no farther till this body be made boiling hot. It is a most faithful carrier of heat, and will deliver its whole charge to any body that can take it. Therefore, although there were no partitions in the stew-chest, and the steam were admitted at the end next the boiler, if the pan at the farther end be colder than the rest, it will all go thither; and will, in short, communicate to every thing impartially according to the demand. If any person has not the confidence in the steam which we express, he may still be certain that there must be a prodigious saving of heat by confining the whole in the stew-chest; and he may make the pans with entire bottoms, and admit the steam into them in the common way, by pipes which come through the sides of the chest and then go into the pan. There will be none lost by condensation on the sides of the chest; and the pans will soon be heated up to the boiling temperature; and hardly any of their heat will be wasted, because the air in the chest will be stagnant. The chief reason for recommending our method is the much greater ease with which the stew-pans can be shifted and cleaned. There will be little difference in the performance.

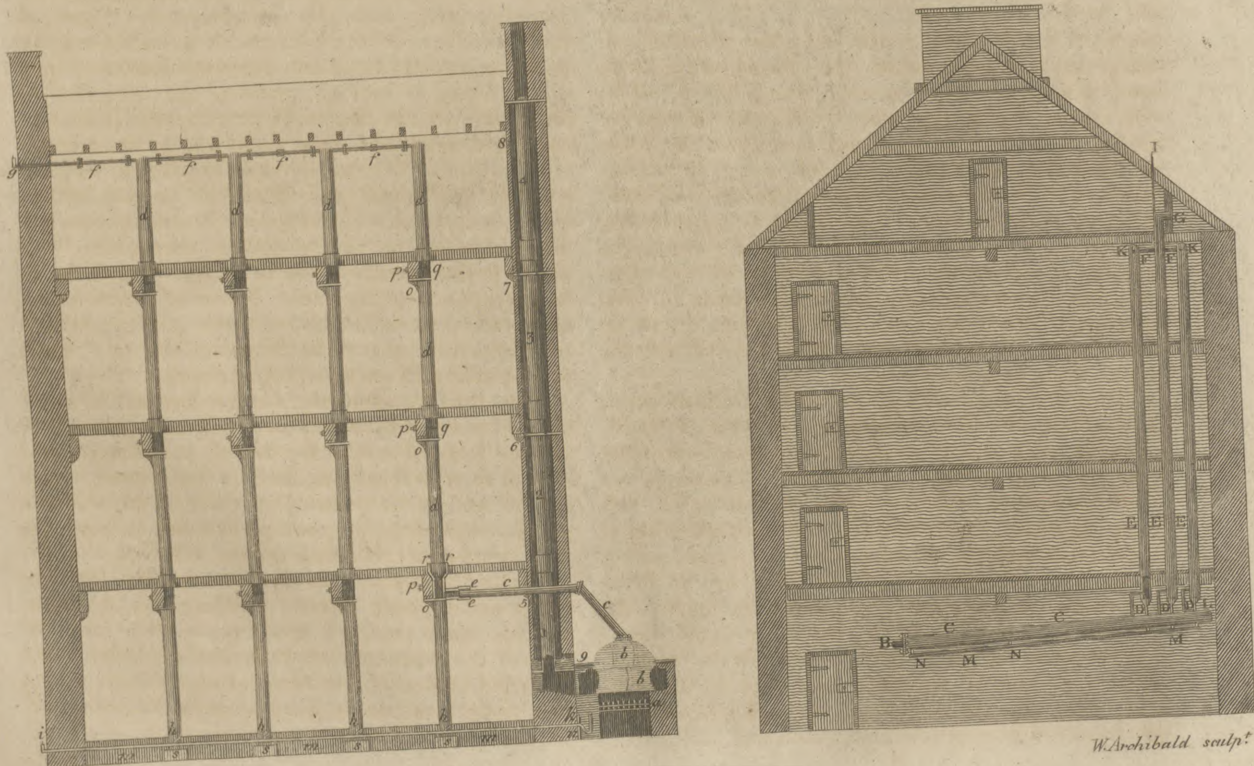
Nay, even the common steam-kitchen may be prodigiously improved by merely wrapping each pan in three or four folds of coarse dry flannel, or making flannel bags of three or four folds fitted to their shape, which can be put on or removed in a minute. It will also greatly conduce to the good performance to wrap the main steam pipe in the same manner in flannel.

We said that this main-pipe is conducted from the boiler with a gentle ascent. The intention of this is, that the water produced by the unavoidable condensation of the steam may run back into the boiler. But the rapid motion of the steam generally sweeps it up hill, and it runs into the branch-pipes and descends into the stew-pans. Perhaps it would be as well to give the main-

STEAM kitchen.



ROOMS heated by STEAM.



W. Archibald sculp^t

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main-pipe a declivity the other way, and allow all the water to collect in a hot well at the farther end, by means of a descending pipe, having a loaded valve at the end. This may be so contrived as to be close by the fire, where it would be so warm that it would not check the boiling if again poured into the boiler. But the utmost attention must be paid to cleanliness in the whole of this passage, because this water is boiled again, and its steam passes through the heart of every dish. This circumstance forbids us to return into the boiler what is condensed in the stew-pans. This would mix the tastes and flavours of every dish, and be very disagreeable. All this must remain in the bottom of each stew-pan; for which reason we put in the pipe rising up in the middle of the bottom. It might indeed be allowed to fall down into the stew-chest, and to be collected in a common receptacle, while the fat would float at top, and the clear gravy be obtained below, perhaps fit for many sauces.

The completest method for getting rid of this condensed steam would be to have a small pipe running along the under side of the main conductor, and communicating with it at different places, in a manner similar to the air discharger on the mains of water-pipes. In the paper manufactory mentioned above, each steam-box has a pipe in its bottom, with a float-cock, by which the water is discharged; and the main pipe being of great diameter, and laid with a proper acclivity, the water runs back into the boiler.

But these precautions are of little moment in a steam-kitchen even for a great table; and for the general use of private families, would hurt the apparatus, by making it complex and of nice management. For a small family, the whole apparatus may be set on a table four feet long and two broad, which may be placed on casters, so as to be wheeled out of the way when not in use. If the main conductor be made of wood, or properly cased in flannel, it will condense so little steam that the cooking table may stand in the remotest corner of the kitchen without sensibly impairing its performance; and if the boiler be properly set up in a small furnace, and the flue made so that the flame may be applied to a great part of its surface, we are persuaded that three-fourths of the fuel used in common cookery will be saved. Its only inconvenience seems to be the indispensable necessity of the most anxious cleanliness in the whole apparatus. The most trifling neglect in this will destroy a whole dinner.

We had almost forgotten to observe, that the boiler must be furnished with a funnel for supplying it with water. This should pass through the top, and its pipe reach near to the bottom. It will be proper to have a cock on this funnel. There should also be another pipe in the top of the boiler, having a valve on the top. If this be loaded with a pound on every square inch, and the fire so regulated that steam may be observed to puff sometimes from this valve, we may be certain that it is passing through our dishes with sufficient rapidity; and if we shut the cock on the funnel, and load the valve a little more, we shall cause the steam to blow at the covers of the stew-pans. If one of these be made very tight, and have a hole also furnished with a loaded valve, this pan becomes a digester, and will dissolve bones, and do many things which are impracticable in the ordinary cookery.

Steam.

STEAM applied to Heating Rooms. Steam has been successfully applied as a substitute for open fires in heating manufactories, and promises to be highly beneficial, not only in point of economy in saving fuel, but also in lessening the danger of accidental fire. The following mode of heating a cotton mill by steam was proposed and practised in 1799 by Mr Niel Snodgrass of Paisley. We shall give an account of it in his own words *.

* *Phil. Mag.* xxvii. 174.

Plate DV. Fig. 1.

"Fig. 1. presents a view of an inner gable, which is at one extremity of the preparation and spinning rooms of the mill. On the other side of this gable there is a space of 17 feet, enclosed by an outer gable, and containing the water-wheel, the staircase, and small rooms for the accommodation of the work. In this space the furnace and boiler are placed on the ground. The boiler cannot be shown here, as it lies behind the gable exhibited; nor is it of any consequence, as there is nothing peculiar in it. It may be of any convenient form. The feeding apparatus, &c. are in every respect the same as in the boiler of a common steam-engine. A circular copper boiler, two feet diameter by two feet deep, containing 30 gallons of water, with a large copper head as a reservoir for the steam, was found to answer in the present instance. The steam is conveyed from the boiler through the gable, by the copper pipe B, into the tin pipe, C, C. From C it passes into the centres of the perpendicular pipes E, E, E, by the small bent copper tubes D, D, D. The pipes E, E, E, are connected under the garret floor by the tubes F, F, for the more easy circulation of the steam. The middle pipe, E, is carried through the garret floor, and communicates with a lying pipe, 36 feet in length (the end of which is seen at G), for heating the garret. At the further extremity of the pipe G, there is a valve falling inwards to prevent a vacuum being formed on the cooling of the apparatus; the consequence of which would be the crushing of the pipes by the pressure of the atmosphere. Similar valves K, K, are placed near the the top of the perpendicular pipes, E, E; and from the middle one E, the small pipe passes through the roof, and is furnished with a valve at I, opening outwards, to suffer the air to escape while the pipes are filling with steam, or the steam itself to escape when the charge is too high.

"The water condensed in the perpendicular pipes E, E, E, trickles down their sides into the three funnels L, L, L, the necks of which may either pass through or round the pipe C, into the copper tube M, M, which also receives the water condensed in C, C, by means of the short tubes N, N. The pipe C, C, is itself so much inclined as to cause the water to run along it to the tubes N, N, and the pipe G in the garret has an inclination of 18 inches in its length, to bring the water condensed in it back to the middle pipe E. The tube M, M, carries back the water through the gable to the boiler, which stands five feet lower than this tube. It is material to return the water to the boiler, as, being nearly at a boiling heat, a considerable expense of fuel is thereby saved.

"The large pipes are ten inches in diameter, and are made of the second kind of tinned iron plates. The dimensions of the smaller tubes may be seen by their comparative size in the engraving, and perhaps they might be varied without inconvenience.

"The apparatus erected as here described, has been found sufficiently strong, and has required no material repairs

Steam.

repairs ſince the firſt alterations were made. The leading object in the inſtance under conſideration being to ſave fuel, in order to derive as much heat as poſſible from a given quantity of fuel, the flue from the furnace, which heats the boiler, is conveyed into common ſtone pipes placed in the gable. Theſe are erected ſo as to prevent any danger of fire, in the manner ſhown in the engraving, fig. 2. The ſteam with this auxiliary communicates a heat of about 70° to the mill, the rooms of which are 50 feet long, 32½ feet wide, and 8½ feet high, except the lower ſtory and garret; the former of which is 11, and the latter ſeven feet high. The rooms warmed in this manner are much more wholeſome and agreeable than thoſe heated by the beſt conſtructed ſtoves, being perfectly free from vapour or contaminated air.

"The application of the principle to buildings already conſtructed, it is preſumed, will be ſufficiently obvious from the foregoing details. In new manufactories, where the mode of heating may be made a part of the original plan, a more convenient apparatus may be introduced. This will be beſt explained by a deſcription of fig. 2. which gives a ſection of a cotton-mill conſtructed ſo as to apply the ſteam apparatus to a new building.

Fig. 2.

"The furnace for the boiler is ſhown at *a* (fig. 2). The flue of the furnace conveys the ſmoke into the caſt iron ſtove pipes, 1, 2, 3, 4. Theſe pipes are placed in a ſpace in the gable, entirely incloſed with brick, except at the ſmall apertures, 5, 6, 7, 8. A current of air is admitted below at 9, and thrown into the rooms by thoſe openings, after being heated by contact with the pipes. This part of the plan is adopted with a view to prevent, as much as poſſible, any of the heat, produced by the fuel uſed, from being thrown away. It may be omitted where any danger of fire is apprehended from it, and the ſmoke may be carried off in any way that is conſidered abſolutely ſecure. So far, however, as appears from experience, there ſeems to be little or no danger of fire from a ſtove of this conſtruction. The greateſt inconvenience of a common ſtove is, that the cockle or metal furnace is liable to crack from the intenſity of the heat. By the continuity of the metal from the fire-place, an intenſe heat is alſo conducted along the pipes, which expoſes them to the ſame accident. Here the ſmoke being previouſly conveyed through a brick flue, can never communicate to the pipes a degree of heat ſufficient to crack them. In like manner the pipes, having no communication with the rooms but by the ſmall apertures, cannot come in contact with any combuſtible ſubſtance; and from being ſurrounded with air, which is conſtantly changing, can impart only a very moderate degree of heat to the walls. The iron ſupporters of the pipes may be imbedded in ſome ſubſtance which is a bad conductor of heat, as furnace aſhes and lime, &c. The emiſſion of heated air into the rooms may be regulated by valves. As the pipes are not expoſed to cracking, there is no riſk of their throwing ſmoke or vapour into the rooms.

"The boiler *b, b*, is ſix feet long, three and a half broad, and three feet deep. As there is nothing peculiar in the feeding apparatus, it is omitted. The boiler may be placed in any convenient ſituation. Where a ſteam engine is uſed for other purpoſes, the ſteam may be taken from its boiler. The pipe *c, c*, conveys the ſteam from the boiler to the firſt perpendicular pipe *d, d, d, d*. There is an expanding joint at *e*, ſtuffed, to make it ſteam-tight. The ſteam aſcending in the firſt pipe *d, d, d*, enters the horizontal pipe *f, f, f, f*, (which is ſlightly inclined) expelling the air, which partly eſcapes by the valve *g*, and is partly forced into the other pipes. The valve *g* being conſiderably loaded, forces the accumulating ſteam down into the reſt of the pipes *d, d, d*. The air in theſe pipes recedes before the ſteam, and is forced through the tubes *h, h, h*, into the pipe *m, m, m*, whence it eſcapes at the valve *i*, and the ſyphon *k*. The water, condenſed in the whole of the pipes, paſſes alſo through the tubes *h, h, h, h*, into the pipe *m, m, m*, which has ſuch a declivity as to diſcharge the water at the ſyphon *k*, into the hot well *n*, whence it is pumped back into the boiler.

Steam, Steatites.

"The whole of the pipes are of caſt iron, except *m, m, m*, which is of copper. The perpendicular pipes ſerve as pillars for ſupporting the beams of the houſe, by means of the projecting pieces *o, o, o*, which may be raiſed or lowered at pleaſure by the wedges *p, p, p*. The pipes are ſunk in the beams about an inch, and are made faſt to them by the iron ſtraps *q, q*. Thoſe in the lower ſtory reſt on the ſtones *s, s, s, s*, and are made tight at the junction with ſtuffing. The pipe in each ſtory ſupports the one in the ſtory above by a ſtuffed joint as ſhown at *r*. The pipes in the lower ſtory are ſeven inches in diameter; thoſe in the higher ſix inches; thoſe in the other two are of intermediate diameters. The thickneſs of the metal is three-eighths of an inch. The lower pipes are made larger than the upper, in order to expoſe a greater heated ſurface in the lower rooms, becauſe the ſteam being thrown from above into all the pipes, except the firſt, would otherwiſe become incapable of imparting an equal heat as it deſcends. There is no neceſſity for valves opening inwards in this apparatus, the pipes being ſtrong enough to reſiſt the preſſure of the atmoſphere.

"The cotton mill is 60 feet long, 33 wide, and four ſtories high, the upper being a garret ſtory. In the engraving, five parts out of nine in the length of the building are only ſhown. The apparatus will heat the rooms to 85° in the coldeſt ſeaſon. It is evident that, by increaſing the ſize, or the number of the pipes, and the ſupply of ſteam, any degree of heat up to 212° may be eaſily produced. It may even be carried beyond that point by an apparatus ſtrong enough to compreſs the ſteam: this, however, can ſeldom be wanted. At firſt it was objected to this conſtruction, that the expanſion of the pipes, when heated, might damage the building: but experience has proved, that the expanſion occaſioned by the heat of ſteam is quite inſenſible."

Steam has alſo been advantageouſly employed in drying muſlin goods, when the ſtate of the weather interrupts this proceſs out of doors. This application of ſteam, we underſtand, was the invention of an ingenious mechanic in Paiſley, who never derived the ſmalleſt benefit from the diſcovery. It was adopted immediately by ſome bleachers in the neighbourhood, and has now come into very general uſe. The ſteam is introduced into cylinders of tin plate, and the goods to be dried are wrapped round the cylinders which communicate to them a heat equal at leaſt to the temperature of boiling water, and in this way the proceſs of drying is expeditiouſly accompliſhed.

STEATITES or *Soap-earth*, a ſpecies of mineral belonging

belonging to the magneſian genus. See MINERALOGY *Index*.

STEATOMA, a kind of encyſted tumor, conſiſting of a matter like ſuet or lard, ſoft, without pain, and without diſcolouring the ſkin.

STEEL, iron united with carbone, from which it poſſeſſes properties diſtinct from thoſe of iron, and which render it of ſuperior value. From its higher degree of hardneſs it admits a finer poliſh and aſſumes a brighter colour. When tempered, it poſſeſſes a higher degree of elaſticity, and is alſo more ſonorous. It is more weakly attracted by the loadſtone, it receives more ſlowly the magnetic power, but it preſerves it longer. When expoſed to a moiſt air, it does not contract ruſt ſo eaſily as iron. See IRON, CHEMISTRY *Index*.

STEEL-Bow Tenants. See TENURE.

STEEL-Yard, is one of the moſt ancient preſents which ſcience has made to ſociety; and though long in deſuetude in this country, is in moſt nations of the world the only inſtrument for aſcertaining the weight of bodies. What is tranſlated *balance* in the Pentateuch, is in fact ſteelyard, being the word uſed by the Arabs to this day for their inſtrument, which is a ſteelyard. It is in common uſe in all the Aſiatic nations. It was the *ſtatera* of the Greeks and Romans, and ſeems to have been more confided in by them than the balance; for which reaſon it was uſed by the goldſmiths, while the balance was the inſtrument of the people.—*Non aurificis ſtatera ſed populari trutina examinare.* Cic. de Orat. 238.

The ſteelyard is a lever of unequal arms, and, in its moſt perfect form, is conſtructed much like a common balance. It hangs in sheers E (fig. 1,) reſting on the nail C, and the ſcale L for holding the goods hangs by a nail D on the ſhort arm BC. The counter weight P hangs by a ring of tempered ſteel, made ſharp in the inſide, that it may bear by an edge on the long arm CA of the ſteelyard. The under edge of the centre nail C, and the upper edge of the nail D, are in the ſtraight line formed by the upper edge of the long arm. Thus the three points of ſuſpenſion are in one ſtraight line. The needle or index of the ſteelyard is perpendicular to the line of the arms, and plays between the ſheers. The ſhort arm may be made ſo maſſive, that, together with the ſcale, it will balance the long arm unloaded. When no goods are in the ſcale, and the counter weight with its hook are removed, the ſteelyard acquires a horizontal poſition, in conſequence of its centre of gravity being below the axis of ſuſpenſion. The rules for its accurate conſtruction are the ſame as for a common balance.

Plate DVI. Fig. 1.

The inſtrument indicates different weights in the following manner: The diſtance CD of the two nails is conſidered as an unit, and the long arm is divided into a number of parts equal to it; and theſe are ſubdivided as low as is thought proper; or in general, the long arm is made a ſcale of equal parts, commencing at the edge of the nail C; and the ſhort arm contains ſome determined number of thoſe equal parts. Suppoſe, then, that a weight A of 10 pounds is put into the ſcale L. The counterpoiſe P muſt be of ſuch a weight, that, when hanging at the diviſion 10, it ſhall balance this weight A. Now let any unknown weight W be put into the ſcale. Slide the hook of the counterpoiſe along the long arm till it balances this weight. Suppoſe it then hanging at the diviſion 38. We conclude that there is 38 pounds in the ſcale. This we do on the authority of the fundamental property of the lever, that forces acting on it, and balancing each other, are in the inverſe proportion of the diſtances from the fulcrum to their lines of direction. Whatever weight the counterpoiſe is, it is to A as CD to 10, and it is to the weight W as CD to 38; therefore A is to the weight W as 10 to 38, and W is 38 pounds: and thus the weight in the ſcale will always be indicated by the diviſion at which it is balanced by the counterpoiſe.

Our well-informed readers know that this fundamental property of the lever was diſcovered by the renowned Archimedes, or at leaſt firſt demonſtrated by him; and that his demonſtration, beſides the defect of being applicable only to commenſurable lengths of the arms, has been thought by metaphyſicians of the firſt note to proceed on a poſtulate which ſeems equally to need a demonſtration. It has accordingly employed the utmoſt refinement of the firſt mathematicians of Europe to furniſh a demonſtration free from objection. Mr D'Alembert has given two, remarkable for their ingenuity and ſubtlety; Foncenex has done the ſame; and Profeſſor Hamilton of Trinity-college, Dublin, has given one which is thought the leaſt exceptionable. But critics have even objected to this, as depending on a poſtulate which ſhould have been demonſtrated.

The following demonſtration by Mr Vince, we think unexceptionable, and of ſuch ſimplicity that it is aſtoniſhing that it has not occurred to any perſon who thinks on the ſubject. *Phil. Tranſ.* 1794.

Let AE (fig. 2.) be a mathematical lever, or inflexible ſtraight line, reſting on the prop A, and ſupported at D by a force acting upwards. Let two equal weights *b* and *d* be hung on at B and D, equidiſtant from A and E. Preſſures are now exerted at A and E; and becauſe every circumſtance of weight and diſtance is the ſame, the preſſure at E, ariſing from the action of the weight *b* on the point B, muſt be the ſame with the preſſure at A, ariſing from the action of the weight *d* on the point D; and the preſſure at E, occaſioned by the weight *d*, muſt be the ſame with the preſſure at A, occaſioned by the weight *b*. This muſt be the caſe wherever the weights are hung, provided that the diſtance AB and DE are equal. Moreover, the ſum of the preſſures at A and E is unqueſtionably equal to the ſum of the weights, becauſe the weights are ſupported ſolely at A and E. Let the two weights be hung on at C the middle point; the preſſure at E is ſtill the ſame. Therefore, in general, the preſſure excited at the point E, by two equal weights hanging at any points B and D, is the ſame as if they were hung on at the middle point between them: but the preſſure excited at E is a juſt meaſure of the effort or energy of the weights *b* and *d* to urge the lever round the point A. It is, at leaſt, a meaſure of the oppoſite force which muſt be applied at E to ſuſtain or balance this preſſure. A very faſtidious metaphyſician may ſtill ſay, that the demonſtration is limited to a point E, whoſe diſtance from A is twice AC, or $=$ AB $+$ AD. But it extends to any other point, on the authority of a poſtulate which cannot be refuſed, viz. that in whatever proportion the preſſure at E is augmented or diminiſhed, the preſſure at this other point muſt augment or diminiſh in the ſame proportion. This being proved, the general theorem may be demonſtrated Fig. 2.

ted in all proportions of diſtance, in the manner of Archimedes, at once the moſt ſimple, perſpicuous, and elegant of all.

We cannot help obſerving, that all this difficulty (and it is a real one to the philoſopher who aims at rendering mechanics a demonſtrative ſcience) has ariſen from an improper ſearch after ſimplicity. Had Archimedes taken a lever as it really exiſts in nature, and conſidered it as *material*, conſiſting of atoms united by coheſion; and had he traced the intermediate preſſures by whoſe means the two external weights are put in oppoſition to each other, or rather to the ſupport given to the fulcrum; all difficulty would have vaniſhed. (See what is ſaid on this ſubject in the article *STRENGTH of Timber*, &c.

The quantity of goods which may be weighed by this inſtrument depends on the weight of the counterpoiſe, and on the diſtance CD from the fulcrum at which the goods are ſuſpended. A double counterpoiſe hanging at the ſame diviſion will balance or indicate a double quantity of goods hanging at D; and any counterpoiſe will balance and indicate a double quantity of goods, if the diſtance CD be reduced to one half. And it ſometimes occurs that ſteelyards are ſo conſtructed that they have two or more points of ſuſpenſion D, to which the ſcale may occaſionally be attached. It is evident, that in this caſe the value or indication of the diviſions of the long arm will be different, according to the point from which the ſcale is ſuſpended. The ſame diviſion which would indicate 20 pounds when CD is three inches, will indicate 30 pounds when it is two inches. As it would expoſe to chance of miſtakes, and be otherwiſe troubleſome to make this reduction, it is uſual to make as many divided ſcales on the long arm as there are points of ſuſpenſion D on the ſhort arm; and each ſcale having its own numbers, all trouble and all chance of miſtake is avoided.

But the range of this inſtrument is not altogether at the pleaſure of the maker. Beſides the inability of a ſlender beam to carry a great load, the diviſions of the ſcale anſwering to pounds or half-pounds become very minute when the diſtance CD is very ſhort; and the balance becomes leſs delicate, that is, leſs ſenſibly affected by ſmall differences of weight. This is becauſe in ſuch caſes the thickneſs which it is neceſſary to give the edges of the nails does then bear a ſenſible proportion to the diſtance CD between them; ſo that when the balance inclines to one ſide, that arm is ſenſibly ſhortened, and therefore the energy of the preponderating weight is leſſened.

We have hitherto ſuppoſed the ſteelyard to be in equilibrio when not loaded. But this is not neceſſary, nor is it uſual in thoſe which are commonly made. The long arm commonly preponderates conſiderably. This makes no difference, except in the beginning of the ſcale. The preponderancy of the long arm is equivalent to ſome goods already in the ſcale, ſuppoſe four pounds. Therefore when there are really 10 pounds in the ſcale, the counterpoiſe will balance it when hanging at the diviſion 6. This diviſion is therefore reckoned 10, and the reſt of the diviſions are numbered accordingly.

A ſcientific examination of the ſteelyard will convince us that it is inferior to the balance of equal arms in point of ſenſibility: But it is extremely compendious and convenient; and when accurately made and attentively uſed, it is abundantly exact for moſt commercial purpoſes. We have ſeen one at Leipzig which has been in uſe ſince the year 1718, which is very ſenſible to a difference of one pound, when loaded with nearly three tons on the ſhort arm; and we ſaw a waggon loaded with more than two tons weighed by it in about ſix minutes.

The ſteelyard in common uſe in the different countries of Europe is of a conſtruction ſtill ſimpler than what we have deſcribed. It conſiſts of a batten of hard wood, having a heavy lump A (fig. 3.) at one end, and a ſwivel-hook B at the other. The goods to be weighed are ſuſpended on the hook, and the whole is carried in a loop of whip-cord C, in which it is ſlid backward and forward, till the goods are balanced by the weight of the other end. The weight of the goods is eſtimated by the place of the loop on a ſcale of diviſions in harmonic progreſſion. They are marked (we preſume) by trial with known weights. Fig. 3.

The chief uſe that is now made of the ſteelyard in theſe kingdoms is for the weighing of loaded waggons and carts. For this it is extremely convenient, and more than ſufficiently exact for the purpoſe in view. We ſhall deſcribe one or two of the moſt remarkable; and we ſhall begin with that at Leipzig already mentioned.

This ſteelyard is repreſented in fig. 4. as run out, and juſt about to be hooked for lifting up the load. The ſteelyard itſelf is OPQ, and is about 12 feet long. The ſhort arm PQ has two points of ſuſpenſion *c* and *b*; and the ſtirrup which carries the chains for holding the load is made with a double hook, inſtead of a double eye, that it may be eaſily removed from the one pin to the other. For this purpoſe the two hooks are connected above an haſp or ſtaple, which goes over the arm of the ſteelyard like an arch. This is repreſented in the little figure above the ſteelyard. The ſuſpenſion is ſhifted when the ſteelyard is run in under cover, by hooking to this ſtaple the running block of a ſmall tackle which hangs in the door through which the ſteelyard is run out and in. This operation is eaſy, but neceſſary, becauſe the ſtirrup, chains, and the ſtage on which the load is placed, weigh ſome hundreds. Fig. 4.

The outer pin *b* is 14 inches, and the inner one *c* is ſeven inches, diſtant from the great nail which reſts in the ſheers. The other arm is about 10½ feet long, formed with an obtuſe edge above. On the inclined plane on each ſide of the ridge is drawn the ſcale of weights adapted to the inner pin *c*. The ſcales correſponding to the outer pin *b* are drawn on the upright ſides. The counterpoiſe ſlides along this arm, hanging from a ſaddle-piece made of braſs, that it may not contract ruſt. The motion is made eaſy by means of rollers. This is neceſſary, becauſe the counterpoiſe is greatly above a hundred weight. This ſaddle-piece has like two laps on each ſide, on which are engraved vernier ſcales, which divide their reſpective ſcales on the arm to quarters of a pound. Above the ſaddle is an arch, from the ſummit of which hangs a little plummet, which ſhows the equilibrium of the ſteelyard to the weigher, becauſe the ſheers are four feet out of the houſe, and he cannot ſee their coincidence with the needle of the ſteelyard. Laſtly, near the end of the long arm

are

Fig. 4.

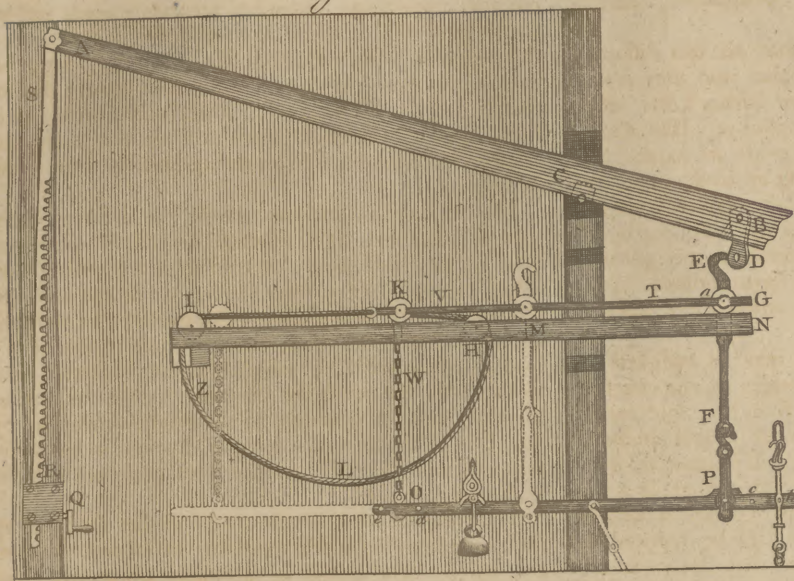


Fig. 2.

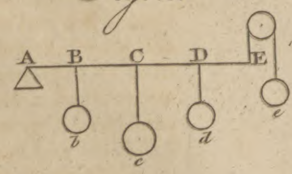


Fig. 1.

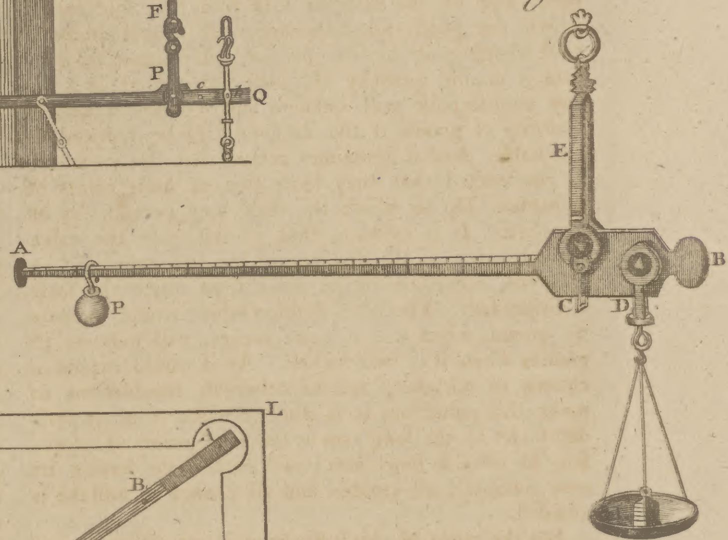
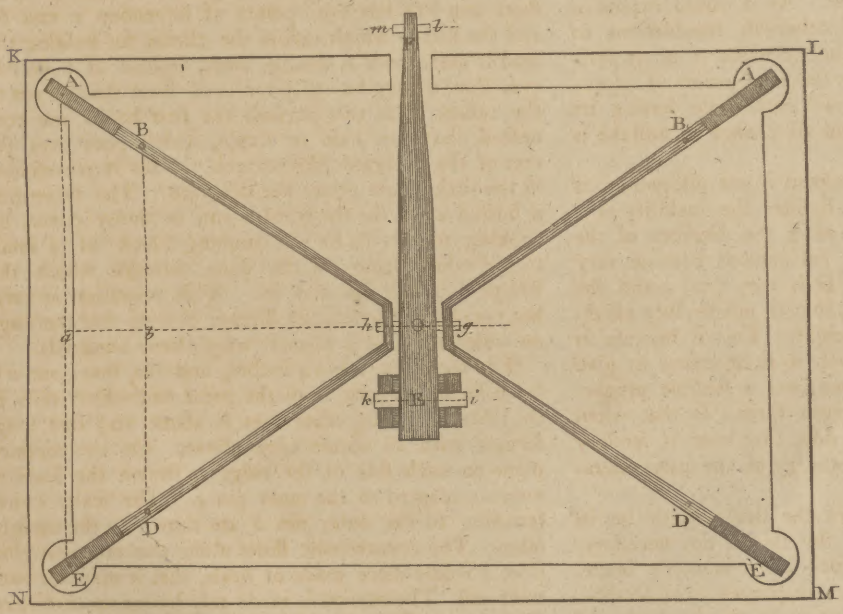


Fig. 5.



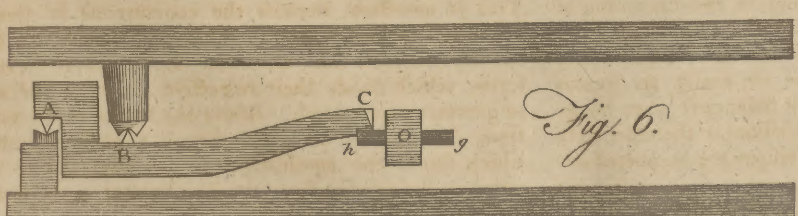
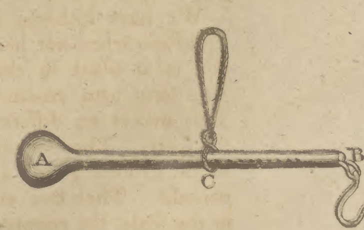


Fig. 6.

Fig. 3.



Steel-yard. are two pins d and e, for ſuſpending occaſionally two eke weights for continuing the ſcale. Theſe are kept hanging on adjoining hooks, ready to be lifted on by a little tackle, which is alſo hooked immediately above the pins d and e.

The ſcales of weights are laid down on the arm as follows. Let the eke-weights appropriated to the pins d and e be called D and E, and call the counterpoiſe C. Although the ſtirrup with its chains and ſtage weigh ſome hundreds, yet the length and ſize of the arm OP gives it a preponderancy of 300 pounds. Here, then, the ſcale of weights muſt commence. The counterpoiſe weighs about 125 pounds. Therefore,

1. When the load hangs by the pin b, 14 inches from the centre, the diſtance from one hundred to another on the ſcale is about 11 inches, and the firſt ſcale (on the ſide of the arm) reaches from 300 to 1200. In order to repeat or continue this, the eke-weight E is hung on the pin e, and the counterpoiſe C is brought back to the mark 300; and the two together balance 1100 pounds hanging at b. Therefore a ſecond ſcale is begun on the ſide of the arm, and continued as far out as the firſt, and therefore its extremity marks 2000; that is, the counterpoiſe C at 2000 and the eke-weight E at e balance 2000 hanging at b.

2. To continue the ſcale beyond 2000, the load muſt be hung on the inner pin c. The eke-weight E is taken off, and the eke-weight D is hung on its pin d. The general counterpoiſe being now brought cloſe to the ſheers, it, together with the weight D at d, balance 2000 pounds hanging at c. A ſcale is therefore begun on one of the inclined planes a-top, and continued out to 4000, which falls very near to the pin d, each hundred pounds occupying about five inches on the arm. To complete the ſcale, hang on the eke-weight E on its pin e, and bring back the counterpoiſe to the ſheers, and the three together balance 3800 hanging at c. Therefore when the counterpoiſe is now ſlid out to 4000, it muſt complete the balance with 5800 hanging at c.

It required a little conſideration to find out what proportion of the three weights C, D, and E, would make the repetitions of the ſcale extend as far as poſſible, having very little of it expreſſed twice, or upon two ſcales, as is the caſe here. We ſee that the ſpace correſponding to a ſingle pound is a very ſenſible quantity on both ſcales, being one-ninth of an inch on the firſt two ſcales, and one-twentieth on the laſt two.

This very ponderous machine, with its maſſy weights, cannot be eaſily managed without ſome aſſiſtance from mechanics. It is extremely proper to have it ſuſceptible of motion out and in, that it may be protected from the weather, which would ſoon deſtroy it by ruſt. The contrivance here is very effectual, and abundantly ſimple.

When the ſteelyard is not in uſe, it is ſupported at one end by the iron rod F, into which the upper end of the ſheers is hooked. The upper end of this rod has a ſtrong hook E, and a little below at a it is pierced with a hole, in which is a very ſtrong bolt or pin of tempered ſteel, having a roller on each end cloſe to the rod on each ſide. Theſe rollers reſt on two joiſts, one of which is repreſented by MN, which traverſe the building, with juſt room enough between them to allow the rod F to hang freely down. The other end O of the ſteelyard reſts in the bight of a large flat hook at the end of a chain W, which hangs down between the joiſts, and is ſupported on them by a frame with rollers H. This is connected with the rollers at G, which carry the ſheers by means of two iron-rods, of which one only can be ſeen. Theſe connect the two ſets of rollers in ſuch a manner that they muſt always move together, and keep their diſtance invariable. This motion is produced by means of an endleſs rope HIZLKVH paſſing over the pulleys I and K, which turn between the joiſts, and hanging down in a bight between them. It is evident that by pulling on the part LZ we pull the frame of rollers in the direction GH, and thus bring the whole into the houſe in the poſition marked by the dotted figure. It is alſo plain, that by pulling on the part LK we force the roller frame and the whole apparatus out again.

It remains to ſhow how the load is raiſed from the ground and weighed. When the ſteelyard is run out for uſe, the upper hook E juſt enters into the ring D, which hangs from the end of the great oaken lever BCA about 22 feet long, turning on gudgeons at C about 5 feet from this end. From the other end A deſcends a long iron-rod SR, which has one ſide formed into a toothed rack that is acted on by a frame of wheel-work turned by an endleſs ſcrew and winch Q. Therefore when the hook E is well engaged in the ring D, a man turns the winch, and thus brings down the end A of the great lever, and raiſes the load two or three inches from the ground. Every thing is now at liberty, and the weigher now manages his weights on the arm of the ſteelyard till he has made an equilibrium.

We need not deſcribe the operation of letting down the load, diſengaging the ſteelyard from the great lever, and bringing it again under cover. The whole of this ſervice is performed by two men, and may be done in ſucceſſion by one, and is over in five or ſix minutes.

The moſt compendious and economical machine of this kind that we have ſeen is one, firſt uſed (we have heard) for weighing the riders of race-horſes, and afterwards applied to the more reputable ſervice of weighing loaded carriages.

Fig. 5. is a plan of the machine. KLMN is the plan of a rectangular box, which has a platform lid or cover, of ſize ſufficient for placing the wheels of a cart or waggon. The box is about a foot deep, and is ſunk into the ground till the platform cover is even with the ſurface. In the middle of the box is an iron lever ſupported on the fulcrum pin ik, formed like the nail of a balance, which reſts with its edge on arches of hardened ſteel firmly faſtened to the bottom of the box. This lever goes through one ſide of the box, and is furniſhed at its extremity with a hard ſteel pin lm, alſo formed to an edge below. In the very middle of the box it is croſſed by a third nail of hardened ſteel gh, alſo formed to an edge, but on the upper ſide. Theſe three edges are in one horizontal plane, as in a well made balance. Fig. 5.

In the four corners A, A′, E′, E, of the box are firmly fixed four blocks of tempered ſteel, having their upper ſurfaces formed into ſpherical cavities, well poliſhed and hard tempered. ABCDE repreſents the upper edge of an iron bar of conſiderable ſtrength, which reſts on the cavities of the ſteel blocks in A and E, by means of

Steel-yard.

of two hard ſteel ſtuds projecting from its under edge, and formed into obtuſe-angled points or cones. Theſe points are in a ſtraight line parallel to the ſide KN of the box. The middle part C of this crooked bar is faced with hard-tempered ſteel below, and is there formed into an edge parallel to AE and KN, by which it reſts on the upper edge of the ſteel pin *g h* which is in the lever. In a line parallel to AE, and on the upper ſide of the crooked bar ACE, are fixed two ſtuds or points of hardened ſteel B and D projecting upwards above half an inch. The platform-cover has four ſhort feet like a ſtool, terminated by hard ſteel ſtuds, which are ſhaped into ſpherical cavities and well poliſhed. With theſe it reſts on the four ſteel points B, B′, D′, D. The bar ACE is kneed in ſuch a manner vertically, that the points A, B, D, E and the edge C are all in a horizontal plane. Theſe particulars will be better underſtood by looking at the elevation in fig. 6. What has been ſaid of the bar ACE muſt be underſtood as alſo ſaid of the bar A′ C′ E′.

Draw through the centre of the box the line *a b c* perpendicular to the line AE, BD. It is evident that the bar ACE is equivalent to a lever *a b c*, having the fulcrum or axis AE reſting with its extremity C on the pin *h g* and loaded at *b*. It is alſo evident that *a* C is to *a b* as the load on this lever to the preſſure which it exerts on the pin *g h*, and that the ſame proportion ſubſiſts between the whole load on the platform and the preſſure which it exerts on the pin *g h*. It will alſo appear on an attentive conſideration, that this proportion is nowiſe deranged in whatever manner the load is placed on the platform. If very unequably, the two ends of the pin *g h* may be unequally preſſed, and the lever wrenched and ſtrained a little; but the total preſſure is not changed.

If there be now placed a balance or ſteelyard at the ſide LK, in ſuch a manner that one end of it may be directly above the pin *l m* in the end of the lever EOF, they may be connected by a wire or ſlender rod, and a weight on the other arm of the balance or ſteelyard may be put in equilibrio with any load that can be laid on the platform. A ſmall counterpoiſe being firſt hung on to balance the apparatus when unloaded, any additional weight will meaſure the load really laid on the platform. If *a b* be to *a c* as 1 to 8, and EO to EF, alſo as 1 to 8, and if a common balance be uſed above, 64 pounds on the platform will be balanced by one pound in the ſcale, and every pound will be balanced by $\frac{1}{4}$th of an ounce. This would be a very convenient partition for moſt purpoſes, as it would enable us to uſe a common balance and common weights to complete the machine: Or it may be made with a balance of unequal arms, or with a ſteelyard.

Some have thought to improve this inſtrument by uſing edges like thoſe of the nails of a balance, inſtead of points. But unleſs made with uncommon accuracy, they will render the balance very dull. The ſmall deviation of the two edges A and E, or of B and D, from perfect parallelism to KN, is equivalent to a broad ſurface equal to the whole deviation. We imagine that, with no extraordinary care, the machine may be made to weigh within $\frac{1}{2000}$ of the truth, which is exact enough for any purpoſe in commerce.

It is neceſſary that the points be attached to the bars. Some have put the points at A and E in the blocks of ſteel faſtened to the bottom, becauſe the cavity there lodged water or dirt, which ſoon deſtroyed the inſtrument with ruſt. But this occaſions a change of proportion in the firſt lever by any ſhifting of the crooked bars; and this will frequently happen when the wheels of a loaded cart are puſhed on the platform. The cavity in the ſteel ſtud ſhould have a little rim round it, and it ſhould be kept full of oil. In a nice machine a quarter of an inch of quickſilver would effectually prevent all theſe inconveniences.

Steel-yard, Steele.

The ſimpleſt and moſt economical form of this machine is to have no balance or ſecond ſteelyard; but to make the firſt ſteelyard EOF a lever of the firſt kind, viz. having the fulcrum between O and F, and allow it to project far beyond the box. The long or outward arm of this lever is then divided into a ſcale of weights, commencing at the ſide of the box. A counterpoiſe muſt be choſen, ſuch as will, when at the beginning of the ſcale, balance the ſmalleſt load that will probably be examined. It will be convenient to carry on this ſcale by means of eke-weights hung on at the *extremity* of the lever, and to uſe but one moveable weight. By this method the diviſions of the ſcale will always have one value. The beſt arrangement is as follows: Place the mark O at the beginning of the ſcale, and let it extend only to 100, if for pounds; or to 112, if for cwts.; or to 10, if for ſtones; and let the eke-weights be numbered 1, 2, 3, &c. Let the loweſt weight be marked on the beam. This is always to be added to the weight ſhown by the operation. Let the eke-weights ſtand at the end of the beam, and let the general counterpoiſe always hang at O. When the cart is put on the platform, the end of the beam tilts up. Hang on the heavieſt eke weight that is not ſufficient to preſs it down. Now complete the balance by ſliding out the counterpoiſe. Suppoſe the conſtant load to be 312lb. and that the counterpoiſe ſtands at 86, and that the eke-weight is 9; we have the load $=986+312,=1298$lbs.

STEELE, Sir Richard, was born about the year 1676 in Dublin; in which kingdom one branch of the family was poſſeſſed of a conſiderable eſtate in the county of Wexford. His father, a counſellor at law in Dublin, was private ſecretary to James duke of Ormond; but he was of Engliſh extraction: and his ſon, while very young, being carried to London, he put him to ſchool at the Charter-houſe, whence he was removed to Merton College in Oxford. Our author left the univerſity, which he did without taking any degree, in the full reſolution to enter into the army. This ſtep was highly diſpleaſing to his friends; but the ardour of his paſſion for a military life rendered him deaf to any other propoſal. Not being able to procure a better ſtation, he entered as a private gentleman in the horſe guards, notwithſtanding he thereby loſt the ſucceſſion to his Iriſh eſtate. However, as he had a flow of good nature, a generous openneſs and frankneſs of ſpirit, and a ſparkling vivacity of wit, theſe qualities rendered him the delight of the ſoldiery, and procured him an enſign's commiſſion in the guards. In the mean time, as he had made choice of a profeſſion which ſet him free from all the ordinary reſtraints in youth, he ſpared not to indulge his inclinations in the wildeſt exceſſes. Yet his gaieties and revels did not paſs without ſome cool hours of reflection; it was in theſe that he drew up his little treatiſe intitled

Steele.

The Christian Hero, with a design, if we may believe himself, to be a check upon his passions. For this purpose it had lain some time by him, when he printed it in 1701, with a dedication to Lord Cutts, who had not only appointed him his private secretary, but procured for him a company in Lord Lucas's regiment of Fusileers.

The same year he brought out his comedy called *The Funeral*, or *Grief à la Mode*. This play procured him the regard of King William, who resolved to give him some essential marks of his favour; and though, upon that prince's death, his hopes were disappointed, yet, in the beginning of Queen Anne's reign, he was appointed to the profitabte place of gazetteer. He owed this post to the friendship of Lord Halifax and the earl of Sunderland, to whom he had been recommended by his schoolfellow Mr Addison. That gentleman also lent him an helping hand in promoting the comedy called *The Tender Husband*, which was acted in 1704 with great success. But his next play, The Lying Lover, had a very different fate. Upon this rebuff from the stage, he turned the same humorous current into another channel; and early in the year 1709, he began to publish the Tatler: which admirable paper was undertaken in concert with Dr Swift. His reputation was perfectly established by this work; and, during the course of it, he was made a commissioner of the stamp-duties in 1710. Upon the change of the ministry the same year, he joined the duke of Marlborough, who had several years entertained a friendship for him; and upon his Grace's dismission from all employments in 1711, Mr Steele addressed a letter of thanks to him for the services which he had done to his country. However, as our author still continued to hold his place in the stamp-office under the new administration, he wisely declined the discussion of political subjects; and, adhering more closely to Mr Addison, he dropt the Tatler, and afterwards, by the assistance chiefly of that steady friend, he carried on the same plan, much improved, under the title of *The Spectator*. The success of this paper was equal to that of the former; which encouraged him, before the close of it, to proceed upon the same design in the character of the Guardian. This was opened in the beginning of the year 1713, and was laid down in October the same year. But in the course of it his thoughts took a stronger turn to politics: he engaged with great warmth against the ministry; and being determined to prosecute his views that way by procuring a seat in the house of commons, he immediately removed all obstacles thereto. For that purpose he took care to prevent a forcible dismission from his post in the stamp-office, by a timely resignation of it to the earl of Oxford; and at the same time gave up a pension, which had been till this time paid him by the queen as a servant to the late Prince George of Denmark. This done, he wrote the famous Guardian upon the demolition of Dunkirk, which was published August 7. 1713; and the parliament being dissolved next day, the Guardian was soon followed by several other warm political tracts against the administration. Upon the meeting of the new parliament, Mr Steele having been returned a member for the borough of Stockbridge in Hampshire, took his seat accordingly in the house of commons; but was expelled thence in a few days after, for writing the close of the paper called the *Englishman*, and one of his political pieces intitled the *Crisis*. Presently after his expulsion, he published proposals for writing the history of the duke of Marlborough; at the same time he also wrote the *Spinster*; and, in opposition to the *Examiner*, he set up a paper called the *Reader*, and continued publishing several other things in the same spirit till the death of the queen. Immediately after which, as a reward for these services, he was taken into favour by her successor to the throne, King George I. He was appointed surveyor of the royal stables at Hampton-Court, governor of the royal company of comedians, put into the commission of the peace for the county of Middlesex, and in 1715 received the honour of knighthood. In the first parliament of that king, he was chosen member for Boroughbridge in Yorkshire; and, after the suppression of the rebellion in the north, was appointed one of the commissioners of the forfeited estates in Scotland. In 1718, he buried his second wife, who had brought him a handsome fortune and a good estate in Wales; but neither this, nor the ample additions lately made to his income, were sufficient to answer his demands. The thoughtless vivacity of his spirit often reduced him to little shifts of wit for its support; and the project of the fish-pool this year owed its birth chiefly to the projector's necessities. This vessel was intended to carry fish alive, and without wasting, to any part of the kingdom: but notwithstanding all his towering hopes, the scheme proved very ruinous to him; for after he had been at an immense expence in contriving and building his vessel, besides the charge of the patent, which he had procured, it turned out upon trial to be a mere project. His plan was to bring salmon alive from the coast of Ireland; but these fish, though supplied by this contrivance with a continual stream of water while at sea, yet uneasy at their confinement, shattered themselves to pieces against the sides of the pool; so that when they were brought to market they were worth very little.

The following year he opposed the remarkable peerage bill in the house of commons; and, during the course of this opposition to the court, his licence for acting plays was revoked, and his patent rendered ineffectual, at the instance of the lord chamberlain. He did his utmost to prevent so great a loss; and finding every direct avenue of approach to his royal master effectually barred against him by his powerful adversary, he had recourse to the method of applying to the public, in hopes that his complaints would reach the ear of his sovereign, though in an indirect course, by that canal. In this spirit he formed the plan of a periodical paper, to be published twice a week, under the title of the *Theatre*; the first number of which came out on the 2d of January 1719-20. In the mean time, the misfortune of being out of favour at court, like other misfortunes, drew after it a train of more. During the course of this paper, in which he had assumed the feigned name of *Sir John Edgar*, he was outrageously attacked by Mr Dennis, the noted critic, in a very abusive pamphlet, entitled *The Character and Conduct of Sir John Edgar*. To this insult our author made a proper reply in the Theatre.

While he was struggling with all his might to save himself from ruin, he found time to turn his pen against the mischievous South sea scheme, which had nearly brought

brought the nation to ruin in 1720; and the next year he was restored to his office and authority in the playhouse in Drury-Lane. Of this it was not long before he made an additional advantage, by bringing his celebrated comedy called the *Conscious Lovers* upon that stage, where it was acted with prodigious success; so that the receipt there must have been very considerable, besides the profits accruing by the sale of the copy, and a purse of 500l. given to him by the king, to whom he dedicated it. Yet notwithstanding these ample supplies, about the year following, being reduced to the utmost extremity, he sold his share in the play-house; and soon after commenced a law-suit with the managers, which in 1726 was decided against him. Having now again, for the last time, brought his fortune, by the most heedless profusion, into a desperate condition, he was rendered altogether incapable of retrieving the loss, by being seized with a paralytic disorder, which greatly impaired his understanding. In these unhappy circumstances, he retired to his seat at Languanor near Caermarthen in Wales, where he died on the 21st of September 1729, and was privately interred, according to his own desire, in the church of Caermarthen. Among his papers were found the manuscripts of two plays, one called *The Gentlemen*, founded upon the Eunuch of Terence, and the other intitled *The School of Action*, both nearly finished.

Sir Richard was a man of undissembled and extensive benevolence, a friend to the friendless, and, as far as his circumstances would permit, the father of every orphan. His works are chaste and manly. He was a stranger to the most distant appearance of envy or malevolence; never jealous of any man's growing reputation; and so far from arrogating any praise to himself from his conjunction with Mr Addison, that he was the first who desired him to distinguish his papers. His great fault was want of economy; and it has been said of him, he was certainly the most agreeable and the most innocent rake that ever trod the rounds of dissipation.

STEEPLE, an appendage erected generally on the western end of churches, to hold the bells. Steeples are denominated from their form, either spires or towers: the first are such as ascend continually diminishing either conically or pyramidally; the latter are mere parallelopipeds, and are covered a-top platform-like.

STEERAGE, on board a ship, that part of the ship next below the quarter-deck, before the bulk-head of the great cabin, where the steersman stands, in most ships of war. See STEERING.

STEERING, in *Navigation*, the art of directing the ship's way by the movements of the helm; or of applying its efforts to regulate her course when she advances.

The perfection of steering consists in a vigilant attention to the motion of the ship's head, so as to check every deviation from the line of her course in the first instant of its motion; and in applying as little of the power of the helm as possible. By this she will run more uniformly in a straight path, as declining less to the right and left; whereas, if a greater effort of the helm is employed, it will produce a greater declination from the course, and not only increase the difficulty of steering, but also make a crooked and irregular track through the water. See HELM.—The helmsman should diligently watch the movements of the head by the land, clouds, moon, or stars; because, although the course is in general regulated by the compass, yet the vibrations of the needle are not so quickly perceived as the sallies of the ship's head to the right or left, which, if not immediately restrained, will acquire additional velocity in every instant of their motion, and demand a more powerful impulse of the helm to reduce them; the application of which will operate to turn her head as far on the contrary side of her course.—The phrases used in steering a ship vary according to the relation of the wind to her course. Thus, if the wind is fair or large, the phrases used by the pilot or officer who superintends the steerage are, *port*, *starboard*, and *steady*. The first is intended to direct the ship's course farther to the right; the second is to guide her farther to the left; and the last is designed to keep her exactly in the line whereon she advances, according to the course prescribed. The excess of the first and second movements is called *hard-a-port*, and *hard-a-starboard*; the former of which gives her the greatest possible inclination to the right, and the latter an equal tendency to the left.—If, on the contrary, the wind is foul or scant, the phrases are *luff*, *thus*, and *no nearer*; the first of which is the order to keep her close to the wind; the second, to retain her in her present situation; and the third to keep her sails full.

In a ship of war, the exercise of steering the ship is usually divided amongst a number of the most expert sailors, who attend the helm in their turns; and are accordingly called *timoneers*, from the French term *timonier*, which signifies "helmsman." The steerage is constantly superintended by the quarter-masters, who also attend the helm by rotation. In merchant ships every seaman takes his turn in this service, being directed therein by the mate of the watch, or some other officer.—As the safety of a ship, and all contained therein, depends in a great measure on the steerage or effects of the helm, the apparatus by which it is managed should often be diligently examined by the proper officers. Indeed, a negligence in this important duty appears almost unpardonable, when the fatal effects which may result from it are duly considered.

STEEVENS, GEORGE, the most successful of all the editors and commentators of Shakespeare, was born in the year 1735. We know nothing respecting his parents, but they appear to have been in affluent circumstances. Our author received the rudiments of his education at Kingston-upon-Thames, and had Gibbon the historian for a companion at that school. From hence he went to Eton, and in a few years was admitted a fellow commoner of King's college, Cambridge; but no mention is made of his peculiar course of studies. It appears, however, that he had little relish for the mathematics, which lead at Cambridge to academical honours. On the first establishment of the Essex militia, he accepted of a commission; but he spent the concluding years of his life in almost total seclusion from the world, seldom mingling with society, but in the shops of booksellers, in the Shakespeare gallery, or in the morning conversations of Sir Joseph Banks.

Although not an original writer, we cannot in justice refuse him a place among the first literary characters of the age, when we consider the works he illustrated, and the learning, sagacity, taste, and general knowledge which he brought to the task. With a versatility of talents,

lents, he was eminent both by his pen and his pencil, but his chief excellence lay in his critical knowledge of an author's text; and the beft fpecimen of his great abilities is his edition of Shakefpeare, in which he has left every competitor far behind him. He had ftudied the age of Shakefpeare, and employed his perfevering induftry in becoming acquainted with the writings, manners, and laws of that period, as well as the provincial peculiarities, whether of language or cuftoms, which prevailed in different parts of the kingdom, but more particularly in thofe where Shakefpeare paffed the early years of his life. He was continually increafing this ftore of knowledge, by the acquifition of the obfolete publications of a former age, which he fpared no expence to obtain. His critical fagacity and obfervation were conftantly employed in calling forth the hidden meanings of the dramatic bard, and of courfe enlarging the difplay of his beauties. This advantage is apparent from his laft edition of Shakefpeare, which contains fo large a portion of new, interefting, and accumulated inftruction. In preparing it for the prefs, he gave an inftance of activity and perfeverance without example. To this work he exclufively devoted a period of 18 months, during which he left his houfe every morning at one o'clock, going to his friend Mr Ifaac Read's chambers in Barnard's-inn, without any confideration of the weather or the feafon, and there he found a fheet of the Shakefpeare letter-prefs ready for correction. Thus, while the printers flept the editor was awake, by which means he completed, in lefs than 20 months, his fplendid edition of Shakefpeare in 15 vols. octavo; a labour almoft incredible, and by which the energy and perfevering powers of his mind were fully proved.

He probably refted fatisfied with being a commentator from the particular habits of his life, and his devotion to the name of Shakefpeare. But at the fame time he was a claffical fcholar of the firft order, and well acquainted with the belles lettres of Europe. He ftudied ancient and modern hiftory; and particularly that of his own country. His genius was ftrong and original; his wit abundant; his imagination of every colour; and his fentiments enlivened with the moft brilliant expreffions. His eloquence was logical and animated; his defcriptions were fo true to nature, his figures fo curioufly felected, and fo happily grouped, that he might be regarded as a fpeaking Hogarth. He fcattered his wit and his humour too freely around him, and they were not loft for want of gathering.

Mr Steevens had a very handfome fortune, which he managed with difcretion. His generofity was equal to his fortune; and though not profufe of his money to fturdy beggars, few perfons diftributed with more liberality to truly deferving objects. He poffeffed all the graces of outward accomplifhment, at a period when civility and politenefs were characteriftics of a gentleman.

He bequeathed his valuable Shakefpeare, illuftrated with about 1500 prints, to Lord Spencer; his Hogarth perfect, with the exception of one or two pieces, to Mr Windham; and his corrected copy of Shakefpeare, with 200 guineas, to his friend Mr Read. He died in the month of January 1800, about 65 years of age.

STEGANOGRAPHY, the art of fecret writing, or of writing in ciphers, known only to the perfons correfponding. See CIPHER.

STELLARIA, a genus of plants belonging to the clafs decandria, and in the natural fyftem arranged under the 22d order, *Caryophylleæ*. See BOTANY *Index*.

STELLATE, in *Botany*, a term applied to leaves which grow not lefs than fix at a joint, and are arranged like the rays of a ftar.

STELLERA, GERMAN GROUNDSEL, a genus of plants belonging to the clafs octandria; and in the natural fyftem arranged under the 31ft order, *Vepreculæ*. See BOTANY *Index*.

STELLIONATE, in the civil law, a kind of crime committed by a fraudulent bargain, where one of the parties fells a thing for what it is not; as if I fell an eftate for my own which belongs to another, or convey a thing as free and clear which is already engaged to another, or put off copper for gold, &c.

STEM, in *Botany*, that part of a plant arifing out of the root, and which fuftains the leaves, flowers, fruits, &c. By wafhing and rubbing the ftems of trees, their annual increafe is promoted; for the method of doing which, fee the article TREE.

STEM of a Ship, a circular piece of timber into which the two fides of a fhip are united at the fore-end: the lower end of it is fcarfed to the keel, and the bowfprit refts upon its upper end. The ftem is formed of one or two pieces, according to the fize of the veffel; and as it terminates the fhip forward, the ends of the wales and planks of the fides and bottom are let into a groove or channel, in the midft of its furface, from the top to the bottom; which operation is called *rabiting*. The outfide of the ftem is ufually marked with a fcale, or divifion of feet, according to its perpendicular height from the keel. The intention of this is to afcertain the draught of water at the forepart, when the fhip is in preparation for a fea-voyage, &c. The ftem at its lower end is of equal breadth and thicknefs with the keel, but it grows proportionally broader and thicker towards its upper extremity. See *SHIP-Building*.

STEMMATA, in the hiftory of infects, are three fmooth hemifpheric dots, placed generally on the top of the head, as in moft of the hymenoptera and other claffes. The name was firft introduced by Linnæus.

STEMODIA, a genus of plants belonging to the clafs didynamia; and in the natural fyftem ranging under the 40th order, *Perfonatæ*. See BOTANY *Index*.

STEMPHYLA, a word ufed by the ancients to exprefs the hufks of grapes, or the remains of the preffings of wine. The fame word is alfo ufed by fome to exprefs the remaining mafs of the olives, after the oil is preffed out.

STEMPHYLITES, a name given by the ancients to a fort of wine preffed hard from the hufks.

STEMPLES, in mining, crofs bars of wood in the fhafts which are funk to mines.

In many places the way is to fink a perpendicular hole, or fhaft, the fides of which are ftrengthened from top to bottom with wood-work, to prevent the earth from falling in; the tranfverfe pieces of wood are called *ftemples*, and by means of thefe the miners in fome places defcend, without ufing any rope.

STEMSON, in a fhip, an arching piece of timber fixed within the apron, to reinforce the fcarf thereof, in the fame manner as the apron fupports the fcarf of the ftern. In large fhips it is ufually formed of two pieces.

STENOGRAPHY (A).

CHAP. I.

THE art of ftenography, or fhort writing, was known and practifed by moft of the ancient civilized nations. The Egyptians, who were diftinguifhed for learning at an early period, at firft expreffed their words by a delineation of figures called *hieroglyphics*. A more concife mode of writing feems to have been afterwards introduced, in which only a part of the fymbol or picture was drawn. This anfwered the purpofe of fhort-hand in fome degree. After them the Hebrews, the Greeks, and the Romans *, adopted different methods of abbreviating their words and fentences, fuited to their refpective languages. The initials, the finals, or radicals, often ferved for whole words; and various combinations of thefe fometimes formed a fentence. Arbitrary marks were likewife employed to determine the meaning, and to affift legibility; and it feems probable that every writer, and every author of antiquity, had fome peculiar method of abbreviation, calculated to facilitate the expreffion of his own fentiments, and intelligible only to himfelf.

* Vide *Buxtorf*, *Diog. Laertius*, *Plutarch*, &c.

It is alfo probable, that fome might by thefe means take down the heads of a difcourfe or oration; but few, very few, it is prefumed, could have followed a fpeaker through all the meanders of rhetoric, and noted with precifion every fyllable, as it dropt from his mouth, in a manner legible even to themfelves.

To arrive at fuch confummate perfection in the art was referved for more modern times, and is ftill an acquifition by no means general.

In every language of Europe, till about the clofe of the 16th century, the Roman plan of abbreviating (viz. fubftituting the initials or radicals, with the help of arbitraries, for words) appears to have been employed. Till then no regular alphabet had been invented exprefsly for ftenography, when an Englifh gentleman of the name of *Willis* invented and publifhed one (B). His plan was foon altered and improved, or at leaft pretended to be fo. One alteration fucceeded another; and at intervals, for a feries of years paft, fome men of ingenuity and application have compofed and publifhed fyftems of ftenography, and doubtlefs have themfelves reaped all the advantages that attend it. But among the various methods that have been propofed, and the different plans that have been adopted by individuals, none has yet appeared fortunate enough to gain general approbation; or proved fufficiently fimple, clear, and concife, to be univerfally ftudied and practifed.

Some fyftems are replete with unmeaning fymbols, perplexing arbitraries, and ill-judged contractions; which render them fo difficult to be attained by a common capacity, or ordinary application, that it is not to be wondered at if they have funk into neglect, and are now no longer known (C). Other fyftems, by being too prolix, by containing a multiplicity of characters, and thofe characters not fimple or eafily remembered, become ineffectual to the purpofe of expedition, and are only fuperior in obfcurity to a common hand. Some, again, not only reject all arbitraries and contractions, but even prepofitions and terminations; which laft, if not too lavifhly employed and badly devifed, highly contribute to promote both expedition and legibility; and though they reduce their characters to fewer than can poffibly exprefs the various modifications of found, yet they make nearly one half of them complex. In the difpofition of the vowels, there is the greateft perplexity in moft fyftems. A dot is fometimes fubftituted for all the vowels indifcriminately, and the judgement is left to determine which letter out of fix any dot is intended to exprefs; or a minute fpace is allotted them; fo that unlefs they be arranged with mathematical precifion they cannot be diftinguifhed from one another; but fuch a minute attention is inconfiftent with the nature of fhort-hand, which fhould teach us to write down in a fhort time, as well as in fmall bounds, what we wifh to preferve of what we hear. Nor is the plan of lifting the pen and putting the next confonant in the vowel's place, in the middle of words, lefs liable to objections; or that of reprefenting all the vowels by diftinct characters, being obvioufly ill calculated for facility and difpatch,

(A) The value of ftenography is not unknown to the learned; and the care and fuccefs with which it has been lately cultivated in thefe kingdoms will, in all probability, foon render it an object of general attention. No one, however, appears to us to have fimplified and improved the art fo much as Dr Mavor, author of *Univerfal Stenography*, who has liberally permitted us to prefent our readers with a complete view of his fcheme. To thofe who wifh to become proficients in SHORT-WRITING, we earneftly recommend his entire publication (printed for Cadell and Davis, Strand, London), which in many fchools of the firft reputation now forms a deferved clafs-book.

(B) Mr Locke fays, a regular method of fhort-writing feems to be known and practifed only in Britain. This is not now the cafe; and indeed there is no reafon to doubt whether characters may not be invented to exprefs the various founds, or letters, employed in any language, either ancient or modern.

(C) A lift of writers on ftenography. Mr Addy, Alridge, Angell, Annet, Blandemore, Bloffet, Botley, Bridges, Byrom, Coles, Crofs, Dix, Everardt, Ewen, Facey, Farthing, Gibbs, Græme, Gurney, Heath, Holdfworth, Hopkins, Jeake, Labourer, Lane, Lyle, Macauley, Mafon, Mavor, Metcalfe, Nicholas, Palmer, Rich, Ridpath, Shelton, Steele, Tanner, Taylor, Thickneffe, Tiffen, Webfter, Wefton, Williamfon, Willis, B. D. and Willis, &c.

dispatch, and consequently inadmissible into any useful system.

It is to be confessed, that the person who first proposed the omission of vowels in the middle of words (D), which it is obvious are not wanted, and invented letters, which could be connected as in a running hand without lifting the pen in the middle of the word, made a real improvement on the works of his predecessors. But, in fine, most systems, either in their plan or execution, labour under some capital defect, attended with circumstances highly discouraging to the learner, and which in a great measure defeat the end of their invention, by being too complicated to be learned with ease and remembered with accuracy, or to be practised with the expedition which is requisite; and so difficult to be deciphered, that a man can scarcely read what he has just written.

To obviate these defects; to provide against prolixity and conciseness, which might occasion obscurity; to exhibit a system founded on the simplest principles, which might be easily learned and read, and yet be capable of the utmost expedition—were the motives that gave rise to the present attempt.

This method will be found different from any yet published, and superior to all in the disposition of the vowels and the facility of arranging them; the confusion in placing which seems to detract from the merit of the best performances on the subject; and it may be affirmed, without ostentation, that characters simpler in their form, and more perfect in their union, have not been applied to the art of stenography.

As well as it could be determined, the simplest characters are appropriated to the letters most usually employed: indeed, as far as possible, those which are complex have been rejected; but as it was an object always kept in view that the writing should be on a line, a few are admitted into the alphabet for that reason.

The characters for the double and triple consonants are the easiest that could be invented, consistent with perspicuity (E); for care has been taken to provide against all obscurity which might arise by adopting letters too similar in their formation; and with respect to the prepositions and terminations, those which occur most frequently are expressed by the simplest characters, which will be found perfectly easy in their application.

The arbitraries are few in number (F), and the arbitrary abbreviations, as they are entirely from the letters of the alphabet, and chosen from some thousands of words in common use, will well repay the learner for an hour's trouble in committing them to memory.

The last chapter lays down a scheme of abbreviation, comprised in a few rules, perfectly easy to be understood and practised by proficients in this art, which we hope will answer the expectation of the author, and will be found free from the perplexity complained of in many systems where abbreviation is admitted. The principal rules are new, are so easy, so extensive in their use, and so consistent with expedition and legibility, if applied with judgement, that they alone might suffice. The learner is however advised by no means to adopt any of them, till experience has convinced him that they may be used without error or injury to legibility. All abbreviating rules are suited to those only who have made some progress in the stenographic art; for although they certainly promote expedition in a wonderful manner, and afford the greatest ease to a proficient, yet a learner, as expedition is not his first, though his ultimate view, should admit of nothing that in the least renders the reading difficult.

CHAP. II.

1 The general principles of stenography.

THE English alphabet consists of twenty-six letters; six of which are vowels, *a*, *e*, *i*, *o*, *u*, and *y*; and the other twenty consonants, *b*, *c*, *d*, *f*, *g*, *h*, *k*, *l*, *m*, *n*, *p*, *q*, *r*, *s*, *t*, *v*, *x*, and *z*.

This alphabet, as is observed by the best grammarians that have written on the language, is both defective and redundant in expressing the various modifications of sound *.

* *Lowth's Gram. Priestley's Gram. Sheridan's Lectures on Elocution.*

Custom or prejudice has assigned some letters a place, when others would with much more propriety express the same sound: and to this may be added, that several letters, sometimes in one word, seem to be admitted for no other reason than to perplex a young beginner or a foreigner, as an obstruction to true pronunciation, and to add to the apparent length of the word, when they are entirely quiescent and useless. That this is the genius of the orthography of our language must be perceived by the most superficial observer; but no modern tongue is absolutely free from the same exceptions. In particular, the French has a great number of dormant letters, which, it is obvious, render the pronunciation more difficult and perplexing to learners (G).

But as it is neither our business nor our intention to propose a mode of spelling different from that in common use, when applied to printing or long-hand writing (since several innovators in orthography have fallen into contempt, and their plans have been only preserved as beacons to warn others of the folly of endeavouring to subvert established principles †); we shall only observe, that in stenography, where the most expeditious and concise

† *Preface to Johnson's Dictionary.*

(D) Mr Byrom rejected vowels entirely in the middle of words, as others before him had only done partially. Without critically examining the executive part of his performance, which is very defective, it must be owned, that it is above the reach of human ingenuity to exceed his general plan; which for ever must be the basis of every future rational system.

(E) Those for *th* and *ch* may be either made upright or sloping to the right.

(F) These are not by any means prescribed; they may be employed or not according to the fancy of the learner.

(G) The Latin and Greek claim a just superiority over every modern tongue in this respect. In them no confusion or doubt can arise from the manner of spelling; and the reader can scarcely be wrong (unless in quantity) in sounding all the letters he sees.

conciſe method is the beſt, if conſiſtent with perſpicuity, the following ſimple rules are ſtudiouſly to be regarded and practiſed.

2 Rules for the conſonants.

Rule I. All quieſcent conſonants in words are to be dropped; and the orthography to be directed only by the pronunciation: which being known to all, will render this art attainable by thoſe who cannot ſpell with preciſion in long hand.

Rule II. When the abſence of conſonants, not entirely dormant, can be eaſily known, they may often be omitted without the leaſt obſcurity.

Rule III. Two or ſometimes more conſonants may, to promote greater expedition, be exchanged for a ſingle one of nearly ſimilar ſound; and no ambiguity as to the meaning enſue (H).

Rule IV. When two conſonants of the ſame kind or ſame ſound come together, without any vowel between them, only one is to be expreſſed; but if a vowel or vowels intervene, both are to be written: only obſerve, if they are perpendicular, horizontal, or oblique lines, they muſt only be drawn a ſize longer than uſual; and characters with loops muſt have the ſize of their heads doubled *.

* See Plate DVII.

3 Firſt rule exemplified.

Might is to be written *mit*, fight *fit*, machine *maſhin*, enough *enuf*, laugh *laf*, prophet *profet*, phyſics *fiſiks*, through *thro'*, foreign *foren*, ſovereign *ſoveren*, pſalm *ſam*, receipt *reſet*, write *rite*, wright *rit*, iſland *iland*, knavery *navery*, temptation *temtation*, knife *nife*, ſtick *ſtik*, thigh *thi*, honour *onour*, indictment *inditement*, acquaint *aquaint*, chaos *kaos*, &c.

4 Second rule exemplified.

Strength *ſtrenth*, length *lenth*, friendſhip *frenſhip*, connect *conek*, commandment *comanment*, conjunct *conjunt*, humble *humle*, lumber *lumer*, ſlumber *ſlumer*, number *numer*, exemplary *exemlary*, &c.

5 Third rule exemplified.

Rocks *rox*, acts *aks* or *ax*, facts *faks* or *fax*, diſtricts *diſtriks*, or *diſtrix*, affects *afeks* or *afex*, afflicts *afliks* or *aflix*, conquer *konkr*, &c.

6 Fourth rule exemplified.

Letter *leter*, little *litle*, command *comand*, error *eror*, terror *teror*, &c. But in *remember*, *moment*, *ſiſter*, and ſuch like words, where two conſonants of the ſame name have an intervening vowel, both of them muſt be written.

Theſe four rules, with their examples, being carefully conſidered by the learner, will leave him in no doubt concerning the diſpoſition and management of the conſonants in this ſcheme of ſhort-writing; we ſhall therefore proceed to lay down rules for the application of the vowels with eaſe and expedition.

7 Rules for the vowels.

Rule I. Vowels, being only ſimple articulate ſounds, though they are the connectives of conſonants, and employed in every word and every ſyllable, are not neceſſary to be inſerted in the middle of words; becauſe the conſonants, if fully pronounced, with the aſſiſtance of connection, will always diſcover the meaning of a word, and make the writing perfectly legible.

Rule II. If a vowel is not ſtrongly accented in the incipient ſyllable of a word, or if it is mute in the final, it is likewiſe to be omitted; becauſe the ſound of the incipient vowel is often implied in that of the firſt conſonant, which will conſequently ſupply its place.

Rule III. But if the vowel conſtitutes the firſt or laſt ſyllable of a word, or is ſtrongly accented at its beginning or end, that vowel is continually to be written.

Rule IV. If a word begins or ends with two or more vowels though ſeparated, or when there is a coalition of vowels, as in diphthongs and triphthongs; only one of them is to be expreſſed, which muſt be that which agrees beſt with the pronunciation.

Rule V. In monoſyllables, if they begin or end with a vowel, it is always to be inſerted, unleſs the vowel be *e* mute at the end of a word.

Such are the general principles of this art; in vindication and ſupport of which it will be needleſs to offer any arguments, when it is conſidered that brevity and expedition are the chief objects, if conſiſtent with legibility; and the ſubſequent ſpecimens in the orthography recommended will, we hope, be ſufficient to ſhow that there is no real deficiency in the laſt mentioned particular.

8 Specimen of the mode of ſpelling in ſtenography.

He who md us mſt be etrnl, grt, nd mnptnt. It is or dty, as rſnl bngs, to ſrv, lv, nd oby hm.—A mn tht wd avd blm, ſhd be ſrkmſpk in al hs axns, nd ndvr wth al hs mt to pls evry bdy.—I wd nt frm any knxns wth a mn who hd no rgrd fr hmslf; nthr wd I blv a mn who hd ons tld me a li.—Onr is of al thngs the mſt dfklt to prſrv ntrnſhd; nd whn ons mpchd, lk the chſty of a wmn, nvr ſhns wth its wntd lſtr.—Wth gd mnrs, kmplſms nd an eſy plt adrs, mny mk a fgr in the wrl, whs mnl ablts wd ſkrſly hv rsd thm aby the rnk of a ſtmn.—Idlns is the prnt of a thſnd msfrtns, wch ar nvr flt by the ndſtrs: it is a pn nd a pnſhmnt of itslf, nd brngs wnt nd bgry in its trn.—Vrtu is the frſt thng tht ſhd be rgrdd; it is a rwrd of itslf; mks a mn rſpktbl hr, nd wl mk hm etrnly hpy hrftr.—Prd is a mſt prnſs psn, wch yt ws plntd by hvn in ur ntr, to rs ur emlsn to imtt grt nd wrthy krktrs or axns, to xt in us a sl fr wht is rt nd gſt, nd a ldbl ndgnſn gnſt oprſrs nd wrks of any knd of nkyty; in ſhrt, to mk us st a prpr vlu upn urvſls, nd dſps a wrthls flo, hu evr xltd. Ths fr prd is a vrtu, nd my gſtly be kld a grtns of ſl. Bt prd, lk othr pſns, gnrly fxs upon rng obgks, or is apld in rng prprſns. Hu kmn is it to ſe a rtch whm evry vs hs rndrd mſrbl, nd evry fly kntmtbl, vlng hmſlf on hs hi brth, nd bſtng ths ilſtrs nſſtrs, of whm he nhrts nthng bt the nm or ttl! nſſtrs who if thy nu hm, wd dſn thr dſndnt wth kntmt. But al prd of ths ſrt is fly, nd evr to be avdd.

CHAP. III.

As the whole of this art depends upon a regular method and a ſimple alphabet, we have not only endeavoured to eſtabliſh the former on ſatisfactory principles, but have been careful to appropriate, according to the comparative frequency of their occurrence, ſuch characters

(H) By this rule likewiſe *q* and *v* in the middle of words, but never in the beginning, may be exchanged for *k* and *f*, when they admit of an eaſier connecting with the following character, or will make the writing appear neater.

ters for the letters as, after repeated trials and alterations, were conceived to be the beſt adapted for diſpatch.

9 Stenographic alphabet. Plate DVII.

The ſtenographic alphabet conſiſts of 18 diſtinct characters (viz. two for the vowels and the reſt for the conſonants), taken from lines and ſemicircular curves; the formation and application of which we ſhall now explain, beginning with the vowels.

For the three firſt vowels, *a*, *e*, and *i*, a comma is appropriated in different poſitions; and for the other three, *o*, *u*, and *y*, a point. The comma and point, when applied to *a*, and *o*, is to be placed, as in the Plate DVII. at the top of the next character; when for *e* and *u*, oppoſite to the middle; and when for *i* and *y*, at the bottom.

This arrangement of the vowels is the moſt ſimple and diſtinct that can eaſily be imagined. Places at the top, the middle, and the bottom of characters, which make three different poſitions, are as eaſily diſtinguiſhed from one another as any three ſeparate characters could be; and a comma is made with the ſame facility as a point.

10 Lines.

Simple lines may be drawn four different ways; perpendicular, horizontal, and with an angle of about 45 degrees to the right and left. An aſcending oblique line to the right, which will be perfectly diſtinct from the reſt when joined to any other character, may likewiſe be admitted. Theſe characters being the ſimpleſt in nature, are aſſigned to thoſe five conſonants which moſt frequently occur, viz. *l*, *r*, *t*, *c* hard or *k*, and *c* ſoft or *s*.

11 Circles.

Every circle may be divided with a perpendicular and horizontal line, ſo as to form likewiſe four diſtinct characters. Theſe being the next to lines in the ſimplicity of their formation, we have appropriated them for *b*, *d*, *n*, and *m*.

12 Curves and lines.

The characters expreſſing nine of the conſonants are all perfectly diſtinct from one another; eight only remain which are needful, viz. *f*, *g* or *j*, *h*, *p*, *q*, *v*, *w*, and *x*; to find characters for which we muſt have recourſe to mixed curves and lines. The characters which we have adopted are the ſimpleſt in nature after thoſe already applied, admit of the eaſieſt joining, and tend to preſerve lineality and beauty in the writing.

It muſt be obſerved that we have no character for *c* when it has a hard ſound, as in *caſtle*; or ſoft, as in *city*; for it naturally takes the ſound of *k* or *s*, which in all caſes will be ſufficient to ſupply its place.

R likewiſe is repreſented by the ſame character as *l*; only with this difference, *r* is written with an aſcending ſtroke (I), and *l* with a deſcending; which is always to be known from the manner of its union with the following character; but in a few monoſyllables where *r* is the only conſonant in the word, and conſequently ſtands alone, it is to be made as is ſhown in the alphabet for diſtinction's ſake.

Z, as it is a letter ſeldom employed in the Engliſh language, and only a coarſer and harder expreſſion of *s*, muſt be ſupplied by *s* whenever it occurs; as for *Zedekiah* write *Sedekiah*, &c.

CHAP. IV.

13 Rules for prepoſitions and terminations.

The prepoſitions and terminations in this ſcheme are ſo ſimple, that the greateſt benefit may be reaped from them, and very little trouble required to attain them; as the incipient letter or the incipient conſonant of all the prepoſitions and of ſeveral of the terminations is uſed to expreſs the whole. But although in Plate DVII. ſufficient ſpecimens are given of the manner of their application, that the learner of leſs ingenuity or more ſlow perception may have every aſſiſtance, we have ſubjoined the following directions.

Rule I. The prepoſition is always to be written without joining, yet ſo near as plainly to ſhow what word it belongs to; and the beſt way is to obſerve the ſame order as if the whole was to be connected.

Rule II. A prepoſition, though the ſame letters that conſtitute it may be met with in the middle or end of a word, is never to be uſed, becauſe it would expoſe to obſcurity.

Rule III. Obſerve that the prepoſition *omni* is expreſſed by the vowel *o* in its proper poſition; and for *anti*, *anta*, *ante*, by the vowel *a*, which the radical part of the word will eaſily diſtinguiſh from being only ſimple vowels.

The firſt rule for the prepoſitions is (allowing ſuch exceptions as may be ſeen in the Plate) to be obſerved for the terminations; and alſo the ſecond, *mutatis mutandis*; except that whenever *ſis*, *ſus*, *ſys*, *cious*, *tious*, and *ces* occur, they are to be expreſſed as directed in the fourth rule for the conſonants, whether in the beginning, middle, or end of words (K).

Rule IV. The terminative character for *tion*, *ſion*, *cion*, *cian*, *tian*, is to be expreſſed by a ſmall circle joined to the neareſt letter, and turned to the right; and the plurals *tions*, *ſions*, *cions*, *cians*, *tians*, *tience*, by a dot on the ſame ſide.

Rule V. The terminative character for *ing*, is to be expreſſed likewiſe by a ſmall circle, but drawn to the left hand; and its plural *ings* by a dot (L).

Rule VI. The plural ſign *s* is to be added to the terminative characters when neceſſary.

Rule VII. The ſeparated terminations are never to be uſed but in polyſyllables or words of more ſyllables than one.

Theſe rules duly obſerved will point out a method as conciſe and elegant as can be deſired, for expreſſing the moſt

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(I) The character for *h*, when lineality requires it, may be made from the bottom and inverted (ſee Plate DVII.) And often *h* may be omitted entirely, or a vowel may be ſubſtituted in its ſtead, without any injury to legibility, it being rather a breathing than letter.

(K) But in a few words where three horizontal characters meet, it will be better to expreſs the *ſis*, &c. by the ſemielliptical character in Plate DVII. oppoſite *tious*.

(L) In horizontal characters, by the left hand is meant the top, and by the right the ſpace below the letter (ſee *ing* joined, Plate DVII.). In all other characters the right and left poſitions will naturally be known.

moſt frequent and longeſt prepoſitions and terminations in the Engliſh language. If it ſhould be thought neceſſary to increaſe their number by the addition of others, it will be an eaſy matter for any one of the leaſt diſcernment to do ſo, by proceeding on the principles before laid down.

CHAP. V.

14 Rules for abbreviation.

THOUGH a more conciſe method of writing, or more numerous abbreviations, may not be indiſpenſably neceſſary, if the foregoing directions be practiſed for a conſiderable time, yet contractions will be found extremely uſeful and convenient to thoſe who have attained a proper knowledge of the ſubject, and lead to a greater degree of expedition, at the ſame time that they diminiſh the labour of writing. It has been obſerved in the introduction, that abbreviations are only to be employed by proficients in this art; becauſe expedition is not the firſt, though the ultimate, object in view; and that an eaſy legibility is of the utmoſt conſequence to the learner; which, however, cannot be preſerved, if he adopts too ſoon thoſe very rules which in time will afford him the greateſt eaſe when applied with judgement.

The following ſhort and practical rules will be found, we hope, fully adequate to every purpoſe for which they were intended, and are far ſuperior in the facility of their application to any which we have ſeen.

RULE I. The uſual abbreviations in long hand are always to be followed; as Mr for Maſter, M. D. for Doctor of Phyſic, and Abp. for Archbiſhop, &c.

RULE II. Subſtantives, adjectives, verbs, and participles, when the ſenſe will direct to the meaning, are to be expreſſed by their initial conſonant with the diſtinguiſhing marks exhibited in Plate DVII. viz. a ſubſtantive muſt have the dot exactly over its initial conſonant; an adjective muſt have a dot under it; a verb is to be expreſſed by a comma over its initial conſonant; and a participle by a comma under (M). Theſe being the four principal parts of ſpeech will be ſufficient; and an adept will never be at a loſs to know when he can with ſafety apply this rule to them.

RULE III. To render the writing more legible, the laſt letter of the word may be joined to the firſt, and the proper mark applied.

RULE IV. The conſtituent or radical part of words, eſpecially if they are long, will often ſerve for the whole, or ſometimes the firſt ſyllable: as, we ought to moderate our *ex.* by our *circum.*; a man's *man.* commonly ſhape his *for.*

RULE V. All long words without exception may have their prepoſitions or terminations expreſſed by the incipient conſonant of ſuch prepoſition or termination.

RULE VI. When there is a great dependence between the parts of a ſentence, the initial letter will often ſuffice; as *L.* is the capital of Great *B.*; the eldeſt *S.* of the king of Great *B.* is ſtyled prince of *W.* Every one, it is preſumed, will allow this to be perfectly legible in long-hand, then why may it not in ſtenography?

RULE VII. The terminations *neſs* and *leſs* may be omitted; as *faithfulneſs* is only to be written *faithful*; *forwardneſs*, *forward*; *heedleſs*, *heed*; *ſtubborneſs*, *ſtubborn*, &c.

RULE VIII. The ſecond and third perſons of verbs, ending in *eth* and *eſt*, may be expreſſed by *s*; as, he *loves*, thou *teaches*; inſtead of he *loveth*, thou *teacheſt*: or even without *s*; as, he *love*, &c.

RULE IX. Words may often be entirely omitted, and yet no ambiguity enſue; as, *In beginning God created heaven and earth*, for In *the* beginning God created *the* heaven and *the* earth.

RULE X. When there is an immediate repetition of a ſentence or word, a line is to be drawn under the ſentence or word to be repeated; as, Amen, Amen, is to be written *Amen*; but if any words intervene before a word or ſentence is to be repeated, the line muſt be drawn as before, and a ʌ or mark of omiſſion placed where the repetition ſhould begin; as, *Is it juſt the innocents ſhould be* condemned ʌ reviled?

The CONTENTS *of the* STENOGRAPHIC PLATES.

Fabricius's Reply to Pyrrhus.

As to my poverty, you have indeed, Sir, been rightly informed. My whole eſtate conſiſts in a houſe of but mean appearance, and a little ſpot of ground, from which by my own labour I draw my ſupport. But if by any means you have been perſuaded to think, that this poverty makes me leſs conſidered in my country, or in any degree unhappy, you are extremely deceived. I have no reaſon to complain of fortune, ſhe ſupplies me with all that nature requires; and if I am without ſuperfluities, I am alſo free from the deſire of them. With theſe I confeſs I ſhould be more able to ſuccour the neceſſitous, the only advantage for which the wealthy are to be envied; but as ſmall as my poſſeſſions are, I can ſtill contribute ſomething to the ſupport of the ſtate and the aſſiſtance of my friends. With regard to honours, my country places me, poor as I am, upon a level with the richeſt: for Rome knows no qualifications for great employments but virtue and ability. She appoints me to officiate in the moſt auguſt ceremonies of religion; ſhe entruſts me with the command of her armies; ſhe confides to my care the moſt important negotiations. My poverty does not leſſen the weight and influence of my counſels in the ſenate; the Roman people honour me for that very poverty which you conſider as a diſgrace; they know the many opportunities I have had in war to enrich myſelf without incurring cenſure; they are convinced of my diſintereſted zeal for their proſperity; and if I have any thing to complain of in the return they make, it is only the exceſs of their applauſe. What value then can I ſet upon your gold and ſilver! What king can add any thing to my fortune! Always attentive to diſcharge the duties incumbent

Plate DVIII.

(M) The dot or comma being placed thus will never occaſion them to be miſtaken for vowels, becauſe they ſhould always be on one ſide or other; whereas the mark for parts of ſpeech may conſtantly be placed exactly over or under.

incumbent on me, I have a mind free from ſelf-reproach, and I have an honeſt fame. *Dodſley's Preceptor.*

Letter to a Friend againſt waſte of Time.

Converſe often with yourſelf, and neither laviſh your time, nor ſuffer others to rob you of it. Many of our hours are ſtolen from us, and others paſs inſenſibly away; but of both theſe loſſes the moſt ſhameful is that which happens through our own neglect. If we take the trouble to obſerve, we ſhall find that one conſiderable part of our life is ſpent in doing evil, and the other in doing nothing, or in doing what we ſhould not do. We don't ſeem to know the value of time, nor how precious a day is; nor do we conſider that every moment brings us nearer our end. Reflect upon this, I entreat you, and keep a ſtrict account of time. Procraſtination is the moſt dangerous thing in life. Nothing is properly ours but the inſtant we breathe in, and all the reſt is nothing; it is the only good we poſſeſs; but then it is fleeting, and the firſt comer robs us of it. Men are ſo weak, that they think they oblige by giving of trifles, and yet reckon that time as nothing for which the moſt grateful perſon in the world can never make amends. Let us therefore conſider time as the moſt valuable of all things; and every moment ſpent, without ſome improvement in virtue or ſome advancement in goodneſs, as the greateſt ſublunary loſs.

St Paul's Speech before Agrippa and Feſtus.

I think myſelf happy, King Agrippa, that I ſhall anſwer for myſelf this day before thee, touching all things whereof I am accuſed of the Jews: eſpecially becauſe I know thee to be expert in all cuſtoms and queſtions which are among the Jews, wherefore I beſeech thee to hear me patiently. My manner of life from my youth, which was at firſt among mine own nation at Jeruſalem, know all the Jews, which knew me from the beginning (if they would teſtify), that, after the ſtraiteſt ſect of our religion I lived a Phariſee. And now I ſtand and am judged for the hope of the promiſe made by God unto our fathers: unto which promiſe our twelve tribes inſtantly ſerving God day and night hope to come; for which hope's ſake, King Agrippa, I am accuſed of the Jews. Why ſhould it be thought a thing incredible with you, that God ſhould raiſe the dead, when God himſelf has given aſſurance of it unto all men, in that he hath raiſed Chriſt from the dead? As for my own part, moſt noble Feſtus, I own I once verily thought that even I myſelf ought to do many things contrary to the name of Jeſus of Nazareth. Which thing I alſo did in Jeruſalem. I puniſhed the ſaints oft in every ſynagogue, and compelled them to blaſpheme; and being exceedingly mad againſt them, I perſecuted them even unto ſtrange cities. In purſuit of which, as I went to Damaſcus, with authority and commiſſion from the chief prieſts: At mid-day, O king, I ſaw in the way a light from heaven, above the brightneſs of the ſun, ſhining about me, and them which journeyed with me. And when we were all fallen to the earth, I heard a voice ſpeaking unto me, and ſaying in the Hebrew tongue, Saul, Saul, why perſecuteſt thou me? It is hard for thee to kick againſt the pricks. And I ſaid, Who art thou, Lord? And he ſaid, I am Jeſus whom thou perſecuteſt. But riſe, and ſtand upon thy feet: for I have appeared unto thee for this purpoſe, to make thee a miniſter and a witneſs both of theſe things which thou haſt ſeen, and of thoſe things in which I will appear unto thee. Whereupon, O king Agrippa, I was not diſobedient to the heavenly viſion: but ſhewed firſt unto them of Damaſcus, and at Jeruſalem, and throughout all the coaſts of Judea, and then to the Gentiles, that they ſhould repent and turn to God. For theſe cauſes the Jews caught me in the temple, and went about to kill me. Having therefore obtained help of God, I continue unto this day, witneſſing both to ſmall and great, ſaying none other things than thoſe which the prophets and Moſes did ſay ſhould come: That Chriſt ſhould ſuffer, and that he ſhould be the firſt that ſhould riſe from the dead, and ſhould ſhow light unto the people, and to the Gentiles. This is the real truth: Believe me, I am no peſtilent fellow, nor mover of ſedition; but always endeavour all that lies in me to preſerve a conſcience void of offence towards God and towards man: nor can the Jews prove the things whereof they now accuſe me. Neither am I, Feſtus, beſides myſelf; but ſpeak thus freely before the king, becauſe he knows theſe things to be fact; yea, I am fully perſuaded the king knows them all to be fact; for they were not done in a corner. King Agrippa, believeſt thou the prophets? I know that thou believeſt. And would to God that not only thou, but alſo all that hear me this day, were altogether ſuch as I am except theſe bonds. *Holmes's Rhetoric.*

Pope to Atterbury.

Once more I write to you as I promiſed, and this once I fear will be the laſt; the curtain will ſoon be drawn between my friend and me, and nothing left but to wiſh you a long good night; may you enjoy a ſtate of repoſe in this life not unlike that ſleep of the ſoul which ſome have believed is to ſucceed it, where we lie utterly forgetful of that world from which we are gone, and ripening for that to which we are to go. If you retain any memory of the paſt, let it only image to you what has pleaſed you beſt; ſometimes preſent a dream of an abſent friend, or bring you back an agreeable converſation. But, upon the whole, I hope you will think leſs of the time paſt than the future; as the former has been leſs kind to you than the latter infallibly will be. Do not envy the world your ſtudies: They will tend to the benefit of men, againſt whom you can have no complaint; I mean, of all poſterity: and, perhaps, at your time of life, nothing elſe is worth your care. What is every year of a wiſe man's life but a cenſure or critic on the paſt? Thoſe whoſe date is the ſhorteſt, live long enough to laugh at one half of it: The boy deſpiſes the infant, the man the body, the philoſopher both, and the Chriſtian all. You may now begin to think your manhood was too much a puerility; and you will never ſuffer your age to be but a ſecond infancy. The toys and baubles of your childhood are hardly now more below you than thoſe toys of our riper and our declining years; the drums and rattles of ambition, and the dirt and bubbles of avarice. At this time, when you are cut off from a little ſociety, and made a citizen of the world at large, you ſhould bend your talents not to ſerve a party, or a few, but all mankind. Your genius ſhould mount above that miſt, in which its participation and neighbourhood with earth hath long involved it: To ſhine abroad, and to heaven,

ought

ought to be the businefs and the glory of your prefent fituation. Remember it was at fuch a time that the greateft lights of antiquity dazzled and blazed the moft; in their retreat, in their exile, or in their death. But why do I talk of dazzling or blazing? it was then that they did good, that they gave light, and that they became guides to mankind. Thofe aims alone are worthy of fpirits truly great, and fuch I therefore hope will be yours. Refentment indeed may remain, perhaps cannot be quite extinguifhed, in the nobleft minds; but revenge will never harbour there: Higher principles than thofe of the firft, and better principles than thofe of the latter, will infallibly influence men whofe thoughts and whofe hearts are enlarged, and caufe them to prefer the whole to any part of mankind, efpecially to fo fmall a part as one's fingle felf. Believe me, my Lord, I look upon you as a fpirit entered into another life, as one juft upon the edge of immortality, where the paffions and affections muft be much more exalted, and where you ought to defpife all little views and all mean retrofpects. Nothing is worth your looking back: and therefore look forward, and make (as you can) the world look after you; but take care it be not with pity, but with efteem and admiration. I am, with the greateft fincerity and paffion for your fame as well as happinefs, your, &c.

The above moft charming and moft affectionate letter was written about a month before Atterbury bifhop of Rochefter was fent into banifhment, and is univerfally admired.

STENTOROPHONIC TUBE, a fpeaking trumpet; thus called from Stentor, a perfon mentioned by Homer. See TRUMPET.

STEP, in a fhip, a block of wood fixed on the decks or bottom of a fhip, and having a hole in its upper fide, fitted to receive the heel of a maft or capftern. The fteps of the main and foremafts of every fhip reft upon the kelfon, to which they are firmly fecured by knees, bolts, or fpike-nails. The ftep of the mizen-maft ufually refts upon the lower deck.

STEPHANIUM, a genus of plants belonging to the pentandria clafs; and in the natural method ranking under the 47th order, *Stellatæ*. See BOTANY *Index*.

STEPHANOPHORUS, in antiquity, the chief prieft of Pallas, who prefided over the reft. It was ufual for every god to have a chief prieft; that of Pallas was the Stephanophorus juft mentioned, and that of Hercules was called Dadouchus.—Stephanophorus was alfo a prieft who affifted the women in the celebration of the feftival Thefmophoria.

STEPHANUS BYZANTINUS, an able grammarian, who lived in the fifth or fixth century. He wrote a Dictionary, in which he made a great number of obfervations, borrowed from mythology and hiftory, which fhowed the origin of cities and colonies, of which we have nothing remaining but a mean abridgement by Hermolaus the grammarian; but from that work the learned have received great light; and Sigonius, Cafaubon, Scaliger, Salmafius, &c. have employed themfelves in illuftrating it.

STEPHEN, king of England. See ENGLAND, N° 108, &c.

STEPHEN, or *St Stephen's Day*, a feftival of the Chriftian church, obferved on the 26th of December, in memory of the firft martyr St Stephen.

STEPHENS, a family of printers defervedly celebrated. They flourifhed at the time of the revival of learning, and contributed a great deal towards difpelling the cloud of ignorance which had fo long overfhadowed Europe. Some of the claffics before the 16th century were in a great meafure loft, and all of them were exceedingly

corrupted. By their abilities and indefatigable induftry thefe defects were fupplied, and the learned were furnifhed with beautiful and correct editions of the Greek and Roman authors. Thus the world was not only fupplied with an inexhauftible fund of amufement and inftruction in thefe ancient writings; but it is to the ardour which they infpired, and to the model of elegance which they difplayed, that the prefent advanced ftate of literature is in a great meafure owing.

HENRY STEPHENS, the firft of thefe illuftrious men, was born in France, foon after the difcovery of printing, perhaps about the year 1465. He fettled as a printer at Paris, and was probably patronized by Louis XII. A great proportion of the books which he publifhed were Latin: They are printed in the Roman letter, and are not inelegant, though fome of them abound rather too much in contractions. He died about the year 1520, and left behind him three fons, Francis, Robert, and Charles. His widow married Simeon de Colines (*Colinæus* in Latin), who thus got poffeffion of Henry's printing-houfe, and continued the profeffion till his death.

Of FRANCIS, the eldeft fon, little more is known than that he carried on bufinefs along with his father-in-law Colinæus, and that he died at Paris in 1550.

ROBERT STEPHENS, the fecond fon, was born in 1503. In his youth he made great proficiency in the Roman, Greek, and Hebrew languages, and at the age of 19 had acquired fo much knowledge, that his father-in-law entrufted him with the management of his prefs. An edition of the New Teftament was publifhed under his infpection, which gave great offence to the Paris divines, who accufed him of herefy, and threatened to prevent the fale of the book. Soon after he began bufinefs himfelf, and married Perrete the daughter of Jodocus Badius, a printer and an author. She was a woman of learning, and underftood Latin, which indeed was the neceffary confequence of her fituation. Her hufband always entertained a number of learned men as correctors of the prefs: Being foreigners, and of different nations, they made ufe of no other language but Latin; which Perrete being accuftomed to hear, was able in a fhort time

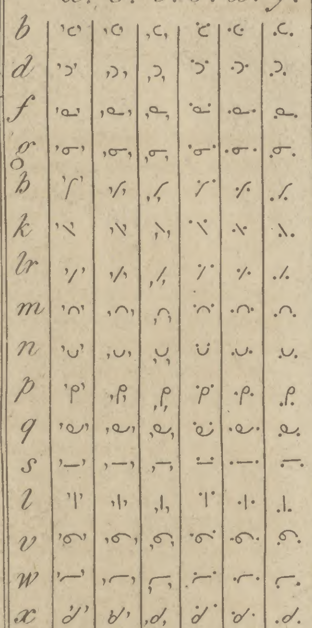
The ALPHABET with the Double and Triple Consonants.

Let.	Arb. Abbrev.
a	a, an, above
b	be, by, because
c	
d	do, did
e	ever, every, mid
f	from, if
g j	God, give, gives
h	he, had, his
i	I, eye, below
k	king, know
l	Lord, will, all
m	me, my, most
n	and, in, nature
o	O, oh, owe, above
p	people, peace
q	ques^tn quantity
r	or, are
s	is, us, soon
t	the, to, it
v	have, save
u	you, view, middle
w	we, with
x	except, example
y	ye, your, yes, bel
z	

D.C.&c.	Arb. Abbrev.
ch	each, such
sh	shall, she
th	that, they
thr	therefore
str	strive, strong
wh	who, which

Vowels Places

a. e. i. o. u. y.



The PREPOSITIONS and TERMINATIONS.

Prepos.	Signifi.
abs obs	abstain
anti ante anta	antidote
contr-i-a contro counter	counterfeit
dis-in-com	discompose
hyp-o-er	hypocrite
magn-i-a multi	magnify
omni	omniscience
inter-er-ro enter	entertain
post preter	postpone
recon recom	reconcile
satis super circum	satisfy
trans	transfer
eat-er-in extra	extirpate

Term.	Signifi.
able ible	stable
flict flect full ference	conflict
ing	thing
ings	things
tion cion sian cian tian &c	petition
tions &c sifs ces sys sus	petitions
tious cious &c	thesis
lefs	harmlefs
ment	indictment
self	
stract strict	substract
ward	forward

Arbitraries.

on one
for
of oft often
at am
as
only
nothing
where-fore

Points.

A Comma
A Semicolon ;
A Colon
A Period
A Point of Interrogation ?
A Point of Admiration !

Figures.

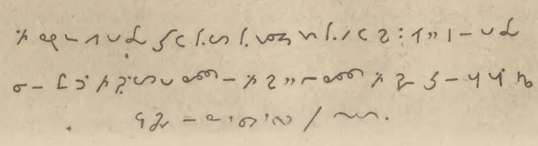
1 2 3 4 5 6 7 8 9 0

1779. £567. 17.

Abbreviating Marks

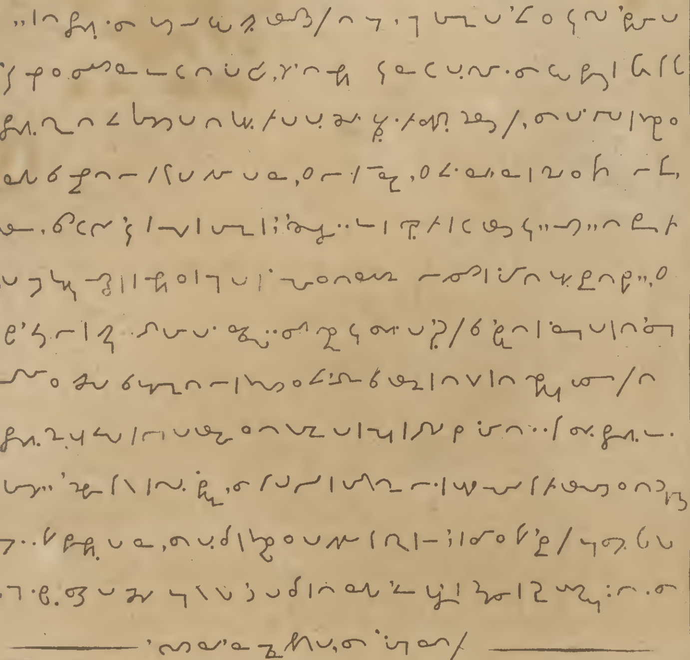
A Substantive
An Adjective
A Verb
A Participle
Division
Divisible
Divide
Dividing

The LORDS Prayer.

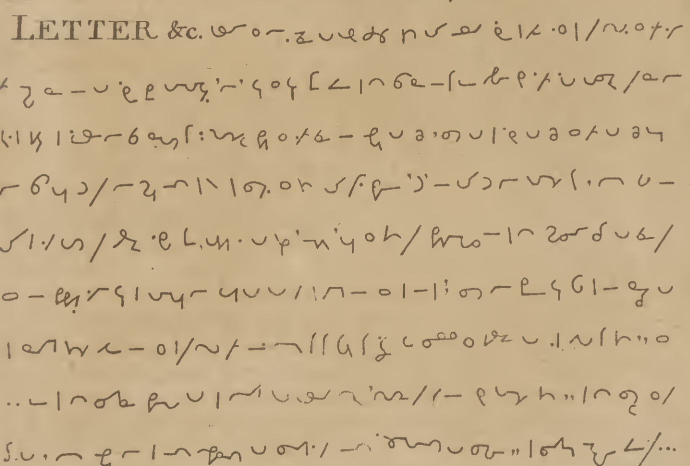


W. Tram Sculp^t.

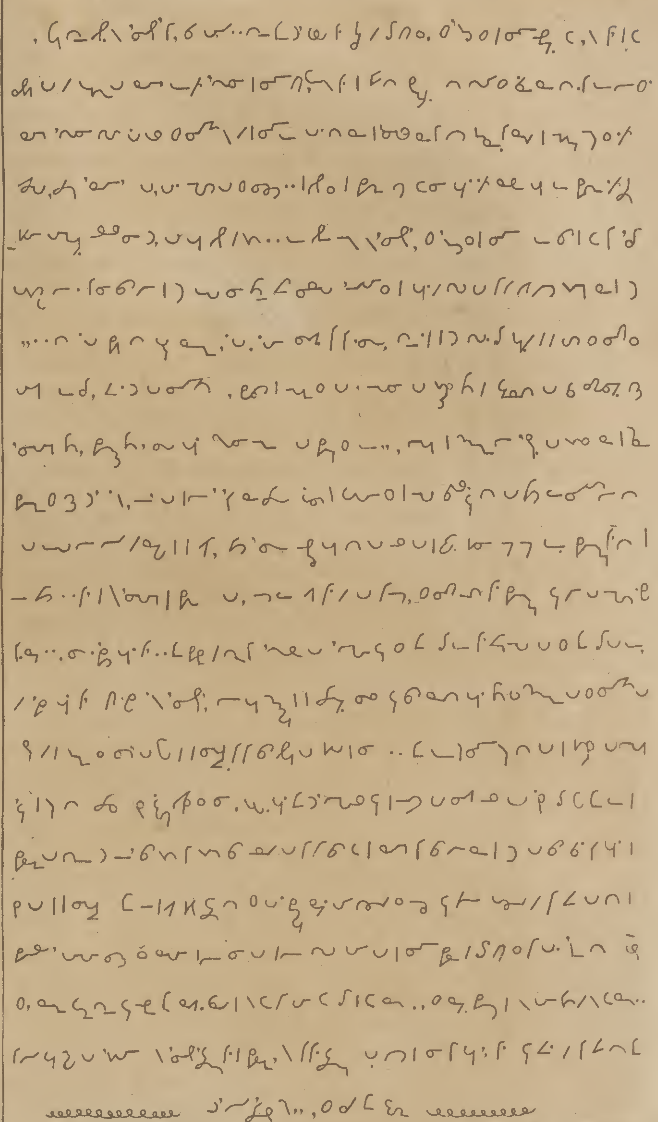
FABRICIUS' Reply to PYRRHUS.

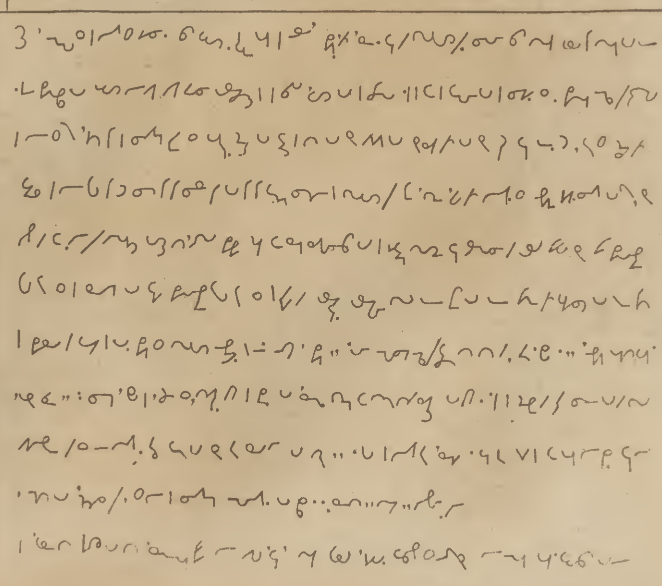


LETTER &c.

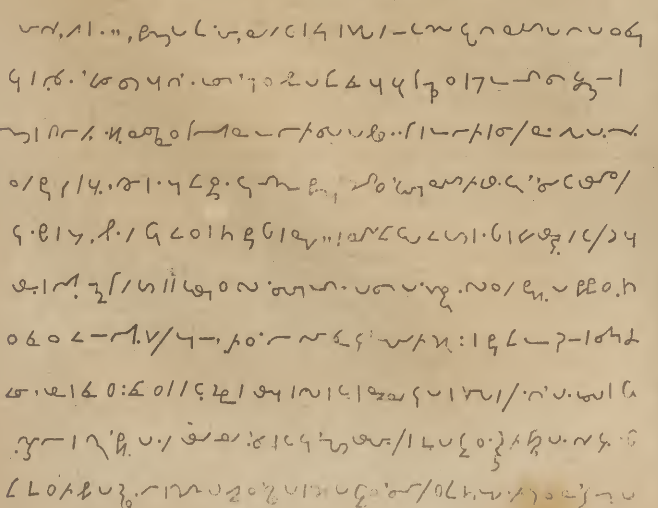


St. PAUL'S SPEECH.





POPE *to* ATTERBURY.



W. Train Sculpt.

Stephens. not only to underſtand, but even to ſpeak with tolerable eaſe.

In 1531 he publiſhed his Latin "Theſaurus;" a work of great importance, which he laboured at for two years. The mark which he put upon all his books was a tree branched, with a man looking upon it, and theſe words *noli altum ſapere*, to which he ſometimes added *ſed time*. In 1539, Francis I. made him his printer, and ordered a new ſet of elegant types to be founded for him. His frequent editions of the New Teſtament gave great offence to the doctors of the Sorbonne, who accuſed him of hereſy for his annotations, and inſiſted upon the ſuppreſſion of ſome of his books. Although Henry the French king in ſome meaſure protected him, the perſecution of theſe divines rendered him ſo unhappy, not to mention the expence and loſs of time which an almoſt conſtant attendance at court unavoidably occaſioned, that in 1552 he abandoned his country and went to Geneva. Here he embraced the Proteſtant religion, and thus juſtified in ſome meaſure the ſuſpicions of his theological enemies. It has been affirmed by ſeveral writers that he carried along with him the royal types, and the moulds alſo in which they were caſt; but it is certain that he never afterwards made uſe of thoſe types. Beſides, is it poſſible that the author of ſo daring a theft could have been not only protected in Geneva, but even courted and honoured by the moſt eminent men of the age? Is it credible that ſuch a crime could have been concealed for 60 years; or that Henry, the ſon and heir of the perpetrator, would have enjoyed the favour of the French king, if Robert Stephens had acted ſuch a ſhameful part? If he was burnt in effigy at Paris, it was not for theft, but for having changed his religion. After his arrival at Geneva, he publiſhed an account of the diſpute between him and the Paris divines, which does as much honour to his abilities as his *Theſaurus* does to his learning. He died in 1559, after a life of the moſt extraordinary induſtry. The books of which he was the editor were not fewer than 360. Many of them were ancient claſſics in different languages. Several were accompanied with annotations which he collected, and all of them were corrected by collating manuſcripts. He was ſo anxious to obtain perfect accuracy, that he uſed to expoſe his proofs in public, and reward thoſe who diſcovered a miſtake. His books conſequently were very correct. It is ſaid that his New Teſtament, called *O Mirificam* (becauſe the preface begins with theſe words), has not a ſingle fault.

It was Robert Stephens who firſt divided the New Teſtament into verſes during a journey between Paris and Lyons. The advantages of this improvement are fully counterbalanced by its defects. It has deſtroyed the unity of the books, and induced many commentators to conſider every verſe as a diſtinct and independent aphoriſm. To this in ſome meaſure is to be aſcribed the many abſurd interpretations and creeds that have been forced out of that book.

By his laſt will his eſtate was left excluſively to ſuch of his children as ſhould ſettle at Geneva. He left behind him three ſons, Henry, Robert, and Francis.

Charles Stephens, the third ſon of Henry, was, like the reſt of his family, familiarly acquainted with the learned languages. This recommended him to Lazarus de Baif, who made him tutor to his ſon, and in 1540 carried him along with him to Germany. He ſtudied medicine, and practiſed it with ſucceſs in France. He did not, however, forſake the profeſſion of his family, but exerciſed it in Paris, where he became the editor of many books remarkable for neatneſs and elegance. He wrote above thirty treatiſes on different ſubjects, particularly on botany, anatomy, and hiſtory. He died in 1564.

Robert Stephens, the ſon of Robert the firſt of that name, did not accompany his father to Geneva, but continued to profeſs the Catholic religion, and to reſide at Paris. His letter was remarkably beautiful.—He was made king's printer, and died about 1589.

His brother Francis was alſo a printer. He embraced the Proteſtant religion, and reſided at Geneva.

Henry Stephens, the remaining ſon of Robert, was born at Paris in 1528. He became the moſt learned and moſt celebrated of all his family. From his very birth almoſt he gave proofs of uncommon abilities, and diſplayed an ardent paſſion for knowledge. The Medea of Euripides, which he ſaw acted while at ſchool, firſt kindled his love for poetry, and inſpired him with the deſire of acquiring the language in which that tragedy is written. He intreated his father not to condemn him to ſtudy Latin, which he already underſtood from converſation, but to initiate him at once into the knowledge of Greek. His father willingly granted his requeſt; and Henry applied with ſuch vigour, that in a ſhort time he could repeat the Medea by heart. He afterwards ſtudied Greek under Peter Daneſius, who was tutor to the Dauphin, and finally heard the lectures of Tuſanus and Turnebus. He became eager at an early age to underſtand aſtrology, and accordingly attended a profeſſor of that myſterious art; but he was not long in diſcovering its abſurdity. At 19 he began his travels, which he undertook in order to examine foreign libraries, and to become acquainted with learned men. He ſpent two years in Italy, and returned into France completely maſter of Italian, and bringing along with him copies of ſeveral ſcarce authors, particularly a part of Anacreon, which before was thought loſt.

He found his father publiſhing an edition of the New Teſtament, to which he prefixed ſome Greek verſes.—Soon after, he viſited England and the Netherlands, where he met with John Clement, an Engliſhman, to whom he was indebted for the remaining odes of Anacreon. During this journey he learned the Spaniſh language, which was very much ſpoken at that time in the Low Countries.

Whether Henry accompanied his father to Geneva or not is uncertain; at leaſt he muſt have returned immediately to France, for we find him ſoon after eſtabliſhed at Paris, and publiſhing the odes of Anacreon. In 1554 he went to Rome, and thence to Naples. This journey was undertaken at the requeſt, and in the ſervice, of the French government. He was diſcovered, and would have been arreſted as a ſpy, had he not by his addreſs and ſkill in the language of the country been able to paſs himſelf for a native of Italy. On his return to France he aſſumed the title of printer to Ulric Fugger, a very rich and learned German nobleman, who allowed him a conſiderable penſion.

In 1560 he married a relation, as is generally ſuppoſed, of Henry Scrimgeour, a Scotch nobleman, with whom he was intimately acquainted. She was a woman, as he himſelf informs us, endowed with the nobleſt ſpirit

Stephens.

ſpirit and the moſt amiable diſpoſitions. Her death, which happened in 1586, brought on a diſeaſe that had twice attacked him before. It was a diſguſt at all thoſe purſuits which had formerly charmed him, an averſion to reading and the ſight of books. It was probably occaſioned by too conſtant and ſevere an application to literary purſuits. In 1572 he publiſhed his *Theſaurus Linguæ Græcæ*, one of the greateſt works, perhaps, that ever was executed by one man, if we conſider the wretched materials which more ancient dictionaries could furniſh, if we conſider the ſize and perfection of the work, and the immenſe labour and learning which muſt have been employed in the compilation. This work had been carried on at a greater expence than he could well bear. He expected to be reimburſed by the ſale of the book, but he was unfortunately diſappointed. John Scapula, one of his own ſervants, extracted from it whatever he thought would be moſt ſerviceable to ſtudents, and publiſhed it beforehand in 4th. By this act of treachery Henry was reduced to poverty.

See *Scapula*.

About this time he was much beloved by Henry III. of France, who treated him ſo kindly, and made him ſuch flattering promiſes, that he reſided frequently at court. But theſe promiſes were never fulfilled, owing to the civil wars which ſoon after diſtracted France, and the unfortunate death of King Henry himſelf. During the remainder of his life his ſituation was very unſettled. We find him ſometimes at Paris, ſometimes in Geneva, in Germany, and even in Hungary. He died at Lyons in 1598, at the age of 70. He was fond of poetry from his very infancy. It was a cuſtom of his to compoſe verſes on horſeback, and even to write them, though he generally rode a very mettleſome ſteed. His *Theſaurus* was his great work, but he was alſo the author of ſeveral other treatiſes. His poems are numerous: His Apology for Herodotus is a witty ſatire on the Roman Catholics. His Concordance to the New Teſtament muſt have been a laborious work, and has deſervedly endeared him to every Chriſtian who wiſhes to acquire a rational and critical knowledge of the Scriptures. The number of books which he publiſhed, though fewer than his father, was great, and ſuperior in elegance to any thing which the world had then ſeen. A great proportion of them were Greek; he was the editor, however, of many Roman and even of ſome eaſtern writings. His Greek claſſics are remarkably correct; the principal of them are Homer, Anacreon, Æſchylus, Maximus Tyrius, Diodorus Siculus, Pindar, Xenophon, Thucydides, Herodotus, Sophocles, Diogenes Laertius, Plutarch, Plato, Apollonius Rhodius, Æſchines, Lyſias, Callimachus, Theocritus, Herodian, Dionyſius Hallicarnaſſenſis, Dion Caſſius, Iſocrates, Appian, Xiphilin, &c. His temper in the latter part of his life is repreſented as haughty and ſevere, owing probably to his diſappointments. He left behind him a ſon and two daughters, one of whom was married to the learned Iſaac Caſaubon.

Paul Stephens, the ſon of Henry, continued his father's profeſſion at Geneva. He was a man of learning, and wrote tranſlations of ſeveral books, and publiſhed a conſiderable number of the ancient claſſics; but his editions poſſeſs little of his father's elegance. He died in 1627, at the age of 60, after ſelling his types to one Chouet a printer.—His ſon Antony, the laſt printer of the family, abandoned the Proteſtant religion, and returned to France, the country of his anceſtors. He received letters of naturalization in 1612, and was made printer to the king; but managing his affairs ill, he was reduced to poverty, and obliged to retire into an hoſpital, where he died in 1674, miſerable and blind, at the age of 80.

Stephens ‖ Stereometer.

STERCORARIANS, or Stercoranistæ, formed from *ſtercus* "dung," a name which thoſe of the Romiſh church anciently gave to ſuch as held that the hoſt was liable to digeſtion, and all its conſequences, like other food.

STERCULIA, a genus of plants belonging to the claſs monœcia; and in the natural ſyſtem ranging under the 38th order, *tricoccæ*. See Botany *Index*.

STEREOGRAPHIC projection, is the projection of the circles of the ſphere on the plane of ſome one great circle, the eye being placed in the pole of that circle. See *Projection of the Sphere*.

STEREOMETER, an inſtrument invented in France for meaſuring the volume of a body, however irregular, without plunging it in any liquid. If the volume of air contained in a veſſel be meaſured, when the veſſel contains air only, and alſo when it contains a body whoſe volume is required to be known, the volume of air aſcertained by the firſt meaſurement, deducting the volume aſcertained by the ſecond, will be the volume of the body itſelf. Again, if the volume of any maſs of air be inverſely as the preſſure to which it is ſubjected, the temperature being ſuppoſed conſtant, it will be eaſy to deduce, from the mathematical relations of quantity, the whole bulk if the difference between the two bulks under two known preſſures be obtained by experiment.

Suppoſe that the firſt preſſure is double the ſecond, or the ſecond volume of air double the firſt, and the difference equal to 50 cubic inches; the firſt volume of air will likewiſe be 50 cubic inches. The deſign of the ſtereometer is to aſcertain this difference at two known preſſures.

The inſtrument is a kind of funnel AB (fig. 1.) compoſed of a capſule A, in which the body is placed, and the tube B as uniform in the bore as can be procured. The upper edge of the capſule is ground with emery, that it may be hermetically cloſed with a glaſs cover M ſlightly greaſed. A double ſcale is paſted on the tube, having two ſets of graduations; one to denote the length, and the other the capacities, as determined by experiment.

Plate DIX. Fig. 1.

When this inſtrument is uſed, it muſt be plunged into a veſſel of mercury, with the tube very upright, till the mercury riſe within and without to a point C of the ſcale. See fig. 2.

Fig. 2.

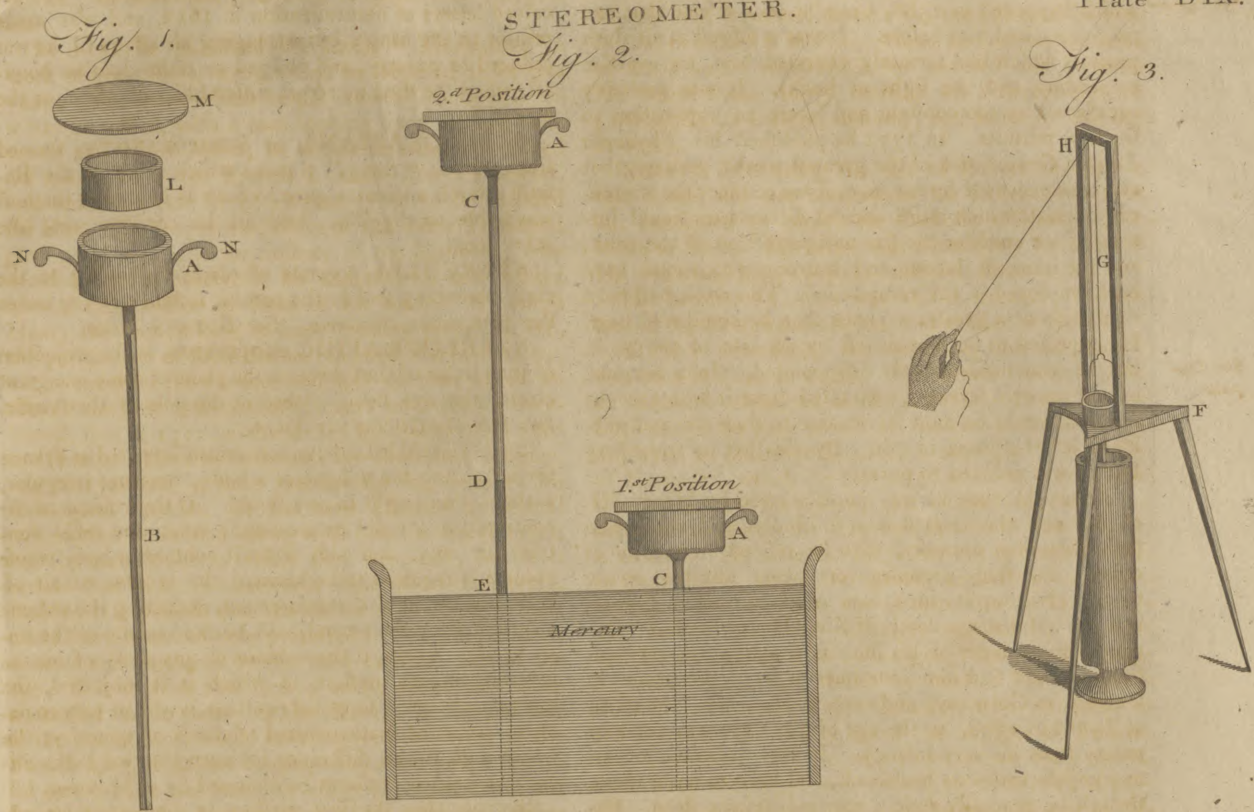
The capſule is then cloſed with the cover, which being greaſed will prevent its communication between the external air and that contained within the capſule and tube.

In this ſituation of the inſtrument, the internal air is compreſſed by the weight of the atmoſphere, expreſſed by the length of the mercury in the tube of the common barometer.

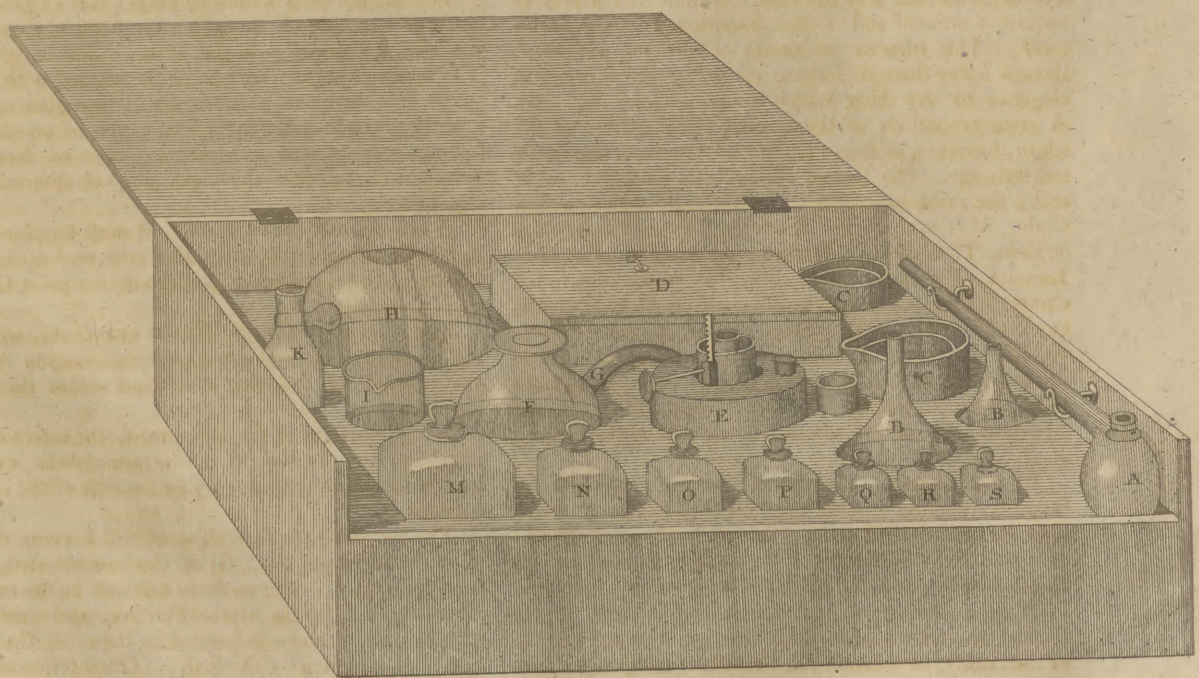
The inſtrument is then elevated, ſtill keeping the tube in the vertical poſition. It is thus repreſented, fig. 2. ſecond poſition. The mercury deſcends in the tube, but not to the level of the external ſurface, and a column of mercury DE remains ſuſpended in the tube, the height of which is known by the ſcale. The interior air is leſs compreſſed

Plate DIX.

STEREOMETER.



SOILS Analysis of.



W. Train Sculpt.

compressed than before, the increase of its volume being equal to the whole capacity of the tube from C to D, indicated by the second scale.

It is therefore known that the pressures are in proportion to the barometrical column, and to the same column —DE. The bulks of the air in these two states are inversely in the same proportion; and the difference between these bulks is the absolute quantity left void in the tube by the fall of the mercury; from which data the following rule is deduced. Multiply the number expressing the less pressure by that which denotes the augmentation of capacity, and divide the product by the number which denotes the difference of the pressures. The quotient is the bulk of the air when subject to the greater pressure.

Suppose the height of the mercury in the barometer to be 78 centimetres, and the instrument being empty to be plunged into the mercury to the point C. It is then covered and raised till the small column of mercury DE is suspended, say at the height of six centimetres. The internal air at first compressed by a force represented by 78 centimetres, is now only compressed by a force $= 72$ centimetres, or $78 - 6 = 72$.

Suppose that the capacity of the part CD of the tube which the mercury has quitted is two cubic centimetres. Then $\frac{72}{6} \times 2 = 24$ cubical centimetres, the volume of the air included in the instrument when the mercury rose as high as C in the tube.

The body of which the volume is to be ascertained must then be placed in the capsule, and the operation repeated. Let the column of mercury suspended be $=8$ centimetres, when the capacity of the part CD of the tube is $=2$ centimetres cubic. Then the greatest pressure being denoted by 78 centimetres, the least will be 70 centimetres, the difference of pressure being 8, and difference of the volumes two cubic centimetres. Hence $\frac{70}{8} \times 2$ gives the bulk of the included air under the greatest pressure 17.5 cubic centimetres. Then $24 - 17.5 = 6.5$ the volume of the body introduced. If the absolute weight of the body be multiplied by its bulk in centimetres, and divided by the absolute weight of one cubic centimetre of distilled water, the quotient will be $=$ the specific gravity of the body in the common form of the tables, where distilled water is taken as unity, or the term of comparison.

Mr Nicholson supposes that the author of the invention had not finished his meditations on the subject. If he had, it is probable that he would have determined his pressures, as well as the measures of bulks, by weight. For if the whole instrument were set to its positions by
Fig. 3. suspending it from one arm of a balance at H (fig. 3.) the quantity of counterpoise, when in equilibrio, might be applied to determine the pressures to a degree of accuracy much greater than can be obtained by linear measurement.

STEREOMETRY, Στερεομετρια, formed of στερεος *solid*, and μετρον *measure*, that part of geometry which teaches how to measure solid bodies, i. e. to find the solidity or solid contents of bodies; as globes, cylinders, cubes, vessels, ships, &c.

STEREOTOMY, formed from στερεος, and τομη, *section*, the art or act of cutting solids, or making sections thereof; as walls and other membranes in the profiles of architecture.

STEREOTYPE PRINTING, a method of printing, which was introduced into this country by William Ged of Edinburgh before the middle of the 18th century, and which has been revived of late, and greatly improved by the French. It has also been brought into practice in Britain by Earl Stanhope, who has produced some beautiful specimens of it. Some persons seem disposed to dispute the invention of Ged, seeing that the same method of printing by wooden blocks was practised by the Chinese and Japanese many hundred years ago. See GED, *life of*, and PRINTING.

STERILITY, barrenness, in opposition to fertility. It has been asserted by many authors, that all monsters produced by a mixture of different species of animals, such as mules, are barren; but this does not hold universally, even with the mule, which is the instance most generally adduced.

Sterility in women sometimes happens from a miscarriage, or violent labour injuring some of the genital parts; but one of the most frequent causes is the suppression of the menstrual flux.—There are other causes arising from various diseases incident to those parts, by which the uterus may be unfit to receive or retain the male seed;—from the tubæ fallopianæ being too short, or having lost their erective power; in either of which cases no conception can take place;—from universal debility and relaxation; or a local debility of the genital system; by which means, the parts having lost their tone or contractile power, the semen is thrown off immediately *post coitum*;—from imperforation of the vagina, the uterus, or the *tubæ*, or from diseased ova, &c. Hence medical treatment can only avail in cases arising from topical or universal debility; in correcting irregularities of the menstrual flux, or in removing tumors, cicatrices, or constrictions of the passage, by the art of surgery.

STERIS, a genus of plants belonging to the class pentandria. See BOTANY *Index*.

STERLING, an epithet by which genuine English money is distinguished. It is unnecessary to mention the various conjecturies of antiquaries about the origin and meaning of this appellation. The most probable opinion seems to be this, that some artists from Germany, who were called *Esterlings*, from the situation of their country, had been employed in fabricating our money, which consisted chiefly of silver pennies; and that from them the penny was called an *esterling*, and our money *esterling* or *sterling* money. *Henry's History of Great Britain*, vol. iii. p. 541.

STERN, the posterior face of a ship; or that part which is represented to the view of a spectator, placed on the continuation of the keel behind. The stern is terminated above by the taffarel, and below by the counters; it is limited on the sides by the quarter-pieces, and the intermediate space comprehends the galleries and windows of the different cabins. See QUARTER *of a Ship*, SHIP, and SHIP-BUILDING.

STERN-Fast, a rope used to confine the stern of a ship or boat to any wharf or jetty head, &c.

STERN-Most, in sea language, usually denotes that part of a fleet of ships which is in the rear, or farthest a-stern, as opposed to head-most.

STERN-Post, a long straight piece of timber erected on the extremity of the keel, to sustain the rudder and terminate the ship behind.

This piece ought to be well secured and supported; because the ends of all the lower planks of the ship's bottom are fixed in a channel, cut on its surface; and the whole weight of the rudder is sustained by it.

STERN-Sheets, that part of a boat which is contained between the stern and the aftmost or hindmost seat of the rowers. It is generally furnished with benches to accommodate the passengers. See BOAT.

STERNA, the TERN; a genus of birds arranged under the order of *palmipedes*. See ORNITHOLOGY *Index*.

STERNE, LAURENCE, an English writer of a very peculiar cast, was born at Clomwell, in the south of Ireland, on 24th November 1713. His father Roger Sterne was the grandson of Sterne archbishop of York, who has been supposed, we know not upon what grounds, to have been the author of the excellent book entitled "The Whole Duty of Man." Laurence inherited nothing of his ancestor's manner of writing, but rather resembled Rabelais, whose wit he carried with him even into the pulpit.

In 1722 he was sent to school at Halifax in Yorkshire, where he continued till 1732, when he was removed to Jesus College in Cambridge. How long he resided in college, or what progress he made in literature or science, is not known: his works display rather native genius than profound erudition. Upon quitting the university he went to York, and being in orders was presented to the living of Sutton by the interest of his uncle Dr Sterne, a prebendary of that church. In 1741 he married, and was soon afterwards made a prebendary of York, by the interest also of his uncle, who was then upon very good terms with him; but "quickly quarrelled with him (he says), and became his bitterest enemy, because he would not be a party man, and write paragraphs in the newspapers." By his wife's means he got the living of Stillington, but remained near 20 years at Sutton, doing duty at both places. He was then in very good health, which, however, soon after forsook him; and books, painting, fiddling, and shooting, were, as he tells us, his amusements.

In 1760, he went to London to publish his two first volumes of "Tristram Shandy;" and was that year presented to the curacy of Coxwold. In 1762 he went to France, and two years after to Italy, for the recovery of his health; but his health never was recovered. He languished under a consumption of the lungs, without the slightest depression of spirits, till 1768, when death put a period to his terrestrial existence.

The works of Sterne are very generally read. They consist of, 1. The Life and Opinions of Tristram Shandy; 2. Sermons; 3. A Sentimental Journey; 4. Letters, published since his death. In every serious page, and in many of much levity, the author writes in praise of benevolence, and declares that no one who knew him could suppose him one of those wretches who heap misfortune upon misfortune: But we have heard anecdotes of him extremely well authenticated, which proved that it was easier for him to praise this virtue than to practise it. His wit is universally allowed; but many readers have persuaded themselves that they found wit in his blank pages, while it is probable that he intended nothing but to amuse himself with the idea of the sage conjectures to which these pages would give occasion. Even his originality is not such as is generally supposed by those fond admirers of the Shandean manner, who have presumed to compare him with Swift, Arbuthnot, and Butler. He has borrowed both matter and manner from various authors, and in particular from an old work, "The Anatomy of Melancholy by Burton," as every reader may be convinced by the learned, elegant, and candid comments on his works published by Dr Ferriar, in the fourth volume of the Memoirs of the Literary and Philosophical Society of Manchester.

STERNOCOSTALES, commonly called the *musculi triangulares sterni*, in *Anatomy*, are five pairs of fleshy planes, disposed more or less obliquely on each side the sternum, on the insides of the cartilages of the second, third, fourth, fifth, and sixth true ribs.

STERNO-HYOIDÆUS, in *Anatomy*. See *Table of the Muscles*, under the article ANATOMY.

STERNOMANTIS, in antiquity, a designation given to the Delphian priestess, more usually called PYTHIA.—Sternomantis is also used for any one that had a prophesying demon within him.

STERNOMASTOIDÆUS, a muscle. See *Table of the Muscles*, under ANATOMY.

STERNOTHYROIDEUS, a muscle. See *Table of the Muscles*, under ANATOMY.

STERNUM. See ANATOMY *Index*.

STERNUTATIVE, or STERNUTATORY, a medicine proper to produce sneezing. See SNEEZING.

STETIN, or STETTIN, a sea-port town of Germany, in the circle of Upper Saxony, and capital of Hither Pomerania, with the title of a duchy, and a castle. It had long a famous school, which the wars of Germany never disturbed. The ancient dukes of Pomerania resided here; and it was taken by the elector of Brandenburg in 1676, but given to Sweden by the treaty of Nimeguen. In 1713 it submitted to the allies; and then the said elector was put in possession again of this important place, which is a bulwark to the marche of Brandenburg; and the fortifications have been greatly improved. It is now a flourishing place, and carries on a considerable trade. It is seated on the river Oder, 72 miles north of Francfort, and 70 north by east of Berlin. E. Long. 14. 38. N. Lat. 53. 35. The duchy is 125 miles in length, and borders upon Mecklenburg, and partly upon Brandenburg. The breadth is from 17 to 25 miles, and it is divided by the river Oder into two parts.

STEW, a small kind of fish-pond, the peculiar use of which is to maintain fish, and keep them in readiness for the daily use of the family, &c.

STEWS (from the French *estuves*, i. e. *thermæ*, *balneum*), those places which were permitted in England to women of professed incontinency; so called, because dissolute persons are wont to prepare themselves for venereous acts by bathing; and hot baths were by Homer reckoned among the effeminate sort of pleasures. These stews were suppressed by King Henry VIII. about the year 1546.

STEWARD (*senescallus*, compounded of the Saxon *steda*, i. e. "room" or "stead," and *weard*, "a ward" or "keeper"), an officer appointed in another's stead or place, and always taken for a principal officer within his jurisdiction.

Steward. jurisdiction. Of these there are various kinds. The greatest officer under the crown is the lord high-steward of England, an office that was anciently the inheritance of the earls of Leicester, till forfeited by Simon de Mountfort to King Henry III. But the power of this officer is so very great, that it has not been judged safe to trust it any longer in the hands of a subject, excepting only *pro hac vice*, occasionally: as to officiate at a coronation, at the arraignment of a nobleman for high-treason, or the like. During his office, the steward bears a white staff in his hand; and the trial, &c. ended, he breaks the staff, and with it his commission expires. There is likewise a lord-steward of the king's household, who is the chief officer of the king's court, has the care of the king's house, and authority over all the officers and servants of the household, except such as belong to the chapel, chamber, and stable.

STEWARD, an officer in a ship of war, appointed by the purser to distribute the different species of provisions to the officers and crew; for which purpose he is furnished with a mate and proper assistants.

Court of the Lord High STEWARD of Great Britain, is a court instituted for the trial of peers indicted for treason or felony, or for misprision of either. The office of this great magistrate is very ancient, and was formerly hereditary, or at least held for life, or *dum bene se gesserit*: but now it is usually, and hath been for many centuries past, granted *pro hac vice* only; and it hath been the constant practice (and therefore seems now to have become necessary) to grant it to a lord of parliament, else he is incapable to dry such delinquent peer. When such an indictment is therefore found by a grand jury of freeholders in the King's bench, or at the assizes before the justices of *oyer* and *terminer*, it is to be removed by a writ of *certiorari* into the court of the lord high-steward, which has the only power to determine it. A peer may plead a pardon before the court of King's-bench, and the judges have power to allow it, in order to prevent the trouble of appointing an high-steward merely for the purpose of receiving such plea: but he may not plead in that inferior court any other plea, as guilty or not guilty of the indictment, but only in this court; because, in consequence of such plea, it is possible that judgement of death might be awarded against him. The king, therefore, in case a peer be indicted of treason, felony, or misprision, creates a lord high-steward *pro hac vice* by commission under the great seal; which recites the indictment so found, and gives his Grace power to receive and try it *secundum legem et consuetudinem Angliæ*. Then when the indictment is regularly removed by writ of *certiorari*, commanding the inferior court to certify it up to him, the lord high-steward directs a precept to a serjeant at arms, to summon the lords to attend and try the indicted peer. This precept was formerly issued to summon only 18 or 20 selected from the body of the peers; then the number came to be indefinite; and the custom was for the lord-high-steward to summon as many as he thought proper (but of late years not less than 23); and that those lords only should sit upon the trial; which threw a monstrous weight of power into the hands of the crown, and this its great officer, of selecting only such peers as the then predominant party should most approve of. And accordingly, when the earl of Clarendon fell into disgrace with Charles II. there was a design formed to prorogue the parliament, in order to try him by a select number of peers; it being doubted whether the whole house could be induced to fall in with the views of the court. But now, by statute 7 W. III. c. 3. upon all trials of peers for treason or misprision, all the peers who have a right to sit and vote in parliament, shall be summoned at least 20 days before such trial, to appear and vote therein; and every lord appearing shall vote in the trial of such peer, first taking the oaths of allegiance and supremacy, and subscribing the declaration against popery.

Blackst. Comment. vol. iv.

During the session of parliament, the trial of an indicted peer is not properly in the court of the lord high-steward, but before the court last mentioned of our lord the king in parliament. It is true, a lord high-steward is always appointed in that case to regulate and add weight to the proceedings: but he is rather in the nature of a speaker *pro tempore*, or chairman of the court, than the judge of it; for the collective body of the peers are therein the judges both of law and fact, and the high-steward has a vote with the rest in right of his peerage. But in the court of the lord high-steward, which is held in the recess of parliament, he is the sole judge of matters of law, as the lords triors are in matters of fact; and as they may not interfere with him in regulating the proceedings of the court, so he has no right to intermix with them in giving any vote upon the trial. Therefore, upon the conviction and attainder of a peer for murder in full parliament, it hath been holden by the judges, that in case the day appointed in the judgement for execution should lapse before execution done, a new time of execution may be appointed by either the high court of parliament during its sitting, though no high-steward be existing, or, in the recess of parliament, by the court of King's-bench, the record being removed into that court.

It has been a point of some controversy, whether the bishops have now a right to sit in the court of the lord-high-steward to try indictments of treason and misprision. Some incline to imagine them included under the general words of the statute of King William "all peers who have a right to sit and vote in parliament;" but the expression had been much clearer, if it had been "all lords," and not "all peers;" for though bishops, on account of the baronies annexed to their bishoprics, are clearly lords of parliament, yet their blood not being ennobled, they are not universally allowed to be peers with the temporal nobility: and perhaps this word might be inserted purposely with a view to exclude them. However, there is no instance of their sitting on trials for capital offences, even upon impeachments or indictments in full parliament, much less in the court we are now treating of; for indeed they usually withdraw voluntarily, but enter a protest, declaring their right to stay. It is observable, that in the 11th chapter of the constitutions of Clarendon, made in parliament 11th Henry II. they are expressly excused, rather than excluded, from sitting and voting in trials, which concern life or limb: *episcopi, sicut cæteri barones, debent interesse judiciis cum baronibus, quousque perveniatur ad diminutionem membrorum vel ad mortem.* And Becket's quarrel with the king hereupon was not on account of the exception (which was agreeable to the canon law), but of the general rule, that compelled the bishops to attend at all. And the determination of the house of lords

lords in the earl of Danby's caſe, which hath ever ſince been adhered to, is conſonant to theſe conſtitutions; "that the lords ſpiritual have a right to ſtay and ſit in court in capital caſes, till the court proceeds to the vote of guilty or not guilty." It muſt be noted, that this reſolution extends only to trials in full parliament; for to the court of the lord high-ſteward (in which no vote can be given, but merely that of guilty or not guilty), no biſhop, as ſuch, ever was or could be ſummoned: and though the ſtatute of King William regulates the proceedings in that court, as well as in the court of parliament, yet it never intended to new-model or alter its conſtitution; and conſequently does not give the lords ſpiritual any right, in caſes of blood, which they had not before. And what makes their excluſion more reaſonable is, that they have no right to be tried themſelves in the court of the lord high-ſteward, and therefore ſurely ought not to be judges there. For the privilege of being thus tried depends upon nobility of blood rather than a ſeat in the houſe, as appears from the trials of the popiſh lords, of lords under age, and (ſince the union) of the Scotch nobility, though not in the number of the ſixteen; and from the trials of females, ſuch as the queen conſort or dowager, and of all peereſſes by birth; and peereſſes by marriage alſo, unleſs they have, when dowagers, diſparaged themſelves by taking a commoner to their ſecond huſband.

STEWARD of the Chiltern Hundreds. See *CHILTERN Hundreds*.

STEWART, DR MATTHEW, an eminent mathematician, was in 1717 born at Rothſay in the iſle of Bute, of which pariſh his father was miniſter. Being intended for the church, he went through the uſual courſe of a grammar-ſchool education, and was in 1734 received as a ſtudent into the univerſity of Glaſgow. There he had the happineſs of having for his preceptors in moral ſcience and in mathematics the celebrated profeſſors Hutcheſon and Simſon; by the latter of whom he was inſtructed in what may not improperly be called the *arcana* of the ancient geometry.

Account of Dr Stewart in the Edinburgh Philoſophical Tranſactions, vol. i. by Mr Playfair.

Mr Stewart's views making it neceſſary for him to remove to Edinburgh, he was introduced by Dr Simſon to Mr Maclaurin, that his mathematical ſtudies might ſuffer no interruption; and he attended the lectures of that great maſter with ſuch advantage as might be expected from eminent abilities, directed by the judgement of him who made the philoſophy and geometry of Newton intelligible to ordinary capacities. Mr Stewart, however, had acquired, from his intimacy with Dr Simſon, ſuch a predilection for the ancient geometry, as the modern analyſis, however powerfully recommended, could not leſſen; and he kept up a regular correſpondence with his old maſter, giving him an account of his progreſs and his diſcoveries in geometry, and receiving in return many curious communications reſpecting the *Loci Plani* and the poriſms of Euclid. See PORISM and SIMSON.

While the ſecond invention of poriſms, to which more genius was perhaps required than to the firſt diſcovery of them, employed Dr Simſon, Mr Stewart purſued the ſame ſubject in a different and new direction. In doing ſo, he was led to the diſcovery of thoſe curious and intereſting propoſitions which were publiſhed under the title of *General Theorems* in 1746. They were given without the demonſtrations; but did not fail to place their diſcoverer at once among the geometers of the firſt rank. They are for the moſt part poriſms, though Mr Stewart, careful not to anticipate the diſcoveries of his friend, gave them no other name than that of theorems.

Our author had before this period entered into the church; and obtained, through the patronage of the duke of Argyle and the earl of Bute, the living of Roſeneath, a retired country pariſh in the weſt of Scotland: but in 1747 he was elected to the mathematical chair in the univerſity of Edinburgh, which had become vacant the year before by the death of Mr Maclaurin. The duties of this office gave a turn ſomewhat different to his purſuits, and led him to think of the moſt ſimple and elegant means of explaining thoſe difficult propoſitions which were hitherto only acceſſible to men deeply verſed in the modern analyſis. In doing this, he was purſuing the object which of all others he moſt ardently wiſhed to attain, viz. the application of geometry to ſuch problems as the algebraic calculus alone had been thought able to reſolve. His ſolution of Kepler's problem was the firſt ſpecimen of this kind which he gave to the world; and it was impoſſible to have produced one more to the credit of the method he followed, or of the abilities with which he applied it. On this problem the utmoſt reſources of the integral calculus had been employed. But though many excellent ſolutions had been given, there was none of them at once direct in its method and ſimple in its principles. Mr Stewart was ſo happy as to attain both theſe objects; and his ſolution appeared in the ſecond volume of the Eſſays of the Philoſophical Society of Edinburgh for the year 1756. In the firſt volume of the ſame collection there are ſome other propoſitions of Mr Stewart's, which are an extenſion of a curious theorem in the fourth book of Pappus. They have a relation to the ſubject of poriſms, and one of them forms the 91ſt of Dr Simſon's Reſtoration. They are beſides very beautiful propoſitions, and are demonſtrated with all the elegance and ſimplicity of the ancient analyſis.

The proſecution of the plan which he had formed of introducing into the higher parts of mixed mathematics the ſtrict and ſimple form of ancient demonſtration, produced the Tracts Phyſical and Mathematical, which were publiſhed in 1761, and the Eſſay on the Sun's Diſtance, which was publiſhed in 1763. In this laſt work it is acknowledged that he employed geometry on a taſk which geometry cannot perform; but while it is granted that his determination of the ſun's diſtance is by no means free from error, it may ſafely be aſſerted that it contains a great deal which will always intereſt geometers, and will always be admired by them. Few errors in ſcience are redeemed by the diſplay of ſo much ingenuity, and what is more ſingular, of ſo much ſound reaſoning. The inveſtigation is everywhere elegant, and will probably be long regarded as a ſpecimen of the moſt arduous inquiry which has been attempted by mere geometry.

The Sun's Diſtance was the laſt work which Dr Stewart publiſhed; and though he lived to ſee ſeveral animadverſions on it made public, he declined entering into any controverſy. His diſpoſition was far from polemical; and he knew the value of that quiet which a literary man ſhould rarely ſuffer his antagoniſts to interrupt. He uſed to ſay, that the deciſion of the point in in queſtion was now before the public; that if his inveſtigation was right it would never be overturned, and that if it was wrong it ought not to be defended. A few months before he publiſhed the eſſay juſt mentioned, he gave to the world another work, intitled *Propoſitiones Geometricæ More Veterum Demonſtratæ*. This title, it is ſaid, was given to it by Dr Simſon, who rejoiced in the publication of a work ſo well calculated to promote the ſtudy of the ancient geometry. It conſiſts of a ſeries of geometrical theorems for the moſt part new; inveſtigated firſt by an analyſis, and afterwards ſynthetically demonſtrated by the inverſion of the ſame analyſis.

Dr Stewart's conſtant uſe of the geometrical analyſis had put him in poſſeſſion of many valuable propoſitions which did not enter into the plan of any of the works that have been enumerated. Of theſe not a few have found a place in the writings of Dr Simſon, where they will for ever remain to mark the friendſhip of theſe two mathematicians, and to evince the eſteem which Dr Simſon entertained for the abilities of his pupil.

Soon after the publication of the Sun's Diſtance, Dr Stewart's health began to decline, and the duties of his office became burdenſome to him. In the year 1772 he retired to the country, where he afterwards ſpent the greater part of his life, and never reſumed his labours in the univerſity. But though mathematics had now ceaſed to be his buſineſs, they continued to be his amuſement till a very few years before his death, which happened on the 23d of January 1785, at the age of 68.

The habits of ſtudy, in a man of original genius, are objects of curioſity, and deſerve to be remembered. Concerning thoſe of Dr Stewart, his writings have made it unneceſſary to remark, that from his youth he had been accuſtomed to the moſt intenſe and continued application. In conſequence of this application, added to the natural vigour of his mind, he retained the memory of his diſcoveries in a manner that will hardly be believed. He rarely wrote down any of his inveſtigations till it became neceſſary to do ſo for the purpoſe of publication. When he diſcovered any propoſition, he would put down the enunciation with great accuracy, and on the ſame piece of paper would conſtruct very neatly the figure to which it referred. To theſe he truſted for recalling to his mind at any future period the demonſtration or the analyſis, however complicated it might be. Experience had taught him, that he might place this confidence in himſelf without any danger of diſappointment; and for this ſingular power he was probably more indebted to the activity of his invention than the mere tenaciouſneſs of his memory. Though he was extremely ſtudious, he read few books, and verified the obſervation of M. D'Alembert, that of all the men of letters, mathematicians read leaſt of the writings of one another. His own inveſtigations occupied him ſufficiently; and indeed the world would have had reaſon to regret the miſapplication of his talents, had he employed in the mere acquiſition of knowledge that time which he could dedicate to works of invention.

Stewart, in *Scots Law*. See Law *Index*.

STEWARTIA, a genus of plants belonging to the claſs monadelphia, and in the natural ſyſtem ranging under the 37th order, *Columniferæ*. See Botany *Index*.

STIBADIUM, among the Romans, a low kind of table couch or bed of a circular form, which ſucceeded to the triclinia, and was of different ſizes, according to the number of gueſts for which it was deſigned. Tables of this kind were called *hexaclina*, *octaclina*, or *enneaclina*, according as they held ſix, eight, or nine gueſts, and ſo of any other number.

STIBIUM, a name for Antimony.

STICHOS, a name given by the old writers to a pectoral confection, the principal ingredient of which was the herb *marrubium* or horehound.

STICKLEBACK, a genus of fiſhes. See Gasterosteus, Ichthyology *Index*.

Foot-STICKS, in *Printing*, ſlips of wood that lie between the foot of the page and the cheſs, to which they are wedged faſt by the quoins, to keep the form firm, in conjunction with the ſide-ſticks, which are placed at the ſide of the page, and fixed in the ſame manner by means of quoins.

STIFFLE, or Great Muscle, in the manege, is the part of the hind leg of a horſe which advances towards his belly. This is a moſt dangerous part to receive a blow upon.

STIGMA, a brand or impreſſion with a hot iron; a mark of infamy. See Stigmatizing.

Stigma, in *Botany*, the ſummit or top of the ſtyle, accounted by the ſexualiſts the female organ of generation in plants, which receives the fecundating duſt of the tops of the ſtamina, and tranſmits its vapour or effluvia through the ſtyle into the heart of the ſeed-bud, for the purpoſe of impregnating the ſeeds.

STIGMATA, in *Natural Hiſtory*, the apertures in different parts of the bodies of inſects communicating with the tracheæ or air-veſſels, and ſerving for the office of reſpiration.

Stigmata, in antiquity, certain marks impreſſed on the left ſhoulders of the ſoldiers when liſted.

Stigmata, were alſo a kind of notes or abbreviations, conſiſting only of points, diſpoſed various ways; as in triangles, ſquares, croſſes, &c.

Stigmata, is alſo a term introduced by the Franciſcans, to expreſs the marks or prints of our Saviour's wounds, ſaid to have been miraculouſly impreſſed by him on the body of their ſeraphic father St Francis.

STIGMATIZING, among the ancients, was inflicted upon ſlaves as a puniſhment, but more frequently as a mark to know them by: in which caſe, it was done by applying a red-hot iron marked with certain letters to their foreheads, till a fair impreſſion was made; and then pouring ink into their furrows, that the inſcription might be the more conſpicuous.

Soldiers were branded in the hand with the name or character of their general.

After the ſame manner, it was cuſtomary to ſtigmatize the worſhippers and votaries of ſome of the gods. The marks uſed on theſe occaſions were various; ſometimes they contained the name of the god, ſometimes his particular enſign, as the thunderbolt of Jupiter, the trident of Neptune, the ivy of Bacchus, &c. or they marked themſelves with ſome myſtical number, whereby the god's name was deſcribed. To theſe three ways of ſtigmatizing St John is ſuppoſed to refer (Rev. chap. xiii. ver. 16, 17.). Theodoret is of opinion, that the

Jews were forbidden to brand themſelves with ſtigmata, becauſe the idolaters, by that ceremony, uſed to conſecrate themſelves to their falſe gods.

Among ſome nations, ſtigmatizing was conſidered as a diſtinguiſhing mark of honour and nobility. In Thrace, as Herodotus tells us *, it was practiſed by none but perſons of credit, nor omitted by any but perſons of the meaneſt rank. The ancient Britons are alſo ſaid to have imprinted on the bodies of their infants the figures of animals, and other marks, with hot irons.

* Lib. v.

STIL DE GRAIN, in the colour trade, the name of a compoſition uſed for painting in oil or water, and is made of a decoction of the lycium or Avignon berry, in alum-water, which is mixed with whiting into a paſte, and formed into twiſted ſticks. It ought to be choſen of a fine gold yellow, very fine, tender, and friable, and free from dirt.

STILAGO, a genus of plants belonging to claſs gynandria. See BOTANY *Index*.

STILBE, a genus of plants belonging to the claſs polygamia, and order of diœcia. See BOTANY *Index*.

STILBITE, a ſpecies of mineral, or variety of zeolite. See ZEOLITE, MINERALOGY *Index*.

STILE. See STYLE.

STILL, the name of an apparatus uſed in chemiſtry for various purpoſes, and in the diſtillation of ardent ſpirits.

STILL-Bottoms, in the diſtillery, a name given by the traders to what remains in the ſtill after working the waſh into low wines. Theſe bottoms are procured in the greateſt quantity from the malt-waſh, and are of ſo much value to the diſtiller in the fattening of hogs, &c. that he often finds them one of the moſt valuable articles of the buſineſs.

STILLINGFLEET, EDWARD, biſhop of Worceſter, was the ſon of Samuel Stillingfleet, gentleman, and was born at Cranborn in Dorſetſhire in 1635. He was educated at St John's College, Cambridge; and having received holy orders, was, in 1657, preſented to the rectory of Sutton in Nottinghamſhire. By publiſhing his *Origines Sacræ*, one of the ableſt defences of revealed religion that has ever been written, he ſoon acquired ſuch reputation, that was appointed preacher of the Rolls Chapel; and in January 1665 was preſented to the rectory of St Andrew's, Holborn. He was afterwards choſen lecturer at the Temple, and appointed chaplain in ordinary to King Charles II. In 1668 he took the degree of doctor of divinity; and was ſoon after engaged in a diſpute with thoſe of the Romiſh religion, by publiſhing his diſcourſe concerning the idolatry and fanaticiſm of the church of Rome, which he afterwards defended againſt ſeveral antagoniſts. In 1680 he preached at Guildhall chapel a ſermon on Phil. iii. 26. which he publiſhed under the title of *The Miſchief of Separation*; and this being immediately attacked by ſeveral writers, he in 1683 publiſhed his Unreaſonableneſs of Separation. In 1685 appeared his *Origines Britannicæ*, or the Antiquities of the Britiſh Church, in folio. During the reign of King James II. he wrote ſeveral tracts againſt popery, and was prolocutor of the convocation, as he had likewiſe been under Charles II. After the Revolution he was advanced to the biſhopric of Worceſter, and was engaged in a diſpute with the Socinians, and alſo with Mr Locke; in which laſt conteſt he is generally thought to have been unſucceſsful. He died at Weſtminſter in 1699, and was interred in the cathedral of Worceſter, where a monument was erected to his memory by his ſon. Dr Stillingfleet wrote other works beſides thoſe here mentioned, which, with the above, have been reprinted in 6 vols. folio.

STILLINGFLEET, *Benjamin*, an ingenious naturaliſt, was grandſon of the preceding. His father Edward was fellow of St John's College in Cambridge, F. R. S. M. D. and Greſham profeſſor of phyſic: but marrying in 1692, he loſt his lucrative offices and his father's favour; a misfortune that affected both himſelf and his poſterity. However, going into orders, he obtained, by his father's means, the living of Newington-Butts, which he immediately exchanged for thoſe of Wood-Norton and Swanton in Norfolk. He died in 1708.

Benjamin, his only ſon, was educated at Norwich ſchool, which he left in 1720, with the character of an excellent ſcholar. He then went to Trinity-College in Cambridge, at the requeſt of Dr Bentley, the maſter, who had been private tutor to his father, domeſtic chaplain to his grandfather, and much indebted to the family. Here he was a candidate for a fellowſhip, but was rejected by the maſter's influence. This was a ſevere and unexpected diſappointment, and but little alleviated afterwards by the Doctor's apology, that it was a pity that a gentleman of Mr Stillingfleet's parts ſhould be buried within the walls of a college.

Perhaps, however, this ingratitude of Dr Bentley was not of any real diſſervice to Mr Stillingfleet. By being thrown into the world, he formed many honourable and valuable connections. He dedicated ſome tranſlations of Linnæus to the late Lord Lyttleton, partly, he ſays, from motives of private reſpect and honour. Lord Barrington gave him, in a very polite manner, the place of the maſter of the barracks at Kenſington; a favour to which Mr Stillingfleet, in the dedication of his Calendar of Flora to that nobleman, alludes with equal politeneſs, as well as with the warmeſt gratitude. His Calendar of Flora was formed at Stratton in Norfolk in the year 1755, at the hoſpitable ſeat of his very worthy and ingenious friend Mr Marſham, who had made ſeveral obſervations of that kind, and had communicated to the public his curious obſervations on the growth of trees. But it was to Mr Wyndham of Felbrig in Norfolk that he appears to have had the greateſt obligations: he travelled abroad with him, ſpent much of his time at his houſe, and was appointed one of his executors (Mr Garrick was another), with a conſiderable addition to an annuity which that gentleman had ſettled upon him in his lifetime.

Mr Stillingfleet's genius ſeems, if we may judge from his works, to have led him principally to the ſtudy of natural hiſtory; which he proſecuted as an ingenious philoſopher, an uſeful citizen, and a good man. In this walk of learning he mentions, as his friends, Dr Watſon, Mr (afterwards Dr) Solander, Mr Hudſon, Mr Price of Foxley, and ſome others; to whom may be added the ingenious Mr Pennant. Nor can we omit the flattering mention which Mr Gray makes of him in one of his letters, dated from London in 1761: "I have lately made an acquaintance with this philoſopher, who lives in a garret here in the winter, that he may ſupport ſome near relations who depend upon him. He is always employed, conſequently (according to my old maxim)

maxim) always happy, always cheerful, and ſeems to me a very worthy honeſt man. His preſent ſcheme is to ſend ſome perſons, properly qualified, to reſide a year or two in Attica, to make themſelves acquainted with the climate, productions, and natural hiſtory of the country, that we may underſtand Ariſtotle, Theophraſtus, &c. who have been heathen Greek to us for ſo many ages; and this he has got propoſed to Lord Bute, no unlikely perſon to put it in execution, as he is himſelf a botaniſt."

Mr Stillingfleet publiſhed a volume of miſcellaneous tracts, which is in much eſteem, and does great honour to his head and heart. They are chiefly tranſlations of ſome eſſays in the *Amœnitates Academicæ*, publiſhed by Linnæus, interſperſed with ſome obſervations and additions of his own. In this volume he ſhows alſo a taſte for claſſical learning, and entertains us with ſome elegant poetical effuſions of his own. But his Eſſay on Converſation, publiſhed in the firſt volume of Dodſley's Collection of Poems, entitles him to a diſtinguiſhed rank among our Engliſh poets. This poem is addreſſed to Mr Wyndham, with all that warmth of friendſhip which diſtinguiſhes Mr Stillingfleet. As it is chiefly didactic, it does not admit of ſo many ornaments as ſome compoſitions of other kinds. However, it contains much good ſenſe, ſhows a conſiderable knowledge of mankind, and has ſeveral paſſages that in point of harmony and eaſy verſification would not diſgrace the writtings of our moſt admired poets. Here more than once Mr Stillingfleet ſhows himſelf ſtill ſore for Dr Bentley's cruel treatment of him; and towards the beautiful and moral cloſe of it (where it is ſuppoſed he gives us a ſketch of himſelf) ſeems to hint at a mortification of a more delicate nature, which he is ſaid to have ſuffered from the other ſex.

To theſe diſappointments it was perhaps owing that Mr Stillingfleet neither married nor went into orders. His London reſidence was at a ſaddler's in Piccadilly; where he died in 1771, aged above 70, leaving ſeveral valuable papers behind him. He was buried in St James's church, without the ſlighteſt monument to his memory.

STILLINGIA, a genus of plants belonging to the claſs monœcia, and to the order of *monadelphia*. See BOTANY *Index*.

STILYARD. See *STEEL-Yard*.

STILPO, a celebrated philoſopher of Megara, flouriſhed under the reign of Ptolomy Euergetes. In his youth he had been addicted to licentious pleaſures, from which he religiouſly refrained from the moment that he ranked himſelf among philoſophers. When Ptolemy Soter, at the taking of Megara, offered him a large ſum of money, and requeſted that he would accompany him into Egypt, he accepted but a ſmall part of the offer, and retired to the iſland of Ægina, whence, on Ptolemy's departure, he returned to Megara. That city being again taken by Demetrius the ſon of Antigonus, and the philoſopher required to give an account of any effects which he had loſt during the hurry of the plunder, he replied, that he had loſt nothing; for no one could take from him his learning and eloquence. So great was the fame of Stilpo, that the moſt eminent philoſophers of Athens took pleaſure in attending upon his diſcourſes. His peculiar doctrines were, that ſpecies or univerſals have no real exiſtence, and that one thing cannot be predicated of another. With reſpect to the former of theſe opinions, he ſeems to have taught the ſame doctrine with the ſect afterwards known by the appellation of *Nominaliſts*. To prove that one thing cannot be predicated of another, he ſaid, that *goodneſs* and *man*, for inſtance, are different things, which cannot be confounded by aſſerting the one to be the other: he argued farther, that goodneſs is an univerſal, and univerſals have no real exiſtence; conſequently ſince nothing cannot be predicated of any thing, goodneſs cannot be predicated of man. Thus, whilſt this ſubtle logician was, through his whole argument, predicating one thing of another, he denied that any one thing could be the accident or predicate of another. If Stilpo was ſerious in this reaſoning; if he meant any thing more than to expoſe the ſophiſtry of the ſchools, he muſt be confeſſed to have been an eminent maſter of the art of wrangling; and it was not wholly without reaſon that Glycera, a celebrated courtezan, when ſhe was reproved by him as a corrupter of youth, replied, that the charge might be juſtly retorted upon himſelf, who ſpent his time in filling their heads with ſophiſtical quibbles and uſeleſs ſubtleties. In ethics he ſeems to have been a Stoic, and in religion he had a public and a private doctrine, the former for the multitude, and the latter for his friends. He admitted the exiſtence of a ſupreme divinity, but had no reverence for the Grecian ſuperſtitions.

Enfield's History of Philoſophy, vol. i.

STILOBATUM, in *Architecture*, denotes the body of the pedeſtal of any column.

STILTON, a town of England, in Huntingdonſhire, 75 miles from London, ſouth-weſt of Yaxley, on the Roman highway from Caſtor to Huntingdon, called *Ermine-ſtreet*, ſome parts of which, in this neighbourhood, appear ſtill paved with ſtone. This place is famous for cheeſe called *Engliſh Parmeſan*, which is generally kept till it is old before it is brought to table, and even the proceſs of decay is accelerated by various means, to render it agreeable to a vitiated taſte. For making Stilton cheeſe, the following receipt is given in the firſt volume of the *Repoſitory of Arts and Manufactures*:

"Take the night's cream, and put it to the morning's new milk, with the rennet; when the curd is come, it is not to be broken, as is done with other cheeſes, but take it out with a ſoil-diſh altogether, and place it in a ſieve to drain gradually; and as it drains, keep gradually preſſing it till it becomes firm and dry; then place it in a wooden hoop; afterwards to be kept dry on boards, turned frequently, with cloth binders round it, which are to be tightened as occaſion requires, and changed every day until the cheeſe become firm enough to ſupport itſelf; after the cloth is taken off, the cheeſe is rubbed every day all over, for two or three months, with a bruſh; and if the weather be damp or moiſt twice a-day; and even before the cloth is taken off, the top and bottom are well rubbed every day."

STIMULANTS, in *Medicine*, ſubſtances which increaſe the action of certain parts of the body. In particular, they quicken the motion of the blood, increaſe the action of the muſcular fibres, and affect the nervous ſyſtem.

STIMULI, in *Botany*, a ſpecies of armature or offenſive weapon, with which ſome plants, as nettle, caſſada, da, acalypha, and tragia, are furnifhed. Their ufe, fays Linnæus, is by their venomous punctures to keep off naked animals that would approach to hurt them.

STING, an apparatus in the bodies of certain infects, in form of a little fpear, ferving them as a weapon of offence.

STING-Ray. See RAIA, ICHTHYOLOGY *Index*.

Falconer's Marine Dictionary. STINK-POT, an earthen jar or fhell, charged with powder, grenadoes, and other materials of an offenfive and fuffocating fmell. It is frequently ufed by privateers, in the weftern ocean, in the attack of an enemy whom he defigns to board; for which purpofe it is furnifhed with a light fufe at the opening or touch-hole. See BOARDING.

STINT, a fpecies of bird. See TRINGA, ORNITHOLOGY *Index*.

STIPA, FEATHER GRASS, a genus of plants belonging to the clafs triandria, and order of digynia; and in the natural fyftem ranging under the 4th order, *Gramina*. See BOTANY *Index*.

STIPEND, among the Romans, fignifies the fame with tribute; and hence *ftipendarii* were the fame with *tributarii*.

STIPEND, in *Scots Law*. See LAW, § clix. 12.

STIPULA, in *Botany*, one of the fulcra or props of plants, defined by Linnæus to be a fcale, or fmall leaf, ftationed on each fide the bafe of the footftalks of the flower and leaves, at their firft appearance, for the purpofe of fupport. Elmgren reftricts it to the footftalks of the leaves only.

STIPULATION, in the civil law, the act of ftipulating, that is, of treating and concluding terms and conditions to be inferted in a contract. Stipulations were anciently performed at Rome, with abundance of ceremonies; the firft whereof was, that one party fhould interrogate, and the other anfwer, to give his confent, and oblige himfelf. By the ancient Roman law, nobody could ftipulate but for himfelf; but as the tabelliones were public fervants, they were allowed to ftipulate for their mafters; and the notaries fucceeding the tabelliones have inherited the fame privilege.

STIRIA, a province of Germany, in the circle of Auftria, with the title of a duchy. It is bounded on the north by the archduchy of Auftria, on the eaft by Hungary, on the fouth by Carniola, and on the weft by Carinthia and the archbifhopric of Saltfburg; it is 125 miles in length and 17 in breadth, and is faid to contain 22 cities, 95 towns, 338 caftles, 15 convents, and 200,000 inhabitants. Though it is a mountainous country, yet there is a great deal of land fit for tillage, and the foil is fo good, that the inhabitants never were in want of corn. In contains mines of very good iron; whence the arms made there are in great efteem. The women differ greatly from the Auftrians, and are very plain and ingenious. They have all fwellings on their throats, called *bronchoceles*. The men are alfo very fimple, and are rather difpofed to indulge in indolence. The chief town is Gratz.

STIRLING, a town of Scotland, fituated on the river Forth, 35 miles north-weft of Edinburgh, in W. Long. 3. 59 N. Lat. 56. 6. It is alfo called *Sterling* and *Striveling*; from the former of which Boethius falfely derives the name *Sterling money*; becaufe, fays he, Ofbeit, a Saxon prince, after the overthrow of the Scots, eftablifhed a mint there. The name of *Striveling* is faid to have been derived from the frequency of ftrifes or conflicts in the neighbourhood. The town contains about 4000 inhabitants. It has a manufacture of tartans and fhalloons, and employs about 30 looms in that of carpets. The great ftreet is very broad. In it is the tolbooth, where is kept the ftandard for the wet meafures of Scotland. The other ftreets are narrow and irregular.—Stirling is in miniature a refemblance of Edinburgh; being built on a rock of the fame form, with a fortrefs on the fummit. The origin of the caftle is unknown. The rock of Stirling was ftrongly fortified by the Picts, amongft whom architecture and feveral other ufeful arts had made a confiderable progrefs. As it lay in the extremities of their kingdom, the poffeffion of it was the occafion of frequent contefts betwixt them and their neighbours the Scots and Northumbrians; each of whofe dominions did, for fome time, terminate near it.

When the Scots, under Kenneth II. overthrew the Pictifh empire near the middle of the ninth century, they endeavoured to obliterate every memorial of that people. They not only gave new names to provinces and towns, but, with all the rage of barbarians, demolifhed many magnificent and ufeful edifices which had been reared up by them, and this fortrefs among the reft. It was, however, foon rebuilt, though upon an occafion not very honourable to the Scots.

Upon the death of Kenneth II. in 855, his brother Donald V. mounted the throne of Scotland. In the beginning of his reign the kingdom was invaded by Ofbrecht and Ella, two Northumbrian princes, who, uniting their forces with the Cumbrian Britons, and a number of Picts, who upon their expulfion from their native country had taken refuge in England, advanced to Jedburgh, where Donald encountered them; and, after a fierce and bloody battle, obtained a complete victory: but, having taken up his ftation in Berwick, in fupine fecurity, the Northumbrians, informed of the carelefs pofture in which the Scottifh army lay, furprifed them by a hafty march, difperfed them, and made a prifoner of the king. Purfuing the advantage they had gained, they marched northward, and fubdued all before them to the frith of Forth and the town of Stirling. But the forlorn fituation of the Scots, without a king and without an army, obliging them to fue for peace, they obtained it, upon condition that they fhould pay a fum of money for the ranfom of the king, and yield up all their dominions upon the fouth fide of the Forth to the conquerors.

The Northumbrians taking poffeffion of the territories ceded to them by this treaty, rebuilt the caftle of Stirling, and planted it with a ftrong garrifon, in order to preferve their new conquefts, upon the frontiers of which it was fituated. Our authorities alfo inform us, that they erected a ftone bridge over the Forth, upon the fummit of which a crofs was raifed, with the following infcription in monkifh rhyme.

Anglos a Scotis feparat crux ifta remotis;
Armis hic ftant Bruti, Scoti ftant hic, cruce tuti.

Which is thus tranflated by Bellenden.

I am free marche, as paffengeris may ken,
To Scottis, to Britonis, and to Inglifmen.

None of the ancient Englifh hiftorians mentions this conqueft. The whole ftory, as well as the infcription, wears

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wears much of a monkiſh garb; yet its authenticity is not a little confirmed by the arms of the town of Stirling, upon which is a bridge, with a croſs, and the laſt line of the above Latin diſtich is the motto round it.

We muſt not, however, imagine, that in thoſe times that fortreſs bore any reſemblance to the preſent ſtructure, which is adapted to the uſe of fire-arms. Its ſize and form probably reſembled thoſe caſtles which, under the feudal conſtitution, the Engliſh and Scottiſh barons uſed to erect upon their eſtates for dwelling-houſes; and which, in thoſe barbarous ages, they found neceſſary to fortify for their defence, not only againſt foreign invaders, but often againſt the attacks of their own neighbours. It is directly ſuch a Gothic figure as this which repreſents the *Caſtrum Strivelenſe* upon the arms of Stirling.

This fortreſs, after it had continued in the poſſeſſion of the Northumbrian Saxons about 20 years, was, together with the whole country upon the ſouth ſide of the Forth, reſtored to the Scots, upon condition of their aſſiſting the Saxons againſt their turbulent invaders the Danes. Upon the arms of Stirling are two branches of a tree, to repreſent the *Nemus Strivelenſe*; but the ſituation and boundaries of that foreſt, which was probably a wing of the Caledonian, cannot be aſcertained. Upon the ſouth of Stirling, veſtiges of a foreſt are ſtill diſcernible for ſeveral miles. Banks of natural timber ſtill remain in the caſtle park, at Murray's wood, and near Nether Bannockburn; and ſtumps of trees, with much bruſhwood, are to be ſeen in all the adjacent fields.

When Kenneth III. received intelligence of the Danes having invaded his dominions, he appointed the caſtle of Stirling to be the place of rendezvous for his army; and he marched from thence to the battle of Loncarty, where he obtained a victory over thoſe rovers, in the end of the 10th century.

In the 12th century, this caſtle is ſpoken of as a place of great importance, and one of the ſtrongeſt fortreſſes in the kingdom. In 1174, a calamity, not unuſual amongſt the Scottiſh monarchs, befel William, who at that time occupied the throne. He was taken priſoner in an unſucceſsful expedition which he made into England; and, after having been detained 12 months in captivity, was releaſed, upon ſtipulating to pay a large ſum of money for his ranſom; and, until payment thereof, delivering into the hands of the Engliſh the four principal fortreſſes in the kingdom, which in thoſe days were Stirling, Edinburgh, Roxburgh, and Berwick. This was the firſt great aſcendant that England obtained over Scotland; and indeed the moſt important tranſaction which had paſſed between theſe kingdoms from the Norman conqueſt.

Though the Scottiſh monarchs, in their frequent perambulations through the kingdom, often viſited Stirling, and held their courts for ſome time in the caſtle; yet it did not become a royal reſidence till the family of Stuart mounted the throne, and it was from different princes of this family that it received its preſent form. It was the place of the nativity of James II.; and, when raiſed to the throne, he frequently kept his court in it. It is well known to have been the place where that prince perpetrated an atrocious deed, the murder of William earl of Douglas, whom he ſtabbed with his own hand. The royal apartments were at that time in the north-weſt corner of the caſtle, and are now the reſidence of the fort-major. The room where the murder was committed ſtill goes by the name of *Douglas's room.*

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James III. contracting a fondneſs for the caſtle on account of its pleaſant ſituation, made it the chief place of his reſidence, and added ſeveral embelliſhments to it. He built within it a magnificent hall, which in thoſe days was deemed a noble ſtructure, and is ſtill entire. It now goes by the name of the *parliament-houſe*, having been deſigned for the accommodation of that ſupreme court. It was covered with an oaken roof of exquiſite workmanſhip, which, though very little decayed, was a few years ago removed to make way for one of more modern ſtructure. James alſo erected a college of ſecular prieſts in the caſtle, which he called the *chapel royal*, and which proved one cauſe of his own ruin. As the expences neceſſary for maintaining the numerous officers of ſuch an inſtitution were conſiderable, he annexed to it the revenues of the rich priory of Coldingham in the Merſe, which at that time happened to become vacant. This priory had for a long time been holden by perſons connected with the family of Hume; and that family, conſidering it as belonging to them, ſtrongly oppoſed the annexation. The diſpute ſeems to have laſted ſeveral years; for one parliament had paſſed a vote, annexing the priory to the chapel-royal, and a ſubſequent one enacted a ſtatute prohibiting every attempt that was contrary or prejudicial to that annexation.

James V. was crowned in the caſtle of Stirling; and the palace, which is the chief ornament of it, was the work of that prince. This is a ſtately and commodious ſtructure, all of hewn ſtone, with much ſtatuary work upon it. It is built in form of a ſquare, with a ſmall court in the middle, in which the king's lions are ſaid to have been kept; and hence it ſtill goes by the name of the *lions den.* The palace contains many large and elegant apartments; the ground-ſtory is now converted into barrack-rooms for the ſoldiers of the garriſon; the upper affords a houſe for the governor, with lodgings for ſome of the ſubaltern officers.

Oppoſite to the palace, upon the north, ſtands an elegant chapel, which was built by James VI. for the baptiſm of his ſon, Prince Henry, in 1594. In this chapel is preſerved the hulk of a large boat, which that whimſical monarch cauſed to be built and placed upon carriages, in order to convey into the caſtle the proviſions for that ſolemnity.

A ſtrong battery, with a tier of guns pointing to the bridge over the Forth, was erected during the regency of Mary of Lorraine, mother to Queen Mary. It is called the *French battery*, probably becauſe conſtructed by engineers of that nation. The laſt addition was made to the fortifications in the reign of Queen Anne. Formerly they reached no farther than the old gate, upon which the flag-ſtaff now ſtands: but in that reign they were conſiderably enlarged upon the ſide towards the town; and barracks, which are bomb-proof, with ſeveral other conveniences for a ſiege, were erected.

Upon the ſouth ſide of the caſtle lies a park incloſed with a ſtone-wall, called the *king's park*, and near to the foot of the rock on which the caſtle ſtands, lay the royal gardens; veſtiges of the walks and parterres, with a few ſtumps of fruit-trees, are ſtill viſible; but by long neglect, and the natural wetneſs of the ſoil, the place is now

now little better than a marſh. In the gardens is a mount of earth in form of a table, with benches of earth around it, where, according to tradition, the court ſometimes held *fetes-champetres*. In the caſtle-hill is an hollow, comprehending about an acre of ground, and having all the appearance of an artificial work, which was uſed for jouſts, tournaments, and other feats of chivalry.

Northward of the caſtle lies the Govan, or perhaps more properly the *Gowling* hill (A); in the middle of which is a ſmall mount called *Hurly Haaky*, upon which Duke Murdoch and his two ſons were executed for treaſonable practices in the reign of James I.

The proſpect from the caſtle is moſt delightful, as well as extenſive, being greatly beautified, eſpecially upon the eaſt, by the windings of the Forth; which are ſo numerous, that though the diſtance by land from Stirling to Alloa is, in a ſtraight line, not quite ſix miles, it is ſaid to be 24 by water. As this river generally runs upon plain ground, it rolls its ſtream in ſo ſlow and ſilent a manner, that what Silius Italicus ſaith of the Ticinus is applicable to it, if, inſtead of *lucenti* in that poet, we ſhould read *lutoſo*; for the clay-banks, together with the tide, which flows above Stirling, render the Forth perpetually muddy:

> *Vix credas labi, ripis tam mitis opacis*
> *Somniferam ducit* lutoſo *gurgite lympham.*

The lordſhip and caſtle of Stirling were a part of the uſual dowry of the queens of Scotland, at leaſt after the family of Stuart came to the throne, in which they were inveſted at their marriage.

Robert lord Erſkine was appointed governor of the caſtle by King David II. and the office continued in that family till 1715.

This fortreſs hath been the ſcene of many tranſactions. Being by its ſituation conſidered as a key to the northern parts of the kingdom, the poſſeſſion of it hath been always eſteemed of great importance to thoſe who ſought to be maſters of Scotland. It was undoubtedly a place of ſtrength when the art of war by ordnance was in its infancy; but though it reſiſted the utmoſt efforts of the rebels in 1746, it could not now hold out three days if beſieged by an army of a few thouſand men conducted by an engineer of knowledge and integrity.

STIRLINGSHIRE, a county of Scotland, of which Stirling is the capital. It extends 20 miles in length and 12 in breadth; being bounded on the weſt by part of Lennox and Clydeſdale; on the eaſt, by Clackmannanſhire, the river Forth, and part of Lothian; on the ſouth-eaſt, by Lothian; and on the north by Monteith. The face of the country is open and agreeable, diverſified by hill and dale, well watered with ſtreams and rivers; the principal of which is the Forth, riſing in the neighbourhood of a high mountain called *Ben-Lomond*, and, running eaſtward, forms the frith of Edinburgh. The ſouthern part is hilly, affording plenty of game, and paſturage for ſheep, horſes, and black cattle. The eaſtern part is fertile, producing plentiful harveſts of corn, and great abundance of coal. Lead-ore is found in different parts of the county; and the rivers abound with pike, trout, and ſalmon.

The population of this county at two different periods, and according to the different pariſhes, will be ſeen in the following table:

	Pariſhes.	Population in 1755.	Population in 1790—1798.
	Airth	2316	2350
	Alva	436	612
	Baldernock	621	620
	Balfron	755	1381
5	Bothkennar	529	600
	Buchanan	1699	1111
	Campſie	1399	2517
	Denny	1392	1400
	Drymen	2789	1607
10	Falkirk	3932	8020
	Fintry	891	543
	Gargunnock	956	830
	Killearn	959	973
	Kilſyth	1395	2450
15	Kippen	1799	1777
	Larbert and Dunipace	1864	4000
	Muiravonſide	1539	1065
	Polmont	1094	1400
	St Ninians	6491	7079
20	Slamannan	1209	1010
	Stirling	3951	4698
	Strathblane	797	620
		38,813	46 663
			38.813
		Increaſe,	7850*

* *Statiſt. Hiſt. of Scotland.*

STIRRUP, in the manege, a reſt or ſupport for the horſeman's foot, for enabling him to mount, and for keeping him firm in his ſeat.

Stirrups were unknown to the ancients. The want of them in getting upon horſeback was ſupplied by agility or art. Some horſes were taught to ſtoop to take their riders up; but the riders often leapt up by the help of their ſpears, or were aſſiſted by their ſlaves, or made uſe of ladders for the purpoſe. Gracchus filled the highways with ſtones, which were intended to anſwer the ſame end. The ſame was alſo required of the ſurveyors of the roads in Greece as part of their duty.

Menage obſerves, that St Jerome is the firſt author who mentions them. But the paſſage alluded to is not to be found in his epiſtles; and if it were there, it would prove nothing, becauſe St Jerome lived at a time when ſtirrups are ſuppoſed to have been invented, and after the uſe of ſaddles. Montfaucon denies the authenticity of this paſſage; and, in order to account for the ignorance of the ancients with regard to an inſtrument ſo uſeful and ſo eaſy of invention, he obſerves, that while cloths and houſings only were laid upon the horſes backs, on which the riders were to ſit, ſtirrups could not have been uſed, becauſe they could not have been faſtened with the ſame ſecurity as upon a ſaddle. But it is more

Berenger's Hiſtory and Art of Horſemanſhip, vol. i. p. 65.

(A) So called from the wailings and lamentations (in Scotch, *gowlings*) that were made for Duke Murdoch.

more probable, that in this inſtance, as in many others, the progreſs of human genius and invention is uncertain and ſlow, depending frequently upon accidental cauſes.

Stirrup of a Ship, a piece of timber put upon a ſhip's keel, when ſome of her keel happens to be beaten off, and they cannot come conveniently to put or fit in a new piece; then they patch in a piece of timber, and bind it on with an iron, which goes under the ſhip's keel, and comes up on each ſide of the ſhip, where it is nailed ſtrongly with ſpikes; and this they call a ſtirrup.

STOBÆUS, John, a laborious Greek writer, who lived at the end of the fourth century, compoſed many works, of which there are only his Collections remaining, and even theſe are not as he compoſed them; many things being inſerted by later authors. This work contains many important ſentiments collected from the ancient writers, poets, and philoſophers.

STOCK, in gardening, &c. the ſtem or trunk of a tree. What ſtock is moſt proper for each kind of fruit, ought as well to be conſidered and known, as what ſoil is moſt ſuitable to trees; for on theſe two things the future vigour of trees, and the goodneſs of fruit, equally depend. The beſt way for thoſe who intend to plant, is to raiſe their own ſtocks, by which they will be better aſſured of what they do; but if they ſhould buy their trees of nurſerymen, they ſhould diligently inquire upon what ſtocks they were propagated. See Grafting.

Stock, in trade. See *Capital Sock*.

Stock-Broker. See Broker and Stocks.

Stock-Dove. See Columba, Ornithology *Index*.

Stock-Jobbing, the art or myſtery of trafficking in the public ſtocks or funds. See Fund and *Stock-Jobbing*.

Stock Gilly-flower. See Cheiranthus, Botany *Index*.

STOCKHOLM, the capital of Sweden, is ſituated in the province of Upland, in E. Long. 19. 30. and N. Lat. 59. 20. Its foundation is by the beſt Swediſh writers generally attributed to Birger Jarl, regent of the kingdom about the middle of the 13th century during the minority of his ſon Waldemar, who had been raiſed to the throne by the ſtates of the kingdom; but it was not before the 18th century that the royal reſidence was transferred from Upſala to this city.

This capital, which is very long and irregular, occupies, beſide two peninſulas, ſeven ſmall rocky iſlands, ſcattered in the Mæler, in the ſtreams which iſſue from that lake, and in a bay of the gulf of Bothnia. A variety of contraſted and enchanting views are formed by numberleſs rocks of granite riſing boldly from the ſurface of the water, partly bare and craggy, partly dotted with houſes, or feathered with wood. The harbour is an inlet of the Baltic: the water is clear as cryſtal, and of ſuch depth that ſhips of the largeſt burthen can approach the quay, which is of conſiderable breadth, and lined with ſpacious buildings and ware-houſes. At the extremity of the harbour ſeveral ſtreets riſe one above another in the form of an amphitheatre; and the palace, a magnificent building, crowns the ſummit. Towards the ſea, about two or three miles from the town, the harbour is contracted into a narrow ſtrait, and, winding among high rocks, diſappears from the ſight; and the proſpect is terminated by diſtant hills, overſpread with

Coxe's Travels, vol. ii.

foreſt. It is far beyond the power of words, or of the pencil, to delineate theſe ſingular views. The central iſland, from which the city derives its name, and the Ritterholm, are the handſomeſt parts of the town. Excepting in the ſuburbs, where the houſes are of wood painted red, the generality of the buildings are of ſtone, or brick ſtuccoed white. The royal palace, which ſtands in the centre of Stockholm, and upon the higheſt ſpot of ground, was begun by Charles XI.: it is a large quadrangular ſtone edifice, and the ſtyle of architecture is both elegant and magnificent.

It is the habitation not only of the royal family, but alſo of the greater part of the officers belonging to the houſehold. It likewiſe comprehends the national or ſupreme court of juſtice, the colleges of war, chancery, treaſury, and commerce; a chapel, armoury, library, and office for the public records; but the greater number of inferior officers and ſervants belonging to the court, are, with the foot-guards, quartered on the burghers. The caſtle, and all the ſtately edifices in the kingdom, are covered with copper. The palace of the nobility, in which this order ſits during the ſeſſion of the diet, is an elegant building adorned on the outſide with marble ſtatues and columns, and on the inſide with painting and ſculpture. This and three other palaces ſtand on the banks of the lake, and are built on the ſame model, ſo as to compoſe an uniform piece of architecture. The bank, built at the expence of the city, is a noble edifice, and joins with many ſumptuous houſes belonging to the nobility in exhibiting a ſplendid appearance. The houſes of the burghers are generally built of brick in the city; but in the ſuburbs they are commonly made up of timber, and therefore very ſubject to conflagrations. Theſe houſes are often framed in Finland, according to the plan and dimenſions preſcribed: whence they are tranſported in pieces to Stockholm by water, and there ſet up by the carpenters. Theſe wooden habitations, if kept in proper repair, will laſt 30 or 40 years, and are deemed warmer, neater, and more healthy, than thoſe of brick or ſtone. To prevent the danger of conflagrations, the city is divided into 12 wards. In each of theſe there is a maſter and four aſſiſtants, who forthwith repair to the place where the fire breaks out; and all porters and labourers are obliged to range themſelves under the maſter of the ward to which they belong. A fire-watch patroles the ſtreets by night, to give warning or aſſiſtance as it may be wanted; and a centinel is maintained in the ſteeple of every church, to toll the bell on the firſt appearance of any ſuch accident. The police of Stockholm is entirely ſubjected to the regulations of the grand governor, aſſiſted by a deputy and bailiff of the caſtle. This city is the emporium of Sweden, to which all the commodities of the kingdom are brought for exportation, and where almoſt all the imports from abroad are depoſited. The port or haven formed by the lake Mæler is large enough to contain 1000 ſail of ſhipping; and furniſhed with a key or wharf about an Engliſh mile in length, to which the veſſels may lie with their broadſides. The greateſt inconveniences attending this ſituation are, the diſtance from the ſea, which is not within leſs than 10 miles of the town; the want of tides; and the winding of the river, which is remarkably crooked. It opens into the Baltic; and the entrance, which is dangerous and rocky, the Swedes have ſecured with two ſmall forts: within, it is perfectly ſafe and commodious.

dious. The northern ſuburbs are remarkable for the king's gardens, and for the great number of artiſans who have choſen their habitations in this quarter. In the ſouthern ſuburbs the Muſcovite commodities are ſold; and here is a magnificent exchange where the merchants daily aſſemble. Population 80,000.

STOCKING, that part of the clothing of the leg and foot which immediately covers and ſcreens them from the rigour of the cold. Anciently, the only ſtockings in uſe were made of cloth, or of milled ſtuffs ſewed together; but ſince the invention of knitting and weaving ſtockings of ſilk, wool, cotton, thread, &c. the uſe of cloth ſtockings is quite diſcontinued. Dr Howel, in his Hiſtory of the World (vol. ii. p. 222.) relates, that Queen Elizabeth, in 1501, was preſented with a pair of black knit ſilk ſtockings by her ſilk-woman, and thenceforth ſhe never wore cloth ones any more. The ſame author adds, that King Henry VIII. ordinarily wore cloth hoſe, except there came from Spain, by great chance, a pair of ſilk ſtockings. His ſon, King Edward VI. was preſented with a pair of long Spaniſh ſilk ſtockings by Sir Thomas Greſham, and the preſent was then much taken notice of. Hence it ſhould ſeem, that the invention of ſilk knit ſtockings originally came from Spain. Others relate, that one William Rider, an apprentice on London bridge, ſeeing at the houſe of an Italian merchant a pair of knit worſted ſtockings from Mantua, took the hint, and made a pair exactly like them, which he preſented to William earl of Pembroke, and that they were the firſt of that kind worn in England, anno 1564.

The modern ſtockings, whether woven or knit, are formed of an infinite number of little knots, called *ſtitches*, *loops*, or *meſhes*, intermingled in one another.

Knit ſtockings are wrought with needles made of poliſhed iron or braſs wire, which interweave the threads and form the meſhes the ſtocking conſiſts of. At what time the art of knitting was invented it is perhaps impoſſible to determine, though it has uſually been attributed to the Scots, as it is ſaid that the firſt works of this kind came from Scotland. It is added, that it was on this account that the company of ſtocking-knitters, eſtabliſhed at Paris 1527, took for their patron St Fiacre, who is ſaid to have been the ſon of a king of Scotland. But it is moſt probable that the method of knitting ſtockings by wires or needles was firſt brought from Spain.

Woven ſtockings are generally very fine; they are manufactured on a frame or machine made of poliſhed iron, the ſtructure of which it is needleſs to deſcribe, as it may be ſeen in almoſt every conſiderable town in Great Britain. The invention of this machine is, by Mr Anderſon, attributed to Williaw Lee, M. A. of St John's College, Cambridge, at a period ſo early as 1589. Others have given the credit of this invention to a ſtudent of Oxford at a much later period, who, it is ſaid by Aaron Hill *, was driven to it by dire neceſſity. This young man, falling in love with an innkeeper's daughter, married her though ſhe had not a penny, and he by his marriage loſt a fellowſhip. They ſoon fell into extreme poverty; and their marriage producing the conſequences naturally to be expected from it, the amorous pair became miſerable, not ſo much on account of their ſufferings, as from the melancholy dread of what would become of their yet unborn infant. Their only means of ſupport were the knitting of ſtockings, at which the woman was very expert: "But ſitting conſtantly together from morning to night, and the ſcholar often fixing his eyes, with ſtedfaſt obſervation, on the motion of his wife's fingers in the dexterous management of her needles, he took it into his imagination, that it was not impoſſible to contrive a little loom which might do the work with much more expedition. This thought he communicated to his wife, and joining his head to her hands, the endeavour ſucceeded to their wiſh. Thus the ingenious ſtocking-loom, which is ſo common now, was firſt invented; by which he did not only make himſelf and his family happy, but has left his nation indebted to him for a benefit which enables us to export ſilk ſtockings in great quantities, and to a vaſt advantage, to thoſe very countries from whence before we uſed to bring them at conſiderable loſs in the balance of our traffic."

* See *An Account of the Riſe and Progreſs of the Beech Oil Invention*, &c. 8vo. 1715.

STOCKS, *or* PUBLIC FUNDS *in England.* By the word *ſtock* was originally meant a particular ſum of money contributed to the eſtabliſhing a fund to enable a company to carry on a certain trade, by means of which the perſon became a partner in that trade, and received a ſhare of the profit made thereby, in proportion to the money employed. But this term has been extended farther, though improperly, to ſignify any ſum of money which has been lent to the government, on condition of receiving a certain intereſt till the money is repaid, and which makes a part of the national debt. As the ſecurity both of the government and of the public companies is eſteemed preferable to that of any private perſon, as the ſtocks are negociable and may be ſold at any time, and as the intereſt is always punctually paid when due; ſo they are thereby enabled to borrow money on a lower intereſt than what could be obtained from lending it to private perſons, where there muſt be always ſome danger of loſing both principal and intereſt.

But as every capital ſtock or fund of a company is raiſed for a particular purpoſe, and limited by parliament to a certain ſum, it neceſſarily follows, that when that fund is completed, no ſtock can be bought of the company; though ſhares already purchaſed may be transferred from one perſon to another. This being the caſe, there is frequently a great diſproportion between the original value of the ſhares and what is given for them when transferred: for if there are more buyers than ſellers, a perſon who is indifferent about ſelling will not part with his ſhare without a conſiderable profit to himſelf; and on the contrary, if many are diſpoſed to ſell, and few inclined to buy, the value of ſuch ſhares will naturally fall in proportion to the impatience of thoſe who want to turn their ſtock into ſpecie.

A ſtock may likewiſe be affected by the court of chancery: for if that court ſhould order the money, which is under their direction, to be laid out in any particular ſtock, that ſtock, by having more purchaſers, will be raiſed to a higher price than any other of the like value.

By what has been ſaid, the reader will perceive how much the credit and intereſt of the nation depends on the ſupport of the public funds. While the annuities and intereſt for money advanced is there regularly paid, and the principal inſured by both prince and people (a

ſecurity

fecurity not to be had in other nations), foreigners will lend us their property, and all Europe be interefted in our welfare; the paper of the companies will be converted into money and merchandife, and Great Britain can never want cafh to carry her fchemes into execution. See the article FUND.

STOCKS, a frame erected on the fhore of a river or harbour, whereon to build fhipping. It generally confifts of a number of wooden blocks, ranged parallel to each other, at convenient diftances, and with a gradual declivity towards the water.

STOCKS, a wooden machine to put the legs of offenders in, for fecuring diforderly perfons, and by way of punifhment in divers cafes, ordained by ftatute, &c.

STOCKTON upon Tees, a handfome town in the county of Durham, about 16 miles fouth of the city of Durham. It is now a port of confiderable trade; though, at the reftoration, it was a defpicable village, the beft houfe in which could hardly boaft of any thing better than clay-walls and a thatched roof. About 40 years ago it fent out in one year 75 veffels for the port of London; and the trade is much increafed fince.

STOEBE, BASTARD ÆTHIOPIAN, a genus of plants belonging to the clafs fyngenefia; and in the natural fyftem ranging under the 49th order *compofitæ*. See BOTANY *Index*.

STOKESIA, a genus of plants belonging to the fyngenefia clafs, and order of polygamia æqualis. The corollets in the ray are difpofed in the fhape of a funnel, and are long and irregular. The down is four-briftled, and the receptacle is naked. One fpecies only is known, which is a herbaceous plant, and a native of South Carolina.

STOICS, the name given to a fect of Grecian philofophers, from Στοα, "the porch in Athens," which the founder of the fect chofe for his fchool. For the peculiar tenets of this fect, fee METAPHYSICS, Chap. iv. Part 3. MORAL PHILOSOPHY, n° 8. and ZENO.

STOLBERG, a fmall town of Germany, in the circle of Upper Saxony, and territory of Thuringia, of which it is the capital place. It is fituated between two mountains, 50 miles north-weft of Leipfic. E. Long. 11. 8. N. Lat. 51. 42.

STOLE, a facerdotal ornament worn by the Romifh parifh priefts above their furplice, as a mark of fuperiority in their refpective churches; and by other priefts over the alb, at celebrating of mafs, in which cafe it goes acrofs the ftomach; and by deacons, over the left fhoulder, fcarf-wife: when the prieft reads the gofpel for any one, he lays the bottom of his ftole on his head. The ftole is a broad fwath, or flip of ftuff, hanging from the neck to the feet, with three croffes thereon.

Groom of the STOLE, the eldeft gentleman of his Majefty's bedchamber, whofe office it is to prefent and put on his Majefty's firft garment, or fhirt, every morning, and to order the things in the chamber.

STOMACH, in *Anatomy*. See ANATOMY, n° 91.

STOMACHIC MEDICINES are fuch as ftrengthen the ftomach and promote digeftion, &c.

Stomachic corroboratives are fuch as ftrengthen the tone of the ftomach and inteftines; among which are carminatives, as the roots of galangals, red gentian, zedoary, pimpinella, calamus aromaticus, and arum. Of barks and rinds, thofe of canella alba, faffafras, citrons, Seville and China oranges, &c. Of fpices, pepper, ginger, cloves, cinnamon, cardamums, and mace.

STOMOXYS, a genus of infects belonging to the order of diptera. See ENTOMOLOGY, p. 214.

STONE, EDMUND, a diftinguifhed felf-taught mathematician, was born in Scotland; but neither the place nor the time of his birth is well known; nor have we any memoirs of his life, except a letter from the Chevalier de Ramfay, author of the Travels of Cyrus, in a letter to Father Caftel, a Jefuit at Paris, and publifhed in the Memoirs de Trevoux, p. 109, as follows: "True genius overcomes all the difadvantages of birth, fortune, and education; of which Mr Stone is a rare example. Born a fon of a gardener of the duke of Argyle, he arrived at eight years of age before he learnt to read.—By chance a fervant having taught young Stone the letters of the alphabet, there needed nothing more to difcover and expand his genius. He applied himfelf to ftudy, and he arrived at the knowledge of the moft fublime geometry and analyfis, without a mafter, without a conductor, without any other guide but pure genius.

"At 18 years of age he had made thefe confiderable advances without being known, and without knowing himfelf the prodigies of his acquifitions. The duke of Argyle, who joined to his military talents a general knowledge of every fcience that adorns the mind of a man of his rank, walking one day in his garden, faw lying on the grafs a Latin copy of Sir Ifaac Newton's celebrated *Principia*. He called fome one to him to take and carry it back to his library. Our young gardener told him that the book belonged to him. 'To you?' replied the duke. 'Do you underftand geometry, Latin, Newton?' I know a little of them, replied the young man with an air of fimplicity arifing from a profound ignorance of his own knowledge and talents. The duke was furprifed; and having a tafte for the fciences, he entered into a converfation with the young mathematician: he afked him feveral queftions, and was aftonifhed at the force, the accuracy, and the candour of his anfwers. 'But how (faid the duke) came you by the knowledge of all thefe things?' Stone replied, 'A fervant taught me, ten years fince, to read: Does one need to know any thing more than the 24 letters in order to learn every thing elfe that one wifhes?' The duke's curiofity redoubled—he fat down upon a bank, and requefted a detail of all his proceedings in becoming fo learned.

"I firft learned to read, faid Stone: the mafons were then at work upon your houfe: I went near them one day, and I faw that the architect ufed a rule, compaffes, and that he made calculations. I inquired what might be the meaning and ufe of thefe things; and I was informed that there was a fcience called Arithmetic: I purchafed a book of arithmetic, and I learned it.—I was told there was another fcience called Geometry: I bought the books, and I learnt geometry. By reading I found that there were good books in thefe two fciences in Latin: I bought a dictionary, and I learned Latin. I underftood alfo that there were good books of the fame kind in French: I bought a dictionary, and I learned French. And this, my lord, is what I have done: it feems to me that we may learn every thing when we know the 24 letters of the alphabet."

"This account charmed the Duke. He drew this

wonderful

Stone. wonderful genius out of his obſcurity; and he provided him with an employment which left him plenty of time to apply himſelf to the ſciences. He diſcovered in him alſo the ſame genius for muſic, for painting, for architecture, for all the ſciences which depend on calculations and proportions."

"I have ſeen Mr Stone. He is a man of great ſimplicity. He is at preſent ſenſible of his own knowledge; but he is not puffed up with it. He is poſſeſſed with a pure and diſintereſted love for the mathematics, though he is not ſolicitous to paſs for a mathematician; vanity having no part in the great labour he ſuſtains to excell in that ſcience. He deſpiſes fortune alſo; and he has ſolicited me twenty times to requeſt the duke to give him leſs employment, which may not be worth the half of that he now has, in order to be more retired, and leſs taken off from his favourite ſtudies. He diſcovers ſometimes, by methods of his own, truths which others have diſcovered before him. He is charmed to find on theſe occaſions that he is not a firſt inventor, and that others have made a greater progreſs than he thought. Far from being a plagiary, he attributes ingenious ſolutions, which he gives to certain problems, to the hints he has found in others, although the connection is but very diſtant," &c.

Mr Stone was author and tranſlator of ſeveral uſeful works; viz. 1. A New Mathematical Dictionary, in 1 vol. 8vo, firſt printed in 1726. 2. Fluxions, in 1 vol. 8vo, 1730. The Direct Method is a tranſlation from the French, of Hoſpital's Analyſe des Infiniments Petits; and the Inverſe Method was ſupplied by Stone himſelf. 3. The Elements of Euclid, in 2 vols. 8vo, 1731. A neat and uſeful edition of thoſe Elements, with an account of the life and writings of Euclid, and a defence of his Elements againſt modern objectors. Beſide other ſmaller works. Stone was a fellow of the Royal Society, and had inſerted in the Philoſophical Tranſactions (vol. xli. p. 218), an "Account of two ſpecies of lines of the 3d order, not mentioned by Sir Iſaac Newton or Mr Stirling."

STONE, *Jerome*, the ſon of a reputable ſeaman, was born in the pariſh of Scoonie, in the county of Fife, North Britain. His father died abroad when he was but three years of age, and his mother, with her young family, was left in very narrow circumſtances. Jerome, like the reſt of the children, having got the ordinary ſchool education, reading Engliſh, writing, and arithmetic, betook himſelf to the buſineſs of a travelling chapman. But the dealing in buckles, garters, and ſuch ſmall articles, not ſuiting his ſuperior genius, he ſoon converted his little ſtock into books, and for ſome years went through the country, and attended the fairs as an itinerant bookſeller. There is great reaſon to believe that he engaged in this new ſpecies of traffic, more with a view to the improvement of his mind than for any pecuniary emolument. Formed by nature for literature, he poſſeſſed a peculiar talent for acquiring languages with amazing facility. Whether from a deſire to underſtand the Scriptures in their original languages, or from being informed that theſe languages are the parents of many others, he began his philological purſuits with the ſtudy of the Hebrew and Greek tongues; and, by a wonderful effort of genius and application, made himſelf ſo far maſter of theſe, without any kind of aſſiſtance, as to be able to interpret the Hebrew Bible and Greek Teſtament into Engliſh *ad aperturam libri*. At this time he did not know one word of Latin. Senſible that he could make no great progreſs in learning, without the knowledge of at leaſt the grammar of that language, he made application to the pariſh ſchoolmaſter for his aſſiſtance. Some time afterwards, he was encouraged to proſecute his ſtudies at the univerſity of St Andrews. An unexampled proficiency in every branch of literature recommended him to the eſteem of the profeſſors; and an uncommon fund of wit and pleaſantry rendered him, at the ſame time, the favourite of all his fellow ſtudents, ſome of whom ſpeak of him to this day with an enthuſiaſtic degree of admiration and reſpect. About this period ſome very humorous poetical pieces of his compoſition were publiſhed in the Scots Magazine. Before he had finiſhed his third ſeſſion, or term, at St Andrew's, on an application to the college by the maſter of the ſchool of Dunkeld for an uſher, Mr Stone was recommended as the beſt qualified for that office; and about two or three years after, the maſter being removed to Perth, Mr Stone, by the favour of his Grace the Duke of Atholl, who had conceived a high opinion of his abilities, was appointed his ſucceſſor.

When he firſt went to Dunkeld, he entertained but an unfavourable opinion of the Gaelic language, which he conſidered as nothing better than a barbarous inarticulate gibberiſh; but being bent on inveſtigating the origin and deſcent of the ancient Scots, he ſuffered not his prejudices to make him neglect the ſtudy of their primitive tongue. Having, with his uſual aſſiduity and ſucceſs, maſtered the grammatical difficulties which he encountered, he ſet himſelf to diſcover ſomething of the true genius and character of the language. He collected a number of ancient poems, the production of Iriſh or Scottiſh bards, which, he ſaid, were daring, innocent, paſſionate, and bold. Some of theſe poems were tranſlated into Engliſh verſe, which ſeveral perſons now alive have ſeen in manuſcript, before Mr Macpherſon publiſhed any of his tranſlations from Oſſian.

He died while he was writing and preparing for the preſs a treatiſe, intitled, "An Inquiry into the Original of the Nation and Language of the ancient Scots, with Conjectures about the Primitive State of the Celtic and other European Nations;" an idea which could not have been conceived by an ordinary genius. In this treatiſe he proves that the Scots drew their original, as well as their language, from the ancient Gauls. Had Mr Stone lived to finiſh this work, which diſcovers great ingenuity, immenſe reading, and indefatigable induſtry, it would have thrown light upon the dark and early periods of the Scottiſh hiſtory, as he opens a new and plain path for leading us through the unexplored labyrinths of antiquity. But a fever put an end to his life, his labours, and his uſefulneſs, in the year 1757, being then only in the 30th year of his age. He left, in manuſcript, a much eſteemed and well-known allegory, intitled "The Immortality of Authors," which has been publiſhed and often reprinted ſince his death, and will be a laſting monument of a lively fancy, ſound judgement, and correct taſte. It was no ſmall ornament of this extraordinary character, that he paid a pious regard to his aged mother, who ſurvived him two years, and received an annual penſion from the Ducheſs of Atholl as a teſtimony of reſpect to the memory of her ſon.

STONEHIVE,

STONEHIVE, or STONEHAVEN, a ſmall town in the county of Kincardine, in Scotland, 15 miles ſouth from Aberdeen. It was built in the time of Charles II. and ſtands at the foot of ſome high cliffs, in a ſmall bay, with a rocky bottom, opening a little in one part, ſo that ſmall veſſels may find admittance, but only at high water. A pier runs out from the harbour on the north ſide to ſecure them after their entrance. The town contains about 800 inhabitants. The manufactures are ſail-cloths and oſnaburghs, knit worſted and thread ſtockings.

STONES, in *Natural Hiſtory*, have been defined bodies which are inſipid, not ductile, nor inflammable, nor ſoluble in water. For a view of the claſſification of ſtones and of their diſtribution, ſee MINERALOGY and GEOLOGY.

Here we ſhall make a few obſervations on ſome ſpeculative diſcuſſions relative to their natural hiſtory.

As philoſophers have perplexed themſelves much about the origin and formation of the earth (a ſubject certainly far beyond the ken of the human intellect, at leaſt if we believe that it was made by the Almighty power of God), ſo they have alſo propoſed theories to explain the origin of ſtones. When philoſophers limit their inquiries within the boundaries of ſcience, where they are led by the ſober and ſafe conduct of obſervation and experiment, their concluſions may be ſolid and may be uſeful; but when, throwing experiment and obſervation aſide, they rear a theory upon an airy nothing, or upon a ſingle detached fact, their theories will vaniſh before the touch of true philoſophy as a romantic palace before the rod of the enchanter. Sometimes from whim, or caprice, or vanity, they attempt to confound every thing: they wiſh to prove that the ſoul is mere matter, that plants are animals, and that foſſils are plants, and thus would baniſh two ſubſtances, ſpirit and dead matter, entirely from the world; as if the Author of Nature were actuated by ſordid views of parſimony in the works of creation, though we evidently ſee that a generous profuſion is one of the characteriſtic marks of theſe works. We leave the taſk of confounding the different claſſes of being to thoſe philoſophers whoſe minds are too contracted to comprehend a great variety of being at one view, or who prefer novelty to every thing elſe. We content ourſelves with the old opinion, that the ſoul is a ſpiritual ſubſtance; that plants are plants, and that ſtones are ſtones.

We have been led into theſe remarks by finding that ſome philoſophers ſay that ſtones are vegetables; that they grow and increaſe in ſize like a plant. This theory, we believe, was firſt offered to the world by M. Tournefort, in the year 1702, after returning from his travels in the eaſt. It was founded on a curious fact. In ſurveying the labyrinth of Crete, he obſerved that the names which viſitors had engraved upon the rock were not formed of hollow but of prominent letters like baſſo relievos. He ſuppoſes that theſe letters were at firſt hollowed out by knives; that the hollows have ſince been filled up by the growth of the ſtone; and hence he concludes that ſtones vegetate. We wiſh we were fully aſſured of the fact that the letters were at firſt hollowed, before we attempt to account for their prominency. But even allowing the ſuppoſition to be true that they were at firſt hollow, we reply it is only a ſingle fact, and that it is altogether unphiloſophical to deduce a general ſyſtem from a ſingle fact.

In the *ſecond* place, this protuberancy of the characters is very improperly called vegetation, for it is not produced by a proceſs in any reſpect like the vegetation of a plant. Vegetation ſuppoſes veſſels containing fluids and growth by expanſion; but who ever heard of veſſels in a ſtone, of fluids moving in them, or of the different parts expanding and ſwelling like the branch or trunk of a tree? Even the fact which Tournefort mentions proves nothing. He does not pretend to ſay, that the rock itſelf is increaſing, but only that a few ſmall hollows are filled with new ſtony matter, which riſes a little above the ſurrounding ſurface of the rock. This matter evidently has been once liquid, and at length has congealed in the channel into which it had run. But is not this eaſily explained by a common proceſs, the formation of ſtalactites? When water charged with calcareous matter is expoſed to the action of air, the water evaporates, and leaves the calcareous earth behind, which hardens and becomes like a ſtone.

Having thus examined the principal fact upon which M. Tournefort founds his theory, it is unneceſſary to follow him minutely through the reſt of his ſubject.— He compares the accretion of matter in the labyrinth to the conſolidation of a bone when broken, by a callus formed of the extravaſated nutritious juice. This obſervation is thought to be confirmed, by finding that the projecting matter of the letters is whitiſh and the rock itſelf greyiſh. But it is eaſy to find compariſons. The difficulty, as Pope ſays, is to apply them. The reſemblance between the filling up of the hollow of a ſtone, and the conſolidation of a broken bone by a callus, we confeſs ourſelves not philoſophers enough to ſee. Were we writing poetry in bad taſte, perhaps it might appear. The circumſtance, that the prominent matter of the letters is whitiſh, while the rock is greyiſh, we flatter ourſelves ſtrengthens our ſuppoſition that it conſiſts of a depoſition of calcareous matter. Upon the whole, we conclude, we hope logically, that no ſuch theory as this, that ſtones are vegetables, can be drawn from the ſuppoſed fact reſpecting the labyrinth. We have to regret, that the account which we have ſeen of the ſubject is ſo imperfect, that we have not ſufficient materials for a proper inveſtigation. Tournefort has not even told us of what kind of ſtone or earth the accretion conſiſts; yet this ſingle information would probably have decided the queſtion (A).

(A) To give a more diſtinct notion of Tournefort's theory, we ſhall ſubjoin his concluſions: From theſe obſervations (he ſays) it follows, that there are ſtones which grow in the quarries, and of conſequence that are fed; that the ſame juice which nouriſhes them ſerves to rejoin their parts when broken; juſt as in the bones of animals, and the branches of trees, when kept up by bandages; and, in a word, that they vegetate. There is, then (he ſays), no room to doubt but that they are organized; or that they draw their nutritious juice from the

STONES AND EARTHS, Analysis of.

Preliminary Proceſſes.

AT the cloſe of our article Mineralogy, we referred to this place for an account of the method of examining the chemical conſtitution of earths and ſtones. In the article Ores, we have given a pretty full detail of the methods of analyſing that claſs of minerals. In this place we propoſe briefly to point out the moſt improved proceſſes for the analyſis of the other three claſſes of mineral bodies, viz. earths and ſtones, ſalts, and combuſtibles; to which we ſhall add ſome account of the method of examining ſoils.

But before proceeding to the immediate object of this treatiſe, it may be uſeful to make ſome obſervations on ſome preliminary proceſſes connected with the ſubject under conſideration.

In the firſt place, it is neceſſary that the mineral to be examined be reduced to a fine powder. To effect this with very hard ſtones, they are made red hot, and in this ſtate thrown into cold water. By the ſudden change of temperature in the different parts of the ſtone, it cracks, and falls to pieces. If the pieces be not ſufficiently ſmall, the ſame proceſs is to be repeated. The fragments are then to be reduced to ſmaller pieces in a poliſhed ſteel mortar, and the cavity of this mortar ought to be cylindrical. A peſtle of the ſame metal ſhould be made to fit it exactly, that no part of the ſtone may eſcape during the operation of pounding. The ſtone being in this way reduced to powder, a determinate quantity is taken, 100 or 200 grains, for example, and this is to be reduced to as fine a powder as poſſible; or, as it is called, to an impalpable powder. This operation is moſt ſucceſsfully performed in an agate mortar, with a peſtle of the ſame mineral; a mortar of about four inches in diameter, and rather more than one inch deep, is found to anſwer the purpoſe very well. It is found moſt convenient to operate on ſmall quantities only at a time; not more than five or ſix grains. When the powder feels ſoft, adheres, and appears under the peſtle in the form of a cake, it is then as fine as poſſible. It is now to be accurately weighed, and it is uſually found to have acquired ſome additional weight, ariſing from part of the mortar being worn off during the pounding. This additional weight muſt be attended to, and after the analyſis is completed, a part of the ſubſtance of the mortar muſt be ſubtracted. In the caſe of an agate or flint mortar being uſed, the portion rubbed off, which increaſes the weight, may be regarded as pure ſiliceous earth.

The chemical veſſels neceſſary for the analyſis of minerals are crucibles for expoſing the ſubſtances to heat, glaſſes and ſhallow diſhes for ſolutions and evaporations. The crucibles ſhould be of platina or pure ſilver, and of ſuch a capacity as to hold from ſeven to eight cubic inches of water. The veſſels in which the ſolutions, evaporations, and other proceſſes are performed, ſhould be of glaſs or porcelain; the glaſs veſſels, as being more brittle, and therefore more apt to break, are found to be leſs economical than thoſe of porcelain. Some chemiſts employ porcelain veſſels which are in the form of ſections of ſpheres, and are glazed both in the inſide and outſide, excepting part of the bottom, which comes into immediate contact with the fire. Wedgewood's glazed veſſels for evaporations, are found to anſwer very well; the glaze is thin, and the veſſels are not very apt to crack; but it is ſuppoſed by ſome chemiſts, that it is occaſionally acted on by ſtrong acids. It is ſcarcely neceſſary to add, that an accurate balance is a neceſſary inſtrument in the hands of the analyſt.

Preliminary Proceſſes.

I. *Of the Analyſis of* Earths *and* Stones.

The ingredients which have been diſcovered by means of analyſis, in the compoſition of ſimple ſtones are, ſilica, alumina, lime, magneſia, zirconia, and glucina, with ſome of the metallic oxides, as thoſe of iron, copper, mangaueſe, chromium, and nickel; but it never happens that the whole of theſe ſubſtances are found in combination; and indeed it is a rare circumſtance to meet with more than four or five in the ſame ſtone. With a view of diſcovering the different ſubſtances which enter into the compoſition of ſtones, the following method is recommended.

Take 200 grains of the ſtone to be examined, or, if it be inconvenient to procure this quantity, 100 grains will be ſufficient. Let it be reduced to a fine powder, mixed with three times its weight of pure potaſh, and a ſmall portion of water, and then ſubjected to heat in a crucible of ſilver. The heat muſt be applied ſlowly at firſt, and the matter is to be conſtantly ſtirred, that no part of it may be thrown out of the crucible by the ſwelling of the potaſh. The water being evaporated, the mixture is to be kept at a red heat for half an hour; and being removed from the furnace, ſome notion may be formed of the nature of the ingredients, by examining the contents; for, if the mixture be in a liquid ſtate, the ſtone is chiefly compoſed of ſiliceous earth; if it be of the conſiſtence of paſte, and have an opaque appear-

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the earth. This juice muſt be firſt filtrated and prepared in their ſurface, which may be here eſteemed as a kind of bark; and hence it muſt be conveyed to all the other parts. It is highly probable the juice which filled the cavities of the letters was brought thither from the bottom of the roots; nor is there any more difficulty in conceiving this than in comprehending how the ſap ſhould paſs from the roots of our largeſt oaks to the very extremities of their higheſt branches. Some ſtones, then (he concludes), muſt be allowed to vegetate and grow like plants: but this is not all; (he adds), that probably they are generated in the ſame manner; at leaſt, that there are abundance of ſtones whoſe generation is inconceivable, without ſuppoſing that they come from a kind of ſeeds, wherein the organical parts of the ſtones are wrapped up as thoſe of the largeſt plants are in their ſeeds.

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ance, the other earths predominate; but if it remain in a powdery form, the aluminous earth is in greatest proportion. The oxides of different metals are indicated by the colour of the mass; when it is of a dark or brownish red, the metallic oxide is that of iron; a grass green colour denotes manganese; and yellowish green the oxide of chromium.

But there are some stones on which potash has a very feeble action, and in this case borax has been substituted for the alkali. This is the method which was followed by Mr Chenevix in analysing aluminous stones. A hundred grains of sapphire in powder were mixed with 250 grains of calcined borax, and subjected to a strong heat in a crucible of platina for two hours. When the mass was cold, it exhibited the appearance of a greenish blue glass, which adhered strongly to the crucible; but the whole being boiled for some hours in muriatic acid, it was completely dissolved; the earthy matter was then precipitated by means of sub-carbonate of ammonia, and the precipitate, after being well washed, was again dissolved in muriatic acid; and in this way the borax was separated. The remaining part of the analysis was nearly similar to that directed for other stones, excepting only that the alumina was separated from the potash by means of muriate of ammonia.

But to return to the examination and farther treatment of the mass in the silver crucible, which after being removed from the furnace, and wiped on the outside, is to be placed in a porcelain capsule; it is then filled with water, and this water is renewed occasionally, till the whole matter is separated from the crucible. By this means a part of the compound of the alkali with the siliceous and aluminous earths, is dissolved, and with a sufficient quantity of water, the whole may be dissolved. Muriatic acid is now to be added till the whole of the mass is brought to a state of solution. This, however, will not be the case, if the stone be composed chiefly of silica. On the first addition of the acid, a flakey precipitate is produced, because the acid unites with the alkali, which held the mass in solution. An effervescence afterwards takes place, which arises from the decomposition of a portion of carbonate of potash, formed during the fusion; and the flakey precipitate is again dissolved, as well as the matter which remained in the form of powder at the bottom of the vessel. If the powder be silica and alumina, there is no effervescence; but if it contain lime, an effervescence is produced. The solution in the muriatic acid being formed, if it shall appear colourless, it may be inferred that it contains no metallic oxide, or at least a very small portion. An orange red colour shews that it contains iron, a purplish red indicates manganese, and a golden yellow, chromium.

The solution is now to be introduced into an evaporating dish of porcelain, and being covered with paper, is to be placed on a sand bath, and evaporated to dryness. Towards the end of the evaporation, as the liquid assumes the form of a jelly, it must be constantly stirred with a rod of silver or porcelain, to permit the acid and water to pass off, and to allow the whole mass to be equally dried; for it is in this way that the silica and alumina are separated from each other. The matter being reduced to a dry powder, add to it a large quantity of pure water, expose it to a moderate heat, and pour it on a filter. This solution may be denominated A. Wash repeatedly the powder which remains upon the filter, till the water with which it is washed no longer precipitates silver from its solutions. The powder remaining is siliceous earth, which is first to be dried between folds of blotting paper, and then made red hot in a crucible of platina or silver; and when it is cold it is to be accurately weighed. If it be pure siliceous earth, it is in the form of a white powder, is of a white colour, does not adhere to the fingers, and is insoluble in acids. If it be at all coloured, it shews that it contains some metallic oxide, and is a proof that the evaporation has been carried on with too great a heat. To separate the oxide, boil the silica with an acid, and then wash and dry it as before. This acid solution is to be added to the solution A, and the whole is to be evaporated to about the quantity of an English pint; then add to it a solution of carbonate of potash, till the precipitation ceases; and it may be necessary to boil it a few moments, to allow the whole of the precipitate to fall to the bottom. The whole of the precipitate being collected at the bottom, the supernatant liquid is decanted off, and the water being put in its place, the precipitate and water are thrown on a filter; and when the water has run off, the filter with the precipitate upon it is placed on the folds of blotting paper. After the precipitate has acquired some degree of consistence, collect it carefully with an ivory knife, mix it with a solution of pure potash, and boil it in a capsule of porcelain. The potash dissolves the alumina or glucina, and the other substances remain in the form of a powder. This powder may be called B.

Add to the solution of potash as much acid as will saturate the potash, and also redissolve any precipitate which at first appeared; and then add carbonate of ammonia till the taste of it be perceptible in the liquid. The whole of the alumina is now precipitated in the form of white flakes, while the glucina remains dissolved, if a sufficient quantity of carbonate of ammonia had been employed. Filter the liquid; and the alumina remaining on the filter being washed and dried, and after being made red hot, and allowed to cool, is weighed. To prove its being alumina, dissolve it in sulphuric acid, and a sufficient quantity of sulphate or acetate of potash being added, the whole of it will be converted into alum crystals, if the earth employed be aluminous earth.

To separate the glucina, the liquid which passed through the filter is to be boiled for some time, and if the solution contain any of this earth it will be precipitated in the form of a light powder, which may be dried in the usual manner, and weighed. It is a fine, soft, light, tasteless powder, when in a state of purity; and the application of heat does not make it concrete, as happens to alumina.

We now return to the residuum B, in which may be expected lime, magnesia, and some of the metallic oxides. But if it be suspected that this residuum contains any yttria, it is to be treated with carbonate of ammonia, which dissolves the yttria, and leaves the other bodies untouched. The yttria being separated, the residuum B is to be dissolved in weak sulphuric acid, and the solution evaporated to dryness. Add a small quantity of water, which will dissolve the sulphate of magnesia, as well as the metallic sulphates; but the sulphate of lime remains undissolved, or if any part of it should

dissolve,

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dissolve, it may be thrown down by adding a small portion of weak alcohol. After being made red hot in a crucible, it is to be weighed, and the lime will amount to $\frac{42}{100}$ of the weight. The solution containing the remaining sulphates being diluted with a large portion of water, a small excess of acid is to be added, and then a saturated carbonate of potash. The magnesia and oxide of manganese remain dissolved, and the oxides of chromium, iron, and nickel, are precipitated. This precipitate may be denominated C.

Add to the solution a solution of hydrosulphuret of potash, and the manganese in the state of a hydrosulphuret will be precipitated. Calcine the precipitate in contact with air, and weigh it. The addition of pure potash to the solution will precipitate the magnesia, which being washed, and subjected to a red heat, is also to be weighed.

The residuum C is to be repeatedly boiled with nitric acid, and then mixed with pure potash; and, being heated, the liquid is to be decanted off. The precipitate thus obtained, consisting of the oxides of iron and nickel, is to be washed with pure water, and this water is to be added to the solution of the nitric acid and potash. The chromium, if any be present, is contained in that solution, and is in the form of an acid. Add to the solution muriatic acid in excess, and let the evaporation be continued till the liquor become of a green colour; then add a pure alkali, by which the chromium is precipitated in the state of oxide, which is to be dried in the usual way, and weighed.

The precipitate containing the oxides of iron and nickel is to be dissolved in muriatic acid; ammonia is to be added in excess, when the oxide of iron precipitates; and being collected, washed and dried, is to be weighed. By evaporating the solution, the oxide of nickel will be also precipitated, or the whole may be precipitated by the addition of hydrosulphuret of ammonia. This being treated in the same manner as the other substances, is also to be weighed.

The weight of the whole substances thus obtained being added together, and being compared with the weight of the matter originally operated upon, if the two be equal, or if the difference do not exceed three or four parts in 100, it may be inferred that the analysis is nearly correct; but a considerable loss of weight indicates some error, and requires the analysis to be carefully repeated. If the same loss of weight appear, it may be concluded that the stone contained some substance which is soluble in water, or has been driven off by the heat. To ascertain the last point, a portion of the stone is to be broken into small pieces, and exposed to a strong heat, in a porcelain retort. If it contain water, or any volatile substance, it will come over into the receiver, and by this means the nature and weight of the ingredients separated may be ascertained. If nothing come over into the receiver, or if what is obtained be not equal to the deficient weight, it may be inferred that the stone contains some matter which is soluble in water.

A fixed alkali has been not unfrequently found in simple stones; and to ascertain whether the mineral subjected to analysis contains any alkaline matter, different methods have been pursued. These methods we shall now describe. The stone being reduced to an impalpable powder, is cautiously heated repeatedly with sulphuric acid, and the mass is to be digested in water; and this solution being properly concentrated, is set aside for some days. The appearance of crystals of alum is a certain indication that the mineral contained potash; and the quantity of potash may be estimated at $\frac{104}{1000}$ of the weight of those crystals; but if no crystals be obtained, the solution is to be evaporated to dryness, and the residuum exposed to a moderate red heat. Digest it afterwards in water, and add carbonate of ammonia, and filter; evaporate again to dryness, expose the residue to a heat of 700°, and redissolve it. The solution being properly concentrated, will give crystals of sulphate of soda or of potash, as the one or the other alkali is present. Potash may be discovered by adding to the solution of the salt, a solution of nitro-muriate of platina somewhat concentrated. A yellow precipitate, which is muriate of platina and potash, is thus obtained.

Klaproth's method for discovering fixed alkalies in minerals is the following. He takes four parts of nitrate of barytes to one of the mineral to be examined, and fuses them together in a porcelain crucible. A spongy mass of a light-blue colour was thus obtained, and with the addition of diluted muriatic acid, was completely dissolved. The solution, which was of a yellow colour, was then mixed with a sufficient quantity of sulphuric acid, by which the barytes is precipitated, and the muriatic acid expelled. The liquid is next evaporated to dryness, and the mass being digested in water, is filtered, and the sulphate of barytes and silica remain on the filter. The clear solution is saturated with carbonate of ammonia, and filtered a second time; and all the earthy and metallic bodies being separated, the sulphates of fixed alkali and ammonia only remain in the solution, which being evaporated to dryness, the dry saline mass is introduced into a porcelain crucible, and subjected to such a degree of heat as is sufficient to drive off the sulphate of ammonia. The residuum is then dissolved in water, and crystallized; and thus a pure, fixed alkaline sulphate is obtained, which is again dissolved in water, and decomposed, by adding acetate of barytes. The solution is then filtered, and the liquid is evaporated to dryness. The saline mass obtained is the acetate of a fixed alkali, which being exposed to heat in a crucible, became of a reddish colour. The carbonaceous residuum is then to be dissolved in water, filtered, and crystallized, and the salt thus procured is a carbonate of a fixed alkali, the nature of which may be easily recognised by the means stated above.

Mr Davy's method of detecting a fixed alkali in minerals, is different *. One hundred grains of the stone in very fine powder are to be fused for half an hour at a strong red heat, in a crucible of platina or silver, with 200 grains of boracic acid. An ounce and half of nitric acid diluted with seven or eight times its quantity of water, is then digested upon the fused mass, till the decomposition of the whole is completed. Evaporate the fluid to about two ounces, or one ounce and a half; by this means the siliceous earth is separated, which being collected on a filter, is to be washed with distilled water, till the boracic acid and the whole of the saline matter are separated. The fluid is then mixed with water that has passed through the filter, and evaporated to the quantity of half a pint, after which it is saturated with carbonate of ammonia, and boiled with an excess of this salt, till the whole of the substances capable of being

* *Nichol. Jour.* xiii. 86.

being precipitated, have been thrown down. The ſolution being filtered, the earths and metallic oxides remain on the filter. Add nitric acid to the liquid till it acquire a ſtrong ſour taſte, and evaporate till the boracic acid appear free.

The fluid is then to be filtered, and evaporated to dryneſs, and the dry maſs being expoſed to a heat of about 450° Fahrenheit, the nitrate of ammonia is decompoſed, and the nitrate of potaſh or ſoda remains behind.

To detect fluoric acid, which has been ſometimes met with as a component part of ſtones, Klaproth heats the mineral with ſulphuric acid in a glaſs retort, the corroſion of which, and the depoſition of ſilica in the water of the receiver, are certain teſts of fluoric acid.

After the general obſervations which have now been offered, we proceed to give examples of the analyſis of minerals belonging to the different genera of earths and ſtones; and we ſhall follow the ſame order in which thoſe genera are deſcribed in the article MINERALOGY.

1. ZIRCON Genus.

The mineral affording the earth which characteriſes this genus, was analyſed by Klaproth in the following manner *. We ſelect that ſpecies which is called hyacinth.

* *Eſſays*, i. 195.

A. 100 grains of hyacinth being levigated in the flint-mortar, received an increaſe of weight of half a grain.

B. This pulverized hyacinth, digeſted with two ounces of nitro-muriatic acid, yielded, upon ſaturating the ſolution with potaſh, a light-brown precipitate, of three grains and a half, when dried. Ammonia, added to it, diſſolved nothing; and it remained colourleſs. After the precipitate had been again ſeparated from the volatile alkali, muriatic acid was added, which diſſolved its ferruginous contents, leaving a white earth behind, which, when ignited, weighed $1\frac{1}{2}$ grain. The portion of iron, precipitated by cauſtic ammonia from the muriatic ſolution, weighed half a grain, when ignited, and became black and reſplendent. It was fuſed with a neutral phoſphate, upon charcoal, to find whether it contained mangāneſe; no trace was perceptible.

C. The above $1\frac{1}{2}$ grains of earth B were now added again to the hyacinth, after treatment with acids. The ſtone was then ſubjected to red heat, with ſix times its quantity of cauſtic alkali, in the manner explained in the eſſay on the jargon of Ceylon; the ignited maſs was again liquefied with water; and the earth remaining after this proceſs weighed 123 grains, when collected, edulcorated, and dried.

D. The alkaline lixivium was then ſaturated with muriatic acid, and evaporated. At firſt it continued clear; but towards the end ſiliceous earth ſeparated, the quantity of which, after ignition, amounted to ſix grains.

E. To the 123 grains, previouſly well waſhed with water, a ſufficient quantity of muriatic acid was added; which, with the aſſiſtance of heat, diſſolved nearly the whole, a trifling reſidue excepted. This muriatic ſolution, evaporated in a moderate heat to a ſixth or eighth part, loſt its fluidity, and formed a limpid gelatinous coagulum. It was then covered with water, and expoſed, with repeated agitation, to a digeſting heat. By this management, the ſiliceous earth ſeparated in ſlimy, intumeſced grains, and weighed, after ignition, $23\frac{1}{2}$ grains.

F. The ſolution, thus freed from its ſilica, was now ſaturated with a boiling ley of mild alkali; and the precipitate was waſhed and dried in the air. This laſt weighed 114 grains, proving, upon every trial, to be jargonic earth. A fourth part of it, heated to redneſs, weighed $16\frac{1}{2}$ grains; which make the whole amount to 66 grains.

G. The above ſix grains D, with the $23\frac{1}{2}$ grains E, in the whole $29\frac{1}{2}$ grains of ſiliceous earth, were ignited with a quadruple weight of vegetable alkali. When this maſs had been again ſoftened with water, it left a reſidue, which was extracted by muriatic acid. From this muriatic ſolution, alſo, when ſaturated with potaſh, jargonic earth fell down, weighing four grains after ignition. Hence, ſubtracting theſe, the quantity of ſiliceous earth is reduced to $25\frac{1}{2}$ grains.

One hundred parts of hyacinth, therefore, have given

Jargonia -	F	66	70
	G	4	
Silica -	G	$25\frac{1}{2}$	
Subtract	A	$\frac{1}{2}$	
			25
Oxide of iron	B	-	0.50
			95.50
		Loſs	4.50
			100

2. Of the SILICEOUS Genus.

A great proportion of the ſtones belonging to this genus are tranſparent, and have a vitreous appearance. They are ſo hard as to ſcratch glaſs, and, excepting the fluoric acid, they are not acted upon by acids. By fuſion with alkalies they form glaſs; they alſo enter into fuſion with boracic acid, and the acid of phoſphorus. Stones compoſed chiefly of pure ſilica, are tranſparent and colourleſs. When a mineral is preſented for examination, even if it poſſeſs moſt of the properties which characterize ſtones belonging to this genus, ſome preliminary proceſſes may be purſued to aſcertain farther its nature and component parts.

A. It is ſometimes difficult to reduce ſiliceous ſtones to a fine powder. To facilitate this operation, a a portion of the ſtone may be heated to redneſs, and in this ſtate ſuddenly plunged into cold water. If by the firſt heating it is not ſufficiently brittle, the operation may be repeated until the mineral can be reduced to a fine powder, as already directed.

B. One part of the ſtone in fine powder is now to be mixed with four or five parts of potaſh, diſſolved in the ſame quantity of water. The mixture is introduced into a ſilver crucible, and evaporated to dryneſs, ſtirring it conſtantly with a ſilver rod, according to the directions given above. The maſs being evaporated to dryneſs, the heat is to be gradually increaſed, till the crucible appears of a dull red heat, or till the maſs enter into quiet fuſion. In this ſtate it is kept for an hour.

C. Remove the crucible from the fire before it is completely cold; ſoften the maſs with water, by adding freſh

freſh portions from time to time, till the whole is detached from the crucible, and then add 12 times its bulk of water to effect a ſolution. If the ſtone conſiſted chiefly of ſiliceous earth, the greater part of the maſs will be diſſolved.

D. Add muriatic acid till no farther precipitate is effected, and without ſeparating the precipitate, evaporate the whole to dryneſs.

E. Pour ſix times its bulk of muriatic acid, previouſly diluted with four parts of water, on the dry maſs; boil the mixture for half an hour; let the inſoluble part ſubſide, and then collect it on a filter, and after being dried, ſubject it in a crucible to a red heat. This powder is the ſiliceous earth contained in the mineral.

But ſtones included under this genus contain very different proportions, not only of ſiliceous earth, but alſo of the other earths; and ſome of them even contain a far greater proportion of other earths than that which characterizes the genus under which they are arranged.

Analyſis of Leucite.

The analyſis of this mineral is particularly intereſting, not only as Klaproth firſt detected in it potaſh, which was ſuppoſed to belong excluſively to the vegetable kingdom, and hence called vegetable alkali, but alſo as it places the ſkill and addreſs of that eminent chemiſt in its examination in a very conſpicuous light. The proceſs was conducted in the following manner*.

* *Eſſays*, i. 348.

Ignited alone upon charcoal, the leucite is completely infuſible. It undergoes no manner of alteration, and its ſplinters loſe nothing of their luſtre.

A ſmall fragment, put into fuſed borax, is for a long time moved about in it before it diſſolves, which it does by degrees; and the glaſs globule obtained is clear and light-brown.

By fuſion with a neutral phoſphate, the ſolution is ſtill ſlower, and a colourleſs rifty glaſs pearl is produced.

One hundred grains of coarſely pounded leucite expoſed for an hour to a ſtrong red heat, in a ſmall porcelain pot, loſt of weight only one-eighth of a grain, and even the violent heat of the porcelain furnace produced in the leucite only an inconſiderable change.

A. One hundred grains of leucite, reduced to an impalpable powder, being ſeveral times digeſted in muriatic acid, diſſolved a conſiderable part. A ſiliceous reſidue of 54 grains remained after ignition.

B. The ſiliceous earth ignited with twice its weight of cauſtic alkali, ſoftened again with water, covered with muriatic acid, added to exceſs of ſaturation, and, after ſufficient digeſtion with this laſt, being collected on the filter, and heated to redneſs, was found to have loſt little of its weight.

C. Pruſſiate of potaſh added to the muriatic ſolution produced a precipitate which indicated one-eighth of a grain of oxide of iron.

D. The ſolution by cauſtic ammonia being decompoſed, and the precipitate being ſeparated, the remaining liquor was tried with carbonate of ſoda, but no farther change was effected.

E. The precipitate produced by means of pure ammonia D was firſt dried. It was next purified by digeſting it with diſtilled vinegar, and afterwards neutralizing this acid by ammonia. It weighed 24 grains and a half, when edulcorated and ignited. Diluted ſulphuric acid completely diſſolved it to a limpid liquor, and when properly treated, the ſolution yielded only alum.

F. To obtain the earth, which poſſibly might have remained latent in the ſeveral waſhings, the whole were evaporated to dryneſs. After having re-diſſolved the ſaline maſs in water, the remaining portion of earth was collected, it amounted only to half a grain, and was ſiliceous earth.

There were therefore obtained,

Silica	-	(A)	54		
———	-	(F)	$\frac{1}{2}$		
			$54\frac{1}{2}$	-	54.50
Alumina	-	(E)	-	-	24.50
					79
			Loſs		21
					100

The remarkable loſs of more than one-fifth of the whole weight of the mineral under examination, excited ſuſpicion that ſome error had crept into the analyſis, and led to a repetition of the experiments, by varying the proceſſes as follows.

A. One hundred grains of leucite in fine powder were ignited for half an hour, with double their weight of cauſtic potaſh. To the maſs ſoftened with water muriatic acid was added, juſt to the point of ſaturation, and the mixture being filtered, the remaining undiſſolved reſiduum was waſhed and dried.

B. The mineral thus prepared for decompoſition, was then treated with muriatic acid, and kept for ſome time at a boiling heat. By this proceſs a quantity of ſilica ſeparated, which after being heated to redneſs weighed 54 grains and a half.

C. Oxalate of potaſh being added to the muriatic ſolution, concentrated by evaporation, produced no turbidity. The alumina was ſeparated by the ſame means as in the former experiments, and its weight amounted to nearly the ſame. By other trials it did not appear to have any mixture of other earths, and no other earth could be obtained by evaporating the waters with which the powders had been waſhed.

Thus, after varying the experiments, the ſame reſults were obtained, and the ſame loſs ſtill appeared. In the farther proſecution of this inveſtigation, the following experiments were had recourſe to.

A. Two hundred grains of leucite in fine powder were repeatedly digeſted with muriatic acid, and the ſiliceous earth collected on the filter, waſhed, and weighed after being red hot, amounted to 109 grains.

B. The muriatic ſolution was of a yellowiſh colour, and being reduced by evaporation in a ſand heat to the conſiſtence of honey, the ſurface appeared covered with a ſaline cruſt; and when completely cooled, the maſs appeared like a thick clear oil, of a golden yellow colour, and full of cryſtals, ſome of which were of a cubical, and ſome of a tabular form. The yellow fluid was gently poured off, and the ſalt rinſed with ſmall portions of alcohol. The ſolution diluted with alcohol was again evaporated, and the ſmall portion of ſalt thus obtained

Siliceous Genus.

tained was again washed with alcohol, and added to the first. The whole of the salt being dried, weighed 70 grains. This was dissolved in water, and some drops of a solution of ammonia being added, threw down some particles of alumina. The solution being crystallized in a warm place, yielded only cubical crystals, some of which were elongated to four-sided columns.

C. That part of the muriatic solution which shot into crystals being diluted with water, and decomposed in a boiling heat, by carbonate of soda, yielded a precipitate, which after washing, drying, and ignition, amounted to $47\frac{3}{4}$ grains of aluminous earth. Three times its weight of concentrated sulphuric acid was added, and the mixture was evaporated nearly to dryness. The mass was again dissolved in water, and combined with a solution of acetate of potash, which being crystallized, produced only alum.

D. The siliceous earth A was mixed with double its weight of potash, and subjected to a strong red heat for an hour. The mass was reduced to powder, and diluted with water. Muriatic acid was added in excess, and digested with it. The filtered muriatic solution being saturated with soda yielded $1\frac{1}{2}$ grain of aluminous earth, after which there remained of silica $107\frac{1}{2}$ grains.

The 200 grains of leucite have thus afforded of

	grs.
Silica D	107.50
Alumina C	47.75
——— D	1.55
	156.75

Here there was still a deficiency of 43.25 grains, to account for which the 70 grains of salt B must be examined. This examination was conducted in the following manner.

1. The taste and figure of the crystals were found to be the same with those of muriate of potash.

2. The solution produced no change in vegetable blues, or in reddened litmus paper.

3. When heated to redness, the salt made a crackling noise, and remained fixed in the fire.

4. Neither carbonate of soda nor caustic ammonia produced any turbidity in the solution.

5. Two parts of strong sulphuric acid were added to three of the salt, and the muriatic acid being driven off by heat, the mass was again dissolved in water, which afforded crystals of sulphate of potash.

6. The remaining portion of salt was dissolved in a small quantity of water, and to this was added a concentrated solution of crystallized acid of tartar. The acidulous tartrate of potash (cream of tartar) was thus immediately produced and precipitated in the form of sand. This was washed, dried, burnt in a silver crucible, and the coal obtained repeatedly washed with water. The solution being evaporated to dryness, after being examined by the proper tests, appeared to be a carbonate of potash, which being saturated with nitric acid, afforded nitrate of potash.

Thus it appears that the base of the 70 grains of salt consisted entirely of pure potash, which was neutralized by part of the muriatic acid employed in decomposing the mineral; and according to the proportion of base in muriate of potash, the 70 grains A contain 42.7 grains of alkali; and in this way the deficiency in the examination of the leucite is accounted for.

Siliceous Genus.

The result of the analysis is as follows.

	grs.
Silica -	53.75
Alumina	24.62
Potash	21.35
	129.72

Analysis of Pitchstone.

The pitchstone which is the subject of the following analysis, also conducted by Klaproth, is the transparent yellowish or olive green variety of that mineral from Meissen. It affords an example of soda, the other fixed alkali, forming a component part of stones.

A. 100 grains in coarse fragments were introduced into a covered crucible, and were subjected to a red heat for half an hour. When taken from the fire they appeared of a white gray mixed with a yellowish colour, and having a rough feel, with something of the appearance of glazing. They lost $8\frac{1}{2}$ grains of weight.

B. In the heat of a porcelain furnace, the pitchstone was fused both in the clay and charcoal crucible, and was converted into a clear glass, full of small froth holes.

C. 100 grains of pitchstone in fine powder were treated with a solution of 200 grains of caustic soda, and being put into a silver crucible, were kept for half an hour in a pretty strong red heat. The mass was then softened with water; muriatic acid was added in excess; the solution was evaporated in a sand heat, nearly to dryness; water was again poured upon it, after which it was filtered, and 73 grains of siliceous earth were obtained.

D. Caustic soda was mixed in excess with the muriatic solution, and the whole was digested in a boiling heat, by which the precipitate formed at the beginning of the process was again dissolved; a brown residuum still remained, which being separated, the alkaline solution was neutralized, and precipitated with carbonate of soda. The precipitate, which was alumina, after being washed, dried, and heated to redness, amounted to $14\frac{1}{2}$ grains. The whole of it yielded crystals of alum, with sulphuric acid and potash.

E. The residuum which remained undissolved by the caustic soda D, was first dissolved in muriatic, and then united with sulphuric acid. Sulphate of lime was obtained, which was collected, and washed with diluted alcohol. By reducing the filtered fluid by evaporation to a smaller quantity, and combining it with sulphuric acid, another portion of sulphate of lime, which, added to the first, amounted to three grains, indicating 18 grains of pure lime.

F. The fluid was now freed from the calcareous earth; the iron which it contained was precipitated by carbonate of ammonia, which amounted to one grain. The remaining fluid was evaporated to dryness, and water being added to the saline residuum, fine minute flocks of oxide of manganese separated, but in no greater quantity than one-tenth of a grain.

G. 100 grains of pitchstone in powder were mixed with 300 grains of crystallized nitrate of barytes, and heated to redness in a porcelain vessel, till the salt was entirely

Argillaceous Genus.

entirely decompofed. The cold mafs was foftened with water, neutralized with muriatic acid, and combined in fuch proportion with fulphuric acid, that the latter, after the evaporation of the mixture, and feparation of the muriatic acid by heat, was ftill in excefs. The mafs was wafhed with hot water; the refiduum feparated by filtration; and the clear fluid was mixed with carbonate of ammonia in excefs. The precipitate thus obtained was collected on a filter, and the remaining fluid was evaporated to drynefs, and the portion of fulphate of ammonia fubjected to a moderate heat in a porcelain veffel, was driven off. A fixed falt remained, which appeared to be fulphate of foda. This was rediffolved, and decompofed by acetate of barytes; the filtered folution was evaporated to drynefs; the dry falt was heated to rednefs in a crucible of platina. The faline refiduum being rediffolved, filtered, and again evaporated to drynefs, yielded three grains of dry carbonate of foda, indicating $1\frac{3}{4}$ grain of pure foda. This being neutralized with nitric acid, gave cryftals cf nitrate of foda.

The 100 grains of the mineral thus examined confift of

	grs.
Silica C	73.
Alumina D	14.5
Lime E	1.
Oxide of iron D	1.
——— manganefe D	.10
Soda G	1.75
Water A	8.50
	99.85

3. Argillaceous Genus.

As many of the ftones included under this genus are compofed of fimilar fubftances with thofe arranged in the former genus, it is obvious that the examination is to be conducted in the fame way. We fhall therefore give one example of the analyfis of a ftone belonging to this genus, and the example is that of bafalt by Klaproth *.

* Effays, ii. 195.

Analyfis of Bafalt.

A. Small fragments of this ftone were fubjected to a ftrong red heat for 30 minutes; the lofs of weight was two per cent. and the mafs became of a lighter colour, and more readily yielded to the peftle.

B. Bafalt expofed to the heat of a porcelain furnace in a common clay crucible, fufed into a compact black brown glafs, which in thin fplinters was tranfparent. It alfo entered into thin fufion in a crucible of femi-indurated fteatites; part of it ran into the clefts produced in the fteatites, and the reft was found cryftallized in brown fhining lamellæ, which on the furface were ftriated, and cellularly concreted. In a charcoal crucible it was converted into a dull gray and finely porous mafs, in which were inferted numerous grains of iron.

C. To afcertain whether this ftone contained foda, 100 grains of bafalt in fine powder were mixed with 400 grains of nitrate of barytes, and were at firft expofed in a large porcelain veffel to a moderate heat, and afterwards to a heat gradually raifed to ignition. The mixture fwelled up, and when the heat was increafed, white fumes arofe on uncovering the veffel, which led to a fuppofition that the foda was beginning to volatilize. The fire was then removed.

Argillaceous Genus.

D. The porous mafs, after cooling and being reduced to powder, was drenched with water, and treated with muriatic acid. The whole entered into folution, and produced a clear yellow fluid. The folution was evaporated, and fulphuric acid was added gradually, till it was in excefs. The fulphate of barytes was precipitated.

E. The faline mafs by filtration was reduced to drynefs, and water was added, the fediment feparated, and appeared to confift of the fulphate of barytes, and the filiceous earth of the ftone. The clear fluid was faturated with ammonia, and the precipitate which was obtained being filtered off, the neutralized liquor was evaporated to drynefs, and then expofed in a porcelain veffel to a moderately intenfe heat, till the whole fulphate of ammonia was driven off. The fixed portion remaining diffolved in water, and cryftallized, appeared to be pure fulphate of foda. This was diffolved, decompofed by acetate of barytes; the precipitate, which was fulphate of barytes, was feparated by the filter, and the clear fluid being evaporated to drynefs, the dry acetate of foda was heated to rednefs in a crucible of platina; and in this way $4\frac{1}{2}$ grains of dry carbonate of foda was obtained, which is equal to 2.6 grains of pure foda.

F. To feparate the other ingredients, 100 grains of powdered bafalt were ignited for two hours with 400 grains of carbonate of foda, in a crucible of porcelain; but with a degree of heat which did not produce fufion. It united into a yellowifh, fomewhat hard mafs, which being reduced to powder, and foftened with water, was neutralized with muriatic acid. It was then a little fuperfaturated with nitric acid, and evaporated to drynefs. The colour of the dry mafs was faffron yellow. It was diffufed in water, flightly acidulated with muriatic acid, and after being digefted for a fhort time it was filtered. The filiceous earth collected on the filter was expofed to a red heat, and being weighed, amounted to $44\frac{1}{2}$ grains.

G. The muriatic folution being fufficiently diluted with water, was precipitated at the temperature of boiling water, by means of carbonate of foda. The precipitate being feparated, was digefted with a folution of cauftic foda, and a dark brown refiduum was feparated by filtration. Muriatic acid was added in a fmall excefs to the alkaline fluid, and this was precipitated with carbonate of ammonia. The precipitate obtained, after being wafhed and ignited, amounted to $16\frac{3}{4}$ grains. It yielded alum, when treated with fulphuric acid and potafh, and was therefore aluminous earth.

H. The brown refiduum G was diffolved in muriatic acid with particular attention to the precife point of faturation. Succinate of ammonia was added to the folution, to precipitate the iron; and the fuccinate of iron obtained, when perfectly wafhed and ftrongly heated in a covered crucible, afforded 20 grains of oxide of iron, which were attracted by the magnet.

I. The iron being feparated, the fluid was treated at the temperature of boiling with carbonate of foda; a white precipitate was obtained, which was diffolved in nitric acid; and fulphuric acid being combined with the folution, threw down fulphate of lime. This was feparated, and the remaining liquor being evaporated nearly

Argillaceous Genus.

nearly to dryneſs, was again diluted with a mixture of water and alcohol. Another portion of ſulphate of lime fell down, which being ſeparated, was added to the former. The whole of the ſulphate of lime was decompoſed by boiling it with carbonate of ſoda in ſolution, and the carbonate of lime thus obtained, after being waſhed and dried, weighed 17 grains, indicating nine grains and a half of pure lime.

K. Upon the fluid left from the laſt proceſs, cauſtic ſoda was affuſed; a ſlimy precipitate was formed, which rapidly diſſolved in ſulphuric acid, and communicated a brown colour to the ſolution. It was evaporated in a ſand bath; looſe brown flakes fell down at the commencement of the proceſs, and theſe being ſeparated by the filter, appeared to be oxide of mangneſe; the quantity eſtimated did not exceed one-eighth of a grain.

L. The remaining portion of the fluid was evaporated to dryneſs, and the reſiduum was expoſed in a ſmall crucible to a ſtrong red heat. It was again diſſolved in water, and yielded a ſmall portion of alumina coloured with iron, and contaminated with mangneſe. After ignition it did not weigh more than half a grain; but the clear ſolution was entirely cryſtallized, and afforded ſulphate of magneſia. Carbonate of ſoda was added to the magneſian ſalt in ſolution, by which the earthy baſe was precipitated in the ſtate of carbonate. It weighed ſix grains, which is equal to $2\frac{1}{4}$ grains of pure magneſia.

The following is the reſult of the preceding analyſis.

Silica F	44.5 grs.
Alumina G	16.25
——— I	.5
Oxide of iron H	20.
Lime I	9.5
Magneſia L	2.25
Oxide of mangneſe K	.12
Soda E	2.60
Water A	2.
	97.72

4. Magnesian Genus.

Beſides ſeveral of the earths detected in minerals belonging to the former genera, the ſtones arranged under this genus are diſtinguiſhed by being combined with magneſia. We ſhall only give one example of the analyſis of a magneſian ſtone.

Analysis of Steatites.

This mineral, which was found in Cornwall, was analyzed by Klaproth in the following manner.

A. One ounce of the ſtone in ſmall pieces was ſubjected to a ſtrong red heat, by placing the glaſs retort which contained it in an open fire. A ſmall portion of water diſtilled over, which was pure and taſteleſs. The mineral loſt 75 grains of its weight, and became darker in the colour, and conſiderably harder.

B. After being reduced to powder, it was carefully mixed, and heated red hot, with two ounces of carbonate of potaſh in a porcelain pot. The concreted maſs was levigated with water, and digeſted with muriatic acid in exceſs. A white looſe ſlimy earth was precipitated, which after being waſhed, dried, and ſubjected to a red heat, weighed 204 grains. It was pure ſilica.

Magneſian Genus.

C. Pruſſiate of potaſh was added to the filtered ſolution, and produced a blue precipitate, which being collected, waſhed, dried, and ignited with a little wax, was found, after cooling, to weigh ſeven grains. The whole of it was attracted by the magnet. The portion of iron belonging to the pruſſiate of potaſh being ſubtracted, left $3\frac{3}{4}$ grains of oxide of iron as a conſtituent of the mineral under examination.

D. Carbonate of potaſh being added to the ſolution freed from the iron, precipitated its earthy ingredient. This, after waſhing, and gentle ignition, weighed 192 grains. Theſe were covered with a proportionate quantity of concentrated diſtilled vinegar, and being digeſted in a low heat, were thrown upon the filter. The earth remaining on the paper, which, after being dried and heated red hot, weighed 93 grains, was mixed with three times its weight of ſtrong ſulphuric acid, and the mixture being evaporated in a ſand heat nearly to dryneſs, the dry maſs was diſſolved in water and filtered; 26 grains of ſiliceous earth were thus obtained.

E. In the ſulphuric ſolution D, there ſtill remained 67 grains of earth, which being precipitated by an alkali, appeared to conſiſt entirely of aluminous earth.

F. Ninety-nine grains of the firſt, 192 grains of the earthy precipitate D, were taken up by the acetic acid, which being precipitated by carbonate of potaſh, and the earth obtained being tried by ſulphuric acid, was found to be pure magneſia.

This analyſis ſhows that the 480 grains of ſteatites thus examined, afforded

Silica B	204
——— D	26
Magneſia F	99
Alumina E	67
Oxide of iron C	3.75
Water A	75.
	474.75
Loſs	5.25
	480.00

or 100 parts of the mineral contain

Silica	48
Magneſia	20.5
Alumina	14.
Oxide of iron	1.
Water	15.5
	99.0

5. Calcareous Genus.

The analyſis of ſtones belonging to this genus muſt be varied according to the nature of the combination into which the lime has entered. With regard to the proceſſes to be followed in the examination of calcareous ſtones, they are ſuſceptible of a natural diviſion into ſuch as are ſoluble in muriatic or nitric acid with effervescence, and ſuch as are ſcarcely ſoluble in thoſe acids, and do not effervesce. To the firſt belong all the ſtones called limeſtones, or carbonates of lime; and to the ſecond belongs ſulphate of lime, or gypſum.

Analysis of Carbonate of Lime.

Carbonate of lime, whether in the form of lime ſpar, or in a leſs pure ſtate, in the form of limeſtone, is ſoluble with

with effervescence in nitric or muriatic acid. When exposed to heat, it yields carbonic acid gas, and is converted into quicklime; and when fused with an alkali, does not form a uniform mass. But we shall give a short view of the processes to be followed in a more particular examination.

A. Let a determinate quantity of the stone be reduced to a fine powder. Digest it repeatedly with muriatic acid till no further action is produced upon it. Dilute the solution, throw it upon a filter, and, after drying, weigh the insoluble residuum.

B. Let the remaining solution be diluted with 24 times its bulk of water; add sulphuric acid diluted; a precipitate takes place if the stone contained any barytes, the amount of which, after being collected and dried, may be ascertained by weighing.

C. Add to the filtered solution, after the barytes has been separated, a solution of carbonate of soda, as long as any precipitate is formed. Collect this precipitate, and let it be so much dried that it may be easily removed from the filter.

D. Affuse the precipitate with sulphuric acid till all effervescence ceases.

E. Introduce the whole into a mixture of three parts of distilled water, and one of alcohol, in the proportion of eight parts of the mixture to the quantity of the substance previously dissolved in nitric acid. Let the whole be digested for some hours in the cold, filter the fluid, and dry the insoluble residuum and weigh it.

F. The remaining solution is next to be decomposed by a solution of carbonate of potash, and the precipitate being collected, is to be washed, dried, and weighed.

By this examination, if the stone is to be ranked with carbonate of lime, the weight of the insoluble part E, after subtracting from it one-third, must exceed the weight of the insoluble parts A and B.

Analysis of Sulphate of Lime.

As this is insoluble in nitric or muriatic acids, its analysis must be conducted in a different manner.

A. Let one part of the mineral, reduced to fine powder, be boiled with four times its weight of carbonate of potash, in a sufficient quantity of water for two or three hours; as the fluid evaporates, water is to be added.

B. Introduce the insoluble mass obtained by the last process into a flask containing diluted nitric acid, and the whole being dissolved, let it be evaporated to dryness, and weighed.

C. Add to the dried mass more than its own weight of strong sulphuric acid; apply heat, and let it be gradually increased till fumes cease to rise, and let it be again weighed.

D. Let the insoluble part be digested in twice its weight of cold water; filter the fluid, collect the insoluble residuum, and dry it in a dull red heat. To ascertain the quantity of lime, subtract from the weight of the insoluble mass left (in C) 59 parts; what remains is equal to the quantity of lime.

E. The quantity of lime also may be ascertained, by subjecting for some hours to a red heat, the insoluble mass B; for by this process it will be converted into quicklime.

Analysis of Fluate of Lime.

In the examination of this mineral, a quantity of it may be reduced to powder, and moistened with sulphuric acid, in a leaden or pewter vessel. The mixture being heated, fumes arise, to which a plate of glass being exposed, is soon corroded. In this way the fluoric acid may be detected, and the quantity of base may be ascertained by decomposing the mineral by means of sulphuric acid, and afterwards analysing the sulphate of lime, as already directed.

Analysis of Phosphate of Lime.

The analysis of this mineral may be conducted in the following manner.

A. Let a determinate portion be digested in five times its quantity of muriatic acid, and let the operation be repeated till the acid has no farther action upon the residuum; decant the fluid, and then let it be diluted with water and filtered.

B. Add to the muriatic solution, liquid ammonia; collect the precipitate which is formed, and after being washed and dried, expose it to heat.

C. Add nitric acid to the precipitate till the whole is dissolved. Precipitate again by means of sulphuric acid; let the whole then be filtered, and let the insoluble residuum be washed with as little water as possible.

D. Evaporate the filtered fluid to the consistence of syrup; the fluid thus obtained is phosphoric acid, if the stone examined have been phosphate of lime. The test of phosphoric acid is, that it precipitates lime water, and also forms precipitates with the solutions of sulphate of iron, and nitrate of mercury; but it does not precipitate the muriate or nitrate of barytes.

6. Barytic Genus.

Analysis of Carbonate of Barytes.

A. Take a determinate quantity of the mineral, and dissolve it in diluted nitric acid; take a portion of the solution, and add to it a solution of sulphate of soda. If a precipitate take place, by adding a small quantity of the salt to the solution of the earth, diluted with 24 times its bulk of water, it may be inferred that the base of the mineral is barytes.

B. Let the nitric solution be evaporated to dryness, and exposed in a silver crucible to a white heat; the earth obtained is barytes, which is soluble in 20 times its weight of water; and after evaporation, crystallizes into long four-sided prisms.

Analysis of Sulphate of Barytes.

This mineral was analyzed by Klaproth in the following manner.

A. 200 grains were mixed with 500 grains of carbonate of potash, and were exposed for two hours to a red heat; the mass was reduced to powder, boiled with water, and the undissolved earth was collected on the filter.

B. To separate the siliceous earth, the fluid was neutralised by muriatic acid, and evaporated to dryness. The saline mass was redissolved in water, and the silica remaining after being ignited, weighed 18 grains.

C. The barytic earth, freed from the sulphuric acid B, was covered with water; muriatic acid was added; the whole was dissolved by digestion, except two grains of silica. The filtered solution was crystallized, and afforded muriate of barytes.

D. The crystals were redissolved in water, and sulphuric acid was added to the solution, while any precipitate appeared, and the regenerated sulphate of barytes being

Barytic Genus.

being washed and dried, weighed 185 grains, but after ignition, only 180 grains.

One hundred parts of this mineral are therefore composed of

Sulphate of barytes D	90
Silica B	9
—— C	1
	100 *

* Essays, i. 375.

7. Strontian Genus.

Analysis of Carbonate of Strontites.

This mineral was analyzed by Klaproth, in the following manner.

A. 100 parts were dissolved in muriatic acid, diluted with half its quantity of water. Thirty parts of carbonic acid were driven off during the solution, which being evaporated, afforded crystals in the shape of needles; and these crystals being dissolved in alcohol, communicated to it the property of burning with a carmine red flame. This is the test of strontitic earth.

B. To ascertain whether the mineral examined contained any barytes, three drops of a solution of one grain of sulphate of potash in six ounces of water were added to the muriatic solution; no appearance of precipitate was observed till next day, and therefore it contained no barytes, as in that case an immediate precipitate would have taken place.

C. Carbonate of potash was then added to the muriatic solution; a decomposition took place; and the carbonate of strontites was precipitated. This being subjected to a strong heat, the carbonic acid was driven off, and the whole of the remaining earth being dissolved in water, crystallized. After being dried, it weighed 69.5.

One hundred parts of this mineral therefore contain

Pure earth	69.5
Carbonic acid	30.
Water	.5
	100.0 †

† Ibid. i. 231.

II. Salts.

The analysis of minerals arranged under this class, is in general less difficult, in consequence of their easy solubility, than those already examined. We shall therefore give only one example.

Analysis of Native Saltpetre.

This native salt was examined by Klaproth ‡, according to the following method.

‡ Ibid. i. 270.

A. 1000 grains of the native salt, with limestone and gypsum to which it adhered, were covered with boiling water. The colourless solution was gently evaporated; during the crystallization, tender needle-shaped crystals of selenite appeared, and the whole of the solution crystallized to a perfect prismatic nitre. The selenite weighed 40 grains, and the salt amounted to 446 grains.

B. To ascertain whether any common salt could be detected in the mineral, the crystals were redissolved in water, and acetate of barytes was dropt into the solution. A precipitate was obtained, amounting to 26 grains of sulphate of barytes, shewing that $18\frac{1}{2}$ grains of selenite were still combined with the neutral salt. A solution of nitrate of silver was added to the nitric solution, which produced a precipitate of $4\frac{1}{2}$ grains of muriate of silver, so that the quantity of common salt can only be estimated at two grains. The pure nitre is thus reduced to $425\frac{1}{2}$ grains. Klaproth suspects that the neutral muriate mixed with the native nitre, is rather a muriate of potash, than muriate of soda.

Salts.

C. The stony matters remaining amounted to 500 grains; muriatic acid was poured upon them, and produced great effervescence with pieces of limestone. One hundred and eighty-six grains of white gypsum remained; and the sulphuric acid being separated from it, by boiling with carbonate of potash, the carbonate of lime remaining behind dissolved without residuum in nitric acid.

D. The limestone taken up by the muriatic acid, weighed 304 grains. Being farther examined, it appeared to be calcareous earth, slightly contaminated with iron.

One hundred parts, therefore, of this salt contain

Pure prismatic nitre B	42.55
Muriate of a neutral salt B	.20
Sulphate of lime A B C	25.45
Carbonate of lime D	30.4
Loss	1.4
	100.00

III. Combustibles.

Analysis of Coal.

The constituent parts of coal are carbone and bitumen, with some earthy matters, and sometimes a small quantity of metallic matter. The proportion of earthy matters contained in coal may be ascertained by weighing a determinate quantity, and burning it. The nature of the earths contained in the residuum may be discovered by the processes already given.

To ascertain the proportion of charcoal and bitumen contained in coal, we shall describe the method followed by Mr Kirwan.

It has been found that a certain proportion of carbone or pure charcoal, detonated with nitre in the state of ignition, decomposes a given proportion of that salt; and it appears from the experiments of Lavoisier, that 13.21 parts of charcoal decompose 100 parts of nitre, while the detonation is performed in close vessels; but in an open crucible, a smaller proportion of charcoal is required, in consequence of part of the nitre being decomposed by the action of the air of the atmosphere. According to Kirwan, about 10 parts of charcoal are sufficient to decompose 96 parts of nitre. Mr Kirwan also found that vegetable pitch and maltha did not produce any detonation with nitre, but merely burnt on its surface; and that the same quantity of charcoal was required for the decomposition of the nitre, as if no bituminous substance had been employed. Since, therefore, bitumen produces no effect in decomposing nitre, Kirwan thought that the proportion of charcoal, in any coal, might be ascertained by detonation with nitre. In this way the proportion of carbonaceous and earthy matter in any coal being discovered, the proportion of bitumen which it contains may be estimated by calculation.

In the experiments on the analysis of coal, Mr Kirwan employed a large crucible placed in a wind furnace, and exposed to an equable heat. The coal was reduced to small

Combustibles.

ſmall pieces of the ſize of a pin head, and was projected in portions of one or two grains at a time, into the nitre, the moment it became red hot. This was continued till the detonation ceaſed.

By this proceſs it appeared that 50 grains of Kilkenny coal were neceſſary to decompoſe 480 grains of nitre. According to the ſame proportion, 96 grains of nitre would have required for its decompoſition 10 grains of coal, which is exactly equal to the quantity of charcoal that would have been required to produce the ſame effect; and thus it appeared that Kilkenny coal is almoſt entirely compoſed of carbonaceous matter.

In the examination of cannel coal, Mr Kirwan burnt 240 grains, till the whole of the carbonaceous matter was conſumed; a reſiduum of ſeven grains and a half of reddiſh brown aſhes, which appeared to be chiefly aluminous earth, was left, or about 3.12 per cent. Sixty-ſix grains and a half of this coal were found neceſſary to decompoſe 480 grains of nitre. Fifty grains of charcoal would have produced the ſame effect, and hence 66½ grains of coal contain 50 of charcoal, and 2.08 parts of aſhes, which being ſubtracted from 66½ grains, leaves 14.42 for the quantity of bitumen contained in the coal. Hence the conſtituent parts of this coal are,

Charcoal	75.2
Bitumen	21.68
Aſhes	3.1
	99.98

For a more particular analyſis of combuſtible minerals, ſee Mr Hatchett's experiments, detailed in the Philoſophical Tranſactions for 1804.

IV. *Analyſis of* Soils.

The examination of ſoils is by no means the leaſt important, becauſe on a knowledge of the nature and proportions of the ingredients which enter into the compoſition of ſoils, depends the opinion to be formed of their fertility. Soils conſiſt of different combinations of the earths, mixed with a certain proportion of animal and vegetable matter. The inveſtigation of the nature of ſoils has been particularly proſecuted by Mr Kirwan * and Mr Davy. From the obſervations of the latter, the following account of the analyſis of ſoils is extracted.

* See his *Treatiſe on Manures.*

1 Inſtruments for the analyſis of ſoils.

1. The really important inſtruments required for the analyſis of ſoils are few, and but little expenſive. They are, a balance capable of containing a quarter of a pound of common ſoil, and capable of turning when loaded with a grain; and a ſeries of weights from a quarter of a pound troy to a grain; a wire ſieve, ſufficiently coarſe to admit a pepper-corn through its apertures; an Argand lamp and ſtand; ſome glaſs bottles; Heſſian crucibles; porcelain or queen's ware evaporating baſons; a Wedgewood peſtle and mortar; ſome filters made of half a ſheet of blotting paper, folded ſo as to contain a pint of liquid, and greaſed at the edges; a bone knife, and an apparatus for collecting and meaſuring aëriform fluids.

The chemical ſubſtances or reagents required for ſeparating the conſtituent parts of the ſoil, are muriatic acid (ſpirit of ſalt), ſulphuric acid, and pure volatile alkali diſſolved in water, ſolution of pruſſiate of potaſh, ſoap lye, ſolution of carbonate of ammonia, of muriate of ammonia, ſolution of neutral carbonate of potaſh, and nitrate of ammonia.

Soils.

2 Mode of collecting ſoils for analyſis.

2. In caſes when the general nature of the ſoil of a field is to be aſcertained, ſpecimens of it ſhould be taken from different places, two or three inches below the ſurface, and examined as to the ſimilarity of their properties. It ſometimes happens, that upon plains the whole of the upper ſtratum of the land is of the ſame kind, and in this caſe one analyſis will be ſufficient; but in valleys, and near the beds of rivers, there are very great differences, and it now and then occurs that one part of a field is calcareous, and another part ſiliceous; and in this caſe, and in analogous caſes, the portions different from each other ſhould be ſeparately ſubmitted to experiment.

Soils, when collected, if they cannot be immediately examined, ſhould be preſerved in phials quite filled with them, and cloſed with ground glaſs ſtoppers.

The quantity of ſoil moſt convenient for a perfect analyſis is from two to four hundred grains. It ſhould be collected in dry weather, and expoſed to the atmoſphere till it becomes dry to the touch.

The ſpecific gravity of a ſoil, or the relation of its weight to that of water, may be aſcertained by introducing into a phial, which will contain a known quantity of water, equal volumes of water and of ſoil; and this may be eaſily done by pouring in water till it is half full, and then adding the ſoil till the fluid riſes to the mouth; the difference between the weight of the ſoil and that of the water will give the reſult. Thus, if the bottle contain 400 grains of water, and gains 200 grains when half filled with water and half with ſoil, the ſpecific gravity of the ſoil will be two, that is, it will be twice as heavy as water; and if it gained 165 grains, its ſpecific gravity would be 1825, water being 1000.

It is of importance that the ſpecific gravity of a ſoil ſhould be known, as it affords an indication of the quantity of animal and vegetable matter it contains; theſe ſubſtances being always moſt abundant in the lighter ſoils.

The other phyſical properties of ſoils ſhould likewiſe be examined before the analyſis is made, as they denote, to a certain extent, their compoſition, and ſerve as guides in directing the experiments. Thus, ſiliceous ſoils are generally rough to the touch, and ſcratch glaſs when rubbed upon it; aluminous ſoils adhere ſtrongly to the tongue, and emit a ſtrong earthy ſmell when breathed on; and calcareous ſoils are ſoft, and much leſs adheſive than aluminous ſoils.

3 Mode of aſcertaining the quantity of water abſorbed by ſoils.

3. Soils, though as dry as they can be made by continued expoſure to air, in all caſes ſtill contain a conſiderable quantity of water, which adheres with great obſtinacy to the earths and animal and vegetable matter, and can only be driven off from them by a conſiderable degree of heat. The firſt proceſs of analyſis is, to free the given weight of the ſoil from as much of this water as poſſible, without, in other reſpects, affecting its compoſition; and this may be done by heating it for ten or twelve minutes over an Argand's lamp, in a baſon of porcelain, to a temperature equal to 300 Fahrenheit; and in caſe a thermometer is not uſed, the proper degree may be eaſily aſcertained, by keeping a piece of wood in contact with the bottom of the diſh: as long as the colour of the wood remains unaltered, the heat is not too high; but when the wood begins to be charred, the proceſs muſt be ſtopped. A ſmall quantity of water will perhaps remain in the ſoil even after this operation, but

but it always affords uſeful comparative reſults; and if a higher temperature were employed, the vegetable or animal matter would undergo decompoſition, and in conſequence the experiment be wholly unſatisfactory.

The loſs of weight in the proceſs ſhould be carefully noted; and when in 400 grains of ſoil it reaches as high as 50, the ſoil may be conſidered as in the greateſt degree abſorbent, and retentive of water, and will generally be found to contain a large proportion of aluminous earth. When the loſs is only from 20 to 10, the land may be conſidered as only ſlightly abſorbent and retentive, and the ſiliceous earth as moſt abundant.

4 Separation of ſtones, &c.

4. None of the looſe ſtones, gravel, or large vegetable fibres ſhould be divided from the pure ſoil till after the water is drawn off; for theſe bodies are themſelves often highly abſorbent and retentive, and in conſequence influence the fertility of the land. The next proceſs, however, after that of heating, ſhould be their ſeparation, which may be eaſily accompliſhed by the ſieve, after the ſoil has been gently bruiſed in a mortar. The weights of the vegetable fibres or wood, and of the gravel and ſtones, ſhould be ſeparately noted down, and the nature of the laſt aſcertained: if calcareous, they will effervesce with acids; if ſiliceous, they will be ſufficiently hard to ſcratch glaſs; and if of the common aluminous claſs of ſtones, they will be ſoft, eaſily ſcratched with a knife, and incapable of effervescing with acids.

5 Separation of the ſand and clay, or loam, from each other.

5. The greater number of ſoils, beſides gravel and ſtones, contain larger or ſmaller proportions of ſand of different degrees of fineneſs; and it is a neceſſary operation, the next in the proceſs of analyſis, to detach them from the parts in a ſtate of more minute diviſion, ſuch as clay, loam, marle, and vegetable and animal matter. This may be effected in a way ſufficiently accurate, by agitation of the ſoil in water. In this caſe, the coarſe ſand will generally ſeparate in a minute, and the finer in two or three minutes; whilſt the minutely divided animal or vegetable matter will remain in a ſtate of mechanical ſuſpenſion for a much longer time; ſo that, by pouring the water from the bottom of the veſſel, after one, two, or three minutes, the ſand will be principally ſeparated from the other ſubſtances, which, with the water containing them, muſt be poured into a filter, and, after the water has paſſed through, collected, dried, and weighed. The ſand muſt likewiſe be weighed, and their reſpective quantities noted down. The water of lixiviation muſt be preſerved, as it will be found to contain the ſaline matter, and the ſoluble animal or vegetable matters, if any exiſt in the ſoil.

6 Examination of the ſand.

6. By the proceſs of waſhing and filtration, the ſoil is ſeparated into two portions, the moſt important of which is generally the finely divided matter. A minute analyſis of the ſand is ſeldom or never neceſſary, and its nature may be detected in the ſame manner as that of the ſtones or gravel. It is always either ſiliceous ſand, or calcareous ſand, or a mixture of both. If it conſiſt wholly of carbonate of lime, it will be rapidly ſoluble in muriatic acid, with effervescence; but if it conſiſt partly of this ſubſtance, and partly of ſiliceous matter, the reſpective quantities may be aſcertained by weighing the reſiduum after the action of the acid, which muſt be applied till the mixture has acquired a ſour taſte, and has ceaſed to effervesce. This reſiduum is the ſiliceous part; it muſt be waſhed, dried, and heated ſtrongly in a crucible: the difference between the weight of the whole, indicates the proportion of calcareous ſand.

7 Examination of the finely divided matter of ſoils, and mode of detecting mild lime and magneſia.

7. The finely divided matter of the ſoil is uſually very compound in its nature; it ſometimes contains all the four primitive earths of ſoils, as well as animal and vegetable matter; and to aſcertain the proportions of theſe with tolerable accuracy, is the moſt difficult part of the ſubject.

The firſt proceſs to be performed, in this part of the analyſis, is the expoſure of the fine matter of the ſoil to the action of the muriatic acid. This ſubſtance ſhould be poured upon the earthy matter in an evaporating baſon, in a quantity equal to twice the weight of the earthy matter; but diluted with double its volume of water. The mixture ſhould be often ſtirred, and ſuffered to remain for an hour or an hour and a half before it is examined.

If any carbonate of lime or of magneſia exiſt in the ſoil, they will have been diſſolved in this time by the acid, which ſometimes takes up likewiſe a little oxide of iron; but very ſeldom any alumina.

The fluid ſhould be paſſed through a filter; the ſolid matter collected, waſhed with rain water, dried at a moderate heat, and weighed. Its loſs will denote the quantity of ſolid matter taken up. The waſhings muſt be added to the ſolution; which, if not ſour to the taſte, muſt be made ſo by the addition of freſh acid, when a little ſolution of common pruſſiate of potaſh muſt be mixed with the whole. If a blue precipitate occur, it denotes the preſence of oxide of iron, and the ſolution of the pruſſiate muſt be dropped in till no further effect is produced. To aſcertain its quantity, it muſt be collected in the ſame manner as other ſolid precipitates, and heated: the reſult is oxide of iron.

Into the fluid freed from oxide of iron, a ſolution of neutralized carbonate of potaſh muſt be poured till all effervescence ceaſes in it, and till its taſte and ſmell indicate a conſiderable exceſs of alkaline ſalt.

The precipitate that falls down is carbonate of lime; it muſt be collected on the filter, and dried at a heat below that of redneſs.

The remaining fluid muſt be boiled for a quarter of an hour, when the magneſia, if any exiſt, will be precipitated from it, combined with carbonic acid, and its quantity is to be aſcertained in the ſame manner as that of the carbonate of lime.

If any minute proportion of alumina ſhould, from peculiar circumſtances, be diſſolved by the acid, it will be found in the precipitate with the carbonate of lime, and it may be ſeparated from it by boiling for a few minutes with ſoap lye, ſufficient to cover the ſolid matter. This ſubſtance diſſolves alumina, without acting upon carbonate of lime.

Should the finely divided ſoil be ſufficiently calcareous to effervesce very ſtrongly with acids, a very ſimple method may be adopted for aſcertaining the quantity of carbonate of lime, and one ſufficiently accurate in all common caſes.

Carbonate of lime, in all its ſtates, contains a determinate proportion of carbonic acid, *i. e.* about 45 per cent.; ſo that when the quantity of this elaſtic fluid, given out by any ſoil during the ſolution of its calcareous matter in an acid, is known, either in weight or meaſure, the quantity of carbonate of lime may be eaſily diſcovered.

When

Soils.

When the procefs by diminution of weight is employed, two parts of the acid and one part of the matter of the foil muft be weighed in two feparate bottles, and very flowly mixed together till the effervefcence ceafes; the difference between their weight before and after the experiment denotes the quantity of carbonic acid loft; for every four grains and a half of which, ten grains of carbonate of lime muft be eftimated.

The beft method of collecting the carbonic acid, fo as to difcover its volume, is by the pneumatic apparatus, the conftruction and application of which are defcribed at the end of this article. The eftimation is, for every ounce meafure of carbonic acid, two grains of carbonate of lime.

8 Mode of afcertaining the quantity of infoluble finely divided animal and vegetable matter.

8. After the fine matter of the foil has been acted upon by muriatic acid, the next procefs is to afcertain the quantity of finely divided infoluble animal and vegetable matter that it contains.

This may be done with fufficient precifion, by heating it to ftrong ignition in a crucible over a common fire till no blacknefs remains in the mafs. It fhould be often ftirred with a metallic wire, fo as to expofe new furfaces continually to the air; the lofs of weight that it undergoes denotes the quantity of the fubftance that it contains deftructible by fire and air.

It is not poffible to afcertain whether this fubftance is wholly animal or vegetable matter, or a mixture of both. When the fmell emitted during the incineration is fimilar to that of burnt feathers, it is a certain indication of fome animal matter; and a copious blue flame at the time of ignition almoft always denotes a confiderable proportion of vegetable matter. In cafes when the experiment is needed to be very quickly performed, the deftruction of the decompofable fubftances may be affifted by the agency of nitrate of ammonia, which, at the time of ignition, may be thrown gradually upon the heated mafs, in the quantity of twenty grains for every hundred of refidual oil. It affords the principle neceffary to the combuftion of the animal and vegetable matter, which it caufes to be converted into elaftic fluids; and it is itfelf at the fame time decompofed and loft.

9 Mode of feparating aluminous and filiceous matter and oxide of iron.

9. The fubftances remaining after the decompofition of the vegetable and animal matter, are generally minute particles of earthy matter containing ufually alumina and filica with combined oxide of iron.

To feparate thefe from each other, the folid matter fhould be boiled for two or three hours with fulphuric acid, diluted with four times its weight of water; the quantity of the acid fhould be regulated by the quantity of folid refiduum to be acted on, allowing for every hundred grains two drachms or one hundred and twenty grains of acid.

The fubftance remaining after the action of the acid may be confidered as filiceous; and it muft be feparated and its weight afcertained, after wafhing and drying in the ufual manner.

The alumina and the oxide of iron, if they exift, are both diffolved by the fulphuric acid; they may be feparated by carbonate of ammonia, added to excefs; it throws down the alumina, and leaves the oxide of iron in folution; and this fubftance may be feparated from the liquid by boiling.

Should any magnefia and lime have efcaped folution i the muriatic acid, they will be found in the fulphur acid; this, however, is fcarcely ever the cafe; but the procefs for detecting them, and afcertaining their quantities, is the fame in both inftances.

Soils.

The method of analyfis by fulphuric acid is fufficiently precife for all ufual experiments; but if very great accuracy be an object, dry carbonate of potafh muft be employed as the agent, and the refiduum of the incineration muft be heated red for half an hour, with four times its weight of this fubftance, in a crucible of filver, or of well baked porcelain. The mafs obtained muft be diffolved in muriatic acid, and the folution evaporated till it is nearly folid; diftilled water muft then be added, by which the oxide of iron and all the earths, except filica, will be diffolved in combination as muriates. The filex, after the ufual procefs of lixiviation, muft be heated red; the other fubftances may be feparated in the fame manner as from the muriatic and fulphuric folutions.

10. If any faline matter, or foluble vegetable or animal matter, be fufpected in the foil, it will be found in the water of lixiviation ufed for feparating the fand. 10 Mode of difcovering foluble animal and vegetable matter, and faline matter.

This water muft be evaporated to drynefs in an appropriate difh, at a heat below its boiling point.

If the folid matter obtained is of a brown colour and inflammable, it may be confidered as partly vegetable extract. If its fmell, when expofed to heat, be ftrong and fœtid, it contains animal mucilaginous or gelatinous fubftance; if it be white and tranfparent, it may be confidered as principally faline matter. Nitrate of potafh (nitre), or nitrate of lime, is indicated in this faline matter, by its detonating with a burning coal. Sulphate of magnefia may be detected by its bitter tafte; and fulphate of potafh produces no alteration in folution of carbonate of ammonia, but precipitates folution of muriate of barytes.

11. Should fulphate or phofphate of lime be fufpected in the entire foil, the detection of them requires a particular procefs upon it. A given weight of it, for inftance four hundred grains, muft be heated red for half an hour in a crucible, mixed with one third of powdered charcoal. The mixture muft be boiled for a quarter of an hour, in a half-pint of water, and the fluid collected through the filter, and expofed for fome days to the atmofphere in an open veffel. If any foluble quantity of fulphate of lime (gypfum) exifted in the foil, a white precipitate will gradually form in the fluid, and the weight of it will indicate the proportion. 11 Mode of detecting fulphate of lime (gypfum) and phofphate of lime in foils.

Phofphate of lime, if any exift, may be feparated from the foil after the procefs for gypfum. Muriatic acid muft be digefted upon the foil, in quantity more than fufficient to faturate the foluble earths; the folution muft be evaporated, and water poured upon the folid matter. This fluid will diffolve the compounds of earths with the muriatic acid, and leave the phofphate of lime untouched.

12. When the examination of a foil is completed, the products fhould be claffed, and their quantities added together; and if they nearly equal the original quantity of foil, the analyfis may be confidered as accurate. It muft however be noticed, that when phofphate or fulphate of lime is difcovered by the independent procefs 11. a correction muft be made for the general procefs, by fubtracting a fum equal to their weight from the quantity of carbonate of lime obtained by precipitation from the muriatic acid. 12 Refults and products.

In arranging the products, the form fhould be in the order

order of the experiments by which they were obtained.

Thus, 400 grains of a good ſiliceous ſandy ſoil may be ſuppoſed to contain

Of water of abſorption - -	18 grs.
Of looſe ſtones and gravel, principally ſiliceous, - -	42
Of undecompounded vegetable fibres	10
Of fine ſiliceous ſand - -	200
Of minutely divided matter ſeparated by filtration, and conſiſting of	
Carbonate of lime - -	25
Carbonate of magneſia - -	4
Matter deſtructible by heat, principally vegetable, - -	10
Silica - - - - - -	40
Alumina - - - - -	32
Oxide of iron - - - -	4
Soluble matter, principally ſulphate of potaſh and vegetable extract, - -	5
Gypſum - - - - -	3
Phoſphate of lime - -	2
Amount of all the products	395
Loſs - - -	5

In this inſtance the loſs is ſuppoſed ſmall; but in general, in actual experiments, it will be found much greater, in conſequence of the difficulty of collecting the whole quantities of the different precipitates; and when it is within thirty for four hundred grains, there is no reaſon to ſuſpect any want of due preciſion in the proceſſes.

13 Chemical compoſition of fertile corn ſoils in this climate.

13. A very fertile corn ſoil from Ormiſton in Eaſt Lothian afforded, in 100 parts, only 11 parts of mild calcareous earth; it contained 25 parts of ſiliceous ſand: the finely divided clay amounted to 45 parts. It loſt nine in decompoſed animal and vegetable matter, and four in water, and afforded indications of a ſmall quantity of phoſphate of lime.

This ſoil was of a very fine texture, and contained very few ſtones or vegetable fibres. It is not unlikely that its fertility was in ſome meaſure connected with the phoſphate; for this ſubſtance is found in wheat, oats, and barley, and may be a part of their food.

A ſoil from the low lands of Somerſetſhire, celebrated for producing excellent crops of wheat and beans without manure, was found to conſiſt of one-ninth of ſand, chiefly ſiliceous, and eight-ninths of calcareous marl tinged with iron, and containing about five parts in 100 of vegetable matter. No phoſphate or ſulphate of lime could be detected in it; ſo that its fertility muſt have depended principally upon its power of attracting principles of vegetable nouriſhment from water and the atmoſphere.

14 Compoſition of ſoils proper for bulbous roots and for trees.

Mr Tillet, in ſome experiments made on the compoſition of ſoils at Paris, found that a ſoil compoſed of three-eighths of clay, two-eighths of river ſand, and three-eighths of the parings of limeſtone, was very proper for wheat.

14. In general, bulbous roots require a ſoil much more ſandy and leſs abſorbent than the graſſes. A very good potato ſoil, from Varſel in Cornwall, afforded ſeven-eighths of ſiliceous ſand; and its abſorbent power was ſo ſmall, that 100 parts loſt only two by drying at 400 Fahrenheit.

Plants and trees, the roots of which are fibrous and hard, and capable of penetrating deep into the earth, will vegetate to advantage in almoſt all common ſoils which are moderately dry, and which do not contain a very great exceſs of vegetable matter.

The ſoil taken from a field at Sheffield-place in Suſſex, remarkable for producing flouriſhing oaks, was found to conſiſt of ſix parts of ſand, and one part of clay and finely divided matter. And 100 parts of the entire ſoil, ſubmitted to analyſis, produced

Water - -	3 parts
Silica - - -	54
Alumina - - -	28
Carbonate of lime - -	3
Oxide of iron - -	5
Decompoſing vegetable matter	4
Loſs - - -	3

15 Improvements made by changing the compoſition of the earthy parts of ſoils.

15. From the great difference of the cauſes that influence the productiveneſs of lands, it is obvious that, in the preſent ſtate of ſcience, no certain ſyſtem can be deviſed for their improvement, independent of experiment: but there are few caſes in which the labour of analytical trials will not be amply repaid by the certainty with which they denote the beſt methods of amelioration; and this will particularly happen when the defect of compoſition is found in the proportions of the primitive earths.

In ſupplying animal or vegetable manure, a temporary food only is provided for plants, which is in all caſes exhauſted by means of a certain number of crops; but when a ſoil is rendered of the beſt poſſible conſtitution and texture, with regard to its earthy parts, its fertility may be conſidered as permanently eſtabliſhed. It becomes capable of attracting a very large portion of vegetable nouriſhment from the atmoſphere, and of producing its crops with comparatively little labour and expence.

Deſcription of the Apparatus for the Analyſis of Soils. Plate DIX.

A, Retort.

B, B, Funnels for the purpoſe of filtrating.

D, Balance.

E, Argand's lamp.

F, G, H, K, The different parts of the apparatus required for meaſuring the quantity of elaſtic fluid given out during the action of an acid on calcareous ſoils.

F, Repreſents the bottle for containing the ſoil.

K, The bottle containing the acid furniſhed with a ſtopcock.

G, The tube connected with a flaccid bladder.

I, The graduated meaſure.

H, The bottle for containing the bladder. When this inſtrument is uſed, a given quantity of ſoil is introduced into F; K is filled with muriatic acid diluted with an equal quantity of water; and the ſtopcock being cloſed is connected with the upper orifice of F, which is ground to receive it. The tube G is introduced into the lower orifice of F, and the bladder connected with it placed in its flaccid ſtate into H, which is filled with water. The graduated meaſure is placed under the tube of H. When the ſtopcock of K is turned, Soils.

ed, the acid flows into F, and acts upon the soil; the elastic fluid generated passes through G into the bladder, and displaces a quantity of water in H equal to it in bulk, and this water flows through the tube into the graduated measure; the water in which gives by its volume the indication of the proportion of carbonic acid disengaged from the soil; for every ounce measure of which two grains of carbonate of lime may be estimated.

L, Represents the stand for the lamp.

M, N, O, P, Q, R, S, Represent the bottles containing the different reagents.*

* *Phil. Mag.* vol. xxiii. p. 26.

Stones.

Artificial STONE. See STUCCO.

Elastic STONE. Some marbles possess the property of elasticity, and hence come under the denomination of elastic stones. But the most remarkable stone of this nature is the elastic sandstone from Brazils. It is a micaceous sandstone in laminæ not exceeding half an inch in thickness. Some siliceous stones also have the same property, or acquire it by being exposed to a certain degree of heat.

Philosopher's STONE. See PHILOSOPHER'S *Stone*.

Precious STONES. See GEM.

Rocking STONE, or *Logan*, a stone of a prodigious size, so exactly poised, that it would rock or shake with the smallest force. Of these stones the ancients give us some account. Pliny says, that at Harpasa, a town of Asia, there was a rock of such a wonderful nature, that if touched with the finger it would shake, but could not be moved from its place with the whole force of the body*. Ptolemy Hephestion mentions† a gygonian stone near the ocean, which was agitated when struck by the stalk of an asphodel, but could not be removed by a great exertion of force. The word *gygonius* seems to be Celtic; for *gwingog* signifies *motitans*, the rocking-stone.

* Lib. ii. c. 69.
† Lib. iii. c. 3.

Many rocking stones are to be found in different parts of this island; some natural, others artificial, or placed in their position by human art. In the parish of St Leven, Cornwall, there is a promontory called *Castle Treryn*. On the western side of the middle group, near the top, lies a very large stone, so evenly poised that any hand may move it from one side to another; yet it is so fixed on its base, that no lever nor any mechanical force can remove it from its present situation. It is called the *Logan-stone*, and is at such a height from the ground that no person can believe that it was raised to its present position by art. But there are other rocking stones, which are so shaped and so situated, that there can be no doubt but they were erected by human strength. Of this kind Borlase thinks the great *Quoit* or *Karn-lehau*, in the parish of Tywidnek, to be. It is 39 feet in circumference, and four feet thick at a medium, and stands on a single pedestal. There is also a remarkable stone of the same kind in the island of St Agnes in Scilly. The under rock is 10 feet six inches high, 47 feet round the middle, and touches the ground with no more than half its base. The upper rock rests on one point only, and is so nicely balanced, that two or three men with a pole can move it. It is eight feet six inches high, and 47 in circumference. On the top there is a bason hollowed out, three feet eleven inches in diameter at a medium, but wider at the brim, and three feet deep. From the globular shape of this upper stone, it is highly probable that it was rounded by human art, and perhaps even placed on its pedestal by human strength. In Sithney parish, near Helston, in Cornwall, stood the famous logan, or rocking stone, commonly called *Men Amber*, q. d. *Men an Bar*, or the *top-stone*. It was eleven feet by six, and four high, and so nicely poised on another stone that a little child could move it, and all travellers who came this way desired to see it. But Shrubsall, Cromwell's governor of Pendennis, with much ado caused it to be undermined, to the great grief of the country. There are some marks of the tool on it, and, by its quadrangular shape, it was probably dedicated to Mercury.

Borlase, chap. iv. p. 181.

That the rocking stones are monuments erected by the Druids cannot be doubted; but tradition has not informed us for what purpose they were intended. Mr Toland thinks that the Druids made the people believe that they alone could move them, and that by a miracle; and that by this pretended miracle they condemned or acquitted the accused, and brought criminals to confess what could not otherwise be extorted from them. How far this conjecture is right we shall leave to those who are deeply versed in the knowledge of antiquities to determine.

Sonorous STONE, a kind of stone remarkable for emitting an agreeable sound when struck, and much used in China for making musical instruments which they call *king*.

The various kinds of sonorous stones known in China differ considerably from one another in beauty, and in the strength and duration of their tone; and what is very surprising, is that this difference cannot be discovered either by the different degrees of their hardness, weight, or fineness of grain, or by any other qualities which might be supposed to determine it. Some stones are found remarkably hard, which are very sonorous; and others exceedingly soft, which have an excellent tone; some extremely heavy emit a very sweet sound; and there are others as light as pumice stone which have also an agreeable sound.

The chemists and naturalists of Europe have never yet attempted to discover, whether some of our stones may not have the same properties as the sonorous stones of the extremities of Asia. It however appears, that the Romans were formerly acquainted with a sonorous stone of the class of *hiang-che*. Pliny (says the Abbé du Bos, in his Reflections on Poetry and Painting, when speaking of curious stones) observes that the stone called *chalcophonas*, or *brazen sound*, is black; and that, according to the etymology of its name, it sends forth a sound much resembling that of brass when it is struck. The passage of Pliny is as follows: *Chalcophonas nigra est; sed elisa æris tinnitum reddit.*

Some sonorous stones were at length sent into France, and

Stone, Stonehenge.

and the late Duke de Chaulnes examined them with particular attention. The following are some of his observations: "The Academy of Sciences, Mr Romé de Lisle, and several other learned mineralogists, when asked if they were acquainted with the black stone of which the Chinese king was made, for answer cited the passage of Pliny mentioned by Boethius de Bott, Linnæus, and in the Dictionary of Bomare, and added what Mr Anderson says in his Natural History of Iceland respecting a bluish kind of stone which is very sonorous. As the black stone of the Chinese becomes of a bluish colour when filed, it is probably of the same species. None of the rest who were consulted had ever seen it. The Chinese stone has a great resemblance at first sight to black marble, and like it is calcareous; but marble generally is not sonorous. It also externally resembles touchstone, which is a kind of basaltes, and the basaltes found near volcanoes; but these two stones are vitrifications."

The duke next endeavoured to procure some information from the stone-cutters. They all replied, that blue-coloured marble was very sonorous, and that they had seen large blocks of it which emitted a very strong sound; but the duke having ordered a king to be constructed of this kind of stone, it was found that it did not possess that property. By trying the black marble of Flanders, a piece was at length found which emitted an agreeable sound: it was cut into a king, which is almost as sonorous as those of China. All these observations give us reason to believe that the stones of which the king are formed are nothing else but a black kind of marble, the constituent parts of which are the same as those of the marble of Europe, but that some difference in their organization renders them more or less sonorous.

Swine-STONE (lapis suillus), or *fetid stone*, so called from its excessively fetid smell, is a calcareous stone impregnated with petroleum. See MINERALOGY *Index*.

STONE-Marrow, a variety of clay so called from its having the appearance of marrow.

STONE-Ware, a species of pottery so called from its hardness. See *DELFT-Ware* and PORCELAIN.

STONE in the Bladder. See MEDICINE, N° 400, and SURGERY *Index*.

STONE, in merchandize, denotes a certain weight for weighing commodities. A stone of beef at London is the quantity of eight pounds: in Herefordshire 12 pounds: in the North 16 pounds. A stone of glass is five pounds; of wax eight pounds. A stone of wool (according to the statute of 11 Hen. VII.) is to weigh 14 pounds; yet in some places it is more, in others less; as in Gloucestershire 15 pounds; in Herefordshire 12 pounds. Among horse-coursers a stone is the weight of 14 pounds.

The reason of the name is evident. Weights at first were generally made of stone. See Deut. xxv. 13. where the word אבנ, translated *weight*, properly signifies a *stone*.

STONE-Chatter. See MOTACILLA, ORNITHOLOGY *Index*.

STONEHENGE, a celebrated monument of antiquity, stands in the middle of a flat area near the summit of a hill six miles distant from Salisbury. It is inclosed by a circular double bank and ditch near 30 feet broad, after crossing which we ascend 30 yards before we reach the work. The whole fabric consisted of two circles and two ovals. The outer circle is about 108 feet diameter, consisting when entire of 60 stones, 30 uprights and 30 imposts, of which remain only 24 uprights, 17 standing and 7 down, $3\frac{1}{2}$ feet asunder, and 8 imposts. Eleven uprights have their 5 imposts on them by the grand entrance. These stones are from 13 to 20 feet high. The lesser circle is somewhat more than 8 feet from the inside of the outer one, and consisted of 40 lesser stones (the highest 6 feet), of which only 19 remain, and only 11 standing: the walk between these two circles is 300 feet in circumference. The Adytum or Cell is an oval formed of 10 stones (from 16 to 22 feet high), in pairs, with imposts, which Dr Stukeley calls *trilithons*, and above 30 feet high, rising in height as they go round, and each pair separate. and not connected as the outer pair; the highest 8 feet. Within these are 19 more smaller single stones, of which only 6 are standing. At the upper end of the Adytum is the altar, a large slab of blue coarse marble, 20 inches thick, 16 feet long, and 4 broad; pressed down by the weight of the vast stones that have fallen upon it. The whole number of stones, uprights, imposts, and altar, is exactly 140. The stones are far from being artificial, but were most probably brought from those called the *Grey Weathers* on Marlborough Downs, 15 or 16 miles off; and if tried with a tool they appear of the same hardness, grain, and colour, generally reddish. The heads of oxen, deer, and other beasts, have been found on digging in and about Stonehenge; and human bones in the circumjacent barrows. There are three entrances from the plain to this structure, the most considerable of which is from the north-east, and at each of them were raised on the outside of the trench two huge stones with two smaller within parallel to them.

Stonehenge. Gough's edition of Camden's Britannia, vol. i. p. 107.

It has been long a dispute among the learned, by what nation, and for what purpose, these enormous stones were collected and arranged. The first account of this structure we meet with is in Geoffroy of Monmouth, who, in the reign of King Stephen, wrote the history of the Britons in Latin. He tells us, that it was erected by the counsel of Merlin the British enchanter, at the command of Aurelius Ambrosius the last British king, in memory of 460 Britons who were murdered by Hengist the Saxon. The next account is that of Polydore Virgil, who says that the Britons erected this as a sepulchral monument of Aurelius Ambrosius. Others suppose it to have been a sepulchral monument of Boadicea the famous British queen. Inigo Jones is of opinion, that it was a Roman temple; from a stone 16 feet long, and four broad, placed in an exact position to the eastward altar-fashion. Mr Charlton attributed it to the Danes, who were two years masters of Wiltshire. A tin tablet, on which were some unknown characters, supposed to be Punic, was digged up near it in the reign of Henry VIII. but is lost; probably that might have given some information respecting its founders. Its common name, *Stonehenge*, is Saxon, and signifies a "stone gallows," to which those stones, having transverse imposts, bear some resemblance. It is also called in Welch *choir gour*, or "the giants dance."

Mr Grose thinks that Dr Stukeley has completely proved this structure to have been a British temple in which the Druids officiated. He supposes it to have been the metropolitan temple of Great Britain, and translates

tranſlates the words *choir gour* "the great choir or temple." The learned Mr Bryant is of opinion that it was erected by a colony of Cuthites probably before the time of the Druids; becauſe it was uſual with them to place one vaſt ſtone upon another for a religious memorial; and theſe they often placed ſo equably, that even a breath of wind would ſometimes make them vibrate. Of ſuch ſtones one remains at this day in the pile of Stonehenge. The ancients diſtinguiſhed ſtones erected with a religious view, by the name of *amber;* by which was ſignified any thing ſolar and divine. The Grecians called them πετραι αμβροσιαι, *petræ ambroſiæ*. Stonehenge, according to Mr Bryant, is compoſed of theſe amber ſtones: hence the next town is denominated *Ambreſbury;* not from a Roman Ambroſius, for no ſuch perſon ever exiſted, but from the *ambroſiæ petræ*, in whoſe vicinity it ſtood. Some of theſe were rocking ſtones; and there was a wonderful monument of this ſort near Penzance in Cornwall, which ſtill retains the name of *main-amber*, or the ſacred ſtones. Such a one is mentioned by Apollonius Rhodius, ſuppoſed to have been raiſed in the time of the Argonautæ, in the iſland Tenos, as the monument of the two-winged ſons of Boreas, ſlain by Hercules; and there are others in China and other countries.

Groſe's Antiquities, vol. iv. p. 40.

STOOK, a term uſed in many parts of the kingdom for a ſhock of corn containing 12 ſheaves.

STOOL, in *Medicine*, an evacuation or diſcharge of the fæces by the anus.

Stool, in *Mining*, is uſed when the miners leave off digging deeper, and work in the ends forward. The end before them is called the *ſtool.*

Stool, in *Ship building*, the name of the ſupporters of the poop and top lanterns.

STOOPING, in *Falconry*, is when a hawk, being upon her wings at the height of her pitch, bends down violently to take the fowl.

STOPPERS, in a ſhip, certain ſhort pieces of rope, which are uſually knotted at one or both ends, according to the purpoſe for which they are deſigned. They are either uſed to ſuſpend any heavy body, or to retain a cable, ſhroud, &c. in a fixed poſition. Thus, the anchors, when firſt hoiſted up from the ground, are hung to the cat head by a ſtopper attached to the latter, which paſſing through the anchor-ring, is afterwards faſtened to the timber-head; and the ſame rope ſerves to faſten it on the bow at ſea; or to ſuſpend it by the ring which is to be ſunk from the ſhip to the bottom. The ſtoppers of the cable have a large knot and a laniard at one end, and are faſtened to a ring-bolt in the deck by the other. They are attached to the cable by the laniard, which is faſtened ſecurely round both by ſeveral turns paſſed behind the knot, or about the neck of the ſtopper; by which means the cable is reſtrained from running out of the ſhip when ſhe rides at anchor.

The ſtoppers of the ſhroud have a knot and a laniard at each end. They are only uſed when the ſhrouds are cut aſunder in battle, or diſabled by tempeſtuous weather: at which time they are laſhed, in the ſame manner as thoſe of the cables, to the ſeparated parts of the ſhroud, which are thereby reunited, ſo as to be fit for immediate ſervice. This, however, is only a temporary expedient.

STOPS. See Punctuation; and Scripture, N° 136.

STORAX. See Styrax, Materia Medica *Index*.

STORK. See Ardea, Ornithology *Index*.

STOVE for heating apartments, greenhouſes, hothouſes, fruit-walls, &c.

When treating of the mechanical properties of air, we explained in ſufficient detail the manner in which the expanſion produced in a maſs of air by heat produces that motion up our chimneys which is called the draught of the chimney; and, in the article Smoke, we conſidered the circumſtances which tend to check, to promote, or to direct this current, ſo as to free us from the ſmoke and vitiated air which neceſſarily accompanies the conſumption of the fuel. In Pneumatics we alſo attended to the manner in which our fires immediately operate in warming our apartments. At preſent, when about to deſcribe a method of warming intrinſically different, we muſt pay ſome more attention to the diſtinguiſhing circumſtance. Without pretending to explain the phyſical connection of heat and light, it may ſuffice to obſerve, that heat, as well as light, is communicated to diſtant bodies in an inſtant by radiation. A perſon paſſing haſtily by the door of a glaſs-houſe feels the glow of heat in the very moment he ſees the dazzling light of the furnace mouth, and it is interrupted by merely ſcreening his face with his hand. In this way is an apartment partly warmed by an open fire; and we avoid the oppreſſive heat by ſitting where the fire is not ſeen, or by interpoſing a ſcreen. We are apt to connect this ſo ſtrongly in the imagination with the light emitted by the fire, that we attribute the heat to the immediate action of the light. But this opinion is ſhown to be gratuitous by a curious experiment made before the Royal Society by Dr Hooke, and afterwards, with more care and accurate examination, by Mr Scheele. They found, that by bringing a plate of the moſt tranſparent glaſs briſkly between the fire and one's face, the heat is immediately intercepted without any ſenſible diminution of the light. Scheele, by a very pretty inveſtigation, diſcovered that the glaſs made the ſeparation, and did it both in refraction and reflection; for he found, that when the light of the ſame fire was collected into a focus by means of a poliſhed metal concave ſpeculum, a thermometer placed there was *inſtantly* affected. But if we employ a glaſs ſpeculum foiled in the uſual manner with quickſilver, of the ſame diameter and focal diſtance, and of equally brilliant reflection, there is hardly any ſenſible heat produced in the focus, and the thermometer muſt remain there for a very long while before it is ſenſibly affected. When we repeated this curious experiment, we found, that after the glaſs has remained a long while in this poſition, whether tranſmitting or reflecting the light, it loſes in a great meaſure its power of intercepting the heat. By varying this obſervation in many of its circumſtances, we think ourſelves entitled to conclude, that the glaſs abſorbs the heat which it intercepts, and is very quickly heated by the abſorption. While it riſes in its own temperature, it intercepts the heat powerfully; but when it is, as it were, ſaturated, attracting no more than what it immediately imparts to the air in corporeal contact with it, the heat paſſes freely through along with the light. If the

Stove.

the glaſs be held ſo near the fire that the ſurrounding air is very much heated, no ſenſible interruption of heat is perceived after the glaſs is thus ſaturated. We found the cheek more quickly ſenſible than the thermometer of this inſtantaneous radiation of the heat which accompanies the light, or is ſeparated from it in this experiment. It is a very inſtructive experiment in the phyſiology of heat.

We cannot ſay how far this radiation of heat may extend, nor whether the accompanyment of light is abſolutely neceſſary. The mathematician proceeds on the ſuppoſition that it extends as far as the radiation of light, and that, being alſo rectilineal, the denſity of the heat is proportional to that of the light. But theſe notions are ſomewhat gratuitous; and there are appearances which render them doubtful. When with a lens of an inch in diameter we form a focus on a piece of black unpoliſhed marble of an inch diameter, the mathematician muſt allow that no more rays fall on the marble than if the lens were away: therefore the marble ſhould be equally warmed in either caſe. But it is by no means ſo, as we have repeatedly found by expoſing it during equal times, and then dropping it into water. The water which is heated by the marble on which the focus has been formed will be found to have acquired from it much more heat than from the other. The tops of lofty mountains which are never ſhaded by clouds, but enjoy perpetual ſunſhine and ſerenity, inſtead of being warmer than the valleys below, are covered with never-melting ſnow; and we have ſome grounds to ſuſpect that the genial influence of the ſun requires the co-operation of the atmoſphere, and to doubt whether there is any warmth at the moon, on which no atmoſphere like ours can be obſerved. Perhaps the heat which cheers us, and fertilizes our earth, is chemically ſeparated from our atmoſphere by its elective attraction for the light of the ſun. Our ſucceſſors in the ſtudy of meteorology need not fear that the ſubject of their reſearch will be ſoon deprived of ſcientific allurements. We know but little of it after all the progreſs we have made during this laſt century, and it ſtill preſents an ample field of diſcuſſion.

We ſaid that the accompaniment of light is not demonſtrably neceſſary. We are certain that heat may be imparted without any ſenſible light, in a manner which we can hardly ſuppoſe any thing but radiation. If a piece of very hot iron be placed a little without the principal focus of a metallic concave ſpeculum, and a very ſenſible air-thermometer be placed in its conjugate focus, it will inſtantly ſhow an elevation of temperature, although the iron is quite imperceptible to an eye which has even been a long while in the dark. No ſuch riſe of temperature is obſerved if the thermometer be placed a little to one ſide of the focus of the ſpeculum; therefore the phenomenon is preciſely ſimilar to the radiation of light. We are obliged therefore to acknowledge that the heat is radiated in this experiment in the ſame way that light is in the common optical experiments.

Although this is the moſt uſual way that we in this country employ fuel for warming our apartments, it is by no means the only way in which the heat diffuſed from this fuel may be imparted to diſtant bodies. It is not even the moſt effectual method; it is diffuſed alſo by immediate communication to bodies in contact. The air in immediate contact with the burning fuel is heated, and imparts ſome of its heat to the air lying beyond it, and this is partly ſhared with the air which is ſtill farther off; and this diffuſion, by communication *in contactu*, goes on till the remote air contiguous to the walls, the floor, the ceiling, the furniture, the company, all get a ſhare of it in proportion to their attractions and their capacities. And as the air is thus continually ſupplied, and continually gives out heat, the walls, &c. become gradually warmer, and the room becomes comfortable and pleaſant. But we apprehend that no great proportion of the heat actually acquired by the room is communicated in this way. This diffuſion by contact is but ſlow, eſpecially in air which is very dry; ſo ſlow indeed, that the air in the immediate neighbourhood of the fuel is hurried up the chimney before it has time to impart any of the heat received in contact. We know that the time employed in diffuſing itſelf in this way through ſtagnant air to any moderate diſtance is very conſiderable. We imagine therefore that the heat communicated to our rooms by an open fire is chiefly by radiation, but in a way ſomething different from what we mentioned before. We imagine, that as the piece of glaſs in Dr Hooke's experiment abſorbs the heat, ſo the whole maſs of air which fills the room intercepts the radiated heat in every part of the room where the fire is ſeen, and is as it were ſaturated with it throughout, and ready to impart it to every body immerſed in it. We cannot otherwiſe account for the *equability* of the heat in the different parts of the room. Mere radiation on the ſolid bodies would warm them in the inverſe duplicate ratio of their diſtances from the fire; and diffuſion by contact, if compatible with the rapid current up the chimney, would heat the room ſtill more unequably. Recollect how ſlowly, and with what rapid diminution of intenſity, the colour of blue vitriol is communicated to water even to a very ſmall diſtance. But becauſe all parts of the air of the room abſorb radiated heat, what is ſaturated at a higher temperature, being nearer to the fire, riſes to the ceiling, ſpreads outwards along the ceiling, and has its place ſupplied by the air, which is thus puſhed towards the fire from the places which are not directly illuminated.

Far different is the method of warming the room by a ſtove. Here the radiation, if any, is very feeble or ſcanty; and if a paſſage were allowed up the chimney for the warmed air, it would be quickly carried off. This is well known to the Engliſh who reſide in the cold climates of St Peterſburgh, Archangel, &c. They love the exhilerating flutter of an open fire, and often have one in their parlour; but this, ſo far from warming the room during the extreme cold weather, obliges them to heat their ſtoves more frequently, and even abſtracts the heat from a whole ſuite of apartments. But all paſſage this way is ſhut up when we warm a room by ſtoves. The air immediately contiguous to the ſtove is heated by contact, and this heat is gradually, though ſlowly, diffuſed through the whole room. The diffuſion would however be very ſlow indeed, were it not for the great expanſibility of air by heat. But the air ſurrounding the ſtove quickly expands and riſes to the ceiling, while the neighbouring air ſlides in to ſupply the place, nay is even puſhed in by the air which goes outwards aloft. Thus the whole air is ſoon mixed, and the room acquires almoſt an equal temperature throughout.

Stove.

The warming by ſtoves muſt therefore be managed upon very different principles from thoſe adopted in the employment of open fires. The general principle is, 1ſt, To employ the fuel in the moſt effectual manner for heating the external part of the ſtove, which is immediately efficient in warming the contiguous air; and, 2d, To keep in the room the air already warmed, at leaſt as much as is conſiſtent with wholeſomeneſs and cleanlineſs.

The firſt purpoſe is accompliſhed by conducting the flue of the furnace round its external parts, or, in ſhort, by making every part of the flue external. Of all forms, that of a long pipe, returned backwards and forwards, up and down (provided only that the place of its laſt diſcharge be conſiderably higher than its entry from the fire-place), would be the moſt effectual. We have ſeen a very ſmall ſtove conſtructed in this way, the whole being incloſed in a handſome caſe of poliſhed iron plate, pierced and cut into elegant foliage like the cock of a watch, ſo that the odd looking pipes were completely concealed. Though only three feet long, one foot thick, and ſix feet high, it warmed a very lofty room of 24 feet by 18, and conſumed leſs than half the fuel of a ſtove of the more uſual make, which did not ſo fully warm a ſmaller chamber.

It would occupy a volume to deſcribe the immenſe variety of ſtoves which ingenuity or architectonic taſte has conſtructed. We ſhall content ourſelves with giving a ſpecimen of the two chief claſſes into which they may be diſtinguiſhed.

The air of a room may be equally warmed, either by applying it to the ſurface of a ſmall ſtove made very hot, or to the ſurface of a much larger ſtove more moderately heated. The firſt kind is chiefly uſed in Holland, Flanders, and the milder climates of Germany and Poland. The laſt are univerſally uſed in the frozen climates of Ruſſia and Sweden. The firſt are generally made of caſt-iron, and the laſt of brick-work covered with glazed tiles or ſtucco.

Plate DX. Fig. 1.

Fig. 1. repreſents a ſmall German ſtove fully ſufficient for warming a room of 24 feet by 18. The baſe is about three feet broad and 14 inches deep, that is, from back to front, and ſix or ſeven feet high. The decoration is in the faſhion of that country; but the operative ſtructure of it will admit of any ſtyle of ornament. A, is the fire-place, and the wood or charred coal is laid on the bottom, which has no bars. Bars would admit the air too freely among the fuel, and would both conſume it too faſt and raiſe too great a heat. That no heat may be uſeleſsly expended, the ſole of the fire-place and the whole bottom of the ſtove is raiſed an inch or two above the floor of the room, and the air is therefore warmed by it in ſucceſſion, and riſes upwards. For the ſame reaſon the back of the ſtove is not in contact with the wall of the room, or of the niche in which it is placed. The fire-place is ſhut up by a door which fits cloſely to its caſe, and has a ſmall wicket at the bottom, whoſe aperture is regulated by a ſliding plate, ſo as to admit no more air than what ſuffices for ſlowly conſuming the fuel. The flame and heated air riſe to the top of the fire-place three or four inches above the arch or mantle-piece, and get out laterally by two narrow paſſages B, B, immediately below the top-plate of the baſe. The current bends downward on each ſide, paſſes at C, C, under the partition plates which divide the two ſide chambers, and then riſes upwards through the outer diviſion of each, and paſſes through narrow ſlits D, D, in the top plate, and from thence along the two hollow piers E, E. The two lateral currents unite at the top of the arch, and go through the ſingle paſſage F into the larger hollow behind the eſcutcheon G. From this place it either goes ſtraight upwards into the vent in the wall by a pipe on the top of the ſtove, or it goes into the wall behind by a pipe inſerted in the back of the ſtove. The propriety of this conſtruction is very obvious. The current of hot air is applied to exterior parts of the ſtove everywhere except in the two ſide chambers of the baſe, where the partition-plates form one ſide of the canal. Even this might be avoided by making each of theſe ſide-chambers a detached hollow pillar. But this would greatly increaſe the trouble of conſtruction and joining together, and is by no means neceſſary. The arch H has a graceful appearance, and affords a very warm ſituation for any thing that requires it, ſuch as a drink in a ſick perſon's bed-chamber, &c. Perſons of a certain claſs uſe this place for keeping a diſh warm; nay, the lower part of the arch is frequently occupied by an incloſed chamber, where the heat riſes high enough even for dreſſing victuals, as will be eaſily imagined when we reflect that the ſole of it is the roof of the fire-place.

The ſtove now deſcribed is ſupplied with fuel and with air by the front door opening into the room. That there may be room for fuel, this middle part projects a few inches before the two ſide-chambers. Theſe laſt, with the whole upper part of the ſtove, are not more than ten inches deep. The paſſages, therefore, from the fire-place are towards the back of it; ſo that if we have a mind to ſee the fire (which is always cheerful), the door may be thrown open, and there is no danger of the ſmoke coming out after the current has once warmed the upper part of the ſtove. When the ſtove is of ſuch dimenſions that the baſe is about two feet and a half or three feet high, the fire-place may be furniſhed with a ſmall grate in the Britiſh ſtyle. If the door is ſo hung that it can not only be thrown back, but lifted off its hinges, we have a ſtove grate of the completeſt kind, fully adequate, in our mild climate, to warm a handſome apartment, even with an open fire; and when we hang on the door, and ſhut up the fire-place, a ſtove of the dimenſions already given is almoſt too much for a large drawing room.

We have frequently remarked, that one ſide of theſe ſtoves grows much warmer than the other, and that it was difficult to prevent or remedy this; and we imagine that this is an unavoidable defect in all ſtoves with a double flue. It is ſcarcely poſſible to make the fire ſo equable in the fire-place, that one ſide ſhall not be a little warmer than the other, and a briſker current will then be produced in it. This muſt increaſe the conſumption of the fuel on this ſide, which will increaſe the current, will heat this ſide ſtill more, and thus go on continually till the fuel on this ſide is expended; after which the other ſide will obtain and increaſe the ſuperiority. The flue is made double, that the fire-place may occupy the middle of the front; and it will be difficult to gain this point of ſymmetry with one flue. The inconvenience may, however, be corrected by damping valves placed in ſome part of the upright funnels E, E.

In

In the colder winters on the continent, it is thought neceſſary to increaſe the effect by making the fire-place open to the back of the ſtove. Its mouth or door communicates with or is joined to an opening of the ſame dimenſions formed in the wall, and the door is on the other ſide in an antichamber or lobby. In Weſtphalia, and other places of Germany, the apartments are diſpoſed round a ſpacious lobby, into which all their fire-places open, and are there ſupplied with fuel. By this conſtruction it is plain that the air of the room, already warmed by the ſtove, is not carried off, and the room is more heated. But this method is very unfavourable to cheerfulneſs and health. The ſame air, confined, and repeatedly breathed and compounded with all the volatile emanations of the room, quickly loſes that refreſhing quality that is ſo deſirable, and even ſo neceſſary for health. It is never renewed except by very partial admixtures when the room doors are thrown open, and becomes diſagreeable to any perſon coming in from the open air; and in the houſes of the leſs opulent becomes really offenſive and nauſeous.

Something of this is unavoidable in all rooms heated by ſtoves. Even in our apartments in this iſland, perſons of delicate nerves are hurt by what they call the cloſe air of a room; and it is long before the ſmell of dinner is quite removed from a dining-room, notwithſtanding the copious current up the chimney. This muſt be incomparably more ſenſible in a room heated by a ſtove; and this inconvenience is peculiarly ſenſible with reſpect to the ſtove which we are conſidering at preſent, where we employ a ſmall ſurface heated to a great degree.

Such ſtoves are ſeldom made of any thing elſe than caſt-iron. This (in thoſe parts at leaſt which are in immediate contact with the fuel) is in a ſtate of continual calcination, and even throwing off ſcales. This indeed is not ſeen, becauſe it is the bottom or ſole of the fire-place which is ſo heated: but the effect on the air of the room is the ſame. The calcination of the iron is occaſioned by the combination of pure vital air with the iron. This is abſtracted from the general maſs of atmoſpheric air in the room, of which it uſually conſtitutes about two-fifths. By this abſtraction the remainder becomes leſs fit for ſupporting animal life or flame, and may even become highly deleterious. In every degree the remainder becomes leſs refreſhing, and grows dull and oppreſſive. This is always accompanied by a peculiar ſmell, which, though not diſguſting, is unpleaſant. It reſembles the ſmell of burnt feathers, or more exactly the ſmell we feel if we rub violently for ſome time the palms of our hands together when perfectly dry.

For ſimilar reaſons theſe iron ſtoves occaſion a ſickly ſmell, by burning every particle of duſt which falls on the hot parts; and if they be wiped with a woollen cloth, or any cloth not perfectly free from every kind of greaſy or oily matter, a ſmell is produced for a day or days afterwards; ſo that without the moſt ſcrupulous attention we ſuffer by our very cleanlineſs.

For ſuch reaſons we think that the ſtoves of brick-work covered with ſtucco or with glazed tiles are vaſtly preferable. Theſe are much uſed in the genteeler houſes in Flanders and Holland, where they are made in the moſt elegant forms, and decorated with beautiful ſculpture or enamel; but it is plain that they cannot be ſo effectual, nor equally warm a room with the ſame expence of fuel. Earthen ware, eſpecially when covered with porous ſtucco, is far inferior to metal in its power of conducting heat. If built of bricks, they muſt be vaſtly more bulky when the fire-place and flues are of the ſame dimenſions. The moſt perfect way of conſtructing them would certainly be to make them of pottery, in parts exactly fitted to each other, and joined by a proper cement. This mode of conſtructing would admit of every elegance of form or richneſs of ornament, and would not be ſo bulky as thoſe which are built of bricks. The great difficulty is to prevent their cracking by the heat. Different parts of the ſtove being of very different heats, they expand unequally, and there is no cement which can withſtand this, eſpecially when we recollect that the ſame heat which expands the baked earth cauſes the clay or cement, with which the parts of the ſtove are put together or covered, to contract. Accordingly thoſe earthen ware ſtoves ſeldom ſtand a winter or two without cracking in ſome place or other, even when ſtrengthened by iron hoops and cramps judiciouſly diſpoſed within them. Even hooping them them externally, which would be very unſightly, will not prevent this; for nothing can reſiſt the expanſion and contraction by heat and cold. When a crack happens in a ſtove, it is not only unſightly, but highly dangerous; becauſe it may be ſo ſituated, that it will diſcharge into the room the air vitiated by the fire.

For theſe and other reaſons, we can ſcarcely hope to make ſtoves of brick-work or pottery which ſhall bear the neceſſary heat without cracking; and their uſe muſt therefore be confined to caſes where very moderate heat is ſufficient. We need not deſcribe their conſtruction. It is evident that it ſhould be more ſimple than that of iron ſtoves; and we imagine that in the very few caſes in which they are likely to be employed in this country, a ſingle fire-place and an arch over it, divided, if we pleaſe, by a partition or two of thin tile to lengthen the flue, will be quite enough. If the ſtove is made in whole or in part of potters ware, a baſe for the fire-place, with an urn, column, obeliſk, or pyramid above it, for increaſing the ſurface, will alſo be ſufficient. The failure commonly happens at the joinings, where the different pieces of a different heat, and perhaps of a different baking, are apt to expand unequally, and by working on each other one of them muſt give way. Therefore, inſtead of making the joints cloſe and uſing any cement, the upper piece ſhould ſtand in a groove formed in the undermoſt, having a little powdered chalk or clay ſprinkled over it, which will effectually prevent the paſſage of any air; and room being thus given for the unequal expanſion, the joint remains entire. This may be conſidered as a general direction for all furnace-work, where it is in vain to attempt to hinder the mutual working of the parts.

We have ſeen ſtoves in ſmall apartments at St Peterſburg, which were made internally of potters ware, in a great variety of forms, and then covered with a thick coat of ſtucco, finiſhed externally with the utmoſt elegance of ornament, and we were informed that they were very rarely ſubject to crack. They did not give much heat, on account of the very low conducting power of the porous ſtucco; but we imagine that they would be abundantly warm for a moderate room in this country.

Stove.

When fitted up in thefe fituations, and with thefe precautions, the brick or pottery ftoves are incomparably more fweet and pleafant than the iron ones.

But in the intenfe colds of Ruffia and Sweden, or even for very large rooms in this kingdom, ftoves of thefe fmall dimenfions are not fufficiently powerful, and we muft follow the practice of thofe countries where they are made of great fize, and very moderately heated. It is needlefs to defcribe their external form, which may be varied at pleafure. Their internal ftructure is the fame in all, and is diftinctly defcribed in PNEUMATICS, N° 364. We fhall only enlarge a little on the peculiarities connected with the general principle of their conftruction.

The ftove is intended as a fort of magazine, in which a great quantity of heat may be quickly accumulated, to be afterwards flowly communicated to the air of the room. The ftove is therefore built extremely maffive; and it is found that they are more powerful when coated with clay as wet as can be made to hang together. We imagine the reafon of this to be, that very wet clay, and more particularly ftucco, muft be exceedingly porous when dry, and therefore a very flow conductor of heat. Inftead of fticking on the glazed tiles with no more clay or ftucco than is fufficient to attach them, each tile has at its back a fort of box baked in one piece about two or three inches deep. It is reprefented in

Fig. 2.

fig. 2. This is filled with mortar, and then ftuck on the brick-work of the ftove, which has a great number of iron pins or hooks driven into the joints, which may fink into this clay and keep it firmly attached when dry. This coating, with the maffive brick-work, forms a great mafs of matter to be heated by the fuel. The loweft chamber, which is the fire-place, is fomewhat wider, and confiderably thicker than the ftories above, which are merely flues. When the fire-place is finifhed and about to be arched over, a flat iron bar of fmall thicknefs is laid along the top of the fide-wall on both fides, a fet of finifhing bricks being moulded on purpofe with a notch to receive the iron bar. Crofs bars are laid over thefe, one at each end and one or two between, having a bit turned down at the ends, which takes hold of the longitudinal bars, and keeps them from being thruft outwards either by the preffure of the arch or by the fwelling in confequence of the heat. In

Fig. 3.

fig. 3. A is the crofs fection of one of the long bars, and BC is part of one of the crofs bars, and CD is the clench which confines the bar A. This precaution is chiefly neceffary, becaufe the contraction of the ftove upwards obliges the walls of the other ftories to bear a little on the arch of the fire-place. The building above is kept together in like manner by other courfes of iron bars at every fecond return of the flue. The top of the ftove is finifhed by a pretty thick covering of brick-work. The laft paffage for the air at H (fee PNEUMATICS, fig. 62.) has a ring lining its upper extremity, and projecting an inch or two above it. The flat round it is covered with fand. When we would ftop this paffage, a covered fhape like a bafon or cover for difhes at table is whelmed over it. The rim of this, refting on the fand, effectually prevents all air from coming through and getting up the vent. Accefs is had to this damper by a door which can be fhut tight enough to prevent the heated air of the room from wafting itfelf up the vent. When the room is too warm, it may be very rapidly cooled by opening this door. The warm air rufhes up with great rapidity, and is replaced by cool air from without.

Stove.

The management of the ftove is as follows. About eight o'clock in the morning the *pietchnick*, or fervant who has the charge of the ftoves, takes off the cover, fhuts the damper-door, and opens the fire-place door. He then puts in a handful of wood fhavings or ftraw, and kindles it. This warms the ftove and vent, and begins a current of air through it. He then lays a few chips on the fole of the fire-place, immediately within the door; and behind this he arranges the billets of birchwood, with their ends inwards. Then he lays on more wood in the front, till he thinks there is enough. He fets fire to the chips, fhuts the door, and opens the fmall wicket at its bottom. The air blows the flame of the chips upon the billets behind them, and thus kindles them. They confume flowly, while the billets in front remain untouched by the fire. The fervant, having made his firft round of the rooms, returns to this ftove, and opens the door above to admit air into the vent. This is to fupply its draught, and thus to check the draught in the body of the ftove, which is generally too ftrong at this time, and would confume the fuel too faft. By this time the billets in the front are burning, firft at the bottom, and the reft in fucceffion as they fink down on the embers and come oppofite to the wicket. The room does not yet feel any effect from the fire, the heat of which has not yet reached its external furface; but in about half an hour this grows warm. The upper door is fhut again, that no heat may now be wafted. The pietchnick by and by fpreads the embers and afhes over the whole bottom of the fire-place with a rake, by which the bottom is greatly heated, and heats the air contiguous to it externally (for it ftands on little pillars) very powerfully. He takes care to bring up to the top of the afhes every bit of wood or coal that is not yet confumed, that all may be completely expended. He does this as brifkly as poffible, that the room may not lofe much warmed air by keeping open the fire-place door. At his laft vifit, when he obferves no more glowing embers, he fhuts the fire-place door and wicket, and puts the damper on the paffage above, and fhuts its door.—All this is over in about an hour and a half after kindling the fire. All current of air is now at an end within the ftove, and it is now a great mafs of brick-work, heated to a great degree within, but only about blood-warm externally. The heat gradually fpreads outwards, and the external furface of the ftove acquires its greateft heat about three o'clock in the afternoon; after which it gradually cools till next morning.

This heat feldom is fo great that one cannot bear to touch the ftove with his cheek, and to keep it there. In confequence of this it can burn none of the duft which unavoidably falls on the ftove, and we are never troubled with the fickening fmells that are unavoidable when we employ the fmall caft-iron ftoves much heated. The great expence of heat in a room arifes from the glafs windows. The pane is fo thin that the external air keeps it continually cold, and thus the windows are continually robbing the air of the room of its heat. This expence of heat is reduced to lefs than one-third by double cafements. The inner cafement is about as much colder than the room as the outer cafement is warmer

2

Stove.

warmer than the air of the fields; and we have the singular advantage of having no ice formed on the glasses. But to ensure this last advantage, the seams of the inner casement must be pasted with paper, and those of the outer casement must be left unpasted. If we do the contrary, we shall certainly have ice on the outer casement; the reason of which is easily seen.

We have been thus particular in our description of the management, because the reasons of some particulars are not very obvious, and the practice would not readily occur to us in this country; so that a person who, on the faith of our recommendation, should prefer one of these stoves to the German stove, whose management is simple and obvious, might be greatly disappointed. But by following this method, we are confident that the Russian stove will be found much superior both in warmth and agreeable air. The spreading out of the embers, and waiting till all is reduced to ashes before the doors are shut, is also absolutely necessary, and a neglect of it would expose us to imminent danger of suffocation by fixed air; and this is the only inconvenience of the Russian stove, from which the other stove is free. The fixed air has no smell; and the first indication of its presence is a slight giddiness and lassitude, which disposes us to sit down and to sleep. This would be fatal; and we must immediately open the upper passage and the fireplace door, so as to produce a strong current to carry the vitiated air of the room up the chimney. Throwing up the sashes, or at least opening all the doors, is proper on such an occasion.

If we burn pit-coal, either raw or charred, this precaution is still more necessary; because the cinder is not so easily or so soon completely consumed. This fuel will require a little difference in the management from wood fuel, but which is easily seen by any person of reflection. The safe way would be to rake out all half-burnt coal before shutting up the doors.

If we use raw pit-coal, great care is necessary to prevent the accumulation of soot in the upper part of the stove. It is an inaccessible place for the chimney-sweep; and if we attempt to burn it out, we run a great risk of splitting that part of the stove which is the most slightly constructed. It is advisable therefore to burn it away every day, by giving a brisk draught with an open door for five minutes. With wood or coak there is no danger.

It will not be improper in this place to give some instructions for the construction of stoves for warming several floors in a great manufactory, such as a cotton-mill, or a public library or museum.

In such situations we think cleanliness, wholesomeness, and sweetness of air, no less necessary than in the drawing room of a man of opulence. We therefore recommend the brick-stove in preference to the iron one; and though it would not be the best or most economical practice to heat it but once a-day, and we should rather prefer the German practice of constant feeding, we still think it highly proper to limit the heat to a very moderate degree, and employ a large surface.

If the disposition of the rooms allows us the conveniency of a thick party-wall, we would place the stove in the middle of this wall, in an arch which pierces through the wall. Immediately above this arch we would carry up a very wide chimney through the whole height. This chimney must have a passage opening into each floor on both sides, which may be very accurately shut up by a door. The stove being set up under the arch, it must have a pipe communicating with its flue, and rising up through this chimney. Could an earthen pipe be properly supported, and secured from splitting by hoops, we should prefer it for the reasons already given. But as this is perhaps expecting too much, we must admit the use of a cast iron pipe. This is the real chimney or flue of the stove, and must be of as great diameter as possible, that it may act, by an extensive surface, all the way up.

The stove stands under the arch in the wall; but the air that is warmed by its surface would escape on both sides, and would be expended in that single floor. To prevent this, the stove must be inclosed in a case: this may be of brick-work, at the distance of two or three inches from the stove all round. It must be well shut in above, and at the foundation must have a row of small holes to admit the air all around it. This air will then be warmed over the whole space between the stove and the case, pass up the chimney, and there receive additional heat from the flue-pipe which is in the middle. Great care must be taken that the fire-place door have no communication with the space between the stove and its case, but be inclosed in a mouth-piece which comes through the case, and opens into the feeding room. Thus all the air which goes up to the rooms will be pure and wholesome, provided we take care that every thing be kept clean and sweet about the air-holes below. Observe that those air-holes which are near the furnace door must be inclosed in a wooden trunk which takes in its air at some distance from this door; for since the current between the stove and case may be almost as great as the current within the stove (nay, when a puff of wind beats down the chimney, it may even exceed it), there is a risk of some vitiated air and smoke being drawn into the case.

If the stove cannot be placed in the arch of a party-wall, it may be set adjoining to a side or outer wall, and furnished with a case, a large chimney, and a flue-pipe, in the same manner. But in this case a great deal of heat is wasted on this outer wall, and carried off by the external air. In this situation we would recommend to line that part of the wall which is behind the stove (at two or three inches distance), and the whole of the chimney, with plaster on laths. These should be nailed on battens properly fastened on the wall, leaving a space of an inch between the laths and the wall. The plaster should be of the most spungy kind, having in it a quantity of clay in powder instead of the full proportion of sand. Horse-dung, washed with water and strained through coarse flannel, leaves a great portion of unassimilated vegetable fibre, which will mix very intimately in the plaster, and make it a substance very unfit for conducting heat. There is no danger of catching fire by this lining. We have seen a most tremendous fire rage for three hours, in contact with a partition of lath and plaster (on the plaster-side however), without discolouring the thin laths on the other side. We once saw a cottage chimney on fire, and burn till the soot was consumed. This chimney was nothing but a pipe of a foot wide, made of laths, and plastered on the inside and outside; and it passed through a thatched roof. We therefore recommend this in place of the brick-case for inclosing the stove. It would save heat; and as it might be

Stove.

be made in pieces on detached frames, which could be joined by iron ſtraps and hinges, any part of the ſtove could be laid open for repairs at pleaſure.

We have no heſitation in ſaying that a ſtove conſtructed in this manner would be greatly ſuperior in power to any we have ſeen, and would be free from many of their diſguſting defects. We beg leave therefore to introduce here the deſcription of one which was to have been erected in one of the churches of the city of Edinburgh.

Fig. 4.

Fig. 4. is a ſketch of the plan of the church contained in the parallelogram AFED. P marks the place of the pulpit, and LMNO the front of the galleries. Theſe are carried back to the ſide-walls AB and DC. But at the end oppoſite to the pulpit they do not reach ſo far, but leave a ſpace BFEC about 12 feet wide. Below the back of the galleries, on each ſide, there is a paſſage ABGH, KICD, ſeparated from the ſeated part of the church by partitions which reach from the floor to the galleries, ſo that the ſpace HGIK is completely ſhut in. The church is an ancient Gothic building, of a light and airy ſtructure, having two rows of large windows above the arcades, and a ſpacious window in the eaſt end above the pulpit. The congregation complain of a cold air, which they feel pouring down upon their heads. This is more particularly felt by thoſe ſitting in the fronts of the galleries. We imagine that this ariſes chiefly from the extenſive ſurface of the upper row of windows, and of the cold ſtone-walls above, which robs the air of its heat as it glides up along the ſides of the church. It becomes heavier by collapſing, and in this ſtate deſcends in the middle of the church.

The ſtove S is placed againſt the middle of the weſt wall at the diſtance of a few inches, and is completely incloſed in a caſe of lath and plaſter. The vent, which is to carry off the ſmoke and burnt air, is conveyed up or along the wall, and through the roof or ſide-wall, but without any communication with the caſe. In like manner the fire-place door is open to the paſſage, without communicating with the caſe; and care is taken that the holes which admit the air into the caſe are ſo diſpoſed that they ſhall run no riſk of drawing in any air from the fire-place door.

From the top of this caſe proceed two trunks Q, R, each of which is two feet broad and ſix inches deep, coated within and without with the moſt ſpungy plaſter that can be compoſed. For this purpoſe we ſhould recommend a compoſition of powdered charcoal and as much clay and quicklime as will give it a very ſlight coheſion. We know that a piece of this may be held in the hand, without inconvenience, within an inch of where it is of a glowing red heat.—Theſe trunks open into another trunk XVTYZ, which ranges along the partition immediately under the galleries, and may be formed externally into a corniche, a little maſſive indeed, but not unſightly in a building of this ſtyle. This trunk is coated in the ſame manner. It has ſeveral openings *a*, *a*, &c. which have ſliders that can be drawn aſide by means of handles acceſſible from the outer paſſage.—At the extremities X and Z of this trunk are two perpendicular trunks which come up through the galleries, and are continued to a conſiderable height. At their junction with the horizontal trunk are two doors large enough to admit a lamp. Each perpendicular trunk has alſo a valve by which it can be completely ſtopped.

The ſtove is managed as follows: Early in the morning the ſuperintendant ſhuts all the ſliders, and ſets a lamp (burning) in each of the trunks X and Z, and ſhuts the doors. He then puts on and kindles the fire in the ſtove, and manages it either in the Ruſſian or German method. Perhaps the latter is preferable, as being liable to feweſt accidents from miſtake or neglect.

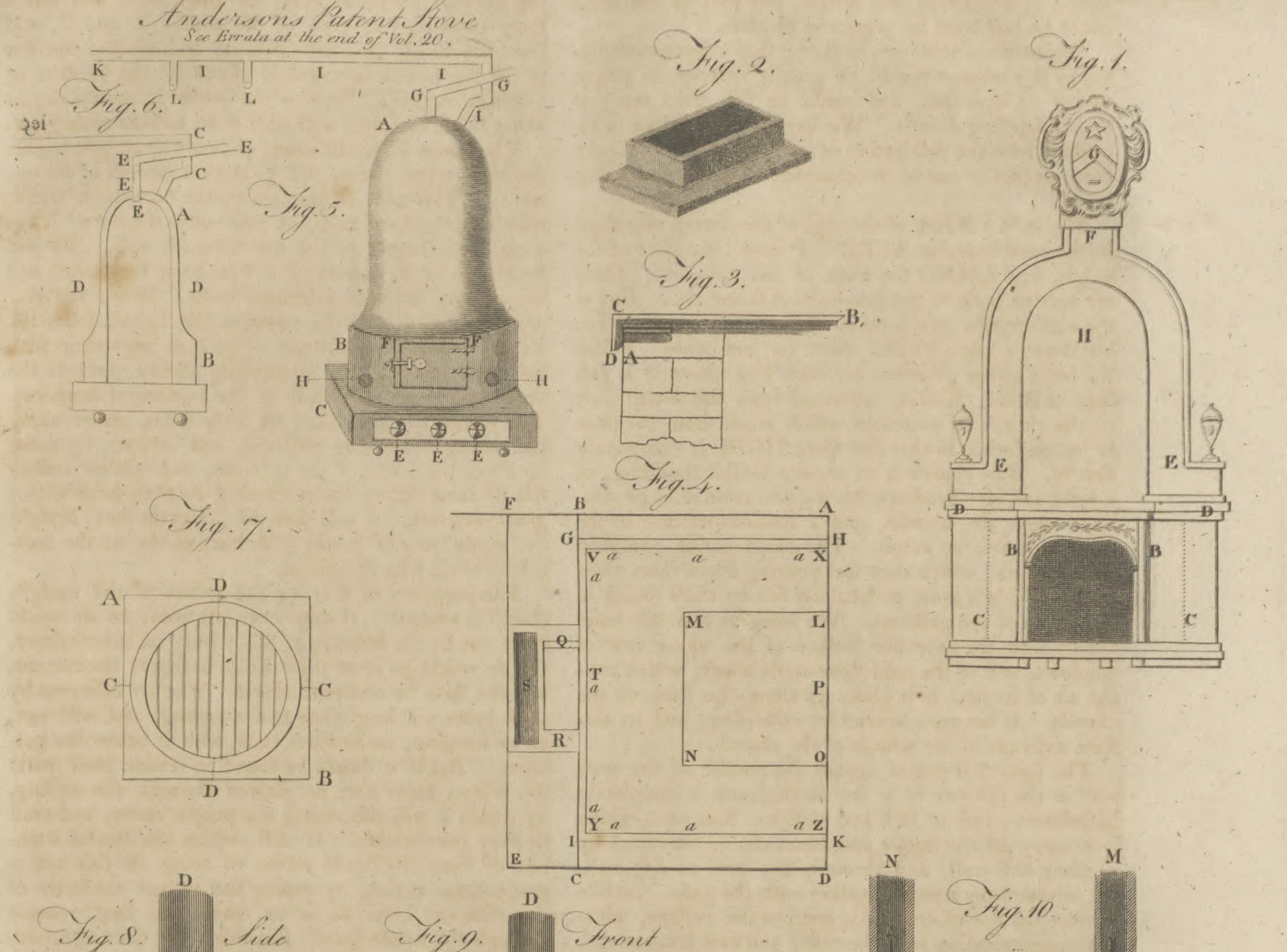
The lamps ſet in the lower ends of the upright trunks preſently warm them, and produce a current of air upwards. This muſt be ſupplied by the horizontal trunk, which muſt take it from the caſe round the ſtove. Thus a current is begun in the direction we wiſh. By and by the air in the caſe acquires heat from the ſtove, and the current becomes extremely briſk. When the manager perceives this, he removes the lamps, ſhuts the valves, and opens the holes *a*, *a*, &c. beginning with the moſt remote, and proceeding ſlowly towards the ſtove from each extremity of the horizontal branches. The heated air now iſſues by theſe holes, glides along the ceiling below the galleries, and eſcapes, by riſing up along the fronts of the galleries, and will be ſenſibly felt by thoſe ſitting there, coming on their faces with a gentle warmth. It will then riſe (in great part) ſtraight up, while ſome of it will glide backwards, to the comfort of thoſe who ſit behind.

The propriety of ſhutting the valves of the upright trunks is evident. If they were left open, no air would come out by the holes *a*, *a*, &c.; but, on the contrary, the air would go in at theſe holes to ſupply the current, and the ſtove be rendered uſeleſs. The air delivered by theſe holes will keep cloſe to the ceiling, and will not, as we imagine, incommode thoſe who ſit below the galleries. But if it ſhould be found to render theſe parts too warm, holes may be pierced through the ceiling, by which it will riſe among the people above, and muſt be very comfortable. It will require the careful attention of ſome intelligent perſon to bring all this into a proper train at firſt, by finding the proper apertures of the different holes, ſo as to render the heat equable through the whole ſpace. But this being once aſcertained the difficulty is over.

The air trunks muſt be very capacious, but may be contracted towards the extremities as their lateral diſcharges diminiſh; and the row of holes which admit the air to the caſe round the ſtove muſt be fully able to ſupply them.

It muſt be obſerved, that in this conſtruction the aſcenſional force is but ſmall. It is only the height of a ſhort column of warm air from the ground to the galleries. At firſt indeed it is great, having the unlimited height of the perpendicular trunks at X and Z; but during the uſe of the ſtove it is reduced to nine or ten feet. It is neceſſary, therefore, that the ſtove be highly heated, perhaps conſiderably beyond the Ruſſian practice, but yet inferior to the heat of the German iron ſtoves. But ſtill we ſtrongly recommend the brick or pottery ſtoves, on account of the wholeſome ſweetneſs of the air which they furniſh; and we are certain that a ſtove of moderate dimenſions, eight feet long, for inſtance, by eight feet high, will be ſufficient for warming a church holding 1200 or 1500 people. If the ſtove could be placed lower, which in many ſituations is very practicable, its effect would be proportionally greater, becauſe all depends on the rapidity of the current. When we are limited in height, we muſt extend the

ſtove



E. Mitchell sculpt

ſtove ſo much the more in length, and make the air trunks more capacious. Theſe and many other circumſtances of local modification muſt be attended to by the erector of the ſtove; and without the judicious attention of an intelligent artiſt, we may expect nothing but diſappointment. It is hardly poſſible to give inſtructions ſuited to every ſituation; but a careful attention to the general principle which determines the aſcenſional force will free the artiſt from any great riſk of failure.

We may ſay the ſame thing of ſtoves for conſervatories, hot-houſes, hot walls, &c. and can hardly add any thing of conſequence to what we have already ſaid on theſe heads in the article Pneumatics.

We muſt not, however, diſmiſs the ſubject without taking notice of the very ſpecious projects which have been frequently offered for drying malt by ſtoves. Many of theſe are to be ſeen in the publications of the Academies of Stockholm, Upſal, Copenhagen; and ſome have been erected in this kingdom, but they have not been found to anſwer.

We apprehend that they cannot anſwer. To dry malt, and make it fit for the ales and beers for which this iſland is ſo famous, it is by no means enough that we give it a proper and an equable ſupply of heat.—This alone would bake it and make it flinty, cauſing the moiſture to penetrate the mealy particles of the grain; and, by completely diſſolving the ſoluble parts, would render each kernel an uniform maſs, which would dry into a flinty grain, breaking like a piece of glaſs.—A grain of malt is not an inert pulp. It is a SEED, in an active ſtate, growing, and of an organized ſtructure. We wiſh to ſtop it in this ſtate, and kill it, not by heating it, but by abſtracting its moiſture. We thus leave it in its granulated or organized form, ſpungy, and fit for imbibing water in the maſh tub, without running into a paſte.

To accompliſh theſe purpoſes, the conſtruction of our malt kilns ſeems very well adapted. The kiln is the only flue of the furnace, and a copious *current* of air is formed through among the grains, carrying off with it the water which is evaporating by the heat. But this evaporation, being chiefly in conſequence of the vapour being immediately diſſolved by the paſſing air, will ſtop as ſoon as the current of air ſtops. This current has to make its way through moiſt grain, laid in a pretty thick bed, and matted together. Some force, therefore, is neceſſary to drive it through. This is furniſhed by the draught of the kiln. Subſtituting a ſtove, immediately applied to the malt, will not have this effect. The only way in which we think this can be done different from the preſent, is to have a horizontal flue, as has been propoſed in theſe projects, ſpread out at a ſmall diſtance below the grate on which the malt is laid, and to cover the whole with a high dome, like a glaſs-houſe dome. This being filled with a tall column of hot air, and having no paſſage into it but through the malt, would produce the current which we want. We are convinced that this will make much leſs fuel ſerve; but we are by no means certain that the ſulphureous and carbonic acid which accompanies the air in our common kiln is not a neceſſary or a uſeful ingredient in the proceſs. It is well known that different coaks, cinders, or charcoals, impart different qualities to the malts, and are preferred *each for its own purpoſe.*

A ſtove conſtructed on ſimilar principles, but compoſed of very different materials, has been lately erected in ſeveral of the churches in Edinburgh. This ſtove, which is formed entirely of caſt iron, may be conſidered as a double ſtove, an outer caſe, and a furnace or inner ſtove. The fuel is burnt in the inner ſtove; and the ſmoke produced during the proceſs of combuſtion, is carried off by a chimney, which paſſes through the top of the outer ſtove, and is conveyed to the outſide of the building. The outer caſe includes not only the furnace or inner ſtove, but alſo a conſiderable ſpace, occupied by the air of the atmoſphere, which is freely admitted through a number of openings placed around it; and when any current of air is produced, it paſſes off from the ſpace between the outer caſe and inner ſtove, and is conveyed by tubes through the body of the apartment. But we ſhall firſt deſcribe the different parts of which the ſtove is compoſed, after which we ſhall be better able to underſtand its mode of operation.

Fig. 5. exhibits a perſpective view of this ſtove. AB is the body, which is about three feet high, and of a circular form. BC is a ſquare pedeſtal on which the ſtove is placed, and which contains the aſh pit DD. The height of the pedeſtal is about a foot, and it is nearly inſulated by reſting on the ſpherical ſupports *a a*, alſo of caſt iron. EEE are openings in front of the aſh pit through which the air enters to ſupport the combuſtion. Theſe openings can be enlarged or diminiſhed, or opened and ſhut at pleaſure. FF is the door of the furnace through which the fuel is introduced. This door is attached to the inner furnace, and is double. It is one foot broad, and 11 inches high. GG is the chimney, which paſſes from the furnace within, through the outer caſe, and conveys the ſmoke out of the building. HH are openings in the outer caſe, and are eight in number, through which the air enters, and being heated, is greatly rarified, and paſſes off through the funnel or pipe IIII. This pipe communicates only with the outer ſtove, and being ſhut at the end K, the air ruſhes out from the ſmall tubes LL, inſerted into the ſide of the pipe IIII, and thus mixes with the cold air of the church. The diameter of the outer caſe at the bottom is about two feet, and the diameter of the furnace within is about 16 inches.

Fig. 6. is a ſection of the ſtove. AB is the outer caſe, from which paſſes off the pipe or funnel CCC, by which the heated air is conveyed through the church. DD is the furnace in the inſide, in which the fuel is burnt, and EEE is the chimney or funnel which conveys the ſmoke from the inner furnace out of the building. It paſſes through the outer ſtove AB at F.

Fig. 7. is a plan of this ſtove. AB is the pedeſtal on which it reſts, and which contains the aſh pit. CC is the outer caſe, and DD is the furnace within, in which are ſeen the tranſverſe bars which ſupport the fuel.

The length of the body of the church, in which two ſtoves of the form and dimenſions now deſcribed are erected, is about 60 feet, and the breadth is about 45 feet. The tubes IIII are conveyed along the lower edge of the gallery, about half the length of the church. The fires are lighted up about four or five o'clock on the Sunday morning, during the earlier part of the cold ſeaſon; but as the ſeaſon advances, it is uſual to light them up the night before. From this time till the congregation aſſemble for the afternoon ſervice, the furnaces are

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are kept conftantly fupplied with fuel. By this management the air in the church is kept comfortably warm during the coldeft feafon of the year.

Thefe ftoves, it appears to us, are fufceptible of fome improvement, both in their conftruction and in the places in which they are erected. With regard to the firft circumftance, an external coating of plafter work, or of the fame kind of materials as are ufed for coating the infide of chemical furnaces, would be of fome ufe in preventing an unneceffary wafte of heat, as well as the difagreeable fmell which is fometimes complained of, and which is fuppofed to arife from the combuftion of light bodies floating in the air and drawn by the current to the heated metal; and with regard to the laft, viz. the places in which they are erected, it is perfectly obvious that they ought to be as completely infulated as poffible, and particularly ought not to communicate with any body which is a good conductor of heat. Some of the ftoves erected in the churches of Edinburgh, which we have examined, are faulty in this refpect. One in particular is placed in clofe contact with a gable wall.

The quantity of coals confumed in two of thefe ftoves in one of the churches of Edinburgh during the courfe of a feafon, we have been informed, amounts to about five carts of 12 cwt. each; fo that at the Edinburgh prices of coal, the expence for fuel for heating one of the churches is about 50 fhillings. This being added to the expences of attendance, includes the whole expenditure, befides fome occafional repairs which are required in heating a church of the above dimenfions.

The following is the defcription of an improved ftove by Mr Field of Newman Street London, in which, it is ftated by the author, the various advantages of heating, boiling, fteaming, evaporating, drying, ventilating, &c. are united; fome of which we fhall detail in his own words.

"Fig. 8. reprefents a longitudinal fection of the ftove, fhowing the courfe of the air from its entrance into the flues of the ftove at A, to its entrance into the upper chamber of the ftove at B; and alfo the courfe of the fmoke from the fire-place at C, till it efcapes from the ftove at D. E, E, are the doors or openings of the fire-place and afh-hole.

"Fig. 9. is a fimilar fection at right angles with the above, exhibiting the courfe of the air through the chambers of the ftove, from its entrance into the chamber N° 1. at B to its entrance beneath the fire-place at F. This figure alfo fhows fections of the flues, with the divifions through which the air and fmoke pafs feparately, the fmoke-flue in the centre, and the air-flues on each fide. G, G, are doors and openings through which the articles to be dried are introduced into the chambers.

"When the fire is lighted, and the doors of the chambers, afh hole, and fire-place, clofed, the air by which the fire is fupplied enters at A, fig 8. paffes through the air-flues *a*, *a*, *a*, *a*, enters the upper chamber at B, traverfes and defcends through the chambers N° 1, 2, 3, and arrives beneath the fire at F, fig. 9. Having fupplied the fire with oxygen, it paffes through the flue with the fmoke, and efcapes at D, heating in its protracted courfe the chambers and air-flues.

"As the cold air enters the ftove at A, immediately above a plate forming the top of the fire-place, and purfues a fimilar route with the fire-flue, it enters the chambers very much heated and rarefied. Hence any moift fubftance placed in the chambers evaporates in confequence, not only of the heated flues circulating round them, but of a ftream of warm rarefied air, which, while it continually raifes evaporation, as continually bears away the exhaled moifture in its paffage to the fire, thus imitating the gradual and efficacious plan of nature in drying by the fun and air. While thefe effects are taking place within the ftove, part of the air which enters at A, fig. 8. and 9. paffes through air-flues on the other fide of the fire-flue, purfues a parallel courfe with the firft, and gives out a current of warm air to the room at an aperture H. This effect may be obtained in a much higher degree, if the doors of the chambers and afh-hole are opened: fhould the hand or face be then brought near, they would be fanned with a ftream of warm air, efpecially from the upper chamber.

Stove, Stourbridge.

"By means of this ftove I have evaporated milk to drynefs, without burning or difcolouring it; and have dried cherries, plums, and other fruits, fo as to imitate thofe which are received from abroad. I have repeatedly dried colours and the moft delicate fubftances without the flighteft injury, even though the operation proceeded quickly.

"The height of the ftove is about five feet and a half; its diameter two feet and a half, and that of the flues four inches. The external part is conftructed of brick, and the internal parts of thin Ryegate or fire-ftone, except the top of the fire-place, which is a plate of caft iron. Were it to be wholly formed of iron, its effects would neceffarily be more powerful.

"Fig. 10. reprefents an extenfion of the plan, in which ftoves of this kind may be advantageoufly connected with one or more furnaces for chemical or other ufes. The fire-place, brought out, either in front or on one fide, by the prefent pofitions of its crown I, forms a reverberatory furnace, or will make a fand-bath by reverfing it.

"The fpace occupied by the fire-place in fig. 8. may in this be converted into apartments for evaporating fubftances, or occafionally for cooling them by an opening at K to admit cold air, while the warm air of the ftove is excluded by a regifter or door. The dotted lines fhow the manner in which a fecond furnace may be connected by an opening into the flue at L.

"In addition to the ufes already pointed out, this ftove would probably be found extremely ferviceable in drying japanners goods, and confuming the noxious fumes and gas which arife from the oil and varnifh ufed in this bufinefs.

"Since the ftove is not limited to any certain dimenfions, it might be adapted to the drying of malt and hops, perhaps of herbs, corn, and feeds generally. It might alfo be accommodated to the purpofes of the fugar-bakers, connected with the great fires they employ for their boilers. It has been fhown to be ufeful in the confectioners art, and probably it may be equally fo in baking bifcuits for the navy; nor lefs fo in drying linen for the laundrefs, dyer, calico-printer, and bleacher. I have myfelf found it well accommodated for a chemical elaboratory *."

* *Phil. Mag.* vol. xxvii.

STOURBRIDGE, or STURBICH, the name of a field near Cambridge, noted for its famous fair kept annually on the 7th of September, and which continues for a fortnight. The commodities are, horfes, hops, iron, wool, leather, cheefe, &c. This place is alfo noted

noted for an excellent ſpecies of clay capable of reſiſting an intenſe heat. It is uſed in making pots for glaſs-houſes, fire-bricks, &c.; and is ſold at an high price.

STOW, the name of a market-town in Glouceſterſhire in England, ſituated in W. Long. 1. 50. N. Lat. 51. 54. It is alſo the name of a fine ſeat of the marquis of Buckingham in Buckinghamſhire. Here are the beſt gardens in England, adorned with buſts, ſtatues, obeliſks, pavilions, and temples. It is two miles from the town of Buckingham.

STOW, *John*, the induſtrious hiſtorian, ſon of Thomas Stow merchant-taylor of St Michael's, Cornhill, in London, was born about the year 1525. Of the early part of his life we know very little, except that he was bred to his father's buſineſs, which in the year 1560 he relinquiſhed, devoting himſelf entirely to the ſtudy of our ancient hiſtorians, chronicles, annals, charters, regiſters, and records. Of theſe he made a conſiderable collection, travelling for that purpoſe to different parts of the kingdom, and tranſcribing ſuch manuſcripts as he could not purchaſe. But this profeſſion of an antiquary being attended with no preſent emolument, he was obliged for ſubſiſtence to return to his trade.—It happened, however, that his talents and neceſſities were made known to Dr Parker archbiſhop of Canterbury; who being himſelf an antiquary, encouraged and enabled Mr Stow to proſecute his darling ſtudy. In thoſe times of perſecution, though Elizabeth was then upon the throne, honeſt John Stow did not eſcape danger. His collection of Popiſh records was deemed cauſe of ſuſpicion. His younger brother Thomas preferred no leſs than 140 articles againſt him before the eccleſiaſtical commiſſion; but the proof being inſufficient, he was acquitted. In 1565 he firſt publiſhed his Summary of the Chronicles of England. About the year 1584 he began his Survey of London. In 1585 he was one of the two collectors for a great muſter of Limeſtreet ward: in the ſame year he petitioned the corporation of London to beſtow on him the benefit of two freemen, to enable him to publiſh his ſurvey; and in 1589 he petitioned again for a penſion. Whether he ſucceeded, is not known. He was principally concerned in the ſecond edition of Holinſhed's chronicle, publiſhed in 1587. He alſo corrected, and twice augmented, Chaucer's works, publiſhed in 1561 and in 1597. His ſurvey of London was firſt publiſhed in 1598. To theſe laborious works he would have added his large Chronicle, or Hiſtory of England; but he lived only to publiſh an abſtract of it, under the title of *Flores Hiſtoriarum*. The folio volume, which was printed after his death, with the title of *Stow's Chronicle*, was taken from his papers by Edmund Howes. Having thus ſpent his life and fortune in theſe laborious purſuits, he was at laſt obliged to ſolicit the charitable and well diſpoſed for relief. For this purpoſe, King James I. granted him, in 1603, a brief, which was renewed in 1604, authorizing him to collect in churches the benefactions of his fellow-citizens. He died in April 1605, aged 80; and was buried in his pariſh church of St Andrew's, Underſhaft, where his widow erected a decent monument to his memory. John Stow was a moſt indefatigable antiquarian, a faithful hiſtorian, and an honeſt man.

STOWMARKET, a town of Suffolk, in England, ſituated in E. Long. 1. 6. N. Lat. 52. 16. It is a large handſome place, ſituated between the branches of the rivers Gypping and Orwell, and is remarkable for having the beſt cherries in England.

STOWAGE, the general diſpoſition of the ſeveral materials contained in a ſhip's hold, with regard to their figure, magnitude, or ſolidity.

In the ſtowage of different articles, as ballaſt, caſks, caſes, bales, and boxes, there are ſeveral general rules to be obſerved, according to the circumſtances or qualities of thoſe materials. The caſks which contain any liquid are, according to the ſea phraſe, to be *bung-up* and *bilge-free*, i. e. cloſely wedged up in an horizontal poſition, and reſting on their quarters: ſo that the bilges where they are thickeſt being entirely free all round, cannot rub againſt each other by the motion of the veſſel. Dry goods, or ſuch as may be damaged by the water, are to be carefully incloſed in caſks, bales, caſes, or wrappers; and wedged off from the bottom and ſides of the ſhip, as well as from the bow, maſts, and pump-well. Due attention muſt likewiſe be had to their diſpoſition with regard to each other, and to the trim and centre of gravity of the ſhip; ſo that the heavieſt may always be neareſt the keel, and the lighteſt gradually above them.

STRABISMUS, ſquinting. See MEDICINE *Index*.

STRABO, a celebrated Greek geographer, philoſopher, and hiſtorian, was born at Amaſia, and was deſcended from a family ſettled at Gnoſſus in Crete. He was the diſciple of Xenarchus, a Peripatetic philoſopher, and at length attached himſelf to the Stoics. He contracted a ſtrict friendſhip with Cornelius Gallus, governor of Egypt, and travelled into ſeveral countries to obſerve the ſituation of places, and the cuſtoms of nations. He flouriſhed under Auguſtus, and died under Tiberius about the year 25, in a very advanced age.—He compoſed ſeveral works, all of which are loſt except his Geography in 17 books; which are juſtly eſteemed very precious remains of antiquity. The two firſt books are employed in ſhowing, that the ſtudy of geography is not only worthy of, but even neceſſary to, a philoſopher; the third deſcribes Spain; the fourth, Gaul and the Britannic iſles; the fifth and ſixth, Italy and the adjacent iſles; the ſeventh, which is imperfect at the end, Germany, the countries of the Getæ and Illyrii, Taurica Cherſoneſus, and Epirus; the eighth, ninth, and tenth, Greece with the neighbouring iſles; the four following, Aſia within Mount Taurus; the fifteenth and ſixteenth, Aſia without Taurus, India, Perſia, Syria, Arabia; and the ſeventeenth, Egypt, Æthiopia, Carthage, and other places of Africa. Strabo's work was publiſhed with a Latin verſion by Xylander, and notes by Iſaac Caſaubon, (or rather by Henry Scrimzeer, from whom Caſaubon chiefly ſtole them), at Paris, 1620, in folio. But the beſt edition is that of Amſterdam in 1707, in two volumes folio, by the learned Theodore Janſonius ab Almelooveen, with the entire notes of Xylander, Caſaubon, Meurſius, Cluver, Holſtenius, Salmaſius, Bochart, Ez. Spanheim, Cellarius, and others. To this edition is ſubjoined the *Chreſtomathiæ*, or epitome of Strabo; which according to Mr Dodwell, who has written a very elaborate and learned diſſertation about it, was made by ſome unknown perſon between the years of Chriſt 676 and 996. It has been found of ſome uſe, not only in helping to correct the original, but in supplying in some measure the defect in the seventh book. Mr Dodwell's dissertation is prefixed to this edition.

STRADA, Famianus, a very ingenious and learned Jesuit, was born at Rome in the latter end of the 16th century, and taught rhetoric there, in a public manner, for fifteen years. He wrote several pieces upon the art of oratory, and published some orations with a view of illustrating by example what he had inculcated by precept. But his *Prolusiones Academicæ* and his *Historia de Bello Belgico* are the works which raised his reputation, and have preserved his memory. His history of the war of Flanders was published at Rome; the first decad in 1640, the second in 1647; the whole extending from the death of Charles V. which happened in 1558, to the year 1590. It is written in good Latin, as all allow; but its merit in other respects has been variously determined. His *Prolusiones Academicæ* show great ingenuity, and a masterly skill in classical literature; that prolusion especially in which he introduces Lucan, Lucretius, Claudian, Ovid, Statius, and Virgil, each of them versifying according to his own strain. They have been often printed. We know not the year of Strada's birth or of his death.

STRAHAN, William, an eminent printer, was born at Edinburgh in the year 1715. His father, who had a small appointment in the customs, gave his son the education which every one of decent rank then received in a country where the avenues to learning were easy, and open to men of the most moderate circumstances. After having passed through the tuition of a grammar school, he was put apprentice to a printer; and when a very young man, removed to a wider sphere in that line of business, and went to follow his trade in London. Sober, diligent, and attentive, while his emoluments were for some time very scanty, he contrived to live rather within than beyond his income; and though he married early, and without such a provision as prudence might have looked for in the establishment of a family, he continued to thrive, and to better his circumstances. This he would often mention as an encouragement to early matrimony; and used to say, that he never had a child born that Providence did not send some increase of income to provide for the increase of his household. With sufficient vigour of mind, he had that happy flow of animal spirits that is not easily discouraged by unpromising appearances.

His abilities in his profession, accompanied with perfect integrity and unabating diligence, enabled him, after the first difficulties were overcome, to advance with rapid success. And he was one of the most flourishing men of the trade, when, in the year 1770, he purchased a share of the patent for king's printer of Mr Eyre, with whom he maintained the most cordial intimacy during the rest of his life. Beside the emoluments arising from this appointment, as well as from a very extensive private business, he now drew largely from a field which required some degree of speculative sagacity to cultivate on account of the great literary property which he acquired by purchasing the copy-rights of the most celebrated authors of the time. In this his liberality kept pace with his prudence, and in some cases went perhaps rather beyond it. Never had such rewards been given to the labours of literary men as now were received from

him and his associates in those purchases of copy-rights from authors.

Having now attained the first great object of business, wealth, Mr Strahan looked with a very allowable ambition on the stations of political rank and eminence, Politics had long occupied his active mind, which he had for many years pursued as his favourite amusement, by corresponding on that subject with some of the first characters of the age. Mr Strahan's queries to Dr Franklin in the year 1769, respecting the discontents of the Americans, published in the London Chronicle of 28th July 1778, show the just conception he entertained of the important consequences of that dispute, and his anxiety as a good subject to investigate, at that early period, the proper means by which their grievances might be removed, and a permanent harmony restored between the two countries, In the year 1775 he was elected a member of parliament for the borough of Malmsbury in Wiltshire, with a very illustrious colleague, the Hon. C. J. Fox; and in the succeeding parliament, for Wootton Basset, in the same county. In this station, applying himself with that industry which was natural to him, he was a useful member, and attended the house with a scrupulous punctuality. His talents for business acquired the consideration to which they were intitled, and were not unnoticed by the minister.

In his political connection he was constant to the friends to whom he had first been attached. He was a steady supporter of that party who were turned out of administration in spring 1784, and lost his seat in the house of commons by the dissolution of parliament with which that change was followed: a situation which he did not shew any desire to resume on the return of the new parliament; arising from a feeling of some decline in his health, which had rather suffered from the long sittings and late hours with which the political warfare in the preceding had been attended. Without any fixed disease, his strength visibly declined; and though his spirits survived his strength, yet the vigour and activity of his mind were considerably impared. Both continued gradually to decline till his death, which happened on the 9th of July 1785 in the 71st year of his age.

Endued with much natural sagacity, and an attentive observation of life, he owed his rise to that station of opulence and respect which he attained, rather to his own talents and exertion, than to any accidental occurrence of favourable or fortunate circumstances. His mind was not uninformed by letters; and from a habit of attention to style, he acquired a considerable portion of critical acuteness in the discernment of its beauties and defects? In one branch of writing he particularly excelled—the epistolary; in which he not only showed the precision and clearness of business, but possessed a neatness as well as a fluency of expression which few letter-writers have been known to surpass. Letter-writing was one of his favourite amusements; and among his correspondents were men of such eminence and talents as well repaid his endeavours to entertain them. Among these, as before mentioned, was the justly celebrated Dr Franklin, originally a printer like Mr Strahan, whose friendship and correspondence, notwithstanding the difference of their sentiments in political matters,

he

he continued to enjoy till his death. One of the latest letters which he received from his illustrious and venerable friend contained a humorous allegory of the state of politics in Britain, drawn from the profession of printing; of which, though the doctor had quitted the exercise, he had not forgotten the terms.

The judicious disposition which Mr Strahan made of his property, affords an evident proof of his good sense and propriety. After providing munificently for his widow and children, his principal study seems to have been to mitigate the affliction of those (and many there were) who would more immediately have felt his loss, by bequeathing them liberal annuities for their lives; and (recollecting that all of a profession are not equally provident) he left 1000l. to the Company of Stationers, the interest to be divided among infirm old printers.

As the virtuous connections of the life and the heart are always pleasing to trace,—of Mr Strahan it may briefly be said, that his capacity, diligence, and probity, raised him to the head of his profession. The good humour and obliging disposition which he owed to nature, he cultivated with care, and confirmed by habit. His sympathetic heart beat time to the joy and sorrow of his friends. His advice was always ready to direct youth, and his purse open to relieve indigence. Living in times not the purest in the English annals, he escaped unsullied through the artifices of trade and the corruption of politics. In him a strong natural sagacity, improved by an extensive knowledge of the world, served only to render respectable his unaffected simplicity of manners, and to make his Christian philanthropy more discerning and useful. The uninterrupted health and happiness which accompanied him for half a century in the capital, proves honesty to be the best policy, temperance the greatest luxury, and the essential duties of life its most agreeable amusement. In his elevated fortune, none of his former acquaintance ever accused him of neglect. He attained prosperity without envy, enjoyed wealth without pride, and dispensed bounty without ostentation.

STRAIKS, in the military art, are strong plates of iron, six in number, fixed with large nails called *straik-nails*, on the circumference of a cannon-wheel, over the joints of the fellows; both to strengthen the wheel, and to save the fellows from wearing on hard ways or streets.

STRAIN, a pain occasioned by the violent extension of some membranous or tendinous part.

STRAIN, *Stress*, in *Mechanics*, are terms indiscriminately used to express the force which is *excited* in any part of a machine or structure of any kind tending to break it in that part. Thus every part of a rope is *equally* strained by the weight which it suspends. Every part of a pillar is *equally* strained by the load which it supports. A mill axle is *equally* twisted and strained in every part which lies between the part of the wheel actuated by the moving power and the part which is resisted by the work to be performed. Every part of a lever or joist is *differently* strained by a force acting on a distant part.

It is evident that we cannot make the structure fit for its purpose, unless the strength at every part be at least equal to the stress laid on, or the strain excited in that part. It is no less plain, that if we are ignorant of the principles which determine this strain, both in intensity and direction, in relation to the magnitude and the situation of its remote cause, the only security we have for success is to give to every part of the assemblage such solidity that we can leave no doubt of its sufficiency. But daily experience shows us that this vague security is in many cases uncertain, if we are thus ignorant. In all cases it is slovenly, unlike an artist, attended with useless expence, and in machines is attended with a loss of power which is wasted in changing the motions of a needless load of matter.

It must therefore greatly tend to the improvement of all professions occupied in the erection or employment of such structures, to have a distinct notion of the strains to which these parts are exposed. Frequently, nay generally, these strains are not immediate, but arise from the action of forces on distant parts, by which the assemblage is strained, and there is a tendency to rupture in every part. This strain is *induced* on every part, and is there modified by fixed mechanical laws. These it is our business to learn; but our chief object in this investigation is to determine the strength of materials which it is necessary to oppose in every part to this strain; and how to oppose this strength in such a manner that it shall be exerted to the best advantage. The notions of strain and strength therefore hardly admit of separation; for it is even by means of the strength of the intermediate parts that the strain is propagated to, or excited in, the part under consideration. It is proper therefore to consider the whole together under the article *STRENGTH of Materials* in mechanics.

STRAINING, is the clarification of a liquor, by passing it through a sieve or filter. The word is derived from the French, *estreindre;* which is formed from *ex*, "out of," and *stringere*, "to press."

STRAIT, a narrow channel or arm of the sea, shut up between lands on either side, and affording a passage out of one great sea into another.

There are three kinds of straits. 1. Such as join one ocean to another. Of this kind are the straits of Magellan and Le Maire. 2. Those which join the ocean to a gulf: the straits of Gibraltar and Babelmandel are of this kind, the Mediterranean and Red sea being only large gulfs. 3. Those which join one gulf to another; as the straits of Caffa, which join the Palus Mæotis to the Euxine or Black sea. The passage of straits is commonly dangerous, on account of the rapidity and opposite motion of currents. The most celebrated strait in the world is that of Gibraltar, which is about from 24 to 36 miles long, and from 15 to 24 broad, joining the Mediterranean sea with the Atlantic ocean. The straits of Magellan, discovered in 1520 by F. Magellan, were used some time as a passage out of the North into the South sea; but since the year 1616, that the strait of Le Maire has been discovered, the former has been disused; both because of its length, which is full three hundred miles, and because the navigation thereof is very dangerous, from the waves of the North and South seas meeting in it and clashing. The strait at the entrance of the Baltic is called the *Sound;* that between England and France, *Le pas de Calais*, or the *Channel*. There are also the straits of Weigats, of Jesso, of Anian, of Davis, and Hudson, &c.

STRAKES, or STREAKS, in a ship, the uniform ranges of planks on the bottom and sides of a ship, or the continuation of planks joined to the ends of each other, and reaching from the ſtem to the ſtern-poſt and faſhion-pieces; the loweſt of theſe, which is called the *garboard-ſtreak*, is let into the keel below, and into the ſtem and ſtern-poſt. They ſay alſo a ſhip *heels a ſtrake*, that is, hangs or inclines to one ſide the quantity of a whole plank's breadth.

STRAKES, or *ſtreks*, in mining, are frames of boards fixed on or in the ground, where they waſh and dreſs the ſmall ore in a little ſtream of water, hence called *ſtraked ore*.

STRALSUND, a ſtrong and rich ſea-port town of Germany, in Hither Pomerania, formerly an important trading-place. In 1678 it was forced to ſurrender to the elector of Brandenburg, after 1800 houſes had been burnt to aſhes in one night's time. After this the Swedes defended it to the laſt extremity; and Chas. XII. in 1714, came hither after his return out of Turkey. But the thrown of Sweden not being able to hold out againſt five great powers, it was forced to ſubmit in 1715. In 1720 it was rendered back to Sweden, but in a very poor condition. It is almoſt ſurrounded by the ſea and the lake Francen, and has a harbour ſeparated from the iſle of Rugen by a narrow ſtrait. It is 15 miles north-weſt of Grippſwald, and 40 north-eaſt of Guſtrow. E. Long. 13. 28. N. Lat. 54. 17.

STRAMONIUM, a ſpecies of plant. See DATURA, BOTANY *Index*.

STRAND (*Saxon*), any ſhore or bank of a ſea or great river. Hence the ſtreet in the weſt ſuburbs of London, which lay next the ſhore or bank of the Thames, was called the *Strand*. An immunity from cuſtom, and all impoſitions upon goods or veſſels by land or water, was uſually expreſſed by *ſtrand* or *ſtream*.

STRANDED (from the Saxon *ſtrand*), is when a ſhip is by tempeſt, or by ill ſteerage, run on ground, and ſo periſhes. Where a veſſel is ſtranded, juſtices of the peace, &c. ſhall command conſtables near the ſea-coaſts to call aſſiſtance for the preſervation of the ſhip; and officers of men of war are to be aiding and aſſiſting thereto.

STRANGE, SIR ROBERT, an eminent engraver, who carried the art to great perfection in this country, and was diſtinguiſhed not only as an artiſt, but highly reſpected and beloved on account of his private virtues and domeſtic habits. Modeſt as he was ingenious, he uſed to ſay that the works of an artiſt ſhould ſerve for his life and monument. His works no doubt will perpetuate his name whilſt any taſte for the fine arts remains.

Sir Robert Strange was born in the iſland of Pomona in Orkney, July the 14th 1721; and died at London July the 5th 1792. He was lineally deſcended from David Strange or Strang, a younger ſon of the family of the Stranges or Strangs of Balcaſky, in the county of Fife, who ſettled in Orkney at the time of the Reformation. But as there were no males remaining of the elder branch of the Stranges of Balcaſky, Sir Robert became the male repreſentative of it, and was found by a legal inveſtigation to have a right to the armorial bearings and every other mark of honour belonging to that ancient family.

He received his claſſical education at Kirkwall in Orkney, under the care of a learned, worthy, and much reſpected gentleman, Mr Murdoch Mackenzie, who has rendered infinite ſervice to his country by the accurate ſurveys and charts he has given of the iſlands of Orkney, and of the Britiſh and Iriſh coaſts.

Originally intended for the law, Mr Strange ſoon became tired of that profeſſion, and perceived that his genius deciſively led him to the arts of drawing and engraving. For this purpoſe he was introduced to the late Mr Richard Cooper at Edinburgh, the only perſon there who had then any taſte in that line of the fine arts. He was bound with him as an apprentice for ſix years; during which time he made ſuch progreſs in his new profeſſion, that his friends entertained the higheſt expectation of his ſucceſs; nor were they diſappointed.

In the year 1747 he married Iſabella, only daughter of William Lumiſden, ſon of Biſhop Lumiſden; and ſoon after his marriage he went to France, where with the moſt ardent application he proſecuted his ſtudies, chiefly at Paris, under the direction of the celebrated Le Bas, who engraved many excellent prints from the Dutch painters. It was from Le Bas he had the firſt hint of the uſe of the inſtrument commonly called *the dry needle*; but which he afterwards greatly improved by his own genius, and which has added ſuch ſuperior beauties to his engravings.

In the year 1751 Mr Strange removed with his family from Edinburgh and ſettled at London, where he engraved ſeveral fine hiſtorical prints, which juſtly acquired to him great reputation. At this period hiſtorical engraving had made little progreſs in Britain, and he may be properly conſidered as its father.

The admiration he always had for the works of the great Italian painters made him long deſire to viſit Italy, the ſeat of the fine arts; and the farther he advanced in life, he became the more perſuaded that a journey to that country was eſſential to an artiſt who had the laudable ambition to excel in his profeſſion. He therefore undertook this journey in the year 1760. In Italy he made many admirable drawings, ſeveral of which he afterwards engraved. Theſe drawings are now in the poſſeſſion of Lord Dundas.

Everywhere in Italy ſingular marks of attention were beſtowed on Mr Strange; not only by great perſonages, but by the principal academies of the fine arts in that country. He was made a member of the academies of Rome, Florence, and Bologna, and profeſſor in the royal academy at Parma.

To ſhow the eſtimation in which his talents were held at Rome, we cannot but record the following anecdote. The ceiling of the room of the Vatican library, in which the collection of engravings is kept, is elegantly painted by Signor Rotſanelli. It repreſents the progreſs of engraving; and the portraits of the moſt eminent artiſts in that line are there introduced, among which is that of our artiſt. Under his arm he holds a portfolio, on which his name is inſcribed. He is the only Britiſh artiſt on whom this honour has been conferred.

In France, where he reſided many years at different periods, his talents likewiſe received every mark of attention that could be beſtowed on a foreigner. He was made a member of the royal academy of painting at Paris.

His majeſty King George III. ever attentive to the progreſs of the fine arts in Britain, and ſenſible of the advantages of which engraving particularly has been to this

this country, even in a commercial light; and desirous to give a mark of his royal approbation of the merit of Mr Strange, whom he considered as at the head of his profession and the great improver of it—was graciously pleased to confer the honour of knighthood on him the 5th of January 1787.

Such was Sir Robert Strange as an artist; nor was he less distinguished by his truly amiable moral qualities, which endeared him to all who had the happiness to know him.

With regard to his works, he left fifty capital plates, still in good condition, which are carefully preserved in his family. They are engraved from pictures by the most celebrated painters of the Roman, Florentine, Lombard, Venetian, and other schools. They are historical, both sacred and profane, poetical, allegorical.

From his earliest establishment in life, Sir Robert carefully preserved about eighty copies of the finest and most choice impressions of each plate he engraved; which, from length of time, have acquired a beauty, mellowness, and brilliancy, easier seen than described. He did this with a view of presenting them to the public at a period when age should disable him from adding to their number. These he collected into as many volumes, and arranged them in the order in which they were engraved. To each volume he prefixed two portraits of himself, on the same plate, the one an etching, the other a finished proof, from a drawing by John Baptiste Greuse. This is the last plate which he engraved; and is a proof that neither his eyes nor hand were impaired by age. It likewise shows the use he made both of aquafortis and the graver. Each volume, besides a dedication to the king, contains an introduction on the progress of engraving, and critical remarks on the pictures from which his engravings are taken. These volumes were ready to be given to the public, when Sir Robert's death delayed this magnificent publication; a publication which does so much honour to the artist, and to the country which gave him birth. He died at London 5th July 1792.

The following is an authentic catalogue of his works. Plate 1. Two Heads of the author—one an etching, the other a finished proof, from a drawing by John Baptiste Greuse; 2. The Return from Market, by Wouvermans; 3. Cupid, by Vanloo; 4. Mary Magdalen, by Guido; 5. Cleopatra, by the same; 6. The Madonna, by the same; 7. The Angel Gabriel, by the same; 8. The Virgin, holding in her hand a book, and attended by angels, by Carlo Maratt; 9. The Virgin with the Child asleep, by the same; 10. Liberality and Modesty, by Guido; 11. Apollo rewarding Merit and punishing Arrogance, by Andrea Sacchi; 12. The Finding of Romulus and Remus, by Pietro da Cortona; 13. Cæsar repudiating Pompeia, by the same; 14. Three Children of King Charles I. by Vandyke; 15. Belisarius, by Salvator Rosa; 16. St Agnes, by Dominichino; 17. The Judgement of Hercules, by Nicolas Poussin; 18. Venus attired by the Graces, by Guido; 19. and 20. Justice and Meekness, by Raphael; 21. The Offspring of Love, by Guido; 22. Cupid Sleeping, by the same; 23. Abraham giving up the Handmaid Hagar, by Guercino; 24. Esther a Suppliant before Ahasuerus, by the same; 25. Joseph and Potiphar's Wife, by Guido; 26. Venus Blinding Cupid, by Titian; 27. Venus, by the same; 28. Danae, by the same; 29. Portrait of King Charles I. by Vandyke; 30. The Madonna, by Correggio; 31. St Cæcilia, by Raphael; 32. Mary Magdalen, by Guido; 33. Our Saviour appearing to his Mother after his Resurrection, by Guercino; 34. A Mother and Child, by Parmegiano; 35. Cupid Meditating, by Schidoni; 36. Laomedon King of Troy detected by Neptune and Apollo, by Salvator Rosa; 37. The Death of Dido, by Guercino; 38. Venus and Adonis, by Titian; 39. Fortune, by Guido; 40. Cleopatra, by the same; 41. Two Children at School, by Schidoni; 42. Mary Magdalen, by Correggio; 43. Portrait of King Charles I. attended by the marquis of Hamilton, by Vandyke; 44. Queen Henrietta, attended by the Prince of Wales, and holding in her arms the Duke of York, by the same; 45. Apotheosis of the Royal Children, by West; 46. The Annunciation, by Guido; 47. Portrait of Raphael Sancio D'Urbino, by himself; 48. Sappho, by Carlo Dolci; 49. Our Saviour asleep, by Vandyke; 50. St John in the Desert, by Murillo.

STRANGER, in *Law*, denotes a person who is not privy or party to an act. Thus a stranger to a judgement is he to whom a judgement does not belong; in which sense the word stands directly opposed to party or privy.

STRANGLES, in *Farriery*. See that article, N° 481.

STRANGURY, a suppression of urine. See MEDICINE *Index*.

STRAP, among surgeons, a sort of band used to stretch out limbs in the setting of broken or disjointed bones.

STRAP, in a ship, the rope which is spliced about any block, and made with an eye to fasten it anywhere on occasion.

STRAPS, in the manege. The straps of a saddle are small leather straps, nailed to the bows of the saddle, with which we make the girths fast to the saddle.

STRAPADO, or STRAPPADO, a kind of military punishment, wherein the criminals hands being tied behind him, he is hoisted up with a rope to the top of a long piece of wood, and let fall again almost to the ground; so that, by the weight of his body in the shock, his arms are dislocated. Sometimes he is to undergo three strapadoes or more.

STRASBURG, an ancient, large, handsome, and strong city of France, in Alsace, with a population of 40,000. It contains about 200 streets, part of which are very narrow, and most of the houses are built after the ancient taste. However, there are a great number of handsome buildings, such as the hotel of the marshal of France, who is commander of the city; the hotel of the cardinal of Rouen, the bishop's palace, the Jesuits college, the royal hospital, the hotel of Hesse-Darmstadt, the arsenal, the town-house, and the cathedral. It has a wooden bridge over the Rhine, which is thought to be one of the finest in Europe; as is likewise the cathedral church, whose tower is the handsomest in Germany, and the clock is greatly admired by all travellers. Some look upon it as one of the wonders of the world, and the steeple is allowed to be the highest in Europe. The clock not only shows the hours of the day, but the motion of the sun, moon, and stars. Among other things there is an angel, which turns an hour-

Strafburg, Strata.

hour-glaſs every hour; and the twelve apoſtles proclaim noon, by each of them ſtriking a blow with a hammer on a bell. There is likewiſe a cock, which is a piece of clock-work, that crows every hour. There are 700 ſteps up to the tower or ſteeple, it being 500 feet high. It was a free and imperial city; but the king of France became maſter of it in 1681, and greatly augmented the fortifications, though before it had 365 cannon. The inhabitants were formerly Proteſtants, and carried on a great trade; but moſt of them have been obliged to embrace the Romiſh ſuperſtition, though there is ſtill a ſort of toleration. Such was Straſburg before the French revolution; what it is now we have not leiſure to inquire. It is ſeated on the river Ill, 55 miles north of Baſil, 112 ſouth-weſt of Mentz, and 255 eaſt of Paris. E. Long. 7. 51. N. Lat. 48. 35.

STRATA, in *Natural Hiſtory*, the ſeveral beds or layers of different matters whereof the earth is compoſed. See GEOLOGY.

The ſtrata whereof the earth is compoſed are ſo very different in different countries, that it is impoſſible to ſay any thing concerning them that may be generally applicable: and indeed the depths to which we can penetrate are ſo ſmall, that only a very few can be known to us at any rate; thoſe that lie near the centre, or even a great way from it, being for ever hid. One reaſon why we cannot penetrate to any great depth is, that as we go down the air becomes foul, loaded with pernicious vapours, inflammable air, fixed air, &c. which deſtroy the miners, and there is no poſſibility of going on. In many places, however, theſe vapours become pernicious much ſooner than in others, particularly where ſulphureous minerals abound, as in mines of metal, coal, &c.

But however great differences there may be among the under ſtrata, the upper one is in ſome reſpects the ſame all over the globe, at leaſt in this reſpect, that it is fit for the ſupport of vegetables, which the others are not, without long expoſure to the air. Properly ſpeaking, indeed, the upper ſtratum of the earth all round, is compoſed of the pure vegetable mold, though in many places it is mixed with large quantities of other ſtrata, as clay, ſand, gravel, &c.; and hence proceed the differences of ſoils ſo well known to thoſe who practiſe agriculture.

It has been ſuppoſed, by ſome naturaliſts, that the different ſtrata of which the earth is compoſed were originally formed at the creation, and have continued in a manner immutable ever ſince: but this cannot poſſibly have been the caſe, ſince we find that many of the ſtrata are ſtrangely intermixed with each other; the bones of animals both marine and terreſtrial are frequently found at great depths in the earth; beds of oyſter-ſhells are found of immenſe extent in ſeveral countries; and concerning theſe and other ſhell-fiſh, it is remarkable, that they are generally found much farther from the ſurface than the bones or teeth either of marine or terreſtrial animals. Neither are the ſhells or other remains of fiſh found in thoſe countries adjoining to the ſeas where they grow naturally, but in the moſt diſtant regions. Mr Whitehurſt, in his Inquiry into the Original State and Formation of the Earth, has given the following account of many different kinds of animals, whoſe ſhells and other remains or *exuviæ* are found in England; though at preſent the living animals are not to be found except in the Eaſt and Weſt Indies.

A CATALOGUE *of* EXTRANEOUS FOSSILS, *ſhowing where they were dug up; alſo their native Climates. Moſtly ſelected from the curious Cabinet of* Mr NEILSON, *in* King-ſtreet, Red-Lion Square.

Their names, and Places where found.	Native Climates.
CHAMBERED NAUTILUS. Sheppy iſlands; Richmond in Surrey; Sherbone in Dorſetſhire, -	*Chineſe Ocean, and other Parts of that great ſea.*
TEETH OF SHARKS. Sheppy iſland, Oxfordſhire, Middleſex, Surrey, Northamptonſhire, -	*Eaſt and Weſt Indies.*
SEA-TORTOISE, ſeveral kinds; the *Hawkſbill, Loggerhead, and Green* ſpecies. Sheppy iſland, -	*Weſt Indies.*
MANGROVE TREE OYSTERS. Sheppy iſland, - - -	*Weſt Indies.*
COXCOMB TREE OYSTERS. Oxfordſhire, Glouceſterſhire, Dorſetſhire, and Hanover, -	*Coaſt of Guinea.*
VERTEBRÆ *and* PALATES *of the* ORBES. Sheppy iſland, and many other parts of England, -	*Eaſt and Weſt Indies.*
CROCODILE. Germany, Derbyſhire, Nottinghamſhire, Oxfordſhire, and Yorkſhire, -	
ALLIGATOR'S TEETH. Oxfordſhire, Sheppy iſland, -	*Eaſt and Weſt Indies.*
The BANDED BUCCINUM. Oxfordſhire, and the Alps, -	*Weſt Indies.*
The DIPPING-SNAIL, and STAR-FISH. Sheppy iſland, -	*Weſt Indies.*
TAIL BUCCINUM. Sheppy iſland, Hordel Cliff, Hampſhire, -	*Eaſt Indies.*

Nothing has more perplexed thoſe who undertake to form theories of the earth than theſe appearances. Some have at once boldly aſſerted, from theſe and other phenomena, that the world is eternal. Others have had recourſe to the univerſal deluge. Some, among whom is the Count de Buffon, endeavour to prove that the ocean and dry land are perpetually changing places; that for many ages the higheſt mountains have been covered with water, in conſequence of which the marine animals juſt mentioned were generated in ſuch vaſt quantities, that the waters will again cover theſe mountains, the habitable part of the earth become ſea, and the ſea become dry land as before, &c. Others have imagined that they might be occaſioned by volcanoes, earthquakes, &c. which confound the different ſtrata, and often intermix the productions of the ſea with thoſe of the dry land.

But for a view of the different ſtrata ſo far as they are known; as well as for a view of ſome of the theories which have been propoſed to account for the formation and changes of the earth, ſee GEOLOGY.

Mr Forſter has given an account of ſome of the ſtrata of the South-ſea iſlands, the ſubſtance of which may be ſeen in the following table.

SOUTH GEORGIA.

1. No ſoil, except in a few crevices of the rocks.

2.

Strata.

2. Ponderous ſlate, with ſome irony particles, in horizontal ſtrata, perpendicularly interſected with veins of quartz.

Southern Iſle of NEW ZEALAND.

1. Fine light black mould, in ſome places nine inches deep, but generally not ſo much.
2. An argillaceous ſubſtance, nearly related to the claſs of TALCONS, turned into earth by the action of the air.
3. The ſame ſubſtance farther indurated, in oblique ſtrata, generally dipping to the ſouth.

EASTER ISLAND.

1. Reddiſh-brown duſty mould, looking as if it had been burnt.
2. Burnt rocks, reſembling ſlags or droſs and other volcanic matters.

MARQUESAS.

1. Clay mixed with mould.
2. An earthy argillaceous ſubſtance mixed with tarras and puzzolana.

OTAHEITE.

The ſhores are coral rock, extending from the reef encircling theſe iſles to the very high water-mark. There begins the ſand, formed in ſome places from ſmall ſhells and rubbed pieces of coral; but in others the ſhores are covered with blackiſh ſand, conſiſting of the former ſort mixed with black, ſometimes glittering, particles of mica, and here and there ſome particles of the refractory iron ores called in England SKIM, the *ferrum micaceum* of Linnæus, and KALL, the *molybdænum ſpuma lupi* of the ſame author. The plains from the ſhores to the foot of the hills are covered with a very fine thick ſtratum of black mould, mixed with the above-mentioned ſand, which the natives manure with ſhells. The firſt and lower range of hills are formed of a red ochreous earth, ſometimes ſo intenſely red, that the natives uſe it to paint their canoes and cloth. The higher hills conſiſt of a hard, compact, and ſtiff clayey ſubſtance, hardening into ſtone when out of the reach of the ſun and air. At the top of the valleys, along the banks of the rivers, are large maſſes of coarſe granite ſtones of various mixtures; in one place are pillars of a grey, ſolid baſaltes; and, in ſeveral others, fragments of black baſaltes.

FRIENDLY ISLANDS and NEW HEBRIDES.

The ſame with the above.

MALLICOLLO.

Yellowiſh clay mixed with common ſand.

TANNA, *a Volcanic Iſland.*

The chief ſtrata here are clay mixed with aluminous earth, interſperſed with lumps of pure chalk. The ſtrata of the clay are about ſix inches, deviating very little from the horizontal line.

NEW CALEDONIA and the *adjacent Iſles.*

The ſhores conſiſt of ſhell-ſand, and particles of quartz; the ſoil in the plains a black mould mixed with this ſand. The ſides of the hills compoſed of a yellow ochreous clay, richly ſpangled with ſmall particles of cat-ſilver, or a whitiſh kind of daze, the *mica argentea* of Linnæus. The higher parts of the hills conſiſt of a ſtone called by the German miners *geſtelſtein*, compoſed of quartz and great lumps of the above cat-ſilver. The latter is ſometimes of an intenſely red or orange colour, by means of an iron ochre.

"From the above account, ſays Mr Forſter, it appears, I think, evidently, that all the high tropical iſles of the South ſea have been ſubject to the action of volcanoes. Pyritical and ſulphureous ſubſtances, together with a few iron-ſtones, and ſome veſtiges of copper, are no doubt found in ſeveral of them: but the mountains of New Caledonia are the moſt likely to contain the richeſt metallic veins; and the ſame opinion, I ſuſpect, may be formed of the mountains in New Zealand."

In the city of Modena in Italy, and for ſome miles round that place, there is the moſt ſingular arrangement of ſtrata perhaps in the whole world. From the ſurface of the ground to the depth of 14 feet, they meet with nothing but the ruins of an ancient city. Being come to that depth, they find paved ſtreets, artificers ſhops, floors of houſes, and ſeveral pieces of inlaid work. After theſe ruins they find a very ſolid earth, which one would think had never been removed; but a little lower they find it black and marſhy, and full of briars. Signior Ramazzini in one place found a heap of wheat entire at the depth of 24 feet; in another, he found filbert-trees with their nuts. At the depth of about 28 feet, they find a bed of chalk, about 11 feet deep, which cuts very eaſily; after this a bed of marſhy earth of about two feet, mixed with ruſhes, leaves, and branches. After this bed comes another of chalk, nearly of the ſame thickneſs; and which ends at the depth of 42 feet. This is followed by another bed of marſhy earth like the former; after which comes a new chalk-bed, but thinner, which alſo has a marſhy bed underneath it. This ends at the depth of 63 feet; after which they find ſand mingled with ſmall gravel, and ſeveral marine ſhells. This ſtratum is uſually about five feet deep, and underneath it is a vaſt reſervoir of water. It is on account of this water that the ſoil is ſo frequently dug, and the ſtrata ſo well known in this part of the world. After coming to the ſandy bottom above-mentioned, the workmen pierce the ground with a terebra or augre, when the water immediately ſprings up with great force, and fills the well to the brim. The flow is perpetual, and neither increaſes by rain nor decreaſes by drought. Sometimes the augre meets with great trees, which give the workmen much trouble; they alſo ſometimes ſee at the bottom of theſe wells great bones, coals, flints, and pieces of iron.

It has been aſſerted by ſome, that the ſpecific gravity of the ſtrata conſtantly increaſed with the depth from the ſurface. But Dr Leigh, in his Natural Hiſtory of Lancaſhire, ſpeaking of the coal-pits, denies the ſtrata to lie according to the laws of gravitation; obſerving, that the ſtrata there are firſt a bed of marle, then free-ſtone, next iron-ſtone, then coal, or channel mire, then ſome other ſtrata, then coal again, &c. This determined Mr Derham to make a nicer inquiry into the matter: accordingly, in 1712, he cauſed divers places to be bored, laying the ſeveral ſtrata by themſelves;

themselves; and afterwards determined very carefully their specific gravity. The result was, that in his yard the strata were gradually specifically heavier and heavier the lower and lower they went; but in another place in his fields, he could not perceive any difference in the specific gravities.

Acquainting the Royal Society therewith, their operator Mr Hauksbee was ordered to try the strata of a coal pit, which he did to the depth of 30 strata: the thickness and specific gravity of each whereof he gives us in a table in the Philosophical Transactions; and from the whole makes this inference, that it evidently appears the gravities of the several strata are in no manner of order, but purely casual, as if mixed by chance.

Vol. xxvii. p. 541.

STRATAGEM, in the art of war, any device for deceiving and surprising an enemy. The ancients dealt very much in stratagems: the moderns wage war more openly, and on the square. Frontinus has made a collection of the ancient stratagems of war.

STRATEGUS, ϛϱατηγος, in antiquity, an officer among the Athenians, whereof there were two chosen yearly, to command the troops of the state.

Plutarch says, there was one chosen from out of each tribe; but Pollux seems to say they were chosen indifferently out of the people. The people themselves made the choice; and that on the last day of the year, in a place called *Pnyx*. The two *strategi* did not command together, but took their turns day by day; as we find from Herodotus and Cornelius Nepos. Sometimes indeed, as when a person was found of merit vastly superior, and exceedingly famed in war, the command was given to him alone: but it was ever a rule not to put any person in the office but whose estate was in Attica, and who had children, that there might be some hostages and securities for his conduct and fidelity. Constantine the Great, besides many other privileges granted to the city of Athens, honoured its chief magistrate with the title of Μεγας Στϱατηγος, *Magnus Dux*.

STRATH, in the Scottish language, signifies a long narrow valley, with a river running along the bottom.

STRATHEARN, a beautiful and extensive valley in Perthshire, bounded on the north by the lofty ridge of mountains called the *Grampians*, and on the south by the Ochils, which are rounded on the tops and covered with verdure. It is called *Strathearn* from the river Earn, which runs through the middle of it from west to east for about 30 miles. On each side of the banks of this beautiful stream are many villages and country-seats distinguished for romantic situations. Were we to single out any of the villages, we would mention Crieff, which stands on a fine sloping ground on the north side of the Earn, and has been much admired by travellers for its situation, and the variety, contrast, singularity, and beauty of the prospect which it affords.

STRATHNAVER, a subdivision or district of the county of Sutherland in Scotland; bounded on the north by the ocean, on the east by Caithness, on the south by Sutherland properly so called, and on the west partly by Ross and partly by the ocean.

STRATIOTES, WATER-SOLDIER, a genus of plants belonging to the class polyandria. See BOTANY *Index*.

STRATO, a philosopher of Lampsacus, disciple and successor in the school of Theophrastus, about 248 years before the Christian era. He applied himself with uncommon industry to the study of nature; and after the most mature investigations, he supported that nature was inanimate, and that there was no god but nature. (See *PLASTIC Nature*). He was appointed preceptor to Ptolemy Philadelphus, who not only revered his abilities and learning, but also rewarded his labours with unbounded liberality. He wrote different treatises, all now lost.

STRAWBERRY. See FRAGARIA, BOTANY *Index*.

STRAWBERRY-Tree. See ARBUTUS, BOTANY *Index*.

STRENGTH OF MATERIALS, in *Mechanics*, is a subject of so much importance, that in a nation so eminent as this for invention and ingenuity in all species of manufactures, and in particular so distinguished for its improvements in machinery of every kind, it is somewhat singular that no writer has treated it in the detail which its importance and difficulty demands. The man of science who visits our great manufactories is delighted with the ingenuity which he observes in every part, the innumerable inventions which come even from individual artisans, and the determined purpose of improvement and refinement which he sees in every workshop. Every cotton mill appears an academy of mechanical science; and mechanical invention is spreading from these fountains over the whole kingdom: But the philosopher is mortified to see this ardent spirit so cramped by ignorance of principle, and many of these original and brilliant thoughts obscured and clogged with needless and even hurtful additions, and a complication of machinery which checks improvement even by its appearance of ingenuity. There is nothing in which this want of scientific education, this ignorance of principle, is so frequently observed as in the injudicious proportion of the parts of machines and other mechanical structures; proportions and forms of parts in which the strength and position are nowise regulated by the strains to which they are exposed, and where repeated failures have been the only lessons.

1 Importance of the subject.

It cannot be otherwise. We have no means of instruction, except two very short and abstracted treatises of the late Mr Emerson on the strength of materials. We do not recollect a performance in our language from which our artists can get information. Treatises written expressly on different branches of mechanical arts are totally silent on this, which is the basis and *only principle* of their performances. Who would imagine that PRICE's BRITISH CARPENTER, the work of the first reputation in this country, and of which the sole aim is to teach the carpenter to erect solid and durable structures, does not contain one proposition or one reason by which one form of a thing can be shown to be stronger or weaker than another? We doubt very much if one carpenter in an hundred can give a reason to convince his own mind that a joist is stronger when laid on its edge than when laid on its broad side. We speak in this strong manner in hopes of exciting some man of science to publish a system of instruction on this subject. The limits of our Work will not admit of a detail: but we think it necessary to point out the leading principles, and to give the traces of that systematic connection by which all the knowledge already possessed of this subject may be brought

Strength of Materials. brought together and properly arranged. This we ſhall now attempt in as brief a manner as we are able.

2 Strength of materials ariſes from coheſion.

THE ſtrength of materials ariſes immediately or ultimately from the coheſion of the parts of bodies. Our examination of this property of tangible matter has as yet been very partial and imperfect, and by no means enables us to apply mathematical calculations with preciſion and ſucceſs. The various modifications of coheſion, in its different appearances of perfect ſoftneſs, plaſticity, ductility, elaſticity, hardneſs, have a mighty influence on the ſtrength of bodies, but are hardly ſuſceptible of meaſurement. Their texture alſo, whether uniform like glaſs and ductile metals, cryſtallized or granulated like other metals and freeſtone, or fibrous like timber, is a circumſtance no leſs important; yet even here, although we derive ſome advantage from remarking to which of theſe forms of aggregation a ſubſtance belongs, the aid is but ſmall. All we can do in this want of general principles is to make experiments on every claſs of bodies. Accordingly philoſophers have endeavoured to inſtruct the public in this particular. The Royal Society of London at its very firſt inſtitution made many experiments at their meetings, as may be ſeen in the firſt regiſters of the Society *. Several individuals have added their experiments. The moſt numerous collection in detail is by Muſchenbroek, profeſſor of natural philoſophy at Leyden. Part of it was publiſhed by himſelf in his *Eſſais de Phyſique*, in two vols. 4to; but the full collection is to be found in his Syſtem of Natural Philoſophy, publiſhed after his death by Lulofs, in three vols 4to. This was tranſlated from the Low Dutch into French by Sigaud de la Fond, and publiſhed at Paris in 1760, and is a prodigious collection of phyſical knowledge of all kinds, and may almoſt ſuffice for a library of natural philoſophy. But this collection of experiments on the coheſion of bodies is not of that value which one expects. We preſume that they were carefully made and faithfully narrated; but they were made on ſuch ſmall ſpecimens, that the unavoidable natural inequalities of growth or texture produced irregularities in the reſults which bore too great a proportion to the whole quantities obſerved. We may make the ſame remark on the experiments of Couplet, Pitot, De la Hire, Du Hamel, and others of the French academy. In ſhort, if we except the experiments of Buffon on the ſtrength of timber, made at the public expence on a large ſcale, there is nothing to be met with from which we can obtain abſolute meaſures which may be employed with confidence; and there is nothing in the Engliſh language except a ſimple liſt by Emerſon, which is merely a ſet of affirmations, without any narration of circumſtances, to enable us to judge of the validity of his concluſions: but the character of Mr Emerſon, as a man of knowledge and of integrity, gives even to theſe aſſertions a conſiderable value.

3 Experiments to aſcertain it.

* See Birche's *Hiſtory*, and Hooke's *Mathematical Collections*.

4 Rendered uſeful by generalization.

But to make uſe of any experiments, there muſt be employed ſome general principle by which we can generalize their reſults. They will otherwiſe be only narrations of detached facts. We muſt have ſome notion of that intermedium, by the intervention of which an external force applied to one part of a lever, joiſt, or pillar, occaſions a ſtrain on a diſtant part. This can be nothing but the coheſion between the parts. It is this connecting force which is brought into action, or, as we more ſhortly expreſs it, excited. This action is modified in every part by the laws of mechanics. It is this action which is what we call the *ſtrength* of that part, and its effect is the ſtrain on the adjoining parts; and thus it is the ſame force, differently viewed, that conſtitutes both the ſtrain and the ſtrength. When we conſider it in the light of a reſiſtance to fracture, we call it *ſtrength*.

5 Strength defined.

We call every thing a *force* which we obſerve to be ever accompanied by a change of motion; or, more ſtrictly ſpeaking, we infer the preſence and agency of a force wherever we obſerve the ſtate of things in reſpect of motion different from what we know to be the reſult of the action of all the forces which we know to act on the body. Thus when we obſerve a rope prevent a body from falling, we infer a moving force inherent in the rope with as much confidence as when we obſerve it drag the body along the ground. The *immediate action* of this force is undoubtedly exerted between the immediately adjoining parts of the rope. The immediate effect is the keeping the particles of the rope together. They ought to ſeparate by any external force drawing the ends of the rope contrarywiſe; and we aſcribe their not doing ſo to a mechanical force really oppoſing this external force. When deſired to give it a name, we name it from what we conceive to be its effect, and therefore its characteriſtic, and we call it COHESION. This is merely a name for the fact; but it is the ſame thing in all our denominations. We know nothing of the cauſes but in the effects; and our name for the cauſe is in fact the name of the effect, which is COHESION. We mean nothing elſe by gravitation or magnetiſm. What do we mean when we ſay that Newton underſtood thoroughly the nature of gravitation, of the force of gravitation; or that Franklin underſtood the nature of the electric force? Nothing but this: Newton conſidered with patient ſagacity the general facts of gravitation, and has deſcribed and claſſed them with the utmoſt preciſion. In like manner, we ſhall underſtand the nature of coheſion when we have diſcovered with equal generality the laws of coheſion, or general facts which are obſerved in the appearances, and when we have deſcribed and claſſed them with equal accuracy.

6 Cauſes known only from their effects.

Let us therefore attend to the more ſimple and obvious phenomena of coheſion, and mark with care every circumſtance of reſemblance by which they may be claſſed. Let us receive theſe as the laws of coheſion, characteriſtic of its ſuppoſed cauſe, the force of coheſion. We cannot pretend to enter on this vaſt reſearch. The modifications are innumerable: and it would require the penetration of more than Newton to detect the circumſtance of ſimilarity amidſt millions of diſcriminating circumſtances. Yet this is the only way of diſcovering which are the primary facts characteriſtic of the force, and which are the modifications. The ſtudy is immenſe, but it is by no means deſperate; and we entertain great hopes that it will ere long be ſucceſsfully proſecuted: but, in our particular predicament, we muſt content ourſelves with ſelecting ſuch general laws as ſeem to give us the moſt immediate information of the circumſtances that muſt be attended to by the mechanician in his conſtructions, that he may unite ſtrength with ſimplicity, economy, and energy.

1. Then, it is a matter of fact that all bodies are in a certain

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7 All bodies elastic.

certain degree perfectly elaſtic; that is, when their form or bulk is changed by certain moderate compreſſions or diſtractions, it requires the continuance of the changing force to continue the body in this new ſtate; and when the force is removed, the body recovers its original form. We limit the aſſertion to *certain moderate* changes: For inſtance, take a lead wire of one-fifteenth of an inch in diameter and ten feet long; fix one end firmly to the ceiling, and let the wire hang perpendicular; affix to the lower end an index like the hand of a watch; on ſome ſtand immediately below let there be a circle divided into degrees, with its centre correſponding to the lower point of the wire: now turn this index twice round, and thus twiſt the wire. When the index is let go, it will turn backwards again, by the wire's untwiſting itſelf, and make almoſt four revolutions before it ſtops; after which it twiſts and untwiſts many times, the index going backwards and forwards round the circle, diminiſhing however its arch of twiſt each time, till at laſt it ſettles preciſely in its original poſition. This may be repeated for ever. Now, in this motion, every part of the wire partakes equally of the twiſt. The particles are ſtretched, require force to keep them in their ſtate of extenſion, and recover completely their relative poſitions. Theſe are all the characters of what the mechanician calls *perfect* elaſticity. This is a quality quite familiar in many caſes; as in glaſs, tempered ſteel, &c. but was thought incompetent to lead, which is generally conſidered as having little or no elaſticity. But we make the aſſertion in the moſt general terms, with the limitation to moderate derangement of form. We have made the ſame experiment on a thread of pipe-clay, made by forcing ſoft clay through the ſmall hole of a ſyringe by means of a ſcrew; and we found it more elaſtic than the lead wire: for a thread of one-twentieth of an inch diameter and ſeven feet long allowed the index to make two turns, and yet completely recovered its firſt poſition.

2. But if we turn the index of the lead wire four times round, and let it go again, it untwiſts again in the ſame manner, but it makes little more than four turns back again; and after many oſcillations it finally ſtops in a poſition almoſt two revolutions removed from its original poſition. It has now acquired a new arrangement of parts, and this new arrangement is permanent like the former; and, what is of particular moment, it

8 What is meant by a *ſet*.

is perfectly elaſtic. This change is familiarly known by the denomination of a SET. The wire is ſaid to have TAKEN A SET. When we attend minutely to the procedure of nature in this phenomenon, we find that the particles have as it were ſlid on each other, ſtill cohering, and have taken a new poſition, in which their connecting forces are in equilibrio: and in this change of relative ſituation, it appears that the connecting forces which maintained the particles in their firſt ſituation were not in equilibrio in ſome poſition intermediate between that of the firſt and that of the laſt form. The force required for changing this firſt form augmented with the change, but only to a certain degree; and during this proceſs the connecting forces always tended to the recovery of this firſt form. But after the change of mutual poſition has paſſed a certain magnitude, the union has been partly deſtroyed, and the particles have been brought into new ſituations; ſuch, that the forces which now connect each with its neighbour tend, not to the recovery of the firſt arrangement, but to puſh them farther from it, into a new ſituation, to which they now verge, and require force to prevent them from acquiring. The wire is now in fact again perfectly elaſtic; that is, the forces which now connect the particles with their neighbours augment to a certain degree as the derangement from this new poſition augments. This is not reaſoning from any theory. It is narrating facts, on which a theory is to be founded. What we have been juſt now ſaying is evidently a deſcription of that ſenſible form of tangible matter which we call *ductility*. It has every gradation of variety, from the ſoft- 9 Ductility.
neſs of butter to the firmneſs of gold. All theſe bodies have ſome elaſticity; but we ſay they are not perfectly elaſtic, becauſe they do not completely recover their original form when it has been greatly damaged. The whole gradation may be moſt diſtinctly obſerved in a piece of glaſs or hard ſealing wax. In the ordinary form glaſs is perhaps the moſt completely elaſtic body that we know, and may be bent till juſt ready to ſnap, and yet completely recovers its firſt form, and takes no ſet whatever; but when heated to ſuch a degree as juſt to be viſible in the dark, it loſes its brittleneſs, and becomes ſo tough that it cannot be broken by any blow; but it is no longer elaſtic, takes any ſet, and keeps it. When more heated, it becomes as plaſtic as clay; but in this ſtate is remarkably diſtinguiſhed from clay by a quality which we may call VISCIDITY, which is ſome- 10 Viſcidity.
thing like elaſticity, of which clay and other bodies purely plaſtic exhibit no appearance. This is the joint operation of ſtrong adheſion and ſoftneſs. When a rod of perfectly ſoft glaſs is ſuddenly ſtretched a little, it does not at once take the ſhape which it acquires after ſome little time. It is owing to this, that in taking the impreſſion of a ſeal, if we take off the ſeal while the wax is yet very hot, the ſharpneſs of the impreſſion is deſtroyed immediately. Each part drawing its neighbour, and each part yielding, the prominent parts are pulled down and blunted, and the ſharp hollows are pulled upwards and alſo blunted. The ſeal muſt be kept on till all has become not only ſtiff but hard.

11 Obſerved in all homogeneous plaſtic bodies.

This viſcidity is to be obſerved in all plaſtic bodies which are homogeneous. It is not obſerved in clay, becauſe it is not homogeneous, but conſiſts of hard particles of argillaceous earth ſticking together by their attraction for water. Something like it might be made of finely powdered glaſs and a clammy fluid ſuch as turpentine. Viſcidity has all degrees of ſoftneſs till it degenerates to ropy fluidity like that of olive oil. Perhaps ſomething of it may be found even in the moſt perfect fluid that we are acquainted with, as we obſerved in the experiments for aſcertaining ſpecific gravity.

There is in a late volume of the Philoſophical Tranſactions a narrative of experiments, by which it appears that the thread of the ſpider is an exception to our firſt general law, and that it is perfectly ductile. It is there aſſerted, that a long thread of goſſamer, furniſhed with an index, takes any poſition whatever; and that though the index be turned round any number of times (even many hundreds), it has no tendency to recover its firſt form. The thread takes completely any ſet whatever. We have not had an opportunity of repeating this experiment, but we have diſtinctly obſerved a phenomenon totally inconſiſtent with it. If a fibre of goſſamer about an inch long be held by the end horizontally, it bends

downward

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downward in a curve like a slender slip of whalebone or a hair. If totally devoid of elasticity, and perfectly indifferent to any set, it would hang down perpendicularly without any curvature.

When ductility and elasticity are combined in different proportions, an immense variety of sensible modes of aggregation may be produced. Some degree of both are probably to be observed in all bodies of complex constitution; that is, which consist of particles made up of many different kinds of atoms. Such a constitution of a body must afford many situations permanent, but easily deranged.

In all these changes of disposition which take place among the particles of a ductile body, the particles are at such distance that they still cohere. The body may be stretched a little; and on removing the extending force, the body shrinks into its first form. It also resists moderate compressions; and when the compressing

12 Particles acted on by attractions and repulsions

force is removed, the body swells out again. Now the corpuscular *fact* here is, that the particles are acted on by attractions and repulsions, which balance each other when no external force is acting on the body, and which augment as the particles are made, by any external cause, to recede from this situation of mutual inactivity; for since force is requisite to produce either the dilatation or the compression, and to maintain it, we are obliged, by the constitution of our minds, to infer that it is opposed by a force accompanying or inherent in every particle of dilatable or compressible matter; and as this necessity of employing force to produce a change indicates the agency of these corpuscular forces, and marks their kind, according as the tendencies of the particles appear to be toward each other in dilatation, or from each other in compression; so it also measures the degrees of their intensity. Should it require three times the force to produce a double compression, we must reckon the mutual repulsions triple when the compression is doubled; and so in other instances. We see from all this that the phenomena of cohesion indicate some relation between the centres of the particles. To discover

13 The great problem in corpuscular mechanism.

this relation is the great problem in corpuscular mechanism, as it was in the Newtonian investigation of the force of gravitation. Could we discover this law of action between the corpuscles with the same certainty and distinctness, we might with equal confidence say what will be the result of any position which we give to the particles of bodies; but this is beyond our hopes. The law of gravitation is so simple, that the discovery or detection of it amid the variety of celestial phenomena required but one step; and in its own nature its possible combinations still do not greatly exceed the powers of human research. One is almost disposed to say that the Supreme Being has exhibited it to our reasoning powers as sufficient to employ with success our utmost efforts, but not so abstruse as to discourage us from the noble attempt. It seems to be otherwise with respect to cohesion. Mathematics informs us, that if it deviates sensibly from the law of gravitation, the simplest combinations will make the joint action of several particles an almost impenetrable mystery. We must therefore content ourselves, for a long time to come, with a careful observation of the simplest cases that we can propose, and with the discovery of secondary laws of action, in which many particles combine their influence. In pursuance of this plan, we observe,

3. That whatever is the situation of the particles of a body with respect to each other, when in a quiescent state, they are kept in these situations by the balance of

14 Particles kept in their places by a balance of forces.

opposite forces. This cannot be refused, nor can we form to ourselves any other notion of the state of the particles of a body. Whether we suppose the ultimate particles to be of certain magnitudes and shapes, touching each other in single points of cohesion; or whether we (with Boscovich) consider them as at a distance from each other, and acting on each other by attractions and repulsions—we must acknowledge, in the first place, that the centres of the particles (by whose mutual distances we must estimate the distance of the particles) may and do vary their distances from each other. What else can we say when we observe a body increase in length, in breadth, and in thickness, by heating it, or when we see it diminish in all these dimensions by an external compression? A particle, therefore, situated in the midst of many others, and remaining in that situation, must be conceived as maintained in it by the mutual balancing of all the forces which connect it with its

15 Illustration of this proposition.

neighbours. It is like a ball kept in its place by the opposite action of two springs. This illustration merits a more particular application. Suppose a number of balls ranged on the table in the angles of equilateral triangles, and that each ball is connected with the six which lie around it by means of an elastic wire curled like a cork-screw; suppose such another stratum of balls above this, and parallel to it, and so placed that each ball of the upper stratum is perpendicularly over the centre of the equilateral triangle below, and let these be connected with the balls of the under stratum by similar spiral wires. Let there be a third and a fourth, and any number of such strata, all connected in the same manner. It is plain that this may extend to any size and fill any space.—Now let this assemblage of balls be firmly contemplated by the imagination, and be supposed to shrink continually in all its dimensions, till the balls, and their distances from each other, and the connecting wires, all vanish from the sight as discrete individual objects. All this is very conceivable. It will now appear like a solid body, having length, breadth, and thickness; it may be compressed, and will again resume its dimensions; it may be stretched, and will again shrink; it will move away when struck; in short, it will not differ in its sensible appearance from a solid elastic body. Now when this body is in a state of compression, for instance, it is evident that any one of the balls is at rest, in consequence of the mutual balancing of the actions of all the spiral wires which connect it with those around it. It will greatly conduce to the full understanding of all that follows to recur to this illustration. The analogy or resemblance between the effects of this constitution of things and the effects of the corpuscular forces is very great; and wherever it obtains, we may safely draw conclusions from what we know would be the condition of

16 By example.

a body of common tangible matter. We shall just give one instructive example, and then have done with this hypothetical body. We can suppose it of a long shape, resting on one point; we can suppose two weights A, B, suspended at the extremities, and the whole in equilibrio. We commonly express this state of things by saying that A and B are in equilibrio. This is very inaccurate. A is in fact in equilibrio with the united action of all the springs which connect the ball to which it is applied with

with the adjoining balls. These springs are brought into action, and each is in equilibrio with the joint action of all the rest. Thus through the whole extent of the hypothetical body, the springs are brought into action in a way and in a degree which mathematics can easily investigate. We need not do this: it is enough for our purpose that our imagination readily discovers that some springs are stretched, others are compressed, and that a pressure is excited on the middle point of support, and the support exerts a reaction which precisely balances it; and the other weight is, in like manner, in immediate equilibrio with the equivalent of the actions of all the springs which connect the last ball with its neighbours. Now take the analogical or resembling case, an oblong piece of solid matter, resting on a fulcrum, and loaded with two weights in equilibrio. For the actions of the connecting springs substitute the corpuscular forces, and the result will resemble that of the hypothesis.

Now as there is something that is at least analogous to a change of distance of the particles, and a concomitant change of the intensity of the connecting forces, we may express this in the same way that we are accustomed to do in similar cases. Let A and B (fig. 1.) represent the centres of two particles of a coherent elastic body in their quiescent inactive state, and let us consider only the mechanical condition of B. The body may be stretched. In this case the distance A B of the particles may become A C. In this state there is something which makes it necessary to employ a force to keep the particles at this distance. C has a tendency towards A, or we may say that A attracts C. We may represent the magnitude of this tendency of C *towards* A, or this attraction of A, by a line C *c* perpendicular to A C. Again, the body may be compressed, and the distance A B may become A D. Something obliges us to employ force to continue this compression; and D tends *from* A, or A appears to *repel* D. The intensity of this tendency or repulsion may be represented by another perpendicular D *d*; and, to represent the different directions of these tendencies, or the different nature of these actions, we may set D *d* on the opposite side of A B. It is in this manner that the Abbé Boscovich has represented the actions of corpuscular forces in his celebrated Theory of Natural Philosophy. Newton had said, that, as the great movements of the solar system were regulated by forces operating at a distance, and varying with the distance, so he strongly suspected (*valde suspicor*) that all the phenomena of cohesion, with all its modifications in the different sensible forms of aggregation, and in the phenomena of chemistry and physiology, resulted from the similar agency of forces varying with the distance of the particles. The learned Jesuit pursued this thought; and has shown, that if we suppose an ultimate atom of matter endowed with powers of attraction and repulsion, varying, both in kind and degree, with the distance, and if this force be the same in every atom, it may be regulated by such a relation to the distance from the neighbouring atom, that a collection of such may have all the sensible appearance of bodies in their different forms of solids, liquids, and vapours, elastic or unelastic, and endowed with all the properties which we perceive, by whose immediate operation the phenomena of motion by impulse, and all the phenomena of chemistry, and of animal and vegetable economy, may be produced. He shows, that notwithstanding a perfect sameness, and even a great simplicity in this atomical constitution, there will result from this union all that unspeakable variety of form and property which diversify and embellish the face of nature. We shall take another opportunity of giving such an account of this celebrated work as it deserves. We mention it only, by the bye, as far as a general notion of it will be of some service on the present occasion. For this purpose, we just observe that Boscovich conceives a particle of any individual species of matter to consist of an unknown number of particles of simpler constitution; each of which particles, in their turn, is compounded of particles still more simply constituted, and so on through an unknown number of orders, till we arrive at the simplest possible constitution of a particle of tangible matter, susceptible of length, breadth, and thickness, and necessarily consisting of four atoms of matter. And he shows that the more complex we suppose the constitution of a particle, the more must the sensible qualities of the aggregate resemble the observed qualities of tangible bodies. In particular, he shows how a particle may be so constituted, that although it act on one other particle of the same kind through a considerable interval, the interposition of a third particle of the same kind may render it totally, or almost totally, inactive; and therefore an assemblage of such particles would form such a fluid as air. All these curious inferences are made with uncontrovertible evidence; and the greatest encouragement is thus given to the mathematical philosopher to hope, that by cautious and patient proceeding in this way, we may gradually approach to a knowledge of the laws of cohesion, that will not shun a comparison even with the *Principia* of Newton. No step can be made in this investigation, but by observing with care, and generalizing with judgement, the phenomena, which are abundantly numerous, and much more at our command than those of the great and sensible motions of bodies. Following this plan, we observe,

Plate DXI. Fig. 1.

17 How Boscovich represents the action of corpuscular forces.

18 Every body compressible and dilatable.

4. It is matter of fact, that every body has some degree of compressibility and dilatability; and when the changes of dimension are so moderate that the body completely recovers its original dimensions on the cessation of the changing force, the extensions or compressions are sensibly proportional to the extending or compressing forces; and therefore *the connecting forces are proportional to the distances of the particles from their quiescent, neutral, or inactive positions*. This seems to have been first viewed as a law of nature by the penetrating eye of Dr Robert Hooke, one of the most eminent philosophers of the last century. He published a cipher, which he said contained the theory of springiness and of the motions of bodies by the action of springs. It was this, *c e i i i n o s s s t t u u*.—When explained in his dissertation, published some years after, it was *ut tensio sic vis*. This is precisely the proposition just now asserted as a general fact, a law of nature. This dissertation is full of curious observations of facts in support of his assertion. In his application to the motion of bodies he gives his noble discovery of the balance-spring of a watch, which is founded on this law. The spring, as it is more and more coiled up, or unwound, by the motion of the balance, acts on it with a force proportional to the distance of the balance from its quiescent position. The balance therefore is acted on by an accelerating force, which varies in the same manner as the force of gravity

19 Law of nature discovered by Dr Hooke.

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gravity acting on a pendulum swinging in a cycloid. Its vibrations therefore must be performed in equal time, whether they are wide or narrow. In the same dissertation Hooke mentions all the facts which John Bernoulli afterwards adduced in support of Leibnitz's whimsical doctrine of the force of bodies in motion, or the doctrine of the *vires vivæ;* a doctrine which Hooke might justly have claimed as his own, had he not seen its futility.

20
And confirmed by the experiments of others.

Experiments made since the time of Hooke show that this law is strictly true in the extent to which we have limited it, viz. in all the changes of form which will be completely undone by the elasticity of the body. It is nearly true to a much greater extent. James Bernoulli, in his dissertation on the elastic curve, relates some experiments of his own, which seem to deviate considerably from it; but on close examination they do not. The finest experiments are those of Coulomb, published in some late volumes of the memoirs of the Academy of Paris. He suspended balls by wires, and observed their motions of oscillation, which he found accurately corresponding with this law.

This we shall find to be a very important fact in the doctrine of the strength of bodies, and we desire the reader to make it familiar to his mind. If we apply to this our manner of expressing these forces by perpendicular ordinates Cc, Dd (fig. 1.), we must take other situations E, F, of the particle B, and draw Ee, Ff; and we must have $Dd : Ff = BD : BF$, or $Cc : Ee = BC : BE$. In such a supposition $FdBce$ must be a straight line. But we shall have abundant evidence by and bye that this cannot be strictly true, and that the line Bce which limits the ordinates expressing the attractive forces becomes concave towards the line ABE, and that the part Bdf is convex towards it. All that can be safely concluded from the experiments hitherto made is, that *to a certain extent* the forces, both attractive and repulsive, are *sensibly* proportional to the dilatations and compressions. For,

21
When a body is much dilated, a small addition of force will increase its dilatation.

5. It is universally observed, that when the dilatations have proceeded a certain length, a less addition of force is sufficient to increase the dilatation in the same degree. This is always observed when the body has been so far stretched that it takes a set, and does not completely recover its form. The like may be generally observed in compressions. Most persons will recollect, that in violently stretching an elastic cord, it becomes suddenly weaker, or more easily stretched. But these phenomena do not positively prove a diminution of the corpuscular force acting on one particle: It more probably arises from the disunion of some particles, whose action contributed to the whole or sensible effect. And in compressions we may suppose something of the same kind; for when we compress a body in one direction, it commonly bulges out in another; and in cases of very violent action some particles may be disunited, whose transverse action had formerly balanced *part* of the compressing force. For the reader will see on reflection, that since the compression in one direction causes the body to bulge out in the transverse direction; and since this bulging out is in opposition to the transverse forces of attraction, it must employ some part of the compressing force. And the common appearances are in perfect uniformity with this conception of things. When we press a bit of dryish clay, it swells out and cracks transversely. When a pillar of wood is overloaded, it swells out, and small crevices appear in the direction of the fibres. After this it will not bear half of the load. This the carpenters call CRIPPLING; and a knowledge of the circumstances which modify it is of great importance, and enables us to understand some very paradoxical appearances, as will be shown by and bye.

This partial disuniting of particles formerly cohering is, we imagine, the chief reason why the totality of the forces which really oppose an external strain does not increase in the proportion of the extensions and compressions. But sufficient evidence will also be given that the forces which would connect one particle with one other particle do not augment in the accurate proportion of the change of distance; that in extensions they increase more slowly, and in compressions more rapidly.

22
Ductility another cause of deviation.

But there is another cause of this deviation perhaps equally effectual with the former. Most bodies manifest some degree of ductility. Now what is this? The fact is, that the parts have taken a new arrangement, in which they again cohere. Therefore, in the passage to this new arrangement, the sensible forces, which are the joint result of many corpuscular forces, begin to respect this new arrangement instead of the former. This must change the simple law of corpuscular force, characteristic of the particular species of matter under examination. It does not require much reflection to convince us that the possible arrangements which the particles of a body may acquire, without appearing to change their nature, must be more numerous according as the particles are of a more complex constitution; and it is reasonable to suppose that the constitution even of the most simple kind of matter that we are acquainted with is exceedingly complex. Our microscopes show us animals so minute, that a heap of them must appear to the naked eye an uniform mass with a grain finer than that of the finest marble or razor hone; and yet each of these has not only limbs, but bones, muscular fibres, blood-vessels, fibres, and a blood consisting, in all probability, of globules organised and complex like our own. The imagination is here lost in wonder; and nothing is left us but to adore inconceivable art and wisdom, and to exult in the thought that we are the only spectators of this beautiful scene who can derive pleasure from the view. What is trodden under foot with indifference, even by the half-reasoning elephant, may be made by us the source of the purest and most unmixed pleasure. But let us proceed to observe,

23
The forces which connect the particles of tangible bodies change by a change of distance.

6. That the forces which connect the particles of tangible bodies change by a change of distance, not only in degree, but also in kind. The particle B (fig. 1.) is attracted by A when in the situation C or E. It is repelled by it when at D or F. It is not affected by it when in the situation B. The reader is requested carefully to remark, that this is not an inference founded on the authority of our mathematical figure. The figure is an expression (to assist the imagination) of facts in nature. It requires no force to keep the particles of a body in their quiescent situations: but if they are separated by stretching the body, they endeavour (pardon the figurative expression) to come together again. If they are brought nearer by compression, they endeavour to recede. This endeavour is manifested by the necessity of employing force to maintain the extension or condensation; and we represent this by the different position

of

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of our lines. But this is not all: the particle B, which is repelled by A when in the ſituation F or D, is neutral when at B, and is attracted when at C or E, may be placed at ſuch a diſtance AG from A greater than AB that it ſhall be again repelled, or at ſuch a diſtance AH that it ſhall again be attracted; and theſe alterations may be repeated again and again. This is curious and important, and requires ſomething more than a bare aſſertion for its proof.

24 Light alternately attracted and repelled.

In the article OPTICS we mentioned the moſt curious and valuable obſervations of Sir Iſaac Newton, by which it appears that light is thus alternately attracted and repelled by bodies. The rings of colour which appear between the object glaſſes of long teleſcopes ſhowed, that in the ſmall interval of $\frac{1}{1000}$th of an inch, there are at leaſt an hundred ſuch changes obſervable, and that it is highly probable that theſe alternations extend to a much greater diſtance. At one of theſe diſtances the light actually converges towards the ſolid matter of the glaſs, which we expreſs ſhortly, by ſaying that it is attracted by it, and that at the next diſtance it declines from the glaſs, or is repelled by it. The ſame thing is more ſimply inferred from the phenomena of light paſſing by the edges of knives and other opaque bodies. We refer the reader to the experiments themſelves, the detail being too long for this place; and we requeſt him to conſider them minutely and attentively, and to form diſtinct notions of the inferences drawn from them. And we deſire it to be remarked, that although Sir Iſaac, in his diſcuſſion, always conſiders light as a ſet of corpuſcles moving in free ſpace, and obeying the actions of external forces like any other matter, the particular concluſion in which we are juſt now intereſted does not at all depend on this notion of the nature of light. Should we, with Des Cartes or Huygens, ſuppoſe light to be the undulation of an elaſtic medium, the concluſion will be the ſame. The undulations at certain diſtances are diſturbed by forces directed towards the body, and at a greater diſtance, the diſturbing forces tend *from* the body.

25 The ſame alternations of attraction and repulſion obſervable in the particles of other bodies, as glaſs.

But the ſame alternations of attraction and repulſion may be obſerved between the particles of common matter. If we take a piece of very flat and well-poliſhed glaſs, ſuch as is made for the horizon glaſſes of a good Hadley's quadrant, and if we wrap round it a fibre of ſilk as it comes from the cocoon, taking care that the fibre nowhere croſs another, and then preſs this pretty hard on ſuch another piece of glaſs, it will lift it up and keep it ſuſpended. The particles therefore of the one do moſt certainly attract thoſe of the other, and this at a diſtance equal to the thickneſs of the ſilk fibre. This is nearly the limit; and it ſometimes requires a conſiderable preſſure to produce the effect. The preſſure is effectual only by compreſſing the ſilk fibre, and thus diminiſhing the diſtance between the glaſs plates. This adheſion cannot be attributed to the preſſure of the atmoſphere, becauſe there is nothing to hinder the air from inſinuating itſelf between the plates, ſince they are ſeparated by the ſilk. Beſides, the experiment ſucceeds equally well under the receiver of an air-pump. This moſt valuable experiment was firſt made by Huygens, who reported it to the Royal Society. It is narrated in the Philoſophical Tranſactions, N° 86.

Here then is an attraction acting, like gravity, at a diſtance. But take away the ſilk fibre, and try to make the glaſſes touch each other, and we ſhall find a very great force neceſſary. By Newton's experiments it appears, that unleſs the priſmatic colours begin to appear between the glaſſes, they are at leaſt $\frac{1}{890}$th of an inch aſunder or more. Now we know that a very conſiderable force is neceſſary for producing theſe colours, and that the more we preſs the glaſſes together the more rings of colours appear. It alſo appears from Newton's meaſures, that the difference of diſtance between the glaſſes where each of theſe colours appear is about the 89,000th part of an inch. We know farther, that when we have produced the laſt appearance of a greaſy or pearly colour, and then augment the preſſure, making it about a thouſand pounds on the ſquare inch, all colours vaniſh, and the two pieces of glaſs ſeem to make one tranſparent undiſtinguiſhable maſs. They appear now to have no air between them, or to be in mathematical contact. But another fact ſhows this concluſion to be premature. The ſame circles of colours appear in the top of a ſoap bubble; and as it grows thinner at top, there appears an unreflecting ſpot in the middle. We have the greateſt probability therefore that the perfect tranſparency in the middle of the two glaſſes does not ariſe from their being in contact, but becauſe the thickneſs of air between them is too ſmall in that place for the reflection of light. Nay, Newton expreſsly found no reflection where the thickneſs was $\frac{2}{3}$ths or more of the $\frac{1}{89000}$th part of an inch.

All this while the glaſſes are ſtrongly repelling each other, for great preſſure is neceſſary for continuing the appearance of thoſe colours, and they vaniſh in ſucceſſion as the preſſure is diminiſhed. This vaniſhing of the colours is a proof that the glaſſes are moving off from each other, or repelling each other. But we can put an end to this repulſion by very ſtrong preſſure, and at the ſame time ſliding the glaſſes on each other. We do not pretend to account for this effect of the ſliding motion; but the fact is, that by ſo doing, the glaſſes will cohere with very great force, ſo that we ſhall break them by any attempt to pull them aſunder. It commonly happens (at leaſt it did ſo with us), that in this ſliding compreſſion of two ſmooth flat plates of glaſs they ſcratch and mutually deſtroy each other's ſurface. It is alſo worth remarking, that different kinds of glaſs exhibit different properties in this reſpect. Flint glaſs will attract even though a ſilk fibre lies double between them, and they much more readily cohere by this ſliding preſſure.

Here then are two diſtances at which the plates of glaſs attract each other; namely, when the ſilk fibre is interpoſed, and when they are forced together with this ſliding motion. And in any intermediate ſituation they repel each other. We ſee the ſame thing in other ſolid bodies. Two pieces of lead made perfectly clean, may be made to cohere by grinding them together in the ſame manner. It is in this way that pretty ornaments of ſilver are united to iron. The piece is ſcraped clean, and a ſmall bit of ſilver like a fiſh ſcale is laid on. The die which is to ſtrike it into a flower or other ornament is then ſet on it, and we give it a ſmart blow, which forces the metals into contact as firm as if they were ſoldered together. It ſometimes happens that the die adheres to the coin ſo that they cannot be ſeparated: and it is found that this frequently happens, when the engraving is ſuch, that the raiſed figure is not completely

26 Lead and iron.

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ly ſurrounded with a ſmooth flat ground. The probable cauſe of this is curious. When the coin has a flat ſurface all around, this is produced by the moſt prominent part of the die. This applies to the metal, and completely confines the air which filled the hollow of the die. As the preſſure goes on, the metal is ſqueezed up into the hollow of the die; but there is ſtill air compreſſed between them, which cannot eſcape by any paſſage. It is therefore prodigiouſly condenſed, and exerts an elaſticity proportioned to the condenſation. This ſerves to ſeparate the die from the metal when the ſtroke is over. The hollow part of the die has not touched the metal all the while, and we may ſay that the impreſſion was made by air. If this air eſcape by any engraving reaching through the border, they cohere inſeparably.

27 Probable cauſe why the die adheres to the coin.

We have admitted that the glaſs plates are in contact when they cohere thus firmly. But we are not certain of this: for if we take theſe cohering glaſſes, and touch them with water, it quickly inſinuates itſelf between them. Yet they ſtill cohere, but can now be pretty eaſily ſeparated.

28 Repulſion the cauſe of ſome bodies ſwimming in a fluid ſpecifically lighter than themſelves.

It is owing to this repulſion, exerted through its proper ſphere, that certain powders ſwim on the ſurface of water, and are wetted with great difficulty. Certain inſects can run about on the ſurface of water. They have bruſhy feet, which occupy a conſiderable ſurface; and if their ſteps are viewed with a magnifying glaſs, the ſurface of the water is ſeen depreſſed all around, reſembling the footſteps of a man walking on feather-beds. This is owing to a repulſion between the bruſh and the water. A common fly cannot walk in this manner on water. Its feet are wetted, becauſe they attract the water inſtead of repelling it. A ſteel needle, wiped very clean, will lie on the ſurface of water, making an impreſſion as a great bar would make on a feather bed; and its weight is leſs than that of the diſplaced water. A dew drop lies on the leaves of plants without touching them mathematically, as is plain from the extreme brilliancy of the reflection at the poſterior ſurface; nay, it may be ſometimes obſerved that the drops of rain lie on the ſurface of water, and roll about on it like balls on a table. Yet all theſe ſubſtances can be wetted; that is, water can be applied to them at ſuch diſtances that they attract it.

What we ſaid a little ago of water inſinuating itſelf between the glaſs plates without altogether deſtroying their coheſion, ſhows that this coheſion is not the ſame that obtains between the particles of one of the plates; that is, the two plates are not in the ſtate of one continued maſs. It is highly probable, therefore, that between theſe two ſtates there is an intermediate ſtate of repulſion, nay, perhaps many ſuch, alternated with attractive ſtates.

A piece of ice is elaſtic, for it rebounds and rings. Its particles, therefore, when compreſſed, reſile; and when ſtretched, contract again. The particles are therefore in the ſtate repreſented by B in figure 1. acted on by repulſive forces, if brought nearer; and by attractive forces, if drawn further aſunder. Ice expands, like all other bodies, by heat. It abſorbs a vaſt quantity of fire; which, by combining its attractions and repulſions with thoſe of the particles of ice, changes completely the law of action, without making any ſenſible change in the diſtance of the particles, and the ice becomes water. In this new ſtate the particles are again in limits between attractive and repulſive forces; for water has been ſhown, by the experiments of Canton and Zimmerman, to be elaſtic or compreſſible. It again expands by heat. It again abſorbs a prodigious quantity of heat, and becomes elaſtic vapour; its particles repelling each other at all diſtances yet obſerved. The diſtance between the particles of one plate of glaſs and thoſe of another which lies on it, and is carried by it, is a diſtance of repulſion; for the force which ſupports the upper piece is acting in oppoſition to its weight. This diſtance is leſs than that at which it would *ſuſpend* it below it with a ſilk fibre interpoſed; for no priſmatic colours appear between them when the ſilk fibre is interpoſed. But the diſtance at which glaſs attracts water is much leſs than this, for no colours appear when glaſs is wetted with water. This diſtance is leſs, and not greater, than the other; for when the glaſſes have water interpoſed between them inſtead of air, it is found, that when any particular colour appears, the thickneſs of the plate of water is to that of the plate of air which would produce the ſame colour nearly as 3 to 4. Now, if a piece of glaſs be wetted, and exhibit no colour, and another piece of glaſs be ſimply laid on it, no colour will appear; but if they are ſtrongly preſſed, the colours appear in the ſame manner as if the glaſſes had air between. Alſo, when glaſs is ſimply wetted, and the film of water is allowed to evaporate, when it is thus reduced to a proper thinneſs, the colours ſhow themſelves in great beauty.

29 Particles of matter connected by forces acting at a diſtance.

Theſe are a few of many thouſand facts, by which it is unqueſtionably proved that the particles of tangible matter are connected by forces acting at a diſtance, varying with the diſtance, and alternately attractive and repulſive. If we repreſent theſe forces as we have already done in fig. 1. by the ordinates C c, D d, E e, F f, &c. of a curve, it is evident that this curve muſt croſs the axis at all thoſe diſtances where the forces change from attractive to repulſive, and the curve muſt have branches alternately above and below the axis.

All theſe alternations of attraction and repulſion take place at ſmall and inſenſible diſtances. At all ſenſible diſtances the particles are influenced by the attraction of gravitation; and therefore this part of the curve muſt be a hyperbola whoſe equation is $y=\frac{a^3}{x^2}$. What is the form of the curve correſponding to the ſmalleſt diſtance of the particles? that is, what is the mutual action between the particles juſt before their coming into abſolute contact? Analogy ſhould lead us to ſuppoſe it to be repulſion: for ſolidity is the laſt and ſimpleſt form of bodies with which we are acquainted.—Fluids are more compounded, containing fire as an eſſential ingredient. We ſhould conclude that this ultimate repulſion is inſuperable, for the hardeſt bodies are the moſt elaſtic. We are fully entitled to ſay, that this repelling force exceeds all that we have ever yet applied to overcome it; nay, there are good reaſons for ſaying that this ultimate repulſion, by which the particles are kept from mathematical contact, is really inſuperable in its own nature, and that it is impoſſible to produce mathematical contact.

30 Mathematical contact impoſſible.

We ſhall juſt mention one of theſe, which we conſider as unanſwerable. Suppoſe two atoms, or ultimate particles of matter A and B. Let A be at reſt, and B move

move up to it with the velocity 2; and let us ſuppoſe that it comes into mathematical contact, and impels it (according to the common acceptation of the word). Both move with the velocity 1. This is granted by all to be the final reſult of the colliſion. Now the inſtant of time in which this communication happens is no part either of the duration of the ſolitary motion of A, nor of the joint motion of A and B: It is the ſeparation or boundary between them. It is at once the end of the firſt, and the beginning of the ſecond, belonging equally to both. A was moving with the velocity 2. The diſtinguiſhing circumſtance therefore of its mechanical ſtate is, that it has a determination (however incomprehenſible) by which it would move for ever with the velocity 2, if nothing changed it. This it has during the whole of its ſolitary motion, and therefore in the laſt inſtant of this motion. In like manner, during the whole of the joint motion, and therefore in the firſt inſtant of this motion, the atom A has a determination by which it would move for ever with the velocity 1. In one and the ſame inſtant, therefore, the atom A has two incompatible determinations. Whatever notion we can form of this ſtate, which we call velocity, as a diſtinction of condition, the ſame impoſſibility of conception or the ſame abſurdity occurs. Nor can it be avoided in any other way than by ſaying, that this change of A's motion is brought about by inſenſible gradations; that is, that A and B influence each other preciſely as they would do if a ſlender ſpring were interpoſed. The reader is deſired to look at what we have ſaid in the article PHYSICS, § 82.

The two magnets there ſpoken of are good repreſentatives of two atoms endowed with mutual powers of repulſion; and the communication of motion is accompliſhed in both caſes in preciſely the ſame manner.

If, therefore, we ſhall ever be ſo fortunate as to diſcover the law of variation of that force which connects one ATOM of matter with another atom, and which is therefore characteriſtic of matter, and the ultimate ſource of all its ſenſible qualities, the curve whoſe ordinates repreſent the kind and the intenſity of this atomical force will be ſomething like that ſketched in fig. 2. The firſt branch $a\,n\,B$ will have AK (perpendicular to the axis AH) for its aſſymptote, and the laſt branch $l\,m\,o$ will be to all ſenſe a hyperbola, having AO for its aſſymptote; and the ordinates lL, mM, &c. will be proportional to $\frac{1}{AL^2}$, $\frac{1}{AM^2}$, &c. expreſſing the univerſal gravitation of matter. It will have many branches BbC, DdE, FfG, &c. expreſſing attractions, and alternate repulſive branches CcD, EeF, GgH, &c. All theſe will be contained within a diſtance AH, which does not exceed a very minute fraction of an inch.

Fig. 2.

31 The ſimpleſt extended particle conſiſts of four atoms.

The ſimpleſt particle which can be a conſtituent of a body having length, breadth, and thickneſs, muſt conſiſt of four ſuch atoms, all of which combine their influence on each atom of another ſuch particle. It is evident that the curve which expreſſes the forces that connect two ſuch particles muſt be totally different from this original curve, this hylarchic principle. Suppoſing the laſt known, our mathematical knowledge is quite able to diſcover the firſt; but when we proceed to compoſe a body of particles, each of which conſiſts of four ſuch particles, we may venture to ſay, that the compound force which connects them is almoſt beyond our ſearch, and that the diſcovery of the primary force from an *accurate* knowledge of the corpuſcular forces of *this* particular matter is abſolutely out of our power.

All that we can learn is, the poſſibility, nay the certainty, of an innumerable variety of external ſenſible forms and qualities, by which different kinds of matter will be diſtinguiſhed, ariſing from the number, the order of compoſition, and the arrangement of the ſubordinate particles of which a particle of this or that kind of matter is compoſed. All theſe varieties will take place at thoſe ſmall and inſenſible diſtances which are between A and H, and may produce all that variety which we obſerve in the tangible or mechanical forms of bodies, ſuch as elaſticity, ductility, hardneſs, ſoftneſs, fluidity, vapour, and all thoſe unſeen motions or actions which we obſerve in fuſion and congelation, evaporation and condenſation, ſolution and precipitation, cryſtallization, vegetable and animal aſſimilation and ſecretion, &c. &c. &c. while all bodies muſt be, in a certain degree, elaſtic, all muſt gravitate, and all muſt be incompenetrable.

This general and ſatisfactory reſemblance between the appearance of tangible matter and the legitimate conſequence of this general hypothetical property of an atom of matter, affords a conſiderable probability that ſuch is the origin of all the phenomena. We earneſtly recommend to our readers a *careful* peruſal of Boſcovich's celebrated treatiſe. A careful peruſal is neceſſary for ſeeing its value; and nothing will be got by a haſty look at it. The reader will be particularly pleaſed with the facility and evidence with which the ingenious author has deduced all the ordinary principles of mechanics, and with the explanation which he has given of fluidity, and his deduction from thence of the laws of hydroſtatics. No part of the treatiſe is more valuable than the doctrine of the propagation of preſſure through ſolid bodies. This, however, is but juſt touched on in the courſe of the inveſtigation of the principles of mechanics. We ſhall borrow as much as will ſuffice for our preſent inquiry into the ſtrength of materials; and we truſt that our readers are not diſpleaſed with this general ſketch of the doctrine (if it may be ſo called) of the coheſion of bodies. It is curious and important in itſelf, and is the foundation of all the knowledge we can acquire of the preſent article. We are ſorry to ſay that it is as yet a new ſubject of ſtudy; but it is a very promiſing one, and we by no means deſpair of ſeeing the whole of chemiſtry brought by its means within the pale of mechanical ſcience. The great and diſtinguiſhing agent in chemiſtry is heat, or fire the cauſe of heat; and one of its moſt ſingular effects is the converſion of bodies into elaſtic vapour. We have the cleareſt evidence that this is brought about by mechanical forces: for it can be oppoſed or prevented by external preſſure, a very familiar mechanical force. We may perhaps find another mechanical force which will prevent fuſion.

32 The doctrine of coheſion yet a new ſubject.

HAVING now made our readers familiar with the mode of action in which coheſion operates in giving ſtrength to ſolid bodies, we proceed to conſider the ſtrains to which this ſtrength is oppoſed.

A piece of ſolid matter is expoſed to four kinds of ſtrains, pretty different in the manner of their operation.

33 Strains to which ſtrength is oppoſed.

1. It may be torn aſunder, as in the caſe of ropes, ſtretchers, king-poſts, tye-beams, &c.

2.

Strength of Materials.

2. It may be cruſhed, as in the caſe of pillars, poſts, and truſs beams.

3. It may be broken acroſs, as happens to a joiſt or lever of any kind.

4. It may be wrenched or twiſted, as in the caſe of the axle of a wheel, the nail of a preſs, &c.

I. It may be pulled asunder.

34 Matter may be pulled aſunder.

This is the ſimpleſt of all ſtrains, and the others are indeed modifications of it. To this the force of coheſion is *directly* oppoſed, with very little modification of its action by any particular circumſtances.

When a long cylindrical or priſmatic body, ſuch as a rod of wood or metal, or a rope, is drawn by one end, it muſt be reſiſted at the other, in order to bring its coheſion into action. When it is faſtened at one end, we cannot conceive it any other way than as equally ſtretched in all its parts; for all our obſervations and experiments on natural bodies concur in ſhowing us that the forces which connect their particles, in any way whatever, are equal and oppoſite. This is called the *third law of motion*; and we admit its univerſality, while we affirm that it is purely experimental (ſee Physics). Yet we have met with diſſertations by perſons of eminent knowledge, where propoſitions are maintained inconſiſtent with this. During the diſpute about the communication of motion, ſome of the ableſt writers have ſaid, that a ſpring compreſſed or ſtretched at the two ends was gradually leſs and leſs compreſſed or ſtretched from the extremities towards the middle: but the ſame writers acknowledged the univerſal equality of action and reaction, which is quite incompatible with this ſtate of the ſpring. No ſuch inequality of compreſſion or dilatation has ever been obſerved; and a little reflection will ſhow it to be impoſſible, in conſiſtency with the equality of action and reaction.

Since all parts are thus equally ſtretched, it follows, that the ſtrain in any tranſverſe ſection is the ſame, as alſo in every point of that ſection. If therefore the body be ſuppoſed of a homogeneous texture, the coheſion of the parts is equable; and ſince every part is equally ſtretched, the particles are drawn to equal diſtances from their quieſcent poſitions, and the forces which are thus excited, and now exerted in oppoſition to the ſtraining force, are equal. This external force may be increaſed by degrees, which will gradually ſeparate the parts of the body more and more from each other, and the connecting forces increaſe with this increaſe of diſtance, till at laſt the coheſion of ſome particles is overcome. This muſt be immediately followed by a rupture, becauſe the remaining forces are now weaker than before.

It is the united force of coheſion, immediately before the diſunion of the firſt particles, that we call the strength of the ſection. It may alſo be properly called its absolute strength, being exerted in the ſimpleſt form, and not modified by any relation to other circumſtances.

35 A circumſtance to be attended to in every conſtruction requiring ſtrength.

If the external force has not produced any permanent change on the body, and it therefore recovers its former dimenſions when the force is withdrawn, it is plain that this ſtrain may be repeated as often as we pleaſe, and the body which withſtands it once will always withſtand it. It is evident that this ſhould be attended to in all conſtructions, and that in all our inveſtigations on this ſubject this ſhould be kept ſtrictly in view. When we treat a piece of ſoft clay in this manner, and with this precaution, the force employed muſt be very ſmall. If we exceed this, we produce a permanent change. The rod of clay is not indeed torn aſunder; but it has become ſomewhat more ſlender: the number of particles in a croſs ſection is now ſmaller; and therefore, although it will again, in this new form, ſuffer, or allow an endleſs repetition of a *certain* ſtrain without any farther permanent change, this ſtrain is ſmaller than the former.

Something of the ſame kind happens in all bodies which receive a sett by the ſtrain to which they are expoſed. All ductile bodies are of this kind. But there are many bodies which are not ductile. Such bodies break completely whenever they are ſtretched beyond the limit of their perfect elaſticity. Bodies of a fibrous ſtructure exhibit very great varieties in their coheſion. 36

36 Great varieties in coheſion, but

In ſome the fibres have no lateral coheſion, as in the caſe of a rope. The only way in which all the fibres can be made to unite their ſtrength is, to twiſt them together. This cauſes them to bind each other ſo faſt, that any one of them will break before it can be drawn out of the bundle. In other fibrous bodies, ſuch as timber, the fibres are held together by ſome cement or gluten. This is ſeldom as ſtrong as the fibre. Accordingly timber is much eaſier pulled aſunder in a direction tranſverſe to the fibres. There is, however, every poſſible variety in this particular.

In ſtretching and breaking fibrous bodies, the viſible extenſion is frequently very conſiderable. This is not ſolely the increaſing of the diſtance of the particles of the cohering fibre: the greateſt part chiefly ariſes from drawing the crooked fibre ſtraight. In this, too, there is great diverſity; and it is accompanied with important differences in their power of withſtanding a ſtrain. In ſome woods, ſuch as fir, the fibres on which the ſtrength moſt depends are very ſtraight. Such woods are commonly very elaſtic, do not take a ſett, and break abruptly when overſtrained: others, ſuch as oak and birch, have their reſiſting fibres very undulating and crooked, and ſtretch very ſenſibly by a ſtrain. They are very liable to take a ſet, and they do not break ſo ſuddenly, but give warning by *complaining*, as the carpenters call it; that is, by giving viſible ſigns of a derangement of texture. Hard bodies of an uniform glaſſy ſtructure, or granulated like ſtones, are elaſtic through the whole extent of their coheſion, and take no ſett, but break at once when overloaded.

Notwithſtanding the immenſe variety which nature exhibits in the ſtructure and coheſion of bodies, there are certain general facts of which we may now avail ourſelves with advantage. In particular, 37

37 the abſolute coheſion or ſtrength proportional to the area of the ſection perpendicular to the extending force.

The abſolute coheſion is proportional to the area of the ſection. This muſt be the caſe where the texture is perfectly uniform, as we have reaſon to think it is in glaſs and the ductile metals. The coheſion of each particle being alike, the whole coheſion muſt be proportional to their number, that is, to the area of the ſection. The ſame muſt be admitted with reſpect to bodies of a granulated texture, where the granulation is regular and uniform. The ſame muſt be admitted of fibrous bodies, if we ſuppoſe their fibres equally ſtrong, equally denſe,

denſe, and ſimilarly diſpoſed through the whole ſection; and this we muſt either ſuppoſe, or muſt ſtate the diverſity, and meaſure the coheſion accordingly.

We may therefore aſſert, as a general propoſition on this ſubject, that the abſolute ſtrength in any part of a body by which it reſiſts being pulled aſunder, or the force which muſt be employed to tear it aſunder *in that part*, is proportional to the area of the ſection perpendicular to the extending force.

Therefore all cylindrical or priſmatical rods are equally ſtrong in every part, and will break alike in any part; and bodies which have unequal ſections will always break in the ſlendereſt part. The length of the cylinder or priſm has no effect on the ſtrength; and the vulgar notion, that it is eaſier to break a very long rope than a ſhort one, is a very great miſtake. Alſo the abſolute ſtrengths of bodies which have ſimilar ſections are proportional to the ſquares of their diameters or homologous ſides of the ſection.

The weight of the body itſelf may be employed to ſtrain it and to break it. It is evident, that a rope may be ſo long as to break by its own weight. When the rope is hanging perpendicularly, although it is equally ſtrong in every part, it will break towards the upper

38 Relative ſtrength.

end, becauſe the ſtrain on any part is the weight of all that is below it. Its RELATIVE STRENGTH in any part, or power of withſtanding the ſtrain which is actually laid on it, is inverſely as the quantity below that part.

When the rope is ſtretched horizontally, as in towing a ſhip, the ſtrain ariſing from its weight often bears a very ſenſible proportion to its whole ſtrength.

Fig. 3. Let AEB (fig. 3.) be any portion of ſuch a rope, and AC, BC be tangents to the curve into which its gravity bends it. Complete the parallelogram ACBD. It is well known that the curve is a catenaria, and that DC is perpendicular to the horizon; and that DC is to AC as the weight of the rope AEB to the ſtrain at A.

In order that a ſuſpended heavy body may be equally able in every part to carry its own weight, the ſection in that part muſt be proportional to the ſolid contents of all that is below it. Suppoſe it a conoidal ſpindle, formed by the revolution of the curve A *a e*

Fig. 4. (fig. 4.) round the axis CE. We muſt have $AC^2 : ac^2 = AEB \text{ sol.} : a\,E\,b \text{ sol.}$ This condition requires the logarithmic curve for A *a e*, of which C *c* is the axis.

Theſe are the chief general rules which can be ſafely deduced from our cleareſt notions of the coheſion of bodies. In order to make any practical uſe of them, it is proper to have ſome meaſures of the coheſion of ſuch bodies as are commonly employed in our mechanics, and other ſtructures where they are expoſed to this kind of ſtrain. Theſe muſt be deduced ſolely from experiment.

39 The coheſion of metals depends on various circumſtances

Therefore they muſt be conſidered as no more than general values, or as the averages of many particular trials. The irregularities are very great, becauſe none of the ſubſtances are conſtant in their texture and firmneſs. Metals differ by a thouſand circumſtances unknown to us, according to their purity, to the heat with which they were melted, to the moulds in which they were caſt, and the treatment they have afterwards received, by forging, wire-drawing, tempering, &c.

It is a very curious and inexplicable fact, that by forging a metal, or by frequently drawing it through a ſmooth hole in a ſteel plate, its coheſion is greatly increaſed. This operation undoubtedly deranges the natural ſituation of the particles. They are ſqueezed cloſer together in one direction; but it is not in the direction in which they reſiſt the fracture. In this direction they are rather ſeparated to a greater diſtance. The general denſity, however, is augmented in all of them except lead, which grows rather rarer by wire-drawing: but its coheſion may be more than tripled by this operation. Gold, ſilver, and braſs, have their coheſion nearly tripled; copper and iron have it more than doubled. In this operation they alſo grow much harder. It is proper to heat them to redneſs after drawing a little. This is called *nealing* or *annealing* It ſoftens the metal again, and renders it ſuſceptible of another drawing without the riſk of cracking in the operation.

We do not pretend to give any explanation of this remarkable and very important fact, which has ſomething reſembling it in woods and other fibrous bodies, as will be mentioned afterwards.

The varieties in the coheſion of ſtones and other minerals, and of vegetable and animal ſubſtances, are hardly ſuſceptible of any deſcription or claſſification.

40 Coheſion and ſtrength of different metals.

We ſhall take for the meaſure of coheſion the number of pounds avoirdupois which are juſt ſufficient to tear aſunder a rod or bundle of one inch ſquare. From this it will be eaſy to compute the ſtrength correſponding to any other dimenſion.

1ſt, METALS.

		lbs.
Gold, caſt		20,000
		24,000
Silver, caſt		40,000
		43,000
Copper, caſt	Japan	19,500
	Barbary	22,000
	Hungary	31,000
	Angleſea	34,000
	Sweden	37,000
Iron, caſt		42,000
		59,000
Iron, bar	Ordinary	68,000
	Stirian	75,000
	Beſt Swediſh and Ruſſian	84,000
	Horſe-nails	71,000 (A)
Steel, bar	Soft	120,000
	Razor temper	150,000
Tin, caſt	Malacca	3,100
	Banca	3,600
	Block	3,800
	Engliſh block	5,200
	——— grain	6,500
Lead, caſt		860
Regulus of antimony		1,000
Zinc		2,600
Biſmuth		2,900

It

(A) This was an experiment by Muſchenbroek, to examine the vulgar notion that iron forged from old horſe nails was ſtronger than all others, and ſhows its falſity.

Strength of Materials.

41 Tenacity of metals increased by mixtures.

It is very remarkable that almoſt all the mixtures of metals are more tenacious than the metals themſelves. The change of tenacity depends much on the proportion of the ingredients, and the proportion which produces the moſt tenacious mixture is different in the different metals. We have ſelected the following from the experiments of Muſchenbroek. The proportion of ingredients here ſelected is that which produces the greateſt ſtrength.

Two parts of gold with one of ſilver -	28,000
Five parts of gold with one of copper -	50,000
Five parts of ſilver with one of copper -	48,500
Four parts of ſilver with one of tin -	41,000
Six parts of copper with one of tin -	41,000
Five parts of Japan copper with one of Banca tin - - - - - -	57,000
Six parts of Chili copper with one of Malacca tin - - -	60,000
Six parts of Swediſh copper with one of Malacca tin - - -	64,000
Braſs conſiſts of copper and zinc in an unknown proportion; its ſtrength is	51,000
Three parts of block tin with one part of lead - - - -	10,200
Eight parts of block tin with one part of zinc - - - -	10,000
Four parts of Malacca tin with one part of regulus of antimony - -	12,000
Eight parts of lead with one of zinc -	4,500
Four parts of tin with one of lead and one of zinc - - -	13,000

Theſe numbers are of conſiderable uſe in the arts. The mixtures of copper and tin are particularly intereſting in the fabric of great guns. We ſee that, by mixing copper whoſe greateſt ſtrength does not exceed 37,000, with tin which does not exceed 6000, we produce a metal whoſe tenacity is almoſt double, at the ſame time that it is harder and more eaſily wrought. It is, however, more fuſible, which is a great inconvenience. We alſo ſee that a very ſmall addition of zinc almoſt doubles the tenacity of tin, and increaſes the tenacity of lead five times; and a ſmall addition of lead doubles the tenacity of tin. Theſe are economical mixtures. This is a very valuable information to the plumbers for augmenting the ſtrength of water-pipes.

By having recourſe to theſe tables, the engineer can proportion the thickneſs of his pipes (of whatever metal) to the preſſures to which they are expoſed.

2*d*, Woods.

We may premiſe to this part of the table the following general obſervations.

42 Tenacity or ſtrength of wood.

1. The wood immediately ſurrounding the pith or heart of the tree is the weakeſt, and its inferiority is ſo much more remarkable as the tree is older. In this aſſertion, however, we ſpeak with ſome heſitation. Muſchenbroek's *detail* of experiments is decidedly in the affirmative. Mr Buffon, on the other hand, ſays, that his experience has taught him that the heart of a ſound tree is the ſtrongeſt; but he gives no inſtances. We are certain, from many obſervations of our own, on very *large* oaks and firs, that the heart is much weaker than the exterior parts.

2. The wood next the bark, commonly called the *white* or *blea*, is alſo weaker than the reſt; and the wood gradually increaſes in ſtrength as we recede from the centre to the blea.

3. The wood is ſtronger in the middle of the trunk than at the ſpringing of the branches or at the root; and the wood of the branches is weaker than that of the trunk.

4. The wood of the north ſide of all trees which grow in our European climates is the weakeſt, and that of the ſouth-eaſt ſide is the ſtrongeſt; and the difference is moſt remarkable in hedge-row trees, and ſuch as grow ſingly. The heart of a tree is never in its centre, but always nearer to the north ſide, and the annual coats of wood are thinner on that ſide. In conformity with this, it is a general opinion of carpenters that timber is ſtronger whoſe annual plates are thicker. The trachea or air-veſſels are weaker than the ſimple ligneous fibres. Theſe air-veſſels are the ſame in diameter and number of rows in trees of the ſame ſpecies, and they make the viſible ſeparation between the annual plates. Therefore when theſe are thicker, they contain a greater proportion of the ſimple ligneous fibres.

5. All woods are more tenacious while green, and loſe very conſiderably by drying after the trees are felled.

The only author who has put it in our power to judge of the propriety of his experiments is Muſchenbroek. He has deſcribed his method of trial minutely; and it ſeems unexceptionable. The woods were all formed into ſlips fit for his apparatus, and part of the ſlip was cut away to a parallelopiped of $\frac{1}{5}$th of an inch ſquare, and therefore $\frac{1}{25}$th of a ſquare inch in ſection. The abſolute ſtrengths of a ſquare inch were as follow:

43 Abſolute ſtrength of different kinds of wood,

	lib.		lib.
Locuſt tree	20,100	Pomegranate	9,750
Jujeb -	18,500	Lemon	9,250
Beech, oak	17,300	Tamarind	8,750
Orange -	15,500	Fir -	8,330
Alder -	13,900	Walnut -	8,130
Elm -	13,200	Pitch pine	7,650
Mulberry -	12,500	Quince -	6,750
Willow -	12,500	Cypreſs -	6,000
Aſh -	12,000	Poplar -	5,500
Plum -	11,800	Cedar -	4,880
Elder -	10,000		

Mr Muſchenbroek has given a very minute detail of the experiments on the aſh and the walnut, ſtating the weights which were required to tear aſunder ſlips taken from the four ſides of the tree, and on each ſide, in a regular progreſſion from the centre to the circumference. The numbers of this table correſponding to theſe two timbers may therefore be conſidered as the average of more than 50 trials made of each; and he ſays that all the others were made with the ſame care. We cannot therefore ſee any reaſon for not confiding in the reſults; yet they are conſiderably higher than thoſe given by ſome other writers. Mr Pitot ſays, on the authority of his own experiments, and of thoſe of Mr Parent, that 60 pounds will juſt tear aſunder a ſquare line of ſound oak, and that it will bear 50 with ſafety. This gives 8640 for the utmoſt ſtrength of a ſquare inch, which is much inferior to Muſchenbroek's valuation.

We may add to theſe,

Ivory

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44 and of other substances.

Ivory	16,270
Bone	5,250
Horn	8,750
Whalebone	7,500
Tooth of sea-calf	4,075

45 No substance to be strained in architecture above one half its strength.

The reader will surely observe, that these numbers express something more than the utmost cohesion; for the weights are such as will very quickly, that is, in a minute or two, tear the rods asunder. It may be said in general, that two-thirds of these weights will sensibly impair the strength after a considerable while, and that one-half is the utmost that can remain suspended at them without risk for ever; and it is this last allotment that the engineer should reckon upon in his constructions. There is, however, considerable difference in this respect. Woods of a very straight fibre, such as fir, will be less impaired by any load which is not sufficient to break them immediately.

According to Mr Emerson, the load which may be safely suspended to an inch square is as follows:

Iron	76,400
Brass	35,600
Hempen rope	19,600
Ivory	15,700
Oak, box, yew, plum-tree	7,850
Elm, ash, beech	6,070
Walnut, plum	5,360
Red fir, holly, elder, plane, crab	5,000
Cherry, hazel	4,760
Alder, asp, birch, willow	4,290
Lead	430
Freestone	914

He gives us a practical rule, that a cylinder whose diameter is *d* inches, loaded to one-fourth of its absolute strength, will carry as follows:

Iron	135	Cwt.
Good rope	22	
Oak	14	
Fir	9	

The rank which the different woods hold in this list of Mr Emerson's is very different from what we find in Muschenbroek's. But precise measures must not be expected in this matter. It is wonderful that in a matter of such unquestionable importance the public has not enabled some persons of judgement to make proper trials. They are beyond the abilities of private persons.

II. Bodies may be crushed.

46 It is of importance to know what will crush bodies.

It is of equal, perhaps greater, importance to know the strain which may be laid on solid bodies without danger of crushing them. Pillars and posts of all kinds are exposed to this strain in its simplest form; and there are cases where the strain is enormous, viz. where it arises from the oblique position of the parts; as in the stuts, braces, and trusses, which occur very frequently in our great works.

It is therefore most desirable to have some general knowledge of the principle which determines the strength of bodies in opposition to this kind of strain. But unfortunately we are much more at a loss in this than in the last case. The mechanism of nature is much more complicated in the present case. It must be in some circuitous way that compression can have any tendency to tear asunder the parts of a solid body, and it is very difficult to trace the steps.

If we suppose the particles insuperably hard and in contact, and disposed in lines which are in the direction of the external pressures, it does not appear how any pressure can disunite the particles; but this is a gratuitous supposition. There are infinite odds against this precise arrangement of the lines of particles; and the compressibility of all kinds of matter in some degree shows that the particles are in a situation equivalent to distance. This being the case, and the particles, with their intervals, or what is equivalent to intervals, being in situations that are oblique with respect to the pressures, it must follow, that by squeezing them together in one direction, they are made to bulge out or separate in other directions. This may proceed so far that some may be thus pushed laterally beyond their limits of cohesion. The moment that this happens the resistance to compression is diminished, and the body will now be crushed together. We may form some notion of this by supposing a number of spherules, like small shot, sticking together by means of a cement. Compressing this in some particular direction causes the spherules to act among each other like so many wedges, each tending to penetrate through between the three which lie below it: and this is the simplest, and perhaps the only distinct, notion we can have of the matter. We have reason to think that the constitution of very homogeneous bodies, such as glass, is not very different from this. The particles are certainly arranged symmetrically in the angles of some regular solids. It is only such an arrangement that is consistent with transparency, and with the free passage of light in *every* direction.

47 Their strength or power of resistance to such a force

If this be the constitution of bodies, it appears probable that the strength, or the resistance which they are capable of making to an attempt to crush them to pieces, is proportional to the area of the section whose plane is perpendicular to the external force; for each particle being similarly and equally acted on and resisted, the whole resistance must be as their number; that is, as the extent of the section.

Accordingly this principle is assumed by the few writers who have considered this subject; but we confess that it appears to us very doubtful. Suppose a number of brittle or friable balls lying on a table uniformly arranged, but not cohering nor in contact, and that a board is laid over them and loaded with a weight; we have no hesitation in saying, that the weight necessary to crush the whole collection is proportional to their number or to the area of the section. But when they are in contact (and still more if they cohere), we imagine that the case is materially altered. Any individual ball is crushed only in consequence of its being bulged outwards in the direction perpendicular to the pressure employed. If this could be prevented by a hoop put round the ball like an equator, we cannot see how any force can crush it. Any thing therefore which makes this bulging outwards more difficult, makes a greater force necessary. Now this effect will be produced by the mere contact of the balls before the pressure is applied; for the central ball cannot swell outward laterally without pushing away the balls on all sides of it. This is prevented by the friction on the table and upper board

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board, which is at least equal to one third of the pressure. Thus any interior ball becomes stronger by the mere vicinity of the others; and if we farther suppose them to cohere laterally, we think that its strength will be still more increased.

The analogy between these balls and the cohering particles of a friable body is very perfect. We should therefore expect that the strength by which it resists being crushed will increase in a greater ratio than that of the section, or the square of the diameter of similar sections; and that a square inch of any matter will bear a greater weight in proportion as it makes a part of a greater section. Accordingly this appears in many experiments, as will be noticed afterwards. Muschenbroek, Euler, and some others, have supposed the strength of columns to be as the biquadrates of their diameters. But Euler deduced this from formulæ which occurred to him in the course of his algebraic analysis; and he boldly adopts it as a principle, without looking for its foundation in the physical assumptions which he had made in the beginning of his investigation. But some of his original assumptions were as paradoxical, or at least as gratuitous, as these results: and those, in particular, from which this proportion of the strength of columns was deduced, were almost foreign to the case; and therefore the inference was of no value. Yet it was received as a principle by Muschenbroek and by the academicians of St Petersburgh. We make these very few observations, because the subject is of great practical importance; and it is a great obstacle to improvements when deference to a great name, joined to incapacity or indolence, causes authors to adopt his careless reveries as principles from which they are afterwards to draw important consequences. It must be acknowledged that we have not as yet established the relation between the dimensions and the strength of a pillar on solid mechanical principles. Experience plainly contradicts the general opinion, that the strength is proportional to the area of the section; but it is still more inconsistent with the opinion, that it is in the quadruplicate ratio of the diameters of similar sections. It would seem that the ratio depends much on the internal structure of the body; and experiment seems the only method for ascertaining its general laws.

48 to be ascertained only by experiment.

If we suppose the body to be of a fibrous texture, having the fibres situated in the direction of the pressure, and slightly adhering to each other by some kind of cement, such a body will fail only by the bending of the fibres, by which they will break the cement and be detached from each other. Something like this may be supposed in wooden pillars. In such cases, too it would appear that the resistance must be as the number of equally resisting fibres, and as their mutual support, jointly; and, therefore, as some function of the area of the section. The same thing must happen if the fibres are naturally crooked or undulated, as is observed in many woods, &c. provided we suppose some similarity in their form. Similarity of some kind must always be supposed, otherwise we need never aim at any general inferences.

In all cases therefore we can hardly refuse admitting that the strength in opposition to compression is proportional to a function of the area of the section.

As the whole length of a cylinder or prism is equally pressed, it does not appear that the strength of a pillar is at all affected by its length. If indeed it be supposed to bend under the pressure, the case is greatly changed, because it is then exposed to a transverse strain; and this increases with the length of the pillar. But this will be considered with due attention under the next class of strains.

Few experiments have been made on this species of strength and strain. Mr Petit says, that his experiments and those of Mr Parent, show that the force necessary for crushing a body is nearly equal to that which will tear it asunder. He says that it requires something more than 60 pounds on every square line to crush a piece of sound oak. But the rule is by no means general: Glass, for instance, will carry a hundred times as much as oak in this way, that is, resting on it; but will not *suspend* above four or five times as much. Oak will suspend a great deal more than fir; but fir will carry twice as much as a pillar. Woods of a soft texture, although consisting of very tenacious fibres, are more easily crushed by their load. This softness of texture is chiefly owing to their fibres not being straight but undulated, and there being considerable vacuities between them, so that they are easily bent laterally and crushed. When a post is overstrained by its load, it is observed to swell sensibly in diameter. Increasing the load causes longitudinal cracks or shivers to appear, and it presently after gives way. This is called *crippling*.

In all cases where the fibres lie oblique to the strain the strength is greatly diminished, because the parts can then be made to slide on each other, when the cohesion of the cementing matter is overcome.

Muschenbroek has given some experiments on this subject; but they are cases of long pillars, and therefore do not belong to this place. They will be considered afterwards.

The only experiments of which we have seen any detail (and it is useless to insert mere assertions) are those of Mr Gauthey, in the 4th volume of Rozier's *Journal de Physique*. This engineer exposed to great pressures small rectangular parallelopipeds, cut from a great variety of stones, and noted the weights which crushed them. The following table exhibits the medium results of many trials on two very uniform kinds of freestone, one of them among the hardest and the other among the softest used in building.

49 Experiments for this purpose made on freestone

Column 1st expresses the length AB of the section in French lines or 12ths of an inch; column 2d expresses the breadth BC; column 3d is the area of the section in square lines; column 4th is the number of ounces required to crush the piece; column 5th is the weight which was then borne by each square line of the section; and column 6th is the round numbers to which Mr Gauthey imagines that those in column 5th approximate.

Hard Stone.

	AB	BC	AB × BC	Weight	Force	
1	8	8	64	736	11.5	12
2	8	12	96	2625	27.3	24
3	8	16	128	4496	35.1	36

Soft Stone.

4	9	16	144	560	3.9	4
5	9	18	162	848	5.3	4.5
6	18	18	324	29[illegible]8	9	9
7	18	24	432	5296	12.2	12

Little

Strength of Materials.

Little can be deduced from these experiments: The 1st and 3d, compared with the 5th and 6th, should furnish similar results; for the 1st and 5th are respectively half of the 3d and 6th: but the 3d is three times stronger (that is, a line of the 3d) than the first, whereas the 6th is only twice as strong as the 5th.

It is evident, however, that the strength increases much faster than the area of the section, and that a square line can carry more and more weight, according as it makes a part of a larger and larger section. In the series of experiments on the soft stone, the individual strength of a square line seems to increase nearly in the proportion of the section of which it makes a part.

Mr Gauthey deduces, from the whole of his numerous experiments, that a pillar of hard stone of Givry, whose section is a square foot, will bear with perfect safety 664,000 pounds, and that its extreme strength is 871,000, and the smallest strength observed in any of his experiments was 460,000. The soft bed of Givry stone had for its smallest strength 187,000, for its greatest 311,000, and for its safe load 249,000. Good brick will carry with safety 320,000; chalk will carry only 9000. The boldest piece of architecture in this respect which he has seen is a pillar in the church of All-Saints at Angers. It is 24 feet long and 11 inches square, and is loaded with 60,000, which is not one-seventh of what is necessary for crushing it.

We may observe here by the way, that Mr Gauthey's measure of the suspending strength of stone is vastly small in proportion to its power of supporting a load laid above it. He finds that a prism of the hard bed of Givry, of a foot section, is torn asunder by 4600 pounds; and if it be firmly fixed horizontally in a wall, it will be broken by a weight of 56,000 suspended a foot from the wall. If it rest on two props at a foot distance, it will be broken by 206,000 laid on its middle. These experiments agree so ill with each other, that little use can be made of them. The subject is of great importance, and well deserves the attention of the patriotic philosopher.

50 not satisfactory.

A set of good experiments would be very valuable, because it is against this kind of strain that we must guard by judicious construction in the most delicate and difficult problems which come through the hands of the civil and military engineer. The construction of stone arches, and the construction of great wooden bridges, and particularly the construction of the frames of carpentry called *centres* in the erection of stone bridges, are the most difficult jobs that occur. In the centres on which the arches of the bridge of Orleans were built some of the pieces of oak were carrying upwards of two tons on every square inch of their scantling. All who saw it said that it was not able to carry the fourth part of the intended load. But the engineer understood the principles of his art, and ran the risk: and the result completely justified his confidence; for the centre did not complain in any part, only it was found too supple; so that it went out of shape while the haunches only of the arch were laid on it. The engineer corrected this by loading it at the crown, and thus kept it completely in shape during the progress of the work.

51 Good experiments much wanted.

In the Memoirs (old) of the Academy of Petersburgh for 1778, there is a dissertation by Euler on this subject, but particularly limited to the strain on columns, in which the bending is taken into the account. Mr Fuss has treated the same subject with relation to carpentry in a subsequent volume. But there is little in these papers besides a dry mathematical disquisition, proceeding on assumptions which (to speak favourably) are extremely gratuitous. The most important consequence of the compression is wholly overlooked, as we shall presently see. Our knowledge of the mechanism of cohesion is as yet far too imperfect to entitle us to a confident application of mathematics. Experiments should be multiplied.

The only way we can hope to make these experiments useful is to pay a careful attention to the *manner* in which the fracture is produced. By discovering the general resemblances in this particular, we advance a step in our power of introducing mathematical measurement. Thus, when a cubical piece of chalk is slowly crushed between the chaps of a vice, we see it uniformly split in a surface oblique to the pressure, and the two parts then slide along the surface of fracture. This should lead us to examine mathematically what relation there is between this surface of fracture and the necessary force; then we should endeavour to determine experimentally the position of this surface. Having discovered some general law or resemblance in this circumstance, we should try what mathematical hypothesis will agree with this. Having found one, we may then apply our simplest notions of cohesion, and compare the result of our computations with experiment. We are authorised to say, that a series of experiments have been made in this way, and that their results have been very uniform, and therefore satisfactory, and that they will soon be laid before the public as the foundations of successful practice in the construction of arches. 52 How they are to be made useful.

III. A Body may be broken across.

The most usual, and the greatest strain, to which materials are exposed, is that which tends to break them transversely. It is seldom, however, that this is done in a manner perfectly simple; for when a beam projects horizontally from a wall, and a weight is suspended from its extremity, the beam is commonly broken near the wall, and the intermediate part has performed the functions of a lever. It sometimes, though rarely, happens that the pin in the joint of a pair of pincers or scissars is cut through by the strain; and this is almost the only case of a simple transverse fracture. Being so rare, we may content ourselves with saying, that in this case the strength of the piece is proportional to the area of the section. 53 It is of importance to know what strain will break a body transversely.

Experiments were made for discovering the resistances made by bodies to this kind of strain in the following manner: Two iron bars were disposed horizontally at an inch distance; a third hung perpendicularly between them, being supported by a pin made of the substance to be examined. This pin was made of a prismatic form, so as to fit exactly the holes in the three bars, which were made very exact, and of the same size and shape. A scale was suspended at the lower end of the perpendicular bar, and loaded till it tore out that part of the pin which filled the middle hole. This weight was evidently the measure of the lateral cohesion of two sections. The side-bars were made to grasp the middle bar pretty strongly between them, that there might be no distance imposed between the opposite pressures. This would have combined the energy of a lever with the purely transverse pressure. For the same reason it was necessary 54 Experiments made to ascertain it.

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ſary that the internal parts of the holes ſhould be no ſmaller than the edges. Great irregularities occurred in our firſt experiments from this cauſe, becauſe the pins were ſomewhat tighter within than at the edges; but when this was corrected they were extremely regular. We employed three ſets of holes, viz. a circle, a ſquare (which was occaſionally made a rectangle whoſe length was twice its breadth), and an equilateral triangle. We found in all our experiments the ſtrength exactly proportional to the area of the ſection, and quite independent of its figure or poſition, and we found it conſiderably above the direct cohesion; that is, it took conſiderably more than twice the force to tear out this middle piece than to tear the pin aſunder by a direct pull. A piece of fine freeſtone required 205 pounds to pull it directly

55 Their reſult.

aſunder, and 575 to break it in this way. The difference was very conſtant in any one ſubſtance, but varied from four-thirds to ſix-thirds in different kinds of matter, being ſmalleſt in bodies of a fibrous texture. But indeed we could not make the trial on any bodies of conſiderable cohesion, becauſe they required ſuch forces as our apparatus could not ſupport. Chalk, clay baked in the ſun, baked ſugar, brick, and freeſtone, were the ſtrongeſt that we could examine.

But the more common caſe, where the energy of a lever intervenes, demands a minute examination.

56 The ſtrength of a lever. Fig. 5.

Let DABC (fig. 5.) be a vertical ſection of a priſmatic ſolid (that is, of equal ſize throughout), projecting horizontally from a wall in which it is firmly fixed; and let a weight P be hung on it at B, or let any power P act at B in a direction perpendicular to AB. Suppoſe the body of inſuperable ſtrength in every part except in the vertical ſection DA, perpendicular to its length. It muſt break in this ſection only. Let the cohesion be uniform over the whole of this ſection; that is, let each of the adjoining particles of the two parts cohere with an equal force f.

There are two ways in which it may break. The part ABCD may ſimply ſlide down along the ſurface of fracture, provided that the power acting at B is equal to the accumulated force which is exerted by every particle of the ſection in the direction AD.

But ſuppoſe this effectually prevented by ſomething that ſupports the point A. The action at P tends to make the body turn round A (or round a horizontal line paſſing through A at right angles to AB) as round a joint. This it cannot do without ſeparating at the line DA. In this caſe the adjoining particles at D or at E will be ſeparated horizontally. But their cohesion reſiſts this ſeparation. In order, therefore, that the fracture may happen, the energy or momentum of the power P, acting by means of the lever AB, muſt be ſuperior to the accumulated energies of the particles. The energy of each depends not only on its coheſive force, but alſo on its ſituation; for the ſuppoſed inſuperable firmneſs of the reſt of the body makes it a lever turning round the fulcrum A, and the cohesion of each particle, ſuch as D or E, acts by means of the arm DA or EA. The energy of each particle will therefore be had by multiplying the force exerted by it in the inſtant of fracture by the arm of the lever by which it acts.

Let us therefore firſt ſuppoſe, that in the inſtant of fracture every particle is exerting an equal force f. The energy of D will be $f \times \mathrm{DA}$, and that of E will be $f \times \mathrm{EA}$, and that of the whole will be the ſum of all theſe products. Let the depth DA of the ſection be called d, and let any undetermined part of it EA be called x, and then the ſpace occupied by any particle will be $\dot{x}$. The cohesion of this ſpace may be repreſented by $f\dot{x}$, and that of the whole by fd. The energy by which each element $\dot{x}$ of the line DA, or d, reſiſts the fracture, will be $fx\dot{x}$, and the whole accumulated energies will be $f \times \int x\dot{x}$. This we know to be $f \times \frac{1}{2}d^2$, or $fd \times \frac{1}{2}d$. It is the ſame therefore as if the cohesion fd of the whole ſection had been acting at the point G, which is the middle of DA.

The reader who is not familiarly acquainted with this fluxionary calculus may arrive at the ſame concluſion in another way. Suppoſe the beam, inſtead of projecting horizontally from a wall, to be hanging from the ceiling, in which it is firmly fixed. Let us conſider how the equal cohesion of every part operates in hindering the lower part from ſeparating from the upper by opening round the joint A. The equal cohesion operates juſt as equal gravity would do, but in the oppoſite direction. Now we know, by the moſt elementary mechanics, that the effect of this will be the ſame as if the whole weight were concentrated in the centre of gravity G of the line DA, and that this point G is in the middle of DA. Now the number of fibres being as the length d of the line, and the cohesion of each fibre being $=f$, the cohesion of the whole line is $f \times d$ or fd.

The accumulated energy therefore of the cohesion in the inſtant of fracture is $fd \times \frac{1}{2}d$. Now this muſt be equal or juſt inferior to the energy of the power employed to break it. Let the length AB be called l; then $\mathrm{P} \times l$ is the correſponding energy of the power. This gives us $fd\frac{1}{2}d = pl$ for the equation of equilibrium correſponding to the vertical ſection ADCB.

Suppoſe now that the fracture is not permitted at DA, but at another ſection $\delta\alpha$ more remote from B. The body being priſmatic, all the vertical ſections are equal; and therefore $fd\frac{1}{2}d$ is the ſame as before. But the energy of the power is by this means increaſed, being now $= \mathrm{P} \times \mathrm{B}\alpha$, inſtead of $\mathrm{P} \times \mathrm{BA}$: Hence we ſee that when the priſmatic body is not inſuperably ſtrong in all its parts, but equally ſtrong throughout, it muſt break cloſe at the wall, where the ſtrain or energy of the power is greateſt. We ſee, too, that a power which is juſt able to break it at the wall is unable to break it anywhere elſe; alſo an abſolute cohesion fd, which can withſtand the power p in the ſection DA, will not withſtand it in the ſection $\delta\alpha$, and will withſtand more in the ſection $d'a'$.

This teaches us to diſtinguiſh between abſolute and relative ſtrength. The relative ſtrength of a ſection has a reference to the ſtrain actually exerted on that ſection. This relative ſtrength is properly meaſured by the power which is juſt able to balance or overcome it, when applied at its proper place. Now ſince we had $fd\frac{1}{2}d = pl$, we have $p = \frac{fd\frac{1}{2}d}{l}$ for the meaſure of the ſtrength of the ſection of the ſection DA, in relation to the power applied at B.

If the ſolid is a rectangular beam, whoſe breadth is b, it is plain that all the vertical ſections are equal, and that AG or $\frac{1}{2}d$ is the ſame in all. Therefore the equation

tion expreſſing the equilibrium between the momentum of the external force and the accumulated momenta of coheſion will be $p\,l = f\,d\,b \times \frac{1}{2}d$.

The product $d\,b$ evidently expreſſes the area of the ſection of fracture, which we may call s, and we may expreſs the equilibrium thus, $p\,l = f\,s\,\frac{1}{2}d$, and $2\,l : d = f\,s : p$.

Now $f\,s$ is a proper expreſſion of the abſolute coheſion of the ſection of fracture, and p is a proper meaſure of its ſtrength in relation to a power applied at B. We may therefore ſay, that *twice the length of a rectangular beam is to the depth as the abſolute coheſion to the relative ſtrength.*

Since the action of equable coheſion is ſimilar to the action of equal gravity, it follows, that whatever is the figure of the ſection, the relative ſtrength will be the ſame as if the abſolute coheſion of all the fibres were acting at the centre of gravity of the ſection. Let g be the diſtance between the centre of gravity of the ſection and the axis of fracture, we ſhall have $p\,l = f\,s\,g$, and $l : g = f\,s : p$. It will be very uſeful to recollect this analogy in words: "*The length of a priſmatic beam of any ſhape is to the height of the centre of gravity above the lower ſide, as the abſolute coheſion to the ſtrength relative to this length.*"

Becauſe the relative ſtrength of a rectangular beam is $\frac{f\,b\,d\,\frac{1}{2}d}{l}$ or $\frac{f\,b\,d^2}{2\,l}$, it follows, that the relative ſtrengths of different beams are proportional to the abſolute coheſion of the particles, to the breadth, and to the ſquare of the depth directly, and to the length inverſely; alſo in priſms whoſe ſections are ſimilar, the ſtrengths are as the cubes of the diameters.

57 Aſcertained on the hypotheſis of equal coheſion;

Such are the more general reſults of the mechaniſm of this tranſverſe ſtrain, in the hypotheſis that all the particles are exerting equal forces in the inſtant of fracture. We are indebted for this doctrine to the celebrated Galileo; and it was one of the firſt ſpecimens of the application of mathematics to the ſcience of nature.

We have not included in the preceding inveſtigation that action of the external force by which the ſolid is drawn ſidewiſe, or tends to ſlide along the ſurface of fracture. We have ſuppoſed a particle E to be pulled only in the direction Ee, perpendicular to the ſection of fracture, by the action of the crooked lever BAE. But it is alſo pulled in the direction EA; and its reaction is in ſome direction εE, compounded of εf, by which it reſiſts being pulled outwards; and $\varepsilon\,e$ by which it reſiſts being pulled downwards. We are but imperfectly acquainted with the force $\varepsilon\,e$, and only know that their accumulated ſum is equal to the force p; but in all important caſes which occur in practice, it is unneceſſary to attend to this force; becauſe it is ſo ſmall in compariſon of the forces in the direction Ee, as we eaſily conclude from the uſual ſmallneſs of AD in compariſon of AB.

58 but that hypotheſis not conformable to nature.

The hypotheſis of equal coheſion, exerted by all the particles in the inſtant of fracture, is not conformable to nature: for we know, that when a force is applied tranſverſely at B, the beam is bent downwards, becoming convex on the upper ſide; that ſide is therefore on the ſtretch. The particles at D are farther removed from each other than thoſe at E, and are therefore *actually exerting* greater coheſive forces. We cannot ſay with certainty and preciſion in what proportion each fibre is extended. It ſeems moſt probable that the extenſions are proportional to the diſtances from A. We ſhall ſuppoſe this to be really the caſe. Now recollect the general law which we formerly ſaid was *obſerved* in all moderate extenſions, *viz.* that the attractive forces exerted by the dilated particles were proportional to their dilatations. Suppoſe now that the beam is ſo much bent that the particles at D are exerting their utmoſt force, and that this fibre is juſt ready to break or actually breaks. It is plain that a total fracture muſt immediately enſue; becauſe the force which was ſuperior to the full coheſion of the particle at D, and a certain portion of the coheſion of all the reſt, will be more than ſuperior to the full coheſion of the particle next within D, and a ſmaller portion of the coheſion of the remainder.

Now let F repreſent, as before, the full force of the exterior fibre D, which is exerted by it in the inſtant of its breaking, and then the force exerted at the ſame inſtant by the fibre E will be had by this analogy, AD : AE, or $d : x = f : \frac{f\,x}{d}$, and the force really exerted by the fibre E is $f \times \frac{x}{d}$.

The force exerted by a fibre whoſe thickneſs is $\dot{x}$ is therefore $\frac{f\,x\,\dot{x}}{d}$; but this force reſiſts the ſtrain by acting by means of the lever EA or x. Its energy or momentum is therefore $\frac{f\,x^2\,\dot{x}}{d}$, and the accumulated momenta of all the fibres in the line AE will be $f \times$ ſum of $\frac{x^2\,\dot{x}}{d}$. This, when x is taken equal to d, will expreſs the momentum of the whole fibres in the line AD. This, therefore, is $f\frac{\frac{1}{3}d^3}{d}$, or $f\,\frac{1}{3}\,d^2$, or $f\,d \times \frac{1}{3}\,d$. Now $f\,d$ expreſſes the abſolute coheſion of the whole line AD. The accumulated momentum is therefore the ſame as if the abſolute coheſion of the whole line were exerted at one-third of AD from A.

From theſe premiſes it follows that the equation expreſſing the equilibrium of the ſtrain and coheſion is $p\,l = f\,d \times \frac{1}{3}\,d$; and hence we deduce the analogy, "*As thrice the length is to the depth, ſo is the abſolute coheſion to the relative ſtrength.*" 59 The ſtrength aſcertained on other principles.

This equation and this proportion will equally apply to rectangular beams whoſe breadth is b; for we ſhall then have $p\,l = f\,b\,d \times \frac{1}{3}\,d$.

We alſo ſee that the relative ſtrength is proportional to the abſolute coheſion of the particles, to the breadth, and to the ſquare of the depth directly, and to the length inverſely: for p is the meaſure of the force with which it is reſiſted, and $p = \frac{f\,b\,d\,\frac{1}{3}\,d}{l}, = \frac{f\,b\,d^2}{3\,l}$. In this reſpect therefore this hypotheſis agrees with the Galilean; but it aſſigns to every beam a ſmaller proportion of the abſolute coheſion of the ſection of fracture, in the proportion of three to two. In the Galilean hypotheſis this ſection has a momentum equal to one-half of its abſolute ſtrength, but in the other hypotheſis it is only one-third. In beams of a different form the proportion may be different.

As this is a moſt important propoſition, and the foundation

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dation of many practical maxims, we are anxious to have it clearly comprehended, and its evidence perceived by all. Our better informed readers will therefore indulge us while we endeavour to present it in another point of view, where it will be better seen by those who are not familiarly acquainted with the fluxionary calculus.

60 The same proposition presented in another point of view. Fig. 6.

Fig. 6. A is a perspective view of a three-sided beam projecting horizontally from a wall, and loaded with a weight at B just sufficient to break it. DABC is a vertical plane through its highest point D, in the direction of its length. a D a is another vertical section perpendicular to AB. The piece being supposed of insuperable strength everywhere except in the section a D a, and the cohesion being also supposed insuperable along the line a A a, it can break nowhere but in this section, and by turning round a A a as round a hinge. Make D d equal to AD, and let D d represent the absolute cohesion of the fibre at D, which absolute cohesion we expressed by the symbol f. Let a plane $a\,d\,a$ be made to pass through $a\,a$ and d, and let $d\,a'\,a'$ be another cross section. It is plain that the prismatic solid contained between the two sections a D a and $a'\,da'$ will represent the full cohesion of the whole section of fracture; for we may conceive this prism as made up of lines such as Ff, equal and parallel to D d, representing the absolute cohesion of each particle such as F. The pyramidal solid d D a a, cut off by the plane $d\,a\,a$, will represent the cohesions *actually exerted* by the different fibres in the instant of fracture. For take any point E in the surface of fracture, and draw E e parallel to AB, meeting the plane $a\,d\,a$ in e, and let e AE be a vertical plane. It is evident that D d is to E e as AD to AE; and therefore (since the forces exerted by the different fibres are as their extension, and their extension as their distances from the axis of fracture) E e will represent the force actually exerted by the fibre in E, while D is exerting its full force Dd. In like manner, the plane FFff expresses the cohesion exerted by all the fibres in the line FF, and so on through the whole surface. Therefore the pyramid $d\,a\,a$ D expresses the accumulated exertion of the whole surface of fracture.

Farther, suppose the beam to be held perpendicular to the horizon with the end B uppermost, and that the weight of the prism contained between the two sections a D a and $a'\,d\,a'$ (now horizontal) is just able to overcome the full cohesion of the section of fracture. The weight of the pyramid d D $a\,a$ will also be just able to overcome the cohesions *actually exerted* by the different fibres in the instant of fracture, because the weight of each fibre, such as E e, is just superior to the cohesion actually exerted at E.

Let o be the centre of gravity of the pyramidal solid, and draw o O perpendicular to the plane a D a. The whole weight of the solid d D $a\,a$ may be conceived as accumulated in the point o, and as acting on the point O, and it will have the same tendency to separate the two cohering surfaces as when each fibre is hanging by its respective point. For this reason the point O may be called the *centre of actual effort* of the unequal forces of cohesion. The momentum therefore, or energy by which the cohering surfaces are separated, will be properly measured by the weight of the solid d D $a\,a$ multiplied by OA; and this product is equal to the product of the weight p multiplied by BA, or by l.

Thus suppose that the cohesion along the line AD only is considered. The whole cohesion will be represented by a triangle AD d. D d represents f, and AD is d, and AD is x. Therefore AD d is $\frac{1}{2} f d$. The centre of gravity o of the triangle AD d is in the intersection of a line drawn from A to the middle of D d with a line drawn from d to the middle of AD; and therefore the line o O will make AO$=\frac{2}{3}$ of AD. Therefore the actual momentum of cohesion is $f \times \frac{1}{2} d \times \frac{2}{3} d, = f \times d \times \frac{1}{3} d, = f d \times \frac{1}{3} d$, or equal to the absolute cohesion acting by means of the lever $\frac{d}{3}$. If the section of fracture is a rectangle, as in a common joist, whose breadth $a\,a$ is $= b$, it is plain that all the vertical lines will be represented by triangles like AD d; and the whole actual cohesion will be represented by a wedge whose bases are vertical planes, and which is equal to half of the parallelopiped AD$\times$D $d \times a\,a$, and will therefore be $= \frac{1}{2} f b d$; and the distance AO of its centre of gravity from the horizontal line AA′ will be $\frac{2}{3}$ of AD. The momentum of cohesion of a joist will therefore be $\frac{1}{2} f b d \times \frac{2}{3} d$, or $f b d \frac{1}{3} d$, as we have determined in the other way.

The beam represented in the figure is a triangular prism. The pyramid D$a\,a\,d$ is $\frac{1}{3}$ of the prism $a a$D$d a' a'$. If we make s represent the surface of the triangle aDa, the pyramid is $\frac{1}{3}$ of $f s$. The distance AO of its centre of gravity from the horizontal line AA′ is $\frac{1}{2}$ of AD, or $\frac{1}{2} d$. Therefore the momentum of actual cohesion is $\frac{1}{3} f s \times \frac{1}{2} d, = f s \frac{1}{6} d$; that is, it is the same as if the full cohesion of all the fibres were accumulated at a point I whose distance from A is $\frac{1}{6}$th of AD or d; or (that we may see its value in every point of view) it is $\frac{1}{6}$th of the momentum of the full cohesion of all the fibres when accumulated at the point D, or acting at the distance d=AD.

This is a very convenient way of conceiving the momentum of actual cohesion, by comparing it with the momentum of absolute cohesion applied at the distance AD from the axis of fracture. The momentum of the absolute cohesion applied at D is to the momentum of actual cohesion in the instant of fracture as AD to AI. Therefore the length of AI, or its proportion to AD, is a sort of index of the strength of the beam. We shall call it the INDEX, and express it by the symbol i.

Its value is easily obtained. The product of the absolute cohesion by AI must be equal to that of the actual cohesion by AO. Therefore say, "as the prismatic solid $a\,a$ D $d\,a'\,a'$ is to the pyramidal solid $a\,a$ D d, so is AO to AI." We are assisted in this determination by a very convenient circumstance. In this hypothesis of the actual cohesions being as the distances of the fibres from A, the point O is the centre of oscillation or percussion of the surface D $a\,a$ turning round the axis $a\,a$: for the momentum of cohesion of the line FF is FF$\times$F$f\times$EA$=$FF$\times$EA², because Ff is equal to EA. Now AO, by the nature of the centre of gravity, is equal to the sum of all these momenta divided by the pyramid $a\,a$ D d; that is, by the sum of all the FF$\times$Ff; that is, by the sum of all the FF$\times$EA.

Therefore $\text{AO} = \frac{\text{sum of FF} \times \text{EA}^2}{\text{sum of FF} \times \text{EA}}$, which is just the value of the distance of the centre of percussion of the triangle $a\,a$ D from A: (See ROTATION). Moreover, if if G be the centre of gravity of the triangle a D a, we shall have DA to GA as the absolute cohesion to the sum of the cohesions actually exerted in the instant of fracture; for, by the nature of this centre of gravity, AG is equal to $\frac{\text{sum of FF} \times \text{EA}}{\text{sum of FF}}$, and the sum of FF $\times$ AG is equal to the sum of FF $\times$ EA. But the sum of all the lines FF is the triangle a D a, and the sum of all the FF $\times$ EA is the sum of all the rectangles FFff; that is, the pyramid dD $a\,a$. Therefore a prism whose base is the triangle a D a, and whose height is AG, is equal to the pyramid, or will express the sum of the actual cohesions; and a prism, whose base is the same triangle, and whose height is D d or D a, expresses the absolute cohesion. Therefore DA is to GA as the absolute cohesion to the sum of the actual cohesions.

Therefore we have DA : GA = OA : IA.

Therefore, whatever be the form of the beam, that is, whatever be the figure of its section, find the centre of oscillation O, and the centre of gravity G of this section. Call their distances from the axis of fracture o and g. Then AI or $i = \frac{o\,g}{d}$, and the momentum of cohesion is $f\,s \times \frac{o\,g}{d}$, where s is the area of fracture.

This index is easily determined in all the cases which generally occur in practice. In a rectangular beam AI is $\frac{1}{3}$d of AD; in a cylinder (circular or elliptic) AI is $\frac{5}{16}$ths of AD, &c. &c.

In this hypothesis, that the cohesion actually exerted by each fibre is as its extension, and that the extensions of the fibres are as their distances from A (fig. 5.), it is plain that the forces exerted by the fibres D, E, &c. will be represented by the ordinates Dd, E e, &c. to a straight line A d. And we learn from the principles of ROTATION that the centre of percussion O is in the ordinate which passes through the centre of gravity of the triangle AD d, or (if we consider the whole section having breadth as well as depth) through the centre of gravity of the solid bounded by the planes DA, d A; and we found that this point O was the centre of effort of the cohesions *actually* exerted in the instant of fracture, and that I was the centre of an *equal* momentum, which would be produced if all the fibres were accumulated there and exerted their *full* cohesion.

This consideration enables us to determine, with equal facility and neatness, the strength of a beam in any hypothesis of forces. The above hypothesis was introduced with a cautious limitation to moderate strains, which produced no permanent change of form, or no sett as the artists call it: and this suffices for all purposes of practice, seeing that it would be imprudent to expose materials to more violent strains. But when we compare this theory with experiments in which the pieces are really broken, considerable deviations may be expected, because it is very probable that in the vicinity of rupture the forces are no longer proportional to the extensions.

61 How the relative strength may be determined by any other hypothesis.

That no doubt may remain as to the justness and completeness of the theory, we must show how the relative strength may be determined in any other hypothesis. Therefore suppose that it has been established by experiment on any kind of solid matter, that the forces actually exerted in the instant of fracture by the fibres at D, E, &c. are as the ordinates D d', E e', &c. of any curve line A e' d'. We are supposed to know the form of this curve, and that of the solid which is bounded by the vertical plane through AD, and by the surface which passes through this curve A e' d' perpendicularly to the length of the beam. We know the place of the centre of gravity of this curve surface or solid, and can draw a line through it parallel to AB, and cutting the surface of fracture in some point O. This point is also the centre of effort of all the cohesions actually exerted; and the product of AO and of the solid which expresses the actual cohesions will give the momentum of cohesion equivalent to the former $f\,s\,\frac{o\,g}{d}$. Or we may find an index AI, by making AI a fourth proportional to the full cohesion of the surface of fracture, to the accumulated actual cohesions, and to AO; and then $f\,s \times i$ (=AI) will be the momentum of cohesion; and we shall still have I for the point in which all the fibres may be supposed to exert their full cohesion f, and to produce a momentum of cohesion equal to the real momentum of the cohesions actually exerted, and the relative strength of the beam will still be $p = \frac{f\,s\,i}{l}$ or $\frac{f\,s\,g\,o}{d\,l}$. Thus, if the forces be as the squares of the extensions (still supposed to be as the distances from A), the curve A e' d' will be a common parabola, having AB for its axis and AD for the tangent at its vertex. The area AD d' will be $\frac{1}{3}$d AD $\times$ D d; and in the case of a rectangular beam, AO will be $\frac{3}{4}$ths AD, and AI will be $\frac{1}{4}$th of AD.

We may observe here in general, that if the forces actually exerted in the instant of fracture be as any power q of the distance from A, the index AI will be $= \frac{\text{AD}}{q+2}$ for a rectangular beam, and the momentum of cohesion will always be (*cæteris paribus*) as the breadth and as the square of the depth; nay, this will be the case whenever the action of the fibres D and E is expressed by any *similar functions* of d and x. This is evident to every reader acquainted with the fluxionary calculus.

As far as we can judge from experience, no simple algebraic power of the distance will express the actual cohesions of the fibres. No curve which has either AD or AB for its tangent will suit. The observations which we made in the beginning show, that although the curve of fig. 2. must be sensibly straight in the vicinity of the points of intersection with the axis, in order to agree with our observations which show the moderate extensions to be as the extending forces, the curve *must* be concave towards the axis in all its attractive branches, because it cuts it again. Therefore the curve A e' d' of fig. 5. must make a finite angle with AD or AB, and it must, in all probability, be also concave towards AD in the neighbourhood of d'. It may however be convex in some part of the intermediate arch. We have made experiments on the extensions of different bodies, and find great diversities in this respect: But in all, the moderate extensions were as the forces, and this with great accuracy till the body took a sett, and remained longer than formerly when the extending force was removed.

We must now remark, that this correction of the Galilean hypothesis of equal forces was suggested by the bending

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bending which is obſerved in all bodies which are ſtrained tranſverſely. Becauſe they are bent, the fibres on the convex ſide have been extended. We cannot ſay in what proportion this obtains in the different fibres. Our moſt diſtinct notions of the internal equilibrium between the particles render it highly probable that their extenſion is proportional to their diſtance from that fibre which retains its former dimenſions. But by whatever law this is regulated, we ſee plainly that the actions of the ſtretched fibres muſt follow the proportions of ſome function of this diſtance, and that therefore the relative ſtrength of a beam is in all caſes ſuſceptible of mathematical determination.

62 Bernoulli's problem of the elaſtic curve.

We alſo ſee an intimate connection between the ſtrain and the curvature. This ſuggeſted to the celebrated James Bernoulli the problem of the Elastic Curve, i. e. the curve into which an extenſible rigid body will be bent by a tranſverſe ſtrain. His ſolution in the *Acta Lipſiæ* 1694 and 1695 is a very beautiful ſpecimen of mathematical diſcuſſion; and we recommend it to the peruſal of the curious reader, He will find it very perſpicuouſly treated in the firſt volume of his works, publiſhed after his death, where the wide ſteps which he had taken in his inveſtigation are explained ſo as to be eaſily comprehended. His nephew Daniel Bernoulli has given an elegant abridgement in the Peterſburg Memoirs for 1729. The problem is too intricate to be fully diſcuſſed in a work like ours; but it is alſo too intimately connected with our preſent ſubject to be entirely omitted. We muſt content ourſelves with ſhowing the leading mechanical properties of this curve, from which the mathematician may deduce all its geometrical properties.

63 Its leading mechanical property deſcribed.

When a bar of uniform depth and breadth, and of a given length, is bent into an arch of a circle, the extenſion of the outer fibres is proportional to the curvature; for, becauſe the curves formed by the inner and outer ſides of the beam are ſimilar, the circumferences are as the radii, and the radius of the inner circle is to the difference of the radii as the length of the inner circumference is to the difference of the circumferences. The difference of the radii is the depth of the beam, the difference of the circumferences is the extenſion of the outer fibres, and the inner circumference is ſuppoſed to be the primitive length of the beam. Now the ſecond and third quantities of the above analogy, viz. the depth and length of the beam, are conſtant quantities, as is alſo their product. Therefore the product of the inner radius and the extenſion of the outer fibre is alſo a conſtant quantity, and the whole extenſion of the outer fibre is inverſely as the radius of curvature, or is directly as the curvature of the beam.

The mathematical reader will readily ſee, that into whatever curve the elaſtic bar is bent, the whole extenſion of the outer fibre is equal to the length of a ſimilar curve, having the ſame proportion to the thickneſs of the beam that the length of the beam has to the radius of curvature.

Fig. 7.

Now let ADCB (fig. 7.) be ſuch a rod, of uniform breadth and thickneſs, firmly fixed in a vertical poſition, and bent into a curve AEFB by a weight W ſuſpended at B, and of ſuch magnitude that the extremity B has its tangent perpendicular to the action of the weight, or parallel to the horizon. Suppoſe too that the extenſions are proportional to the extending forces. From any two points E and F draw the horizontal ordinates EG, FH. It is evident that the exterior fibres of the ſections E *e* and F *f* are ſtretched by forces which are in the proportion of EG to FH (theſe being the long arms of the levers, and the equal thickneſſes E *e*, F *f* being the ſhort arms). Therefore (by the hypotheſis) their extenſions are in the ſame proportion. But becauſe the extenſions are proportional to ſome ſimilar functions of the diſtance from the axes of fracture E and F, the extenſion of any fibre in the ſection E *e* is to the contemporaneous extenſion of the ſimilarly ſituated fibre in the ſection F *f*, as the extenſion of the exterior fibre in the ſection E *e* is to the extenſion of the exterior fibre in the ſection F *f*: therefore the whole extenſion of E *e* is to the whole extenſion of F *f* as EG to FH, and EG is to FH as the curvature in E to the curvature in F.

Here let it be remarked, that this proportionality of the curvature to the extenſion of the fibres is not limited to the hypotheſis of the proportionality of the extenſions to the extending forces. It follows from the extenſion in the different ſections being as ſome ſimilar function of the diſtance from the axis of fracture; an aſſumption which cannot be refuſed.

This then is the fundamental property of the elaſtic curve, from which its equation, or relation between the abſciſſa and ordinate, may be deduced in the uſual forms, and all its other geometrical properties. Theſe are foreign to our purpoſe; and we ſhall notice only ſuch properties as have an immediate relation to the ſtrain and ſtrength of the different parts of a flexible body, and which in particular ſerve to explain ſome difficulties in the valuable experiments of M. Buffon on the Strength of Beams.

We obſerve, in the firſt place, that the elaſtic curve cannot be a circle, but is gradually more incurvated as it recedes from the point of application B of the ſtraining forces. At B it has no curvature; and if the bar were extended beyond B there would be no curvature there. In like manner, when a beam is ſupported at the ends and loaded in the middle, the curvature is greateſt in the middle; but at the props, or beyond them, if the beam extend farther, there is no curvature. Therefore when a beam projecting 20 feet from a wall is bent to a certain curvature at the wall by a weight ſuſpended at the end, and a beam of the ſame ſize projecting 20 feet is bent to the very ſame curvature at the wall by a greater weight at 10 feet diſtance, the figure and the mechanical ſtate of the beam in the vicinity of the wall is different in theſe two caſes, though the curvature at the very wall is the ſame in both. In the firſt caſe every part of the beam is incurvated; in the ſecond, all beyond the 10 feet is without curvature. In the firſt experiment the curvature at the diſtance of five feet from the wall is three-fourths of the curvature at the wall; in the ſecond, the curvature at the ſame place is but one-half of that at the wall. This muſt weaken the long beam in this whole interval of five feet, becauſe the greater curvature is the reſult of a greater extenſion of the fibres. — 64 It is not a circle.

In the next place, we may remark, that there is a certain determinate curvature for every beam which cannot be exceeded without breaking it; for there is a certain ſeparation of two adjoining particles that puts an end to their coheſion. A fibre can therefore be — 65 Every beam has a certain determinate curvature.

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be extended only a certain proportion of its length. The ultimate extenſion of the outer fibres muſt bear a certain determinate proportion to its length, and this proportion is the ſame with that of the thickneſs (or what we have hitherto called the depth) to the radius of ultimate curvature, which is therefore determinate.

66
And when of uniform breadth and depth is moſt incurvated where the ſtrain is greateſt.

A beam of uniform breadth and depth is therefore moſt incurvated where the ſtrain is greateſt, and will break in the moſt incurvated part. But by changing its form, ſo as to make the ſtrength of its different ſections in the ratio of the ſtrain, is is evident that the curvature may be the ſame throughout, or may be made to vary according to any law. This is a remark worthy of the attention of the watchmaker. The moſt delicate problem in practical mechanics is ſo to taper the balance-ſpring of a watch that its wide and narrow vibrations may be iſochronous. Hooke's principle *ut tenſio ſic vis* is not ſufficient when we take the *inertia* and motion of the ſpring itſelf into the account. The figure into which it bends and unbends has alſo an influence. Our readers will take notice that the artiſt aims at an accuracy which will not admit an error of $\frac{1}{86400}$th, and that Harriſon and Arnold have actually attained it in ſeveral inſtances. The taper of a ſpring is at preſent a noſtrum in the hands of each artiſt, and he is careful not to impart his ſecret.

Again, ſince the depth of the beam is thus proportional to the radius of ultimate curvature, this ultimate or breaking curvature is inverſely as the depth. It may be expreſſed by $\frac{1}{d}$.

67
To what the curvature is proportional.

When a weight is hung on the end of a priſmatic beam, the curvature is nearly as the weight and the length directly, and as the breadth and the cube of the depth inverſely; for the ſtrength is $= f\frac{b\,d^2}{3\,l}$. Let us ſuppoſe that this produces the ultimate curvature $\frac{1}{d}$. Now let the beam be loaded with a ſmaller weight w, and let the curvature produced be C, we have this analogy $f\frac{b\cdot d^2}{3\,l} : w = \frac{1}{d} : \mathrm{C}$, and $\mathrm{C} = \frac{3\,l\,w}{f\,b\,d^3}$. It is evident that this is alſo true of a beam ſupported at the ends and loaded between the props; and we ſee how to determine the curvature in its different parts, whether ariſing from the load, or from its own weight, or from both.

68
Deflection.

When a beam is thus loaded at the end or middle, the loaded point is pulled down, and the ſpace through which it is drawn may be called the DEFLECTION. This may be conſidered as the ſubtenſe of the angle of contact, or as the verſed ſine of the arch into which the beam is bent, and is therefore as the curvature when the length of the arches is given (the flexure being moderate), and as the ſquare of the length of the arch when the curvature is given. The deflection therefore is as the curvature and as the ſquare of the length of the arch jointly; that is, as $\frac{3\,l\,w}{f\,b\,d^3} \times l^2$, or as $\frac{3\,l^3 w}{f\,b\,d^3}$. The deflection from the primitive ſhape is therefore as the bending weight and the cube of the length directly, and as the breadth and cube of the depth inverſely.

In beams juſt ready to break, the curvature is as the depth inverſely, and the deflection is as the ſquare of the length divided by the depth; for the ultimate curvature at the breaking part is the ſame whatever is the length; and in this caſe the deflection is as the ſquare of the length.

69
The theorems reſulting from this ſubject afford the fineſt methods of examining the laws of corpuſcular action.

We have been the more particular in our conſideration of this ſubject, becauſe the reſulting theorems afford us the fineſt methods of examining the laws of corpuſcular action, that is, for diſcovering the variation of the force of coheſion by a change of diſtance. It is true it is not the atomical law, or HYLARCHIC PRINCIPLE as it may juſtly be called, which is thus made acceſſible, but the ſpecific law of the particles of the ſubſtance or kind of matter under examination. But even this is a very great point; and coincidences in this reſpect among the different kinds of matter are of great moment. We may thus learn the nature of the corpuſcular action of different ſubſtances, and perhaps approach to a diſcovery of the *mechaniſm* of chemical affinities. For that chemical actions are inſenſible caſes of local motion is undeniable, and local motion is the province of mechanical diſcuſſion; nay, we ſee that theſe hidden changes are produced by mechanical forces in many important caſes, for we ſee them promoted or prevented by means purely mechanical. The converſion of bodies into elaſtic vapour by heat can at all times be prevented by a *ſufficient* external preſſure. A ſtrong ſolution of Glauber's ſalt will congeal in an inſtant by agitation, giving out its latent heat; and it will remain fluid for ever, and return its latent heat in a cloſe veſſel which it completely fills. Even water will by ſuch treatment freeze in an inſtant by agitation, or remain fluid for ever by confinement. We know that heat is produced or extricated by friction, that certain compounds of gold or ſilver with ſaline matters explode with irreſiſtible violence by the ſmalleſt preſſure or agitation. Such facts ſhould rouſe the mathematical philoſopher, and excite him to follow out the conjectures of the illuſtrious Newton, encouraged by the ingenious attempts of Boſcovich; and the proper beginning of this ſtudy is to attend to the laws of attraction and repulſion exerted by the particles of cohering bodies, diſcoverable by experiments made on their actual extenſions and compreſſions. The experiments of ſimple extenſions and compreſſions are quite inſufficient, becauſe the total ſtretching of a wire is ſo ſmall a quantity, that the miſtake of the 1000th part of an inch occaſions an irregularity which deranges any progreſſion ſo as to make it uſeleſs. But by the bending of bodies, a diſtenſion of $\frac{1}{100}$th of an inch may be eaſily magnified in the deflection of the ſpring ten thouſand times. We know that the inveſtigation is intricate and difficult, but not beyond the reach of our preſent mathematical attainments; and it will give very fine opportunities of employing all the addreſs of analyſis. In the 17th century and the beginning of the 18th this was a ſufficient excitement to the firſt geniuſes of Europe. The cycloid, the catenaria, the elaſtic curve, the velaria, the cauſtics, were reckoned an abundant recompenſe for much ſtudy; and James Bernoulli requeſted, as an honourable monument, that the logarithmic ſpiral might be inſcribed on his tombſtone. The reward for the ſtudy to which we now preſume to incite the mathematicians is the almoſt unlimited extenſion of natural ſcience, important in every particular branch. To go no further than our preſent ſubject, a great deal of important practical know-

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ledge reſpecting the ſtrength of bodies is derived from the ſingle obſervation, that in the moderate extenſions which happen before the parts are overſtrained the forces are nearly in the proportion of the extenſions or ſeparations of the particles. To return to our ſubject.

70 Bernoulli calls in queſtion this law,

James Bernoulli, in his ſecond diſſertation on the elaſtic curve, calls in queſtion this law, and accommodates his inveſtigation to any hypotheſis concerning the relation of the forces and extenſions. He relates ſome experiments of lute ſtrings where the relation was conſiderably different. Strings of three feet long,

Stretched by	2,	4,	6,	8,	10 pds.
Were lengthened	9,	17,	23,	27,	30 lines.

But this is a moſt exceptionable form of the experiment. The ſtrings were twiſted, and the mechaniſm of the extenſions is here exceedingly complicated, combined with compreſſions and with tranſverſe twiſts, &c. We made experiments on fine ſlips of the gum caoutchouc, and on the juice of the berries of the white bryony, of which a ſingle grain will draw to a thread of two feet long, and again return into a perfectly round ſphere. We meaſured the diameter of the thread by a microſcope with a micrometer, and thus could tell in every ſtate of extenſion the proportional number of particles in the ſections. We found, that though the whole range in which the diſtance of the particles was changed in the proportion of 13 to 1, the extenſions did not *ſenſibly* deviate from the proportion of the forces. The ſame thing was obſerved in the caoutchouc as long as it perfectly recovered its firſt dimenſions. And it is on the authority of theſe experiments that we preſume to announce this as a law of nature.

71 which was firſt aſſumed by Dr Hooke.

Dr Robert Hooke was undoubtedly the firſt who attended to this ſubject, and aſſumed this as a law of nature. Mariotte indeed was the firſt who expreſsly uſed it for determining the ſtrength of beams: this he did about the 1679, correcting the ſimple theory of Galileo. Leibnitz indeed, in his diſſertation in the *Acta Eruditorum* 1684 *de Reſiſtentia Solidorum*, introduces this conſideration, and wiſhes to be conſidered as the diſcoverer; and he is always acknowledged as ſuch by the Bernoullis and others who adhered to his peculiar doctrines. But Mariottè had publiſhed the doctrine in the moſt expreſs terms long before; and Bulfinger, in the *Comment. Petropol.* 1729, completely vindicates his claim. But Hooke was unqueſtionably the diſcoverer of this law. It made the foundation of his theory of ſprings, announced to the Royal Society about the year 1661, and read in 1666. On this occaſion he mentions many things on the ſtrength of bodies as quite familiar to his thoughts, which are immediate deductions from this principle; and among theſe *all* the facts which John Bernoulli ſo vauntingly adduces in ſupport of Leibnitz's finical dogmas about the force of bodies in motion; a doctrine which Hooke might have claimed as his own, had he not perceived its frivolous inanity.

72 Though corrected by Mariotte, it does not properly explain the mechaniſm of tranſverſe ſtrain,

But even with this firſt correction of Mariottè, the mechaniſm of tranſverſe ſtrain is not fully nor juſtly explained. The force acting in the direction BP (fig. 5.), and bending the body ABCD, not only ſtretches the fibres on the ſide oppoſite to the axis of fracture, but compreſſes the ſide AB, which becomes concave by the ſtrain. Indeed it cannot do the one without doing the other: For in order to ſtretch the fibres at D, there muſt be ſome fulcrum, ſome ſupport, on which the virtual lever BAD may preſs, that it may tear aſunder the ſtretched fibres. This fulcrum muſt ſuſtain both the preſſure ariſing from the coheſion of the diſtended fibres, and alſo the action of the external force, which immediately tends to cauſe the prominent part of the beam to ſlide along the ſection DA. Let BAD (fig. 5.) be conſidered as a crooked lever, of which A is the fulcrum. Let an external force be applied at B in the direction BP, and let a force equal to the accumulated coheſion of AD be applied at O in the direction oppoſite to AB, that is, perpendicular to AO; and let theſe two forces be ſuppoſed to balance each other by the intervention of the lever. In the firſt place, the force at O muſt be to the force at B as AB to AO: Therefore, if we make AK equal and oppoſite to AO, and AL equal and oppoſite to AB, the common principles of mechanics inform us that the fulcrum A is affected in the ſame manner as if the two forces AK and AL were immediately applied to it, the force AK being equal to the weight P, and AL equal to the accumulated coheſion actually exerted in the inſtant of fracture. The fulcrum is therefore really preſſed in the direction AM, the diagonal of the parallelogram, and it muſt reſiſt in the direction and with the force MA; and this power of reſiſtance, this ſupport, muſt be furniſhed by the repulſive forces exerted by *thoſe particles only* which are in a ſtate of actual compreſſion. The force AK, which is equal to the external force P, muſt be reſiſted in the direction KA by the lateral coheſion of the whole particles between D and A (the particle D is not only drawn forward but downward). This prevents the part CDAB from ſliding down along the ſection DA.

73 as is fully verified by experiment.

This is fully verified by experiment. If we attempt to break a long ſlip of cork, or any ſuch very compreſſible body, we always obſerve it to bulge out on the concave ſide before it cracks on the other ſide. If it is a body of fibrous or foliated texture, it ſeldom fails ſplintering off on the concave ſide; and in many caſes this ſplintering is very deep, even reaching half way through the piece. In hard and granulated bodies, ſuch as a piece of freeſtone, chalk, dry clay, ſugar, and the like, we generally ſee a conſiderable ſplinter or ſhiver fly off from the hollow ſide. If the fracture be ſlowly made by a force at B gradually augmented, the formation of the ſplinter is very diſtinctly ſeen. It forms a triangular piece like *a* I *b*, which generally breaks in the middle. We doubt not but that attentive obſervation would ſhow that the direction of the crack on each ſide of I is not very different from the direction AM and its correſpondent on the other ſide. This is by no means a circumſtance of idle curioſity, but intimately connected with the mechaniſm of coheſion.

74 Conſequences reſulting from the ſtate of the caſe. Fig. 8.

Let us ſee what conſequences reſult from this ſtate of the caſe reſpecting the ſtrength of bodies. Let DΔKC (fig. 8.) repreſent a vertical ſection of a priſm of compreſſible materials, ſuch as a piece of timber. Suppoſe it loaded with a weight P hung at its extremity. Suppoſe it of ſuch a conſtitution that all the fibres in AD are in a ſtate of dilatation, while thoſe in AΔ are in a ſtate of compreſſion. In the inſtant of fracture the particles at D and E are with-held by forces D *d*, E *e*, and the particles at Δ and E repel, reſiſt, or ſupport, with forces Δ δ, E ε.

Some line, ſuch as *d e* A ε δ, will limit all theſe ordinates,

nates, which repreſent the forces actually exerted in the inſtant of fracture. If the forces be as the extenſions and compreſſions, as we have great reaſon to believe, deA and $A\epsilon\partial$ will be two ſtraight lines. They will form *one* ſtraight line $dA\partial$, if the forces which reſiſt a certain dilatation are equal to the forces which reſiſt an equal compreſſion. But this is quite accidental, and is not ſtrictly true in any body. In moſt bodies which have any conſiderable firmneſs, the compreſſions made by any external force are not ſo great as the dilatations which the ſame force would produce; that is, the repulſions which are excited by any ſuppoſed degree of compreſſion are greater than the attractions excited by the ſame degree of dilatation. Hence it will generally follow, that the angle dAD is leſs than the angle $\partial A \Delta$, and the ordinates D d, E e, &c. are leſs than the correſponding ordinates $\Delta\,\partial$, E ϵ, &c.

But whatever be the nature of the line $dA\partial$, we are certain of this, that the whole area ADd is equal to the whole area $A\Delta\partial$: for as the force at B is gradually increaſed, and the parts between A and D are more extended, and greater coheſive forces are excited, there is always ſuch a degree of repulſive forces excited in the particles between A and Δ that the one ſet preciſely balances the other. The force at B, acting perpendicularly to AB, has no tendency to puſh the whole piece cloſer on the part next the wall or to pull it away. The ſum of the attractive and repulſive forces actually excited muſt therefore be equal. Theſe ſums are repreſented by the two triangular areas, which are therefore equal.

The greater we ſuppoſe the repulſive forces correſponding to any degree of compreſſion, in compariſon with the attractive forces correſponding to the ſame degree of extenſion, the ſmaller will $A\Delta$ be in compariſon of AD. In a piece of cork or ſponge, $A\Delta$ may chance to be equal to AD, or even to exceed it; but in a piece of marble, $A\Delta$ will perhaps be very ſmall in compariſon of AD.

75
An important conſequence of the compreſſibility of body fully proved.

Now it is evident that the repulſive forces excited between A and Δ have no ſhare in preventing the fracture. They rather contribute to it, by furniſhing a fulcrum to the lever, by whoſe energy the coheſion of the particles in AD is overcome. Hence we ſee an important conſequence of the compreſſibility of the body. Its power of reſiſting this tranſverſe ſtrain is diminiſhed by it, and ſo much the more diminiſhed as the ſtuff is more compreſſible.

This is fully verified by ſome very curious experiments made by Du Hamel. He took 16 bars of willow 2 feet long and $\frac{1}{2}$ an inch ſquare, and ſupporting them by props under the ends, he broke them by weights hung on the middle. He broke 4 of them by weights of 40, 41, 47, and 52 pounds: the mean is 45. He then cut 4 of them $\frac{1}{3}$d through on the upper ſide, and filled up the cut with a thin piece of harder wood ſtuck in pretty tight. Theſe were broken by 48, 54, 50, and 52 pounds; the mean of which is 51. He cut other four $\frac{1}{2}$ through, and they were broken by 47, 49, 50, 46; the mean of which is 48. The remaining four were cut $\frac{2}{3}$ds; and their mean ſtrength was 42.

Another ſet of his experiments is ſtill more remarkable.

Six battens of willow 36 inches long and $1\frac{1}{2}$ ſquare were broken by 525 pounds at a medium.

Six bars were cut $\frac{1}{3}$d through, and the cut filled with a wedge of hard wood ſtuck in with a little force: theſe broke with 551.

Six bars were cut half through, and the cut was filled in the ſame manner: they broke with 542.

Six bars were cut $\frac{3}{4}$ths through: theſe broke with 530.

A batten cut $\frac{3}{4}$ths through, and loaded till nearly broken, was unloaded, and the wedge taken out of the cut. A thicker wedge was put in tight, ſo as to make the batten ſtraight again by filling up the ſpace left by the compreſſion of the wood: this batten broke with 577 pounds.

From this it is plain that more than $\frac{2}{3}$ds of the thickneſs (perhaps nearly $\frac{3}{4}$ths) contributed nothing to the ſtrength.

The point A is the centre of fracture in this caſe; and in order to eſtimate the ſtrength of the piece, we may ſuppoſe that the crooked lever virtually concerned in the ſtrain is DAB. We muſt find the point I, which is the centre of effort of all the attractive forces, or that point where the full coheſion of AD muſt be applied, ſo as to have a momentum equal to the accumulated momenta of all the variable forces. We muſt in like manner find the centre of effort i of the repulſive or ſupporting forces exerted by the fibres lying between A and Δ.

It is plain, and the remark is important, that this laſt centre of effort is the real fulcrum of the lever, although A is the point where there is neither extenſion nor contraction; for the lever is ſupported in the ſame manner as if the repulſions of the whole line $A\Delta$ were exerted at that point. Therefore let S repreſent the ſurface of fracture from A to D, and f repreſent the abſolute coheſion of a fibre at D in the inſtant of fracture. We ſhall have $fS \times \overline{1+i} = pl$, or $l : 1+i = fS : p$; that is, the length AB is to the diſtance between the two centres of effort I and i, as the abſolute coheſion of the ſection between A and D is to the relative ſtrength of the ſection.

It would be perhaps more accurate to make AI and Ai equal to the diſtances of A from the horizontal lines paſſing through the centres of gravity of the triangles dAD and $\partial A\Delta$. It is only in this conſtruction that the points I and i are the centres of real effort of the accumulated attractions and repulſions. But I and i, determined as we have done, are the points where the full, equal, actions may be all applied, ſo as to produce the ſame momenta. The final reſults are the ſame in both caſes. The attentive and duly informed reader will ſee that Mr Bulfinger, in a very elaborate diſſertation on the ſtrength of beams in the *Comment. Petropolitan.* 1729, has committed ſeveral miſtakes in his eſtimation of the actions of the fibres. We mention this becauſe his reaſonings are quoted and appealed to as authorities by Muſchenbroek and other authors of note. The ſubject has been conſidered by many authors on the continent. We recommend to the reader's peruſal the very minute diſcuſſions in the Memoirs of the Academy of Paris for 1702 by Varignon, the Memoirs for 1708 by Parent, and particularly that of Coulomb in the *Mem. par les Sçavans Etrangers*, tom. vii.

It is evident from what has been ſaid above, that if S and s repreſent the ſurfaces of the ſections above and below A, and if G and g are the diſtances of their centres of gravity from A, and O and o the diſtances of their centres

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centres of oscillation, and D and d their whole depths, the momentum of cohesion will be $\frac{f S \cdot G \cdot O}{D} = \frac{f s . g . o}{d} = p l$.

If (as is most likely) the forces are proportional to the extensions and compressions, the distances AI and Ai, which are respectively $= \frac{G \cdot O}{D}$ and $\frac{g . o}{d}$, are respectively $= \frac{2}{3}$ DA, and $\frac{2}{3} \Delta$ A; and when taken together are $= \frac{2}{3}$ D Δ. If, moreover, the extensions are equal to the compressions in the instant of fracture, and the body is a rectangular prism like a common joist or beam, then D A and Δ A are also equal; and therefore the momentum of cohesion is $f b \times \frac{1}{2} d \times \frac{1}{3} d, = \frac{f b d^2}{6}, = f b d \times \frac{1}{6} d = p l$. Hence we obtain this analogy, "Six times the length is to the depth as the absolute cohesion of the section is to its relative strength."

76 This consequence farther explained.

Thus we see that the compressibility of bodies has a very great influence on their power of withstanding a transverse strain. We see that in this most favourable supposition of equal dilatations and compressions, the strength is reduced to one half of the value of what it would have been had the body been incompressible. This is by no means obvious; for it does not readily appear how compressibility, which does not diminish the cohesion of a single fibre, should impair the strength of the whole. The reason, however, is sufficiently convincing when pointed out. In the instant of fracture a smaller portion of the section is actually exerting cohesive forces, while a part of it is only serving as a fulcrum to the lever, by whose means the strain on the section is produced. We see too that this diminution of strength does not so much depend on the sensible compressibility, as on its proportion to the dilatability by equal forces. When this proportion is small, A Δ is small in comparison of AD, and a greater portion of the whole fibre is exerting attractive forces. The experiments already mentioned, of Du Hamel de Monceau, on battens of willow, show that its compressibility is nearly equal to its dilatability. But the case is not very different in tempered steel. The famous Harrison, in the delicate experiments which he made while occupied in making his longitude watch, discovered that a rod of tempered steel was nearly as much diminished in its length as it was augmented by the same external force. But it is not by any means certain that this is the proportion of dilatation and compression which obtains in the very instant of fracture. We rather imagine that it is not. The forces are nearly as the dilatations till very near breaking; but we think that they diminish when the body is just going to break. But it seems certain that the forces which resist compression increase faster than the compressions, even before fracture. We know incontestably that the ultimate resistances to compression are insuperable by any force which we can employ. The repulsive forces therefore (in their whole extent) increase faster than the compressions, and are expressed by an assymptotic branch of the Boscovician curve formerly explained. It is therefore probable, especially in the more simple substances, that they increase faster, even in such compressions as frequently obtain in the breaking of hard bodies. We are disposed to think that this is always the case in such bodies as do not fly off in splinters on the concave side; but this must be understood with the exception of the permanent changes which may be made by compression, when the bodies are crippled by it. This always increases the compression itself, and causes the neutral point to shift still more towards D. The effect of this is sometimes very great and fatal.

Experiment alone can help us to discover the proportion between the dilatability and compressibility of bodies. The strain now under consideration seems the best calculated for this research. Thus if we find that a piece of wood an inch square requires 12,000 pounds to tear it asunder by a direct pull, and that 200 pounds will break it transversely by acting 10 inches from the section of fracture, we must conclude that the neutral point A is in the middle of the depth, and that the attractive and repulsive forces are equal. Any notions that we can form of the constitution of such fibrous bodies as timber, make us imagine that the *sensible* compressions, including what arises from the bending up of the compressed fibres, is much greater than the real corpuscular extensions. One may get a general conviction of this unexpected proposition by reflecting on what must happen during the fracture. An undulated fibre can only be drawn straight, and then the corpuscular extension begins; but it may be bent up by compression to any degree, the corpuscular compression being little affected all the while. This observation is very important; and though the forces of corpuscular repulsion may be almost insuperable by any compression that we can employ, a *sensible* compression may be produced by forces not enormous, sufficient to cripple the beam. Of this we shall see very important instances afterwards.

77 The proportional strengths of different pieces follow the same ratio.

It deserves to be noticed, that although the relative strength of a prismatic solid is extremely different in the three hypotheses now considered, yet the proportional strengths of different pieces follow the same ratio; namely, the direct ratio of the breadth, the direct ratio of the square of the depth, and the inverse ratio of the length. In the first hypothesis (of equal forces) the strength of a rectangular beam was $\frac{f b d^2}{2 l}$; in the second (of attractive forces proportioned to the extensions) it was $\frac{f b d^2}{3 l}$; and in the third (equal attractions and repulsions proportional to the extensions and compressions) it was $\frac{f b d^2}{6 l}$, or more generally $\frac{f b d^2}{m l}$, where m expresses the unknown proportion between the attractions and repulsions corresponding to an equal extension and compression.

78 The strength of a piece depends chiefly on its depth.

Hence we derive a piece of useful information, which is confirmed by unexceptionable experience, that the strength of a piece depends chiefly on its depth, that is, on that dimension which is in the direction of the strain. A bar of timber of one inch in breadth and two inches in depth is four times as strong as a bar of only one inch deep, and it is twice as strong as a bar two inches broad and one deep; that is, a joist or lever is always strongest when laid on its edge.

79 And therefore a choice in the manner in which the cohesion is opposed to the strain.

There is therefore a choice in the manner in which the cohesion is opposed to the strain. The general aim must be to put the centre of effort I as far from the fulcrum or the neutral point A as possible, so as to give the greatest energy or momentum to the cohesion. Thus if a triangular bar projecting from a wall is loaded with a weight

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weight at its extremity, it will bear thrice as much when one of the ſides is uppermoſt as when it is undermoſt. The bar of fig. 6. would be three times as ſtrong if the ſide AB were uppermoſt and the edge DC undermoſt.

80 The ſtrongeſt joiſt has not the greateſt quantity of timber. Fig. 9.

Hence it follows that the ſtrongeſt joiſt that can be cut out of a round tree is not the one which has the greateſt quantity of timber in it, but ſuch that the product of its breadth by the ſquare of its depth ſhall be the greateſt poſſible. Let ABCD (fig. 9.) be the ſection of this joiſt inſcribed in the circle, AB being the breadth and AD the depth. Since it is a rectangular ſection, the diagonal BD is a diameter of the circle, and BAD is a right-angled triangle. Let BD be called a, and BA be called x; then AD is $=\sqrt{a^2-x^2}$. Now we muſt have $AB \times AD^2$, or $x \times a^2-x^2$, or a^2x-x^3, a maximum. Its fluxion $a^2\dot{x}-3x^2\dot{x}$ muſt be made $=0$, or $a^2=3x^2$, or $x^2=\frac{a^2}{3}$. If therefore we make $DE=\frac{1}{3}DB$, and draw EC perpendicular to BD, it will cut the circumference in the point C, which determines the depth BC and the breadth CD.

Becauſe $BD:BC=CD:CE$, we have the area of the ſection $BC\cdot CD=BD\cdot CE$. Therefore the different ſections having the ſame diagonal BD are proportional to their heights CE. Therefore the ſection BCDA is leſs than the ſection BcDa, whoſe four ſides are equal. The joiſt ſo ſhaped, therefore, is both ſtronger, lighter, and cheaper.

81 A hollow tube ſtronger than a ſolid rod containing the ſame quantity of matter, Fig. 10.

The ſtrength of ABCD is to that of aBcD as 10,000 to 9186, and the weight and expence as 10,000 to 10,607; ſo that ABCD is preferable to aBcD in the proportion of 10,607 to 9186, or nearly 115 to 100.

From the ſame principles it follows that a hollow tube is ſtronger than a ſolid rod containing the ſame quantity of matter. Let fig. 10. repreſent the ſection of a cylindric tube, of which AF and BE are the exterior and interior diameters, and C the centre. Draw BD perpendicular to BC, and join DC. Then, becauſe $BD^2=CD^2-CB^2$, BD is the radius of a circle containing the ſame quantity of matter with the ring. If we eſtimate the ſtrength by the firſt hypotheſis, it is evident that the ſtrength of the tube will be to that of the ſolid cylinder, whoſe radius is BD, as $BD^2\times AC$ to $BD^2\times BD$; that is, as AC to BD: for BD^2 expreſſes the coheſion of the ring or the circle, and AC and BD are equal to the diſtances of the centres of effort (the ſame with the centres of gravity) of the ring and circle from the axis of the fracture.

The proportion of theſe ſtrengths will be different in the other hypotheſes, and is not eaſily expreſſed by a general formula; but in both it is ſtill more in favour of the ring or hollow tube.

The following very ſimple ſolution will be readily underſtood by the intelligent reader. Let O be the centre of oſcillation of the exterior circle, o the centre of oſcillation of the inner circle, and w the centre of oſcillation of the ring included between them. Let M be the quantity of ſurface of the exterior circle, m that of the inner circle, and μ that of the ring.

We have $Fw=\frac{M\cdot FO-m.Fo}{\mu},=\frac{5FC^2+EC^2}{4FC}$ and the ſtrength of the ring $=\frac{f\mu\times Fw}{2}$, and the ſtrength of the ſame quantity of matter in the form of a ſolid cylinder is $f\mu\times\frac{5}{8}BD$; ſo that the ſtrength of the ring is to that of the ſolid rod of equal weight as Fw to $\frac{5}{4}$ BD, or nearly as FC to BD. This will eaſily appear by recollecting that FO is $=\frac{\text{ſum of } p.r^2}{m.FC}$ (ſee Rotation), and that the momentum of coheſion is $\frac{fm\cdot FC\cdot Ca}{2FC}=\frac{fm\cdot Fo}{2}$ for the inner circle, &c.

Emerſon has given a very inaccurate approximation to this value in his *Mechanics*, 4to.

82 and more ſtiff.

This property of hollow tubes is accompanied alſo with greater ſtiffneſs; and the ſuperiority in ſtrength and ſtiffneſs is ſo much the greater as the ſurrounding ſhell is thinner in proportion to its diameter.

83 Hence the wiſdom of God in forming the bones, &c. hollow.

Here we ſee the admirable wiſdom of the Author of nature in forming the bones of animal limbs hollow. The bones of the arms and legs have to perform the office of levers, and are thus oppoſed to very great tranſverſe ſtrains. By this form they become incomparably ſtronger and ſtiffer, and give more room for the inſertion of muſcles, while they are lighter and therefore more agile; and the ſame Wiſdom has made uſe of this hollow for other valuable purpoſes of the animal economy. In like manner the quills in the wings of birds acquire by their thinneſs the very great ſtrength which is neceſſary, while they are ſo light as to give ſufficient buoyancy to the animal in the rare medium in which it muſt live and fly about. The ſtalks of many plants, ſuch as all the graſſes, and many reeds, are in like manner hollow, and thus poſſeſs an extraordinary ſtrength. Our beſt engineers now begin to imitate nature by making many parts of their machines hollow, ſuch as their axles of caſt iron, &c.; and the ingenious Mr Ramſden now makes the axes and framings of his great aſtronomical inſtruments in the ſame manner.

In the ſuppoſition of homogeneous texture, it is plain that the fracture happens as ſoon as the particles at D are ſeparated beyond their utmoſt limit of coheſion. This is a determined quantity, and the piece bends till this degree of extenſion is produced in the outermoſt fibre. It follows, that the ſmaller we ſuppoſe the diſtance between A and D, the greater will be the curvature which the beam will acquire before it breaks. Greater depth therefore makes a beam not only ſtronger but alſo ſtiffer. But if the parallel fibres can ſlide on each other, both the ſtrength and the ſtiffneſs will be diminiſhed. Therefore if, inſtead of one beam DΔKC (fig. 8.) we ſuppoſe two, DABC and AΔKB, not cohering, each of them will bend, and the extenſion of the fibres AB of the under beam will not hinder the compreſſion of the adjoining fibres AB of the upper beam. The two together therefore will not be more than twice as ſtrong as one of them (ſuppoſing DA=AΔ) inſtead of being four times as ſtrong; and they will bend as much as either of them alone would bend by half the load. This may be prevented, if it were poſſible to unite the two beams all along the ſeam AB, ſo that the one ſhall not ſlide on the other. This may be done in ſmall works, by gluing them together with a cement as ſtrong as the natural lateral coheſion of the fibres. If this cannot be done (as it cannot in large works), the ſliding is prevented by joggling the beams together; that is, by cutting down ſeveral rectangular notches in the upper ſide of the lower beam, and making ſimilar notches in

Fig. 8. 84 How a ſtrong compound beam may be formed.

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in the under ſide of the upper beam, and filling up the ſquare ſpaces with pieces of very hard wood firmly driven in, as repreſented in fig. 11. Some employ iron bolts by way of joggles. But when the joggle is much harder than the wood into which it is driven, it is very apt to work looſe, by widening the hole into which it is lodged. The ſame thing is ſometimes done by ſcarfing the one upon the other, as repreſented in fig. 12.); but this waſtes more timber, and is not ſo ſtrong, becauſe the mutual hooks which this method forms on each beam are very apt to tear each other up. By one or other of theſe methods, or ſomething ſimilar, may a compound beam be formed, of any depth, which will be almoſt as ſtiff and ſtrong as an entire piece.

Fig. 11. Fig. 12.

85 How ſtrength may be combined with pliableneſs. Fig. 13.

On the other hand, we may combine ſtrength with pliableneſs, by compoſing our beam of ſeveral thin planks laid on each other, till they make a proper depth, and leaving them at full liberty to ſlide on each other. It is in this manner that coach-ſprings are formed, as is repreſented in fig. 13. In this aſſemblage there muſt be no joggles nor bolts of any kind put through the planks or plates; for this would hinder their mutual ſliding. They muſt be kept together by ſtraps which ſurround them, or by ſomething equivalent.

86 Maxims of conſtruction.

The preceding obſervations ſhow the propriety of ſome maxims of conſtruction, which the artiſts have derived from long experience.

Thus, if a mortiſe is to be cut out of a piece which is expoſed to a croſs ſtrain, it ſhould be cut out from that ſide which becomes concave by the ſtrain, as in fig. 14. but by no means as in fig. 15.

Fig. 14. and 15.

If a piece is to be ſtrengthened by the addition of another, the added piece muſt be joined to the ſide which grows convex by the ſtrain, as in fig. 16. and 17.

Fig. 16. and 17.

Before we go any farther, it will be convenient to recal the reader's attention to the analogy between the ſtrain on a beam projecting from a wall and loaded at the extremity, and a beam ſupported at both ends and loaded in ſome intermediate point. It is ſufficient on this occaſion to read attentively what is delivered in the article ROOF, N° 19.—We learn there that the ſtrain on the middle point C (fig. 17. of the preſent article) of a rectangular beam AB, ſupported on props at A and B, is the ſame as if the part CA projected from a wall, and were loaded with the half of the weight W ſuſpended at A. The momentum of the ſtrain is therefore $\frac{1}{2}W \times \frac{1}{2}AB, = W \times \frac{1}{4}AB = p\frac{1}{4}l$, or $\frac{p\,l}{4}$. The momentum of coheſion muſt be equal to this in every hypotheſis.

Fig. 17.

Having now conſidered in ſufficient detal the circumſtances which affect the ſtrength of any ſection of a ſolid body that is ſtrained tranſverſely, it is neceſſary to take notice of ſome of the chief modifications of the ſtrain itſelf. We ſhall conſider only thoſe that occur moſt frequently in our conſtructions.

The ſtrain depends on the external force, and alſo on the lever by which it acts.

87 The ſtrain depends on the external force.

It is evidently of importance, that ſince the ſtrain is exerted in any ſection by means of the coheſion of the parts intervening between the ſection under conſideration and the point of application of the external force, the body muſt be able in all theſe intervening parts to propagate or excite the ſtrain in the remote ſection. In every part it muſt be able to reſiſt the ſtrain excited in that part. It ſhould therefore be equally ſtrong; and it is uſeleſs to have any part ſtronger, becauſe the piece will nevertheleſs break where it is not ſtronger throughout; and it is uſeleſs to make it ſtronger (relatively to its ſtrain) in any part, for it will nevertheleſs equally fail in the part that is too weak.

Suppoſe then, in the firſt place, that the ſtrain ariſes from a weight ſuſpended at one extremity, while the other end is firmly fixed in a wall. Suppoſing alſo the croſs ſections to be all rectangular, there are ſeveral ways of ſhaping the beam ſo that it ſhall be equally ſtrong throughout. Thus it may be equally deep in every part, the upper and under ſurfaces being horizontal planes. The condition will be fulfilled by making all the horizontal ſections triangles, as in fig. 18. The two ſides are vertical planes meeting in an edge at the extremity L. For the equation expreſſing the balance of ſtrain and ſtrength is $p\,l = f\,b\,d^2$. Therefore ſince d^2 is the ſame throughout, and alſo p, we muſt have $fb = l$, and b (the breadth AD of any ſection ABCD) muſt be proportional to l (or AL), which it evidently is. Fig. 18.

Or, if the beam be of uniform breadth, we muſt have d^2 everywhere proportional to l. This will be obtained by making the depths the ordinates of a common parabola, of which L is the vertex and the length is the axis. The upper or under ſide may be a ſtraight line, as in fig. 19. or the middle line may be ſtraight, and then both upper and under ſurfaces will be curved. It is almoſt indifferent what is the ſhape of the upper and under ſurfaces, provided the diſtances between them in every part be as the ordinates of a common parabola. Fig. 19.

Or, if the ſections are all ſimilar, ſuch as circles, ſquares, or any other ſimilar polygons, we muſt have d^3 or b^3 proportional to l, and the depths or breadths muſt be as the ordinates of a cubical parabola. 88

And on the form of the levers by which it acts.

It is evident that theſe are alſo the proper forms for a lever moveable round a fulcrum, and acted on by a force at the extremity. The force comes in the place of the weight ſuſpended in the caſes already conſidered; and as ſuch levers always are connected with another arm, we readily ſee that both arms ſhould be faſhioned in the ſame manner. Thus in fig. 18. the piece of timber may be ſuppoſed a kind of ſteelyard, moveable round a horizontal axis OP, in the front of the wall, and having the two weights P and π in equilibrio. The ſtrain occaſioned by each at the ſection in which the axis OP is placed muſt be the ſame, and each arm OL and Oλ muſt be equally ſtrong in all its parts. The longitudinal ſections of each arm muſt be a triangle, a common parabola, or a cubic parabola, according to the conditions previouſly given.

And, moreover, all theſe forms are equally ſtrong: For any one of them is equally ſtrong in all its parts, and they are all ſuppoſed to have the ſame ſection at the front of the wall or at the fulcrum. They are not, however, equally ſtiff. The firſt, repreſented in fig. 18. will bend leaſt upon the whole, and the one formed by the cubic parabola will bend moſt. But their curvature at the very fulcrum will be the ſame in all.

It is alſo plain, that if the lever is of the ſecond or third kind, that is, having the fulcrum at one extremity, it muſt ſtill be of the ſame ſhape; for in abſtract mechanics it is indifferent which of the three points is conſidered as the axis of motion. In every lever the two

two forces at the extremities act in one direction, and the force in the middle acts in the opposite direction, and the great strain is always at that point. Therefore a lever such as fig. 18. moveable round an axis passing horizontally through λ, and acting against an obstacle at OP, is equally able in all its parts to resist the strains excited in those parts.

The same principles and the same construction will apply to beams, such as joists, supported at the ends L and λ (fig. 18.), and loaded at some intermediate part OP. This will appear evident by merely inverting the directions of the forces at these three points, or by recurring to the article ROOFS, N° 19.

89 The external straining force may be distributed over the beam.

Hitherto we have supposed the external straining force as acting only in one point of the beam. But it may be uniformly distributed all over the beam. To make a beam in such circumstances equally strong in all its parts, the shape must be considerably different from the former.

90 To make a beam strong which projects from a wall.

Thus suppose the beam to project from a wall.

If it be of equal breadth throughout, its sides being vertical planes parallel to each other and to the length, the vertical section in the direction of its length must be a triangle instead of a common parabola; for the weight uniformly distributed over the part lying beyond any section, is as the length beyond that section: and since it may all be conceived as collected at its centre of gravity, which is the middle of that length, the lever by which this load acts or strains the section is also proportional to the same length. The strain on the section (or momentum of the load) is as the square of that length. The section must have strength in the same proportion. Its strength being as the breadth and the square of the depth, and the breadth being constant, the square of the depth of any section must be as the square of its distance from the end, and the depth must be as that distance; and therefore the longitudinal vertical section must be a triangle.

But if all the transverse sections are circles, squares, or any other similar figures, the strength of every section, or the cube of the diameter, must be as the square of the lengths beyond that section, or the square of its distance from the end; and the sides of the beam must be a semicubical parabola.

If the upper and under surfaces are horizontal planes, it is evident that the breadth must be as the square of the distance from the end, and the horizontal sections may be formed by arches of the common parabola, having the length for their tangent at the vertex.

By recurring to the analogy so often quoted between a projecting beam and a joist, we may determine the proper form of joists which are uniformly loaded through their whole length.

91 The strain upon a beam supported at both ends. Fig. 20.

This is a frequent and important case, being the office of joists, rafters, &c.; and there are some circumstances which must be particularly noticed, because they are not so obvious, and have been misunderstood. When a beam AB (fig. 20.) is supported at the ends, and a weight is laid on any point P, a strain is excited in every part of the beam. The load on P causes the beam to press on A and B, and the props react with forces equal and opposite to these pressures. The load at P is to the pressures at A and B as AB to PB and PA, and the pressure at A is to that at B as PB to PA; the beam therefore is in the same state, with respect to strain in every part of it, as if it were resting on a prop at P, and were loaded at the ends with weights equal to the two pressures on the props: and observe, these pressures are such as will balance each other, being inversely as their distances from P. Let P represent the weight or load at P. The pressure on the prop P must be $P \times \frac{PA}{AB}$. This is therefore the reaction of the prop B, and is the weight which we may suppose suspended at B, when we conceive the beam resting on a prop at P, and carrying the balancing weights at A and B.

The strain occasioned at any other point C, by the load P at P, is the same with the strain at C, by the weight $P \times \frac{PA}{AB}$ hanging at B, when the beam rests on P, in the manner now supposed; and it is the same if the beam, instead of being balanced on a prop at P, had its part AP fixed in a wall. This is evident. Now we have shown at length that the strain at C, by the weight $P \times \frac{PA}{AB}$ hanging at B, is $P \times \frac{PA}{AB} \times BC$. We desire it to be particularly remarked that the pressure at A has no influence on the strain at C, arising from the action of any load between A and C; for it is indifferent how the part AP of the projecting beam PB is supported. The weight at A just performs the same office with the wall in which we suppose the beam to be fixed. We are thus particular, because we have seen even persons not unaccustomed to discussions of this kind puzzled in their conceptions of this strain.

Now let the load P be laid on some point p between C and B. The same reasoning shows us that the point is (with respect to strain) in the same state as if the beam were fixed in a wall, embracing the part pB, and a weight $= P \times \frac{pB}{AB}$ were hung on at A, and the strain at C is $P \times \frac{pB}{AB} \times AC$.

In general, therefore, the strain on any point C, arising from a load P laid on another point P, is proportional to the rectangle of the distances of P and C from the ends nearest to each. It is $P \times \frac{PA \times CB}{AB}$, or $P \times \frac{pB \times CA}{AB}$, according as the load lies between C and A or between C and B. 92 A general proposition.

Cor. 1. The strains which a load on any point P occasions on the points C, c, lying on the same side of P, are as the distances of these points from the end B. In like manner the strains on E and e are as EA and eA.

Cor. 2. The strain which a load occasions in the part on which it rests is as the rectangle of the parts on each side. Thus the strain occasioned at C by a load is to that at D by the same load as $AC \times CB$ to $AD \times DB$. It is therefore greatest in the middle.

Let us now consider the strain on any point C arising from a load uniformly distributed along the beam. Let AP be represented by x, and Pp by $\dot{x}$, and the whole weight on the beam by a. Then 93 The strain arising from a load distributed along the beam.

The weight on Pp is $= a\frac{\dot{x}}{AB}$,

Pressure

Strength of Materials.

$$\text{Pressure on B by the weight on P}p = a\frac{\dot{x}}{AB} \times \overline{AB}$$

$$\text{Or} \quad - \quad - \quad - \quad = a\frac{x\dot{x}}{AB^2}.$$

$$\text{Pres. on B by whole wt. on AC} = a\frac{\frac{1}{2}AC^2}{AB^2} = a\frac{AC^2}{2AB^2}.$$

$$\text{Strain at C by the weight on AC} = a\frac{AC^2 \times BC}{2\,AB^2}.$$

$$\text{Strain at C by the weight on BC} = a\frac{BC^2 \times AC}{2\,AB^2}.$$

$$\text{Do. by whole weight on AB} = a\frac{AC^2 \times BC + BC^2 \times AC}{2\,AB^2},$$

$$= a\frac{AC \times BC \times \overline{AC + CB}}{2\,AB^2}, = a\frac{AC \times BC}{2\,AB}.$$

Thus we fee that the ftrain is proportional to the rectangle of the parts, in the fame manner as if the load a had been laid directly on the point C, and is indeed equal to one-half of the ftrain which would be produced at C by the load a laid on there.

94 Miftakes in this fubject committed by authors of reputation.

It was neceffary to be thus particular, becaufe we fee in fome elementary treatifes of mechanics, publifhed by authors of reputation, miftakes which are very plaufible, and miflead the learner. It is there faid, that the preffure at B from a weight uniformly diffufed along AB is the fame as if it were collected at its centre of gravity, which would be the middle of AB; and then the ftrain at C is faid to be this preffure at B multiplied by BC. But furely it is not difficult to fee the difference of thefe ftrains. It is plain that the preffure of gravity downwards on any point between the end A and the point C has no tendency to diminifh the ftrain at C, arifing from the upward reaction of the prop B; whereas the preffure of gravity between C and B is almoft in direct oppofition to it, and muft diminifh it. We may however avoid the fluxionary calculus with fafety by the confideration of the centre of gravity, by fuppofing the weights of AC and BC to be collected at their refpective centres of gravity; and the refult of this computation will be the fame as above: and we may ufe either method, although the weight is not uniformly diftributed, provided only that we know in what manner it is diftributed.

This inveftigation is evidently of importance in the practice of the engineer and architect, informing them what fupport is neceffary in the different parts of their conftructions. We confidered fome cafes of this kind in the article ROOFS.

95 To form a joift which may have the fame relative ftrength in all its parts.

It is now eafy to form a joift, fo that it fhall have the fame relative ftrength in all its parts.

I. To make it equally able in all its parts to carry a given weight laid on any point C taken at random, or uniformly diffufed over the whole length, the ftrength of the fection at the point C muft be as AC × CB. Therefore

1. If the fides are parallel vertical planes, the fquare of the depth (which is the only variable dimenfion) or CD^2, muft be as $AC \times CB$, and the depths muft be ordinates of an ellipfe.

2. If the tranfverfe fections are fimilar, we muft make CD^3 as $AC \times CB$.

3. If the upper and under furfaces are parallel, the breadth muft be as $AC \times CB$.

II. If the beam is neceffarily loaded at fome given point C, and we would have the beam equally able in all its parts to refift the ftrain arifing from the weight at C, we muft make the ftrength of every tranfverfe fection between C and either end as its diftance from that end. Therefore

1. If the fides are parallel vertical planes, we muft make $CD^2 : EF^2 = AC : AE$.

2. If the fections are fimilar, then $CD^3 : EF^3 = AC : AE$.

3. If the upper and under furfaces are parallel, then, breadth at C : breadth at E = AC : AE.

96 The ftrain and ftrength of fquare or circular plates of different extent, but of equal thicknefs, may be determined from the fame principles.

The fame principles enable us to determine the ftrain and ftrength of fquare or circular plates, of different extent, but equal thicknefs. This may be comprehended in this general propofition.

Similar plates of equal thicknefs fupported all round will carry the fame abfolute weight, uniformly diftributed, or refting on fimilar points, whatever is their extent.

Suppofe two fimilar oblong plates of equal thicknefs, and let their lengths and breadths be L, l, and B, b. Let their ftrength or momentum of cohefion be C, c, and the ftrains from the weights W, w, be S, s.

Suppofe the plates fupported at the ends only, and refifting fracture tranfverfely. The ftrains, being as the weights and lengths, are as WL and wl, but their cohefions are as the breadths; and fince they are of equal relative ftrength, we have $WL : wl = B : b$, and $WLb = wlB$ and $L : l = wB : Wb$: but fince they are of fimilar fhapes $L : l = B : b$, and therefore $w = W$.

The fame reafoning holds again when they are alfo fupported along the fides, and therefore holds when they are fupported all round (in which cafe the ftrength is doubled).

And if the plates are of any other figure, fuch as circles or ellipfes, we need only conceive fimilar rectangles infcribed in them. Thefe are fupported all around by the continuity of the plates, and therefore will fuftain equal weights; and the fame may be faid of the fegments which lie without them, becaufe the ftrengths of any fimilar fegments are equal, their lengths being as their breadths.

Therefore the thicknefs of the bottoms of veffels holding heavy liquors or grains fhould be as their diameters, and as the fquare root of their depths jointly.

Alfo the weight which a fquare plate will bear is to that which a bar of the fame matter and thicknefs will bear as twice the length of the bar to its breadth.

97 The ftrain of a beam arifing from its own weight.

There is yet another modification of the ftrain which tends to break a body tranfverfely, which is of very frequent occurrence, and in fome cafes muft be very carefully attended to, viz. the ftrain arifing from its own weight.

When a beam projects from a wall, every fection is ftrained by the weight of all that projects beyond it. This may be confidered as all collected at its centre of gravity. Therefore the ftrain on any fection is in the joint ratio of the weight of what projects beyond it, and the diftance of its centre of gravity from the fection.

The determination of this ftrain and of the ftrength neceffary for withftanding it muft be more complicated than the former, becaufe the form of the piece which refults from this adjuftment of ftrain and ftrength influences

ences the ſtrain. The general principle muſt evidently be, that the ſtrength or momentum of coheſion of every ſection muſt be as the product of the weight beyond it multiplied by the diſtance of its centre of gravity. For example:

98
General principle reſpecting it.
Fig. 21.

Suppoſe the beam DLA (fig. 21.) to project from the wall, and that its ſides are parallel vertical planes, ſo that the depth is the only variable dimenſion. Let $LB = x$ and $Bb = y$. The element $BbcC$ is $= y\dot{x}$. Let G be the centre of gravity of the part lying without Bb, and g be its diſtance from the extremity L. Then $x - g$ is the arm of the lever by which the ſtrain is excited in the ſection Bb. Let Bb or y be as ſome power m of LB; that is, let $y = x^m$. Then the contents of LBb is $\frac{x^{m+1}}{m+1}$. The momentum of gravity round a horizontal axis at L is $yx\dot{x} = x^{m+1}\dot{x}$, and the whole momentum round the axis is $\frac{x^{m+2}}{m+2}$. The diſtance of the centre of gravity from L is had by dividing this momentum by the whole weight which is $\frac{x^{m+1}}{m+1}$. The quotient or g is $\frac{x \times \overline{m+1}}{m+2}$. And the diſtance of the centre of gravity from the ſection Bb is $x - \frac{x \times \overline{m+1}}{m+2}, = \frac{x \times \overline{m+2} - x \times \overline{m+1}}{m+2}, = \frac{x}{m+2}$. Therefore the ſtrain on the ſection Bb is had by multiplying $\frac{x^{m+1}}{m+1}$ by $\frac{x}{m+2}$. The product is $\frac{x^{m+2}}{\overline{m+2} \times \overline{m+1}}$. This muſt be as the ſquare of the depth, or as y^2. But y is as x^m, and y^2 as x^{2m}. Therefore we have $m+2 = 2m$, and $m = 2$; that is, the depth muſt be as the ſquare of the diſtance from the extremity, and the curve LbA is a parabola touching the horizontal line in L.

99
A conoid equally able in every ſection to bear its own weight.

It is eaſy to ſee that a conoid formed by the rotation of this figure round DL will alſo be equally able in every ſection to bear its own weight.

We need not proſecute this farther. When the figure of the piece is given, there is no difficulty in finding the ſtrain; and the circumſtance of equal ſtrength to reſiſt this ſtrain is chiefly a matter of curioſity.

100
The more a beam projects, the leſs able it is to bear its own weight.

It is evident, from what has been already ſaid, that a projecting beam becomes leſs able to bear its own weight, as it projects farther. Whatever may be the ſtrength of the ſection DA, the length may be ſuch that it will break by its own weight. If we ſuppoſe two beams A and B of the ſame ſubſtance and ſimilar ſhapes, that is, having their lengths and diameters in the ſame proportion; and farther ſuppoſe that the ſhorter can juſt bear its own weight; then the longer beam will not be able to do the ſame: For the ſtrengths of the ſections are as the cubes of the diameters, while the ſtrains are as the biquadrates of the diameters; becauſe the weights are as the cubes, and the levers by which theſe weights act in producing the ſtrain are as the lengths or as the diameters.

101
Small bodies more able to withſtan the ſtrain produced by the weight of the machine than great bodies.

Theſe conſiderations ſhow us, that in all caſes where ſtrain is affected by the weight of the parts of the machine or ſtructure of any kind, the ſmaller bodies are more able to withſtand it than the greater; and there ſeems to be bounds ſet by nature to the ſize of machines conſtructed of any given materials. Even when the weight of the parts of the machine is not taken into the account, we cannot enlarge them in the ſame proportion in all their parts. Thus a ſteam-engine cannot be doubled in all its parts, ſo as to be ſtill efficient. The preſſure on the piſton is quadrupled. If the lift of the pump be alſo doubled in height while it is doubled in diameter, the load will be increaſed eight times, and will therefore exceed the power. The depth of lift, therefore, muſt remain unchanged; and in this caſe the machine will be of the ſame relative ſtrength as before, independent of its own weight. For the beam being doubled in all its dimenſions, its momentum of coheſion is eight times greater, which is again a balance for a quadruple load acting by a double lever.—But if we now conſider the increaſe of the weight of the machine itſelf, which muſt be ſupported, and which muſt be put in motion by the intervention of its coheſion, we ſee that the large machine is weaker and leſs efficient than the ſmall one.

There is a ſimilar limit ſet by nature to the ſize of plants and animals formed of the ſame matter. The coheſion of an herb could not ſupport it if it were increaſed to the ſize of a tree, nor could an oak ſupport itſelf if 40 or 50 times bigger, nor could an animal of the make of a long-legged ſpider be increaſed to the ſize of a man; the articulations of its legs could not ſupport it.

102
Even ſmall animals are remarkable for ſtrength and agility.

Hence may be underſtood the prodigious ſuperiority of the ſmall animals both in ſtrength and agility. A man by falling twice his own height may break his firmeſt bones. A mouſe may fall 20 times its height without riſk; and even the tender mite or wood-louſe may fall unhurt from the top of a ſteeple. But their greateſt ſuperiority is in reſpect of nimbleneſs and agility. A flea can leap above 500 times its own length, while the ſtrength of the human muſcles could not raiſe the trunk from the ground on limbs of the ſame conſtruction.

The angular motions of ſmall animals (in which conſiſts their nimbleneſs or agility) muſt be greater than thoſe of large animals, ſuppoſing the force of the muſcular fibre to be the ſame in both. For ſuppoſing them ſimilar, the number of equal fibres will be as the ſquare of their linear dimenſions; and the levers by which they act are as their linear dimenſions. The energy therefore of the moving force is as the cube of theſe dimenſions. But the momentum of inertia, or $\int p.r^2$, is as the 4th power: Therefore the angular velocity of the greater animals is ſmaller. The number of ſtrokes which a fly makes with its wings in a ſecond is aſtoniſhingly great; yet, being voluntary, they are the effects of its agility.

We have hitherto confined our attention to the ſimpleſt form in which this tranſverſe ſtrain can be produced. This was quite ſufficient for ſhowing us the mechaniſm of nature by which the ſtrain is reſiſted; and a very ſlight attention is ſufficient for enabling us to reduce to this every other way in which the ſtrain can be produced. We ſhall not take up the reader's time with the application of the ſame principles to other caſes of this ſtrain, but refer him to what has been ſaid in the article ROOFS. In that article we have ſhown the analogy between the ſtrain on the ſection of a beam projecting from a wall and loaded at the extremity, and the ſtrain

ſtrain on the ſame ſection of a beam ſimply reſting on ſupports at the ends, and loaded at ſome intermediate point or points. The ſtrain on the middle C of a beam AB (fig. 22.) ſo ſupported, ariſing from a weight laid on there, is the ſame with the ſtrain which half that weight hanging at B would produce on the ſame ſection C if the other end of the beam were fixed in a wall. If therefore 1000 pounds hung on the end of a beam projecting 10 feet from a wall will juſt break it at the wall, it will require 4000 pounds on its middle to break the ſame beam reſting on two props 10 feet aſunder. We have alſo ſhown in that article the additional ſtrength which will be given to this beam by extending both ends beyond the props, and there framing it firmly into other pillars or ſupports.

Fig. 22.

103 Effects of the obliquity of the external force.

We can hardly add any thing to what has been ſaid in that article, except a few obſervations on the effects of the obliquity of the external force. We have hitherto ſuppoſed it to act in the direction BP (fig. 8.) perpendicular to the length of the beam. Suppoſe it to act in the direction BP′, oblique to BA. In the article Roof we ſuppoſed the ſtrain to be the ſame as if the force p acted at the diſtance AB′, but ſtill perpendicular to AB: ſo it is. But the ſtrength of the ſection A Δ is not the ſame in both caſes; for by the obliquity of the action the piece DCKΔ is preſſed to the other. We are not ſufficiently acquainted with the corpuſcular forces to ſay preciſely what will be the effect of the preſſure ariſing from this obliquity; but we can clearly ſee, in general, that the point A, which in the inſtant of fracture is neither ſtretched nor compreſſed, muſt now be farther up, or nearer to D; and therefore the number of particles which are exerting coheſive forces is ſmaller, and therefore the ſtrength is diminiſhed. Therefore, when we endeavour to proportion the ſtrength of a beam to the ſtrain ariſing from an external force acting obliquely, we make too liberal allowance by increaſing this external force in the ratio of AB to AB. We acknowledge our inability to aſſign the proper correction. But this circumſtance is of very great influence. In many machines, and many framings of carpentry, this oblique action of the ſtraining force is unavoidable; and the moſt enormous ſtrains to which materials are expoſed are generally of this kind. In the frames ſet up for carrying the ringſtones of arches, it is hardly poſſible to avoid them: for although the judicious engineer diſpoſes his beams ſo as to ſuſtain only preſſures in the direction of their lengths, tending either to cruſh them or to tear them aſunder, it frequently happens that, by the ſettling of the work, the pieces come to check and bear on each other tranſverſely, tending to break each other acroſs. This we have remarked upon in the article Roofs, with reſpect to a truſs by Mr Price (ſee Roofs, N° 40, 41, 45). Now when a croſs ſtrain is thus combined with an enormous preſſure in the direction of the length of the beam, it is in the utmoſt danger of ſnapping ſuddenly acroſs. This is one great cauſe of the carrying away of maſts. They are compreſſed in the direction of their length by the united force of the ſhrouds, and in this ſtate the tranſverſe action of the wind ſoon completes the fracture.

104 The ſtrain on columns.

When conſidering the compreſſing ſtrains to which materials are expoſed, we deferred the diſcuſſion of the ſtrain on columns, obſerving that it was not, in the caſes which uſually occur, a ſimple compreſſion, but was combined with a tranſverſe ſtrain, ariſing from the bending of the column. When the column ACB (fig. 23.) reſting on the ground at B, and loaded at top with a weight A, acting in the vertical direction AB, is bent into a curve ACB, ſo that the tangent at C is perpendicular to the horizon, its condition ſomewhat reſembles that of a beam firmly fixed between B and C, and ſtrongly pulled by the end A, ſo as to bend it between C and A. Although we cannot conceive how a force acting on a ſtraight column AB in the direction AB can bend it, we may ſuppoſe that the force acted firſt in the horizontal direction Ab till it was bent to this degree, and that the rope was then gradually removed from the direction Ab to the direction AB, increaſing the force as much as is neceſſary for preſerving the ſame quantity of flexure.

Fig. 23.

105 Obſervations on Euler's theory of the ſtrength of columns.

The firſt author (we believe) who conſidered this important ſubject with ſcrupulous attention was the celebrated Euler, who publiſhed in the Berlin Memoirs for 1757 his Theory of the Strength of Columns. The general propoſition eſtabliſhed by this theory is, that the ſtrength of priſmatical columns is in the direct quadruplicate ratio of their diameters, and the inverſe duplicate ratio of their lengths. He proſecuted this ſubject in the Peterſburgh Commentaries for 1778, confirming his former theory. We do not find that any other author has beſtowed much attention on it, all ſeeming to acquieſce in the determinations of Euler, and to conſider the ſubject as of very great difficulty, requiring the application of the moſt refined mathematics. Muſchenbroek has compared the theory with experiment; but the compariſon has been very unſatisfactory, the difference from the theory being ſo enormous as to afford no argument for its juſtneſs. But the experiments do not contradict it, for they are ſo anomalous as to afford no concluſion or general rule whatever.

To ſay the truth, the theory can be conſidered in no other light than as a ſpecimen of ingenious and very artful algebraic analyſis. Euler was unqueſtionably the firſt analyſt in Europe for reſource and addreſs. He knew this, and enjoyed his ſuperiority, and without ſcruple admitted any phyſical aſſumptions which gave him an opportunity of diſplaying his ſkill. The inconſiſtency of his aſſumptions with the known laws of mechaniſm gave him no concern; and when his algebraic proceſſes led him to any concluſion which would make his readers ſtare, being contrary to all our uſual notions, he frankly owned the paradox, but went on in his analyſis, ſaying, "*Sed analyſi magis fidendum.*" Mr Robins has given ſome very riſible inſtances of this confidence in his analyſis, or rather of his confidence in the indolent ſubmiſſion of his readers. Nay, ſo fond was he of this kind of amuſement, that after having publiſhed an untenable Theory of Light and Colours, he publiſhed ſeveral Memoirs, explaining the aberration of the heavenly bodies, and deducing ſome very wonderful conſequences, fully confirmed by experience, from the Newtonian principles, which were oppoſite and totally inconſiſtent with his own theory, merely becauſe the Newtonian theory gave him "*occaſionem analyſeos promovendæ.*" We are thus ſevere in our obſervations, becauſe his theory of the ſtrength of columns is one of the ſtrongeſt inſtances of this wanton kind of proceeding, and becauſe his followers in the Academy of St Peterſburgh, ſuch as Mr Fuſs, Lexill, and others, adopt his concluſions, and merely echo his words. Since the death of Daniel Bernoulli

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Bernoulli no member of that academy has controverted any thing advanced by their *Professor sublimis geometriæ*, to whom they had been indebted for their places and for all their knowledge, having been (most of them) his amanuenses, employed by this wonderful man during his blindness to make his computations and carry on his algebraic investigations. We are not a little surprised to see Mr Emerson, a considerable mathematician, and a man of very independent spirit, hastily adopting the same theory, of which we doubt not but our readers will easily see the falsity.

Fig. 23. Euler considers the column ACB as in a condition precisely similar to that of an elastic rod bent into the curve by a cord AB connecting its extremities.—In this he is not mistaken.—But he then draws CD perpendicular to AB, and considers the strain on the section C as equal to the momentum or mechanical energy of the weight A acting in the direction DB upon the lever $x c$ D, moveable round the fulcrum c, and tending to tear asunder the particles which cohere along the section c C x. This is the same principle (as Euler admits) employed by James Bernoulli in his investigation of the elastic curve ACB. Euler considers the strain on the section $c x$ as the same with what it would sustain if the same power acted in the horizontal direction EF on a point E as far removed from C as the point D is. We reasoned in the same manner (as has been observed) in the article Roofs, where the obliquity of action was inconsiderable. But in the present case, this substitution leads to the greatest mistakes, and has rendered the whole of this theory false and useless. It would be just if the column were of materials which are incompressible. But it is evident, by what has been said above, that by the compression of the parts the real fulcrum of the lever shifts away from the point c, so much the more as the compression is greater. In the great compressions of loaded columns, and the almost unmeasurable compressions of the truss beams in the centres of bridges, and other cases of chief importance, the fulcrum is shifted far over towards x, so that very few fibres resist the fracture by their cohesion; and these few have a very feeble energy or momentum, on account of the short arm of the lever by which they act. This is a most important consideration in carpentry, yet makes no element of Euler's theory. The consequence of this is, that a very small degree of curvature is sufficient to cause the column or strutt to snap in an instant, as is well known to every experienced carpenter. The experiment by Muschenbroek, which Euler makes use of in order to obtain a measure of strength in a particular instance, from which he might deduce all others by his theorem, is an incontestable proof of this. The force which broke the column is not the twentieth part of what is necessary for breaking it by acting at E in the direction EF. Euler takes no notice of this immense discrepancy, because it must have caused him to abandon the speculation with which he was then amusing himself.

106 This theory false and useless.

The limits of this work do not afford room to enter minutely upon the refutation of this theory; but we can easily show its uselessness, by its total inconsistency with common observation. It results legitimately from this theory, that if CD have no magnitude, the weight A can have no momentum, and the column cannot be broken —True,—it cannot be broken in this way, snapped by a transverse fracture, if it do not bend; but we know very well that it can be crushed or crippled, and we see this frequently happen. This circumstance or event does not enter into Euler's investigation, and therefore the theory is imperfect at least and useless. Had this crippling been introduced in the form of a physical assumption, every topic of reasoning employed in the process must have been laid aside, as the intelligent reader will easily see. But the theory is not only imperfect, but false. The ordinary reader will be convinced of this by another legitimate consequence of it. Fig 24. is the same with fig. 106. of *Emerson's Mechanics*, where this subject is treated on Euler's principles, and represents a crooked piece of matter resting on the ground at F, and loaded at A with a weight acting in the vertical direction AF. It results from Euler's theory that the strains at b, B, D, E, &c. are as bc, BC, DI, EK, &c. Therefore the strains at G and H are nothing; and this is asserted by Emerson and Euler as a serious truth; and the piece may be thinned *ad infinitum* in these two places, or, even cut through, without any diminution of its strength. The absurdity of this assertion strikes at first hearing. Euler asserts the same thing with respect to a point of contrary flexure. Farther discussion is (we apprehend) needless. Fig. 24.

107 Yet Euler's dissertations deserve a perusal.

This theory must therefore be given up. Yet these dissertations of Euler in the Petersburgh Commentaries deserve a perusal, both as very ingenious specimens of analysis, and because they contain maxims of practice which are important. Although they give an erroneous measure of the comparative strength of columns, they show the immense importance of preventing all bendings, and point out with accuracy where the tendencies to bend are greatest, and how this may be prevented by very small forces, and what a prodigious accession of force this gives the column. There is a valuable paper in the same volume by Fuss *on the Strains on framed Carpentry*, which may also be read with advantage.

108 A new theory cannot be substituted in place of Euler's, till many experiments be made.

It will now be asked, what shall be substituted in place of this erroneous theory? what is the true proportion of the strength of columns? We acknowledge our inability to give a satisfactory answer. Such can be obtained only by a previous knowledge of the proportion between the extensions and compressions produced by equal forces, by the knowledge of the absolute compressions producible by a given force, and by a knowledge of the degree of that derangement of parts which is termed crippling. These circumstances are but imperfectly known to us, and there lies before us a wide field of experimental inquiry. Fortunately the force requisite for crippling a beam is prodigious, and a very small lateral support is sufficient to prevent that bending which puts the beam in imminent danger. A judicious engineer will always employ transverse bridles, as they are called, to stay the middle of long beams, which are employed as pillars, strutts, or truss beams, and are exposed, by their position, to enormous pressures in the direction of their lengths. Such stays may be observed, disposed with great judgement and economy, in the centres employed by Mr Perronet in the erection of his great stone arches. He was obliged to correct this omission made by his ingenious predecessor in the beautiful centres of the bridge of Orleans, which we have no hesitation in affirming to be the finest piece of carpentry in the world.

It

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It only remains on this head to compare these theoretical deductions with experiment.

Experiments on the transverse strength of bodies are easily made, and accordingly are very numerous, especially those made on timber, which is the case most common and most interesting. But in this great number of experiments there are very few from which we can draw much practical information. The experiments have in general been made on such small scantlings, that the unavoidable natural inequalities bear too great a proportion to the strength of the whole piece. Accordingly, when we compare the experiments of different authors, we find them differ enormously, and even the experiments by the same author are very anomalous. The completest series that we have yet seen is that detailed by Belidor in his *Science des Ingenieurs*. They are contained in the following table. The pieces were found, even-grained oak. The column b contains the breadths of the pieces in inches; the column d contains their depths; the column l contains their lengths; column p contains the weights (in pounds) which broke them when hung on their middles; and m is the column of averages or mediums.

109 Table of experiments made by Belidor.

N°	b	d	l	p	m	
1	1	1	18	400 415 405	406	The ends lying loose.
2	1	1	18	600 600 624	608	The ends firmly fixed.
3	2	1	18	810 795 812	805	Loose.
4	1	2	18	1570 1580 1590	1580	Loose.
5	1	1	36	185 195 180	187	Loose.
6	1	1	36	285 280 285	283	Fixed.
7	2	2	36	1550 1620 1585	1585	Loose.
8	$2\frac{1}{3}$	$2\frac{1}{3}$	36	1665 1675 1640	1660	Loose.

110 Corollaries deduced from them.

By comparing Experiments 1st and 3d, the strength appears proportional to the breadth.

Experiments 3d and 4th shew the strength proportional to the square of the depth.

Experiments 1st and 5th shew the strength nearly in the inverse proportion of the lengths, but with a sensible deficiency in the longer pieces.

Experiments 5th and 7th shew the strengths proportional to the breadths and the square of the depth.

Experiments 1st and 7th shew the same thing, compounded with the inverse proportion of the length: the deficiency relative to the length is not so remarkable here.

Experiments 1st and 2d, and experiments 5th and 6th shew the increase of strength, by fastening the ends, to be in the proportion of 2 to 3. The theory gives the proportion of 2 to 4. But a difference in the manner of fixing may produce this deviation from the theory, which only supposed them to be held down at places beyond the props, as when a joist is held in the walls, and also rests on two pillars between the walls. (See what is said on this subject in the article ROOF, § 19.); where note, that there is a mistake, when it is said that a beam supported at both ends and loaded in the middle, will carry twice as much as if one end were fixed in the wall and the weight suspended at the other end. The reasoning employed there shows that it will carry four times as much.

The chief source of irregularity in such experiments is the fibrous, or rather plated texture of timber. It consists of annual additions, whose cohesion with each other is vastly weaker than that of their own fibres. Let fig. 25. represent the section of a tree, and ABCD, *a b c d* the section of two battens that are to be cut out of it for experiment, and let AD and *a d* be the depths, and DC, *dc* the breadths. The batten ABCD will be the strongest, for the same reason that an assemblage of planks set edgewise will form a stronger joist than planks laid above each other like the plates of a coach-spring. M. Buffon found by many trials that the strength of ABCD was to that of *a b c d* (in oak) nearly as 8 to 7. The authors of the different experiments were not careful that their battens had their plates all disposed similarly with respect to the strain. But even with this precaution they would not have afforded sure grounds of computation for large works; for great beams occupy much, if not the whole, of the section of the tree; and from this it has happened that their strength is less than in proportion to that of a small lath or batten. In short, we can trust no experiments but such as have been made on large beams. These must be very rare, for they are most expensive and laborious, and exceed the abilities of most of those who are disposed to study this matter.

Fig. 25.

But we are not wholly without such authority. M. Buffon and M. Du Hamel, two of the first philosophers and mechanicians of the age, were directed by government to make experiments on this subject, and were supplied with ample funds and apparatus. The relation of their experiments is to be found in the Memoirs of the French Academy for 1740, 1741, 1742, 1768; as also in Du Hamel's valuable performances *sur l'Exploitation des Arbres, et sur la Conservation et le Transport de Bois*. We earnestly recommend these dissertations to the perusal of our readers, as containing much useful information relative to the strength of timber, and the best methods of employing it. We shall here give an abstract of M. Buffon's experiments.

111 Mr Buffon's experiments on bars of found oak.

He relates a great number which he had profecuted during two years on fmall battens. He found that the odds of a fingle layer, or part of a layer, more or lefs, or even a different difpofition of them, had fuch influence that he was obliged to abandon this method, and to have recourfe to the largeft beams that he was able to break. The following table exhibits one feries of experiments on bars of found oak, clear of knots, and four inches fquare. This is a fpecimen of all the reft.

Column 1ft is the length of the bar in clear feet between the fupports.

Column 2d is the weight of the bar (the 2d day after it was felled) in pounds. Two bars were tried of each length. Each of the firft three pairs confifted of two cuts of the fame tree. The one next the root was always found the heavieft, ftiffeft, and ftrongeft. Indeed M. Buffon fays that this was invariably true, that the heavieft was always the ftrongeft; and he recommends it as certain (or fure) rule for the choice of timber. He finds that this is always the cafe when the timber has grown vigoroufly, forming very thick annual layers. But he alfo obferves that this is only during the advances of the tree to maturity; for the ftrength of the different circles approaches gradually to equality during the tree's healthy growth, and then it decays in thefe parts in a contrary order. Our tool-makers affert the fame thing with refpect to beech: yet a contrary opinion is very prevalent; and wood with a fine, that is, a fmall grain, is frequently preferred. Perhaps no perfon has ever made the trial with fuch minutenefs as M. Buffon, and we think that much deference is due to his opinion.

Column 3d is the number of pounds neceffary for breaking the tree in the courfe of a few minutes.

Column 4th is the inches which it bent down before breaking.

Column 5th is the time at which it broke.

1	2	3	4	5
7	60 56	5350 5275	3.5 4.5	29 22
8	68 63	4600 4500	3.75 4.7	15 13
9	77 71	4100 3950	4.85 5.5	14 12
10	84 82	3625 3600	5.83 6.5	15 15
12	100 98	3050 2925	7. 8.	

The experiments on other fizes were made in the fame way. A pair at leaft of each length and fize was taken. The mean refults are contained in the following table. The beams were all fquare, and their fizes in inches are placed at the head of the columns, and their lengths in feet are in the firft column.

	4	5	6	7	8	A
7	5312	11525	18950	32200	47649	11525
8	4550	9787	15525	26050	39750	10085
9	4025	8308	13150	22350	32800	8964
10	3612	7125	11250	19475	27750	8068
12	2987	6075	9100	16175	23450	6723
14		5300	7475	13225	19775	5763
16		4350	6362	11000	16375	5042
18		3700	5562	9245	13200	4482
20		3225	4950	8375	11487	4034
22		2975				3667
24		2162				3362
28		1775				2881

M. Buffon had found by numerous trials that oak-timber loft much of its ftrength in the courfe of drying or feafoning; and therefore, in order to fecure uniformity, his trees were all felled in the fame feafon of the year, were fquared the day after, and tried the third day. Trying them in this green ftate, gave him an opportunity of obferving a very curious and unaccountable phenomenon. When the weights were laid brifkly on, nearly fufficient to break the log, a very fenfible fmoke was obferved to iffue from the two ends with a fharp hiffing noife. This continued all the while the tree was bending and cracking. This fhows that the log is affected or ftrained through its whole length; indeed this muft be inferred from its bending through its whole length. It alfo fhows us the great effects of the compreffion. It is a pity M. Buffon did not take notice whether this fmoke iffued from the upper or compreffed half of the fection only, or whether it came from the whole.

112 Obfervations on Mr Buffon's experiments.

We muft now make fome obfervations on thefe experiments, in order to compare them with the theory which we have endeavoured to eftablifh.

M. Buffon confiders the experiments with the 5-inch bars as the ftandard of comparifon, having both extended thefe to greater lengths, and having tried more pieces of each length.

Our theory determines the relative ftrength of bars of the fame fection to be inverfely as their lengths. But (if we except the five experiments in the firft column) we find a very great deviation from this rule. Thus the 5-inch bar of 28 feet long fhould have half the ftrength of that of 14 feet, or 2650; whereas it is but 1775. The bar of 14 feet fhould have half the ftrength of that of 7 feet, or 5762; whereas it is but 5300. In like manner, the fourth of 11525 is 2881; but the real ftrength of the 28 feet bar is 1775. We have added a column A, which exhibits the ftrength which each of the 5-inch bars ought to have by the theory. This deviation is moft diftinctly feen in fig. 26. where BK is the fcale of lengths, B being at the point 7 of the fcale, and K at 28. The ordinate CB is $= 11525$, and the other ordinates DE, GK, &c. are refpectively $= \frac{7\,\text{CB}}{\text{Length}}$. The lines DF, GH, &c. are made $= 4350$, 1775, &c. expreffing the ftrengths given by experiment. The 10 feet bar and the 24 feet bar are remarkably anomalous. But all are deficient, and the defect has an evident progreffion from the firft to the laft. The fame thing may be

Fig. 26.

be ſhown of the other columns, and even of the firſt, though it is very ſmall in that column. It may alſo be obſerved in the experiments of Belidor, and in all that we have ſeen. We cannot doubt therefore of its being a law of nature, depending on the true principles of coheſion, and the laws of mechanics.

But it is very puzzling, and we cannot pretend to give a ſatisfactory explanation of the difficulty. The only effect which we can conceive the length of a beam to have, is to increaſe the ſtrain at the ſection of fracture by employing the intervening beam as a lever. But we do not diſtinctly ſee what change this can produce in the mode of action of the fibres in this ſection, ſo as either to change their coheſion or the place of its centre of effort: yet ſomething of this kind muſt happen.

We ſee indeed ſome circumſtances which muſt contribute to make a ſmaller weight ſufficient, in Mr Buffon's experiments, to break a long beam, than in the exact inverſe proportion of its length.

In the firſt place, the weight of the beam itſelf augments the ſtrain as much as if half of it were added in form of a weight. Mr Buffon has given the weights of every beam on which he made experiments, which is very nearly 74 pounds per cubic foot. But they are much too ſmall to account for the deviation from the theory. The half weights of the 5-inch beams of 7, 14, and 28 feet length are only 45, 92, and 182 pounds; which makes the real ſtrains in the experiments 11560, 5390, and 1956; which are far from having the proportions of 4, 2, and 1.

Buffon ſays that healthy trees are univerſally ſtrongeſt at the root end; therefore, when we uſe a longer beam, its middle point, where it is broken in the experiment, is in a weaker part of the tree. But the trials of the 4-inch beams ſhow that the difference from this cauſe is almoſt inſenſible.

The length muſt have ſome mechanical influence which the theory we have adopted has not yet explained. It may not however be inadequate to the taſk. The very ingenious inveſtigation of the elaſtic curve by James Bernoulli and other celebrated mathematicians is perhaps as refined an application of mathematical analyſis as we know. Yet in this inveſtigation it was neceſſary, in order to avoid almoſt inſuperable difficulties, to take the ſimpleſt poſſible caſe, viz. where the thickneſs is exceedingly ſmall in compariſon with the length. If the thickneſs be conſiderable, the quantities neglected in the calculus are too great to permit the concluſion to be accurate, or very nearly ſo. Without being able to define the form into which an elaſtic body of conſiderable thickneſs will be bent, we can ſay with confidence, that in an extreme caſe, where the compreſſion in the concave ſide is very great, the curvature differs conſiderably from the Bernoullian curve. But as our inveſtigation is incomplete and very long, we do not offer it to the reader. The following more familiar conſiderations will, we apprehend, render it highly probable that the relative ſtrength of beams decreaſes faſter than in the inverſe ratio of their length. The curious obſervation by Mr Buffon of the vapour which iſſued with a hiſſing noiſe from the ends of a beam of green oak, while it was breaking by the load on its middle, ſhows that the whole length of the piece was affected: indeed it muſt be, ſince it is bent throughout. We have ſhown above, that a certain definite curvature of a beam of a given form is

113 Probable that the relative ſtrength of beams decreaſes faſter than in the inverſe ratio of their length.

always accompanied by rupture. Now ſuppoſe the beam A of 10 feet long, and the beam B of 20 feet long, bent to the ſame degree, at the place of their fixture in the wall; the weight which hangs on A is nearly double of that which muſt hang on B. The form of any portion, ſuppoſe 5 feet, of theſe two beams, immediately adjoining to the wall, is conſiderably different. At the diſtance of 5 feet the curvature of A is ½ of its curvature at the wall. The curvature of B in the correſponding point is ¾ths of the ſame curvature at the wall. Through the whole of the intermediate 5 feet, therefore, the curvature of B is greater than that of A. This muſt make it weaker throughout. It muſt occaſion the fibres to ſlide more on each other (that it may acquire *this* greater curvature), and thus affect their lateral union; and therefore thoſe which are ſtronger will not aſſiſt their weaker neighbours. To this we muſt add, that in the ſhorter beams the force with which the fibres are preſſed laterally on each other is double. This muſt impede the mutual ſliding of the fibres which we mentioned a little ago; nay, this lateral compreſſion may change the law of longitudinal coheſion (as will readily appear to the reader who is acquainted with Boſcovich's doctrines), and increaſe the ſtrength of the very ſurface of fracture, in the ſame way (however inexplicable) as it does in metals when they are hammered or drawn into wire.

The reader muſt judge how far theſe remarks are worthy of his attention. The engineer will carefully keep in mind the important fact, that a beam of quadruple length, inſtead of having ¼th of the ſtrength, has only about ⅙th; and the philoſopher ſhould endeavour to diſcover the cauſe of this diminution, that he may give the artiſt a more accurate rule of computation.

114 We cannot diſcover the preciſe relation between the curvature and the momentum of coheſion.

Our ignorance of the law by which the coheſion of the particles changes by a change of diſtance, hinders us from diſcovering the preciſe relation between the curvature and the momentum of coheſion; and all we can do is to multiply experiments, upon which we may eſtabliſh ſome *empirical* rules for calculating the ſtrength of ſolids. Thoſe from which we muſt reaſon at preſent are too few and too anomalous to be the foundation of ſuch an empirical formula. We may, however, obſerve, that Mr Buffon's experiments give us conſiderable aſſiſtance in this particular: For if to each of the numbers of the column for the 5-inch beams, corrected by adding half the weight of the beam, we add the conſtant number 1245, we ſhall have a ſet of numbers which are very nearly reciprocals of the lengths. Let 1245 be called c, and let the weight which is known by experiment to be neceſſary for breaking the 5-inch beam of the length a be called P. We ſhall have $\frac{\overline{P+c}\times a}{l}-c=p$. Thus the weight neceſſary for breaking the 7-foot bar is 11560. This added to 1245, and the ſum multiplied by 7, gives $\overline{P+c}\times a=89635$. Let l be 18; then $\frac{89635}{18}-1245=3725,=p$, which differs not more than $\frac{1}{40}$th from what experiment gives us. This rule holds equally well in all the other lengths except the 10 and 24 foot beams, which are very anomalous. Such a formula is abundantly exact for practice, and will anſwer through a much greater variety of length, though it cannot be admitted as a true one; becauſe, in a certain very great length,

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length, the ſtrength will be nothing. For other ſizes the conſtant number muſt change in the proportion of d^3, or perhaps of p.

115 Relation between the ſtrength and the ſquare of the depth of the ſection.

The next compariſon which we have to make with the theory is the relation between the ſtrength and the ſquare of the depth of the ſection. This is made by comparing with each other the numbers in any horizontal line of the table. In making this compariſon we find the numbers of the five-inch bars uniformly greater than the reſt. We imagine that there is ſomething peculiar to theſe bars: They are in general heavier than in the proportion of their ſection, but not ſo much ſo as to account for all their ſuperiority. We imagine that this ſet of experiments, intended as a ſtandard for the reſt, has been made at one time, and that the ſeaſon has had a conſiderable influence. The fact however is, that if this column be kept out, or uniformly diminiſhed about one-ſixteenth in their ſtrength, the different ſizes will deviate very little from the ratio of the ſquare of the depth, as determined by theory. There is however a ſmall deficiency in the bigger beams.

We have been thus anxious in the examination of theſe experiments, becauſe they are the only ones which have been related in ſufficient detail, and made on a proper ſcale for giving us data from which we can deduce confidential maxims for practice. They are ſo troubleſome and expenſive that we have little hopes of ſeeing their number greatly increaſed; yet ſurely our navy board would do an unſpeakable ſervice to the public by appropriating a fund for ſuch experiments under the management of ſome man of ſcience.

116 Proportion between the abſolute coheſion and the relative ſtrength.

There remains another compariſon which is of chief importance, namely, the proportion between the ABSOLUTE COHESION and the RELATIVE STRENGTH. It may be gueſſed, from the very nature of the thing, that this muſt be very uncertain. Experiments on the abſolute ſtrength muſt be confined to very ſmall pieces, by reaſon of the very great forces which are required for tearing them aſunder. The values therefore deduced from them muſt be ſubject to great inequalities. Unfortunately we have got no detail of any experiments; all that we have to depend on is two paſſages of Muſchenbroek's *Eſſais de Phyſique*; in one of which he ſays that a piece of ſound oak $\frac{27}{100}$ths of an inch ſquare is torn aſunder by 1150 pounds; and in the other, that an oak plank 12 inches broad and one thick will juſt ſuſpend 189163 pounds. Theſe give for the coheſion of an inch ſquare 15,755 and 15.763 pounds. Bouguer, in his *Traité du Navire*, ſays that it is very well known that a rod of ſound oak one-fourth of an inch ſquare will be torn aſunder by 1000 pounds. This gives 16000 for the coheſion of a ſquare inch. We ſhall take this as a round number, eaſily uſed in our computations. Let us compare this with M. Buffon's trials of beams four inches ſquare.

The abſolute coheſion of this ſection is $16{,}000 \times 16 = 256{,}000$. Did every fibre exert its whole force in the inſtant of fracture, the momentum of coheſion would be the ſame as if it had all acted at the centre of gravity of the ſection at 2 inches from the axis of fracture, and is therefore 512000. The 4-inch beam, 7 feet long, was broken by 5312 pounds hung on its middle. The half of this, or 2656 pounds, would have broken it, if ſuſpended at its extremity, projecting $3\frac{1}{2}$ feet or 42 inches from a wall. The momentum of this ſtrain is therefore $2656 \times 42, = 111552$. Now this is in equilibrio with the actual momentum of coheſion, which is therefore 111552, inſtead of 512000. The ſtrength is therefore diminiſhed in the proportion of 512000 to 111552, or very nearly of 4,59 to 1.

As we are quite uncertain as to the place of the centre of effort, it is needleſs to conſider the full coheſion as acting at the centre of gravity, and producing the momentum 512,000; and we may convert the whole into a ſimple multiplier m of the length, and ſay, *as m times the length is to the depth, ſo is the abſolute coheſion of the ſection to the relative ſtrength.* Therefore let the abſolute coheſion of a ſquare inch be called f, the breadth b, the depth d, and the length l (all in inches), the relative ſtrength, or the external force p, which balances it, is $\frac{f b d^2}{9{,}18\,l}$, or in round numbers $\frac{f b d^2}{9\,l}$; for $m = 2 \times 4{,}59$.

This great diminution of ſtrength cannot be wholly accounted for by the inequality of the coheſive forces exerted in the inſtant of fracture; for in this caſe we know that the centre of effort is at $\frac{1}{3}$d of the height in a rectangular ſection (becauſe the forces really exerted are as the extenſions of the fibres). The relative ſtrength would be $\frac{f b d^2}{3\,l}$, and p would have been 8127 inſtead of 2656.

We muſt aſcribe this diminution (which is three times greater than that produced by the inequality of the coheſive forces) to the compreſſion of the under part of the beam; and we muſt endeavour to explain in what manner this compreſſion produces an effect which ſeems ſo little explicable by ſuch means.

As we have repeatedly obſerved, it is a matter of nearly univerſal experience that the forces *actually* exerted by the particles of bodies, when ſtretched or compreſſed, are very nearly in the proportion of the diſtances to which the particles are drawn from their natural poſitions. Now, although we are certain that, in enormous compreſſions, the forces increaſe faſter than in this proportion, this makes no ſenſible change in the preſent queſtion, becauſe the body is broken before the compreſſions have gone ſo far; nay, we imagine that the compreſſed parts are crippled in moſt caſes even before the extended parts are torn aſunder. Muſchenbroek aſſerts this with great confidence with reſpect to oak, on the authority of his own experiments. He ſays, that although oak will ſuſpend half as much again as fir, it will not ſupport, as a pillar, two-thirds of the load which fir will ſupport in that form.

We imagine therefore that the mechaniſm in the *preſent* caſe is nearly as follows:

Let the beam DCKΔ (fig. 27.) be loaded at its extremity with the weight P, acting in the direction KP perpendicular to DC. Let DΔ be the ſection of fracture. Let DA be about one-third of DΔ. A will be the particle or fibre which is neither extended nor compreſſed. Make $\Delta\delta : Dd = DA : A\Delta$. The triangles DA$d$, ΔAδ, will repreſent the accumulated attracting and repelling forces. Make AI and A$i = \frac{2}{3}$DA and $\frac{2}{3}\Delta$A. The point I will be that to which the full coheſion Dd or f of the particles in AD muſt be applied, ſo as to produce the ſame momentum which the variable forces at I, D, &c. really produce at their ſeveral points Fig. 27.

of

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of application. In like manner, i is the centre of ſimilar effort of the repulſive forces excited by the compreſſion between A and Δ, and it is the real fulcrum of a bended lever IiK, by which the whole effect is produced. The effect is the ſame as if the full coheſion of the ſtretched fibres in AD were accumulated in I, and the full repulſion of all the compreſſed fibres in A Δ were accumulated in i. The forces which are balanced in the operation are the weight P, acting by the arm $k i$, and the full coheſion of AD acting by the arm Ii. The forces exerted by the compreſſed fibres between A and Δ only ſerve to give ſupport to the lever, that it may exert its ſtrain.

We imagine that this does not differ much from the real procedure of nature. The poſition of the point A may be different from what we have deduced from Mr Buffon's experiments, compared with Muſchenbroek's value of the abſolute coheſion of a ſquare inch. If this laſt ſhould be only 12000, DA muſt be greater than we have here made it, in the proportion of 12000 to 16000. For Ii muſt ſtill be made $=\frac{1}{3}$ A Δ, ſuppoſing the forces to be proportional to the extenſions and compreſſions. There can be no doubt that a part only of the coheſion of D Δ operates in reſiſting the fracture in all ſubſtances which have any compreſſibility; and it is confirmed by the experiments of Mr Du Hamel on willow, and the inferences are by no means confined to that ſpecies of timber. We ſay therefore, that when the beam is broken, the coheſion of AD alone is exerted, and that each fibre exerts a force proportional to its extenſion; and the accumulated momentum is the ſame as if the full coheſion of AD were acting by the lever Ii $=\frac{1}{3}$d of D Δ.

It may be ſaid, that if only one-third of the coheſion of oak be exerted, it may be cut two-thirds through without weakening it. But this cannot be, becauſe the coheſion of the whole is employed in preventing the lateral ſlide ſo often mentioned. We have no experiments to determine that it *may not* be cut through one-third without loſs of its ſtrength.

This muſt not be conſidered as a ſubject of mere ſpeculative curioſity. It is intimately connected with all the practical uſes which we can make of this knowledge; for it is almoſt the only way that we can learn the compreſſibility of timber. Experiments on the direct coheſion are indeed difficult, and exceedingly expenſive if we attempt them in large pieces. But experiments on compreſſion are almoſt impracticable. The moſt inſtructive experiments would be, firſt to eſtabliſh, by a great number of trials, the tranſverſe force of a modern batten; and then to make a great number of trials of the diminution of its ſtrength, by cutting it through on the concave ſide. This would very nearly give us the proportion of the coheſion which really operates in reſiſting fractures. Thus if it be found that one-half of the beam may be cut on the under ſide without diminution of its ſtrength (taking care to drive in a ſlice of harder wood), we may conclude that the point A is at the middle, or ſomewhat above it.

Much lies before the curious mechanician, and we are as yet very far from a ſcientific knowledge of the ſtrength of timber.

In the mean time, we may derive from theſe experiments of Buffon a very uſeful practical rule, without relying on any value of the abſolute coheſion of oak. We ſee that the ſtrength is nearly as the breadth, as the ſquare of the depth, and as the inverſe of the length. It is moſt convenient to meaſure the breadth and depth of the beam in inches, and its length in feet. Since, then, a beam four inches ſquare and ſeven feet between the ſupports is broken by 5312 pounds, we muſt conclude that a batten one inch ſquare and one foot between the ſupports will be broken by 581 pounds. Then the ſtrength of any other beam of oak, or the weight which will juſt break it when hung on its middle, is $581\frac{b d^2}{l}$.

Strength of Materials. 117 A uſeful practical rule may be deduced from Mr Buffon's experiments.

But we have ſeen that there is a very conſiderable deviation from the inverſe proportion of the lengths, and we muſt endeavour to accommodate our rule to this deviation. We found, that by adding 1245 to each of the ordinates or numbers in the column of the five-inch bars, we had a ſet of numbers very nearly reciprocal of the lengths; and if we make a ſimilar addition to the other columns in the proportion of the cubes of the ſixes, we have nearly the ſame reſult. The greateſt error (except in the caſe of experiments which are very irregular) does not exceed $\frac{1}{15}$th of the whole. Therefore, for a radical number, add to the 5312 the number 640, which is to 1245 very nearly as 4^3 to 5^3. This gives 5952. The 64th of this is 93, which correſponds to a bar of one inch ſquare and ſeven feet long. Therefore 93×7 will be the reciprocal correſponding to a bar of one foot. This is 651. Take from this the preſent empirical correction, which is $\frac{b\,40}{b\,4}$, or 10, and there remains 641 for the ſtrength of the bar. This gives us for a general rule $p=651\frac{b d^2}{l} - 10 b d^2$.

Example. Required the weight neceſſary to break an oak beam eight inches ſquare and 20 feet between the props, $p=651\times\frac{8\times8^2}{20}-10\times8\times8^2$. This is 11545, whereas the experiment gives 11487. The error is very ſmall indeed. The rule is moſt deficient in compariſon with the five-inch bars, which we have already ſaid appear ſtronger than the reſt.

The following proceſs is eaſily remembered by ſuch as are not algebraiſts.

Multiply the breadth in inches twice by the depth, and call this product f. Multiply f by 651, and divide by the length in feet. From the quotient take 10 times f. The remainder is the number of pounds which will break the beam.

We are not ſufficiently ſenſible of our principles to be confident that the correction $10f$ ſhould be in the proportion of the ſection, although we think it moſt probable. It is quite empirical, founded on Buffon's experiments. Therefore the ſafe way of uſing this rule is to ſuppoſe the beam ſquare, by increaſing or diminiſhing its breadth till equal to the depth. Then find the ſtrength by this rule, and diminiſh or increaſe it for the change which has been made in its breadth. Thus, there can be no doubt that the ſtrength of the beam given as an example is double of that of a beam of the ſame depth and half the breadth.

The reader cannot but obſerve that all this calculation relates to the very greateſt weight which a beam will bear for a very few minutes. Mr Buffon uniformly found

found that two-thirds of this weight ſenſibly impaired its ſtrength, and frequently broke it at the end of two or three months. One-half of this weight brought the beam to a certain bend, which did not increaſe after the firſt minute or two, and may be borne by the beam for any length of time. But the beam contracted a bend, of which it did not recover any conſiderable portion. One-third ſeemed to have no permanent effect on the beam; but it recovered its rectilineal ſhape completely, even after having been loaded ſeveral months, provided that the timber was ſeaſoned when firſt loaded; that is to ſay, one-third of the weight which would quickly break a ſeaſoned beam, or one-fourth of what would break one juſt felled, may lie on it for ever without giving the beam a ſett.

We have no detail of experiments on the ſtrength of other kinds of timber: only Mr Buffon ſays, that fir has about $\frac{6}{10}$ths of the ſtrength of oak; Mr Parent makes it $\frac{10}{12}$ths; Emerſon, $\frac{2}{3}$ds, &c.

We have been thus minute in our examination of the mechaniſm of this tranſverſe ſtrain, becauſe it is the greateſt to which the parts of our machines are expoſed. We wiſh to impreſs on the minds of artiſts the neceſſity of avoiding this as much as poſſible. They are improving in this reſpect, as may be ſeen by comparing the centres on which ſtone arches of great ſpan are now turned with thoſe of former times. They were formerly a load of mere joiſts reſting on a multitude of poſts, which obſtructed the navigation, and were frequently loſing their ſhape by ſome of the poſts ſinking into the ground. Now they are more generally truſſes, where the beams abutt on each other, and are relieved from tranſverſe ſtrains. But many performances of eminent artiſts are ſtill very injudiciouſly expoſed to croſs ſtrains. We may inſtance one which is conſidered as a fine work, viz. the bridge at Walton on Thames. Here every beam of the great arch is a joiſt, and it hangs together by framing. The fineſt piece of carpentry that we have ſeen is the centre employed in turning the arches of the bridge at Orleans, deſcribed by Perronet. In the whole there is not one croſs ſtrain. The beam, too, of Hornblower's ſteam-engine, deſcribed in that article, is very ſcientifically conſtructed.

118 Strain produced by twiſting.

IV. The laſt ſpecies of ſtrain which we are to examine is that produced by twiſting. This takes place in all axles which connect the working parts of machines.

119 The reſiſtance muſt be proportional to the number of particles.

Although we cannot pretend to have a very diſtinct conception of that modification of the coheſion of a body by which it reſiſts this kind of ſtrain, we can have no doubt that, when all the particles act alike, the reſiſtance muſt be proportional to the number. Therefore if we ſuppoſe the two parts ABCD, ABFE (fig. 28.), of the body EFCD to be of inſuperable ſtrength, but cohering more weakly in the common ſurface AB, and that one part ABCD is puſhed laterally in the direction AB, there can be no doubt that it will yield only there, and that the reſiſtance will be proportional to the ſurface.

Fig. 28.

In like manner, we can conceive a thin cylindrical tube, of which KAH (fig. 29.) is the ſection, as cohering more weakly in that ſection than anywhere elſe. Suppoſe it to be graſped in both hands, and the two parts twiſted round the axis in oppoſite directions, as we would twiſt the two joints of a flute, it is plain that it will firſt fail in this ſection, which is the circumference of a circle, and the particles of the two parts which are contiguous to this circumference will be drawn from each other laterally. The total reſiſtance will be as the number of equally reſiſting particles, that is, as the circumference (for the tube being ſuppoſed very thin, there can be no ſenſible difference between the dilatation of the external and internal particles). We can now ſuppoſe another tube within this, and a third within the ſecond, and ſo on till we reach the centre. If the particles of each ring exerted the ſame force (by ſuffering the ſame dilatation in the direction of the circumference), the reſiſtance of each ring of the ſection would be as its circumference and its breadth (ſuppoſed indefinitely ſmall, and the whole reſiſtance would be as the ſurface; and this would repreſent the reſiſtance of a ſolid cylinder. But when a cylinder is twiſted in this manner by an external force applied to its circumference, the external parts will ſuffer a greater circular extenſion than the internal; and it appears that this extenſion (like the extenſion of a beam ſtrained tranſverſely) will be proportional to the diſtance of the particles from the axis. We cannot ſay that this is demonſtrable, but we can aſſign no proportion that is more probable. This being the caſe, the forces ſimultaneouſly exerted by each particle will be as its diſtance from the axis. Therefore the whole force exerted by each ring will be as the ſquare of its radius, and the accumulated force actually exerted will be as the cube of the radius; that is, the accumulated force exerted by the whole cylinder, whoſe radius is CA, is to the accumulated force exerted *at the ſame time* by the part whoſe radius is CE, as CA^3 to CE^3.

Fig. 29.

The whole coheſion now exerted is juſt two-thirds of what it would be if all the particles were exerting the ſame attractive forces which are juſt now exerted by the particles in the external circumference. This is plain to any perſon in the leaſt familiar with the fluxionary calculus. But ſuch as are not may eaſily ſee it in this way.

Let the rectangle AC ca be ſet upright on the ſurface of the circle along the line CA, and revolve round the axis Cc. It will generate a cylinder whoſe height is Cc or Aa, and having the circle KAH for its baſe. If the diagonal Ca be ſuppoſed alſo to revolve, it is plain that the triangle cCa will generate a cone of the ſame height, and having for its baſe the circle deſcribed by the revolution of ca, and the point C for its apex. The cylindrical ſurface generated by Aa will expreſs the whole coheſion exerted by the circumference AHK, and the cylindrical ſurface generated by Ee will repreſent the coheſion exerted by the circumference ELM, and the ſolid generated by the triangle CAa will repreſent the coheſion exerted by the whole circle AHK, and the cylinder generated by the rectangle ACca will repreſent the coheſion exerted by the ſame ſurface if each particle had ſuffered the extenſion Aa.

Now it is plain, in the firſt place, that the ſolid generated by the triangle eEC is to that generated by aAC as EC^3 to AC^3. In the next place, the ſolid generated by aAC is two-thirds of the cylinder, becauſe the cone generated by cCa is one-third of it.

We may now ſuppoſe the cylinder twiſted till the particles in the external circumference loſe their coheſion. There can be no doubt that it will now be wrenched aſunder, all the inner circles yielding in ſucceſſion. Thus we obtain one uſeful information, viz. that a body of homogeneous texture reſiſts a *ſimple twiſt* with two-thirds

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thirds of the force with which it resists an attempt to force one part laterally from the other, or with one-third part of the force which will cut it asunder by a square-edged tool. For to drive a square-edged tool through a piece of lead, for instance, is the same as forcing a piece of the lead as thick as the tool laterally away from the two pieces on each side of the tool. Experiments of this kind do not seem difficult, and they would give us very useful information.

120 With what force a body of a homogeneous texture resists a simple twist.

121 The forces exerted in breaking two cylinders are as the squares of the diameters.

When two cylinders AHK and BNO are wrenched asunder, we must conclude that the external particles of each are just put beyond their limits of cohesion, are equally extended, and are exerting equal forces. Hence it follows, that in the instant of fracture the sum total of the forces actually exerted are as the squares of the diameters.

For drawing the diagonal C e, it is plain that E e, $=$ A a, expresses the distension of the circumference ELM, and that the solid generated by the triangle CE e expresses the cohesion exerted by the surface of the circle ELM, when the particles in the circumference suffer the extension E e equal to A a. Now the solids generated by CA a and CE e being respectively two-thirds of the corresponding cylinders, are as the squares of the diameters.

122 Relative strength of the section to the external force employed to break it.

Having thus ascertained the real strength of the section, and its relation to its absolute lateral strength, let us examine its strength relative to the external force employed to break it. This examination is very simple in the case under consideration. The straining force must act by some lever, and the cohesion must oppose it by acting on some other lever. The centre of the section may be the neutral point, whose position is not disturbed.

Let F be the force exerted laterally by an exterior particle. Let a be the radius of the cylinder, and x the indeterminate distance of any circumference, and $\dot{x}$ the indefinitely small interval between the concentric arches; that is, let $\dot{x}$ be the breath of a ring and x its radius. The forces being as the extensions, and the extensions as the distances from the axis, the cohesion actually exerted at any part of any ring will be $f\,\frac{x\dot{x}}{a}$. The force exerted by the whole ring (being as the circumference or as the radius) will be $f\frac{x^2\dot{x}}{a}$. The momentum of cohesion of a ring, being as the force multiplied by its lever, will be $f\frac{x^3\dot{x}}{a}$. The accumulated momentum will be the sum or fluent of $f\frac{x^3\dot{x}}{a}$; that is, when $x=a$, it will be $\frac{1}{4}f\frac{a^4}{a}, = \frac{1}{4}fa^3$.

123 The resistance of the axle is as the cube of its diameter.

Hence we learn that the strength of an axle, by which it resists being wrenched asunder by a force acting at a given distance from the axis, is as the cube of its diameter.

But farther, $\frac{1}{4}fa^3$ is $=fa^2\times\frac{1}{4}a$. Now fa^2 represents the full lateral cohesion of the section. The momentum therefore is the same as if the full lateral cohesion were accumulated at a point distant from the axis by one-fourth of the radius or one-eighth of the diameter of the cylinder.

Therefore let F be the number of pounds which measures the lateral cohesion of a circular inch, d the diameter of the cylinder in inches, and l the length of the lever by which the straining force p is supposed to act, we shall have $F\times\frac{1}{8}d^3=pl$, and $F\frac{d^3}{8l}=p$.

We see in general that the strength of an axle, by which it resists being wrenched asunder by twisting, is as the cube of its diameter.

124 Hollow axles more proper than solid ones,

We see also that the internal parts are not acting so powerfully as the external. If a hole be bored out of the axle of half its diameter, the strength is diminished only one-eighth, while the quantity of matter is diminished one-fourth. Therefore hollow axles are stronger than solid ones containing the same quantity of matter. Thus let the diameter be 5 and that of the hollow 4: then the diameter of another solid cylinder having the same quantity of matter with the tube is 3. The strength of the solid cylinder of the diameter 5 may be expressed by 5^3 or 125. Of this the internal part (of the diameter 4) exerts 64; therefore the strength of the tube is 125 $-64, = 61$. But the strength of the solid axle of the same quantity of matter and diameter 3 is 3^3, or 27, which is not half of that of the tube.

125 and now generally used.

Engineers, therefore, have of late introduced this improvement in their machines, and the axles of cast iron are all made hollow when their size will admit it. They have the additional advantage of being much stiffer, and of affording much better fixture for the flanches, which are used for connecting them with the wheels or levers by which they are turned and strained. The superiority of strength of hollow tubes over solid cylinders is much greater in this kind of strain than in the former or transverse. In this last case the strength of this tube would be to that of the solid cylinder of equal weight as 61 to 32 and a half nearly.

126 The ratio of resistance to twisting to the simple lateral resistance appears different.

The apparatus which we mentioned on a former occasion for trying the lateral strength of a square inch of solid matter, enabled us to try this theory of twist with all desirable accuracy. The bar which hung down from the pin in the former trials was now placed in a horizontal position, and loaded with a weight at the extremity. Thus it acted as a powerful lever, and enabled us to wrench asunder specimens of the strongest materials. We found the results perfectly conformable to the theory, in as far as it determined the proportional strength of different sizes and forms: but we found the ratio of the resistance to twisting to the simple lateral resistance considerably different; and it was some time before we discovered the cause.

We had here taken the simplest view that is possible of the action of cohesion in resisting a twist. It is frequently exerted in a very different way. When, for instance, an iron axle is joined to a wooden one by being driven into one end of it, the extensions of the different circles of particles are in a very different proportion. A little consideration will show that the particles in immediate contact with the iron axle are in a state of violent extension; so are the particles of the exterior surface of the wooden part, and the intermediate parts are less strained. It is almost impossible to assign the exact proportion of the cohesive forces exerted in the different parts.

parts. Numberleſs caſes can be pointed out where parts of the axle are in a ſtate of compreſſion, and where it is ſtill more difficult to determine the ſtate of the other particles. We muſt content ourſelves with the deductions made from this ſimple caſe, which is fortunately the moſt common. In the experiments juſt now mentioned the centre of the circle is by no means the neutral point, and it is very difficult to aſcertain its place: but when this conſideration occurred to us, we eaſily freed the experiments from this uncertainty, by extending the lever to both ſides, and by means of a pulley applied equal force to each arm, acting in oppoſite directions. Thus the centre became the neutral point, and the reſiſtance to twiſt was found to be two-thirds of the ſimple lateral ſtrength.

127 But when the experiment was altered, it was exactly the ſame.

128 Experiments on chalk, clay, and wax, ſatisfactory; but thoſe on timber irregular.

We beg leave to mention here that our ſucceſs in theſe experiments encouraged us to extend them much farther. We hoped by theſe means to diſcover the abſolute coheſion of many ſubſtances, which would have required an enormous apparatus and a moſt unmanageable force to tear them aſunder directly. But we could reaſon with confidence from the reſiſtance to twiſt (which we could eaſily meaſure), provided that we could aſcertain the proportion of the direct and the lateral ſtrengths. Our experiments on chalk, finely prepared clay, and white bees-wax (of one melting and one temperature), were very conſiſtent and ſatisfactory. But we have hitherto found great irregularities in this proportion in bodies of a fibrous texture like timber. Theſe are the moſt important caſes, and we ſtill hope to be able to accompliſh our project, and to give the public ſome valuable information. This being our ſole object, it was our duty to mention the method which promiſes ſucceſs, and thus excite others to the taſk; and it will be no mortification to us to be deprived of the honour of being the firſt who thus adds to the ſtock of experimental knowledge.

When the matter of the axle is of the moſt ſimple texture, ſuch as that of metals, we do not conceive that the length of the axle has any influence on the fracture. It is otherwiſe if it be of a fibrous texture like timber: the fibres are bent before breaking, being twiſted into ſpirals like a cork-ſcrew. The length of the axle has ſomewhat of the influence of a lever in this caſe, and it is eaſier wrenched aſunder if long. Accordingly we have found it ſo; but we have not been able to reduce this influence to calculation.

129 Concluding remarks.

Our readers are requeſted to accept of theſe endeavours to communicate information on this important and difficult ſubject. We are duly ſenſible of their imperfection, but flatter ourſelves that we have in many inſtances pointed out the method which muſt be purſued for improving our knowledge on this ſubject; and we have given the Engliſh reader a more copious liſt of experiments on the ſtrength of materials than he will meet with in our language. Many uſeful deductions might be made from theſe premiſes reſpecting the manner of diſpoſing and combining the ſtrength of materials in our ſtructures. The beſt form of joints, mortiſes, tenons, ſcarphs; the rules for joggling, tabling, faying, fiſhing, &c. practiſed in the delicate art of maſt-making, are all founded on this doctrine: but the diſcuſſion of theſe would be equivalent to writing a complete treatiſe of carpentry. We hope that this will be executed by ſome intelligent mechanician, for there is nothing in our language on this ſubject but what is almoſt contemptible; yet there is no mechanic art that is more ſuſceptible of ſcientific treatment. Such a treatiſe, if well executed, could not fail of being well received by the public in this age of mechanical improvement.

STRENGTHENERS, or CORROBORANTS, ſuch medicines as are ſuppoſed to add to the firmneſs of the ſolids. See MATERIA MEDICA *Index*.

STRETCHING, in *Navigation*, is generally underſtood to imply the progreſſion of a ſhip under a great ſurface of ſail, when cloſe-hauled. The difference between this term and *ſtanding*, conſiſts apparently in the quantity of ſail; which in the latter may be very moderate; but ſtretching generally ſignifies exceſs; as, we ſaw the enemy at daybreak ſtretching to the ſouthward under a croud of ſail, &c. *Falconer*.

STRETTO, in Italian muſic, is ſometimes uſed to ſignify that the meaſure is to be ſhort and conciſe, and conſequently quick. In this ſenſe it ſtands oppoſed to LARGO.

STRIATED LEAF, among botaniſts, one that has a number of longitudinal furrows on its ſurface.

STRIKE, a meaſure of capacity, containing four buſhels. Alſo an inſtrument uſed in meaſuring corn.

STRIX, the OWL; a genus of birds belonging to the order of accipitres. See ORNITHOLOGY *Index*.

The *bubo*, or great-eared owl inhabits inacceſſible rocks and deſert places, and preys on hares and feathered game. Its appearance in cities was deemed an unlucky omen; Rome itſelf once underwent a luſtration becauſe one of them ſtrayed into the capitol. The ancients had them in the utmoſt abhorrence; and thought them, like the ſcreech-owls, the meſſengers of death. Pliny ſtyles it *bubo funebris*, and *noctis monſtrum*.

> *Solaque culminibus* ferali *carmine* bubo
> *Sæpe queri et longas in fletum ducere voces.* VIRGIL.

> Perch'd on the roof, the bird of night complains,
> In lengthen'd ſhrieks and dire funereal ſtrains.

STROBILUS, in *Botany*, a pericarp formed from an amentum by the hardening of the ſcales.

STROKING, or rubbing gently with the hand, a method which has been employed by ſome perſons for curing diſeaſes.

Mr Greatrakes or Greatrix, the famous Iriſh ſtroker, is ſaid to have performed many wonderful cures. He gives the following account of his diſcovery of this art, and of the ſucceſs with which he practiſed it. "About 1662 I had an impulſe (ſays he), or a ſtrange perſuaſion in my own mind (of which I am not able to give any rational account to another), which did very frequently ſuggeſt to me, that there was beſtowed on me the gift of curing the king's evil; which, for the extraordinarineſs of it, I thought fit to conceal for ſome time; but at length I communicated this to my wife, and told her, that I did verily believe that God had given me the bleſſing of curing the king's evil; for whether I were in private or public, ſleeping or waking, ſtill I had the ſame impulſe. But her reply to me was, that ſhe conceived this was a ſtrange imagination; yet, to prove the contrary, a few days after there was one William Mather of Salterbridge in the pariſh of Liſmore, who brought his ſon William to my houſe, deſiring my wife to cure him, who was a perſon ready to afford her charity to her neighbours, according to her ſmall ſkill in chirurgery.

See *Brief Account of Mr Valentine Greatrakes*, Lond. 1666, 4to.

Fig. 1.

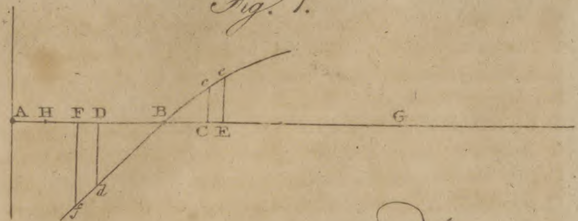


Fig. 3.

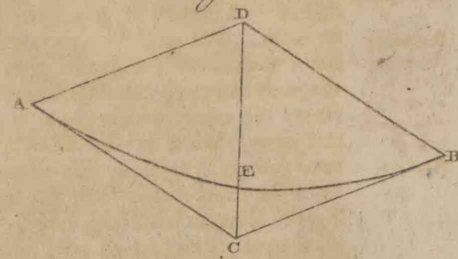


Fig. 2.

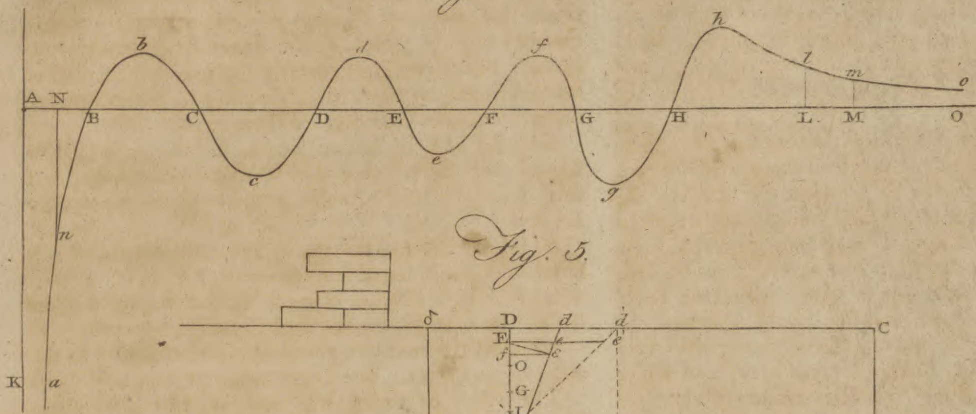


Fig. 4.

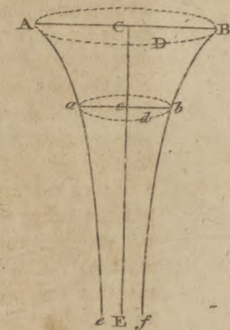


Fig. 5.

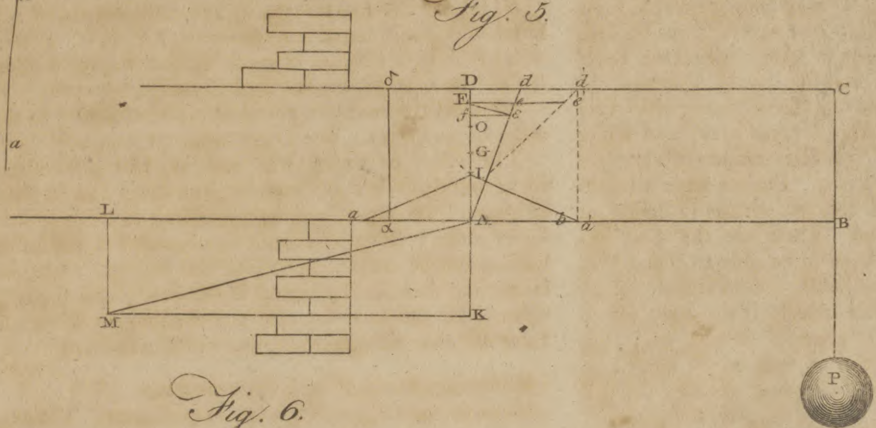


Fig. 6.

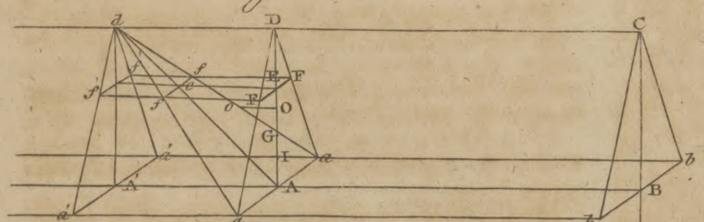


Fig. 8.

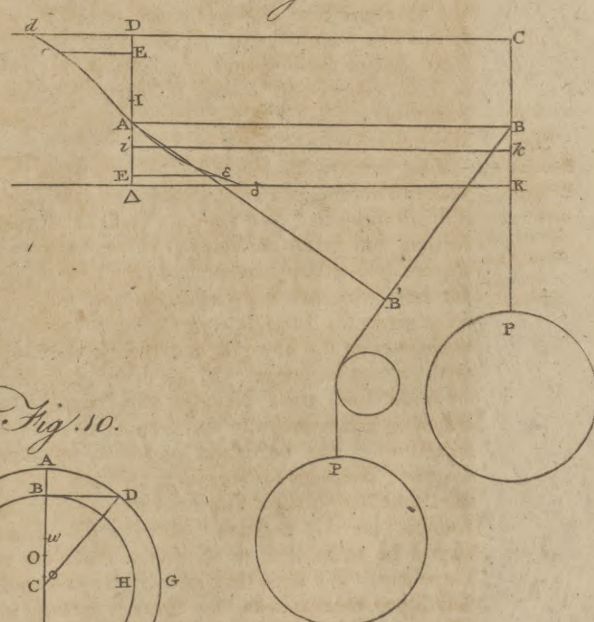


Fig. 7.

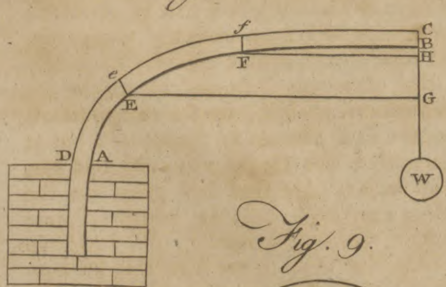


Fig. 10.

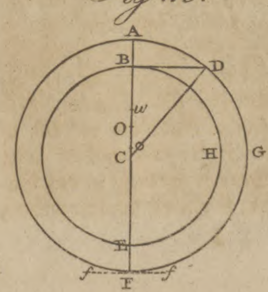
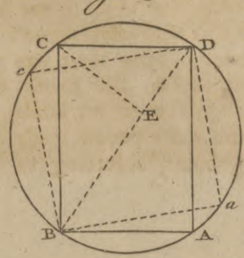
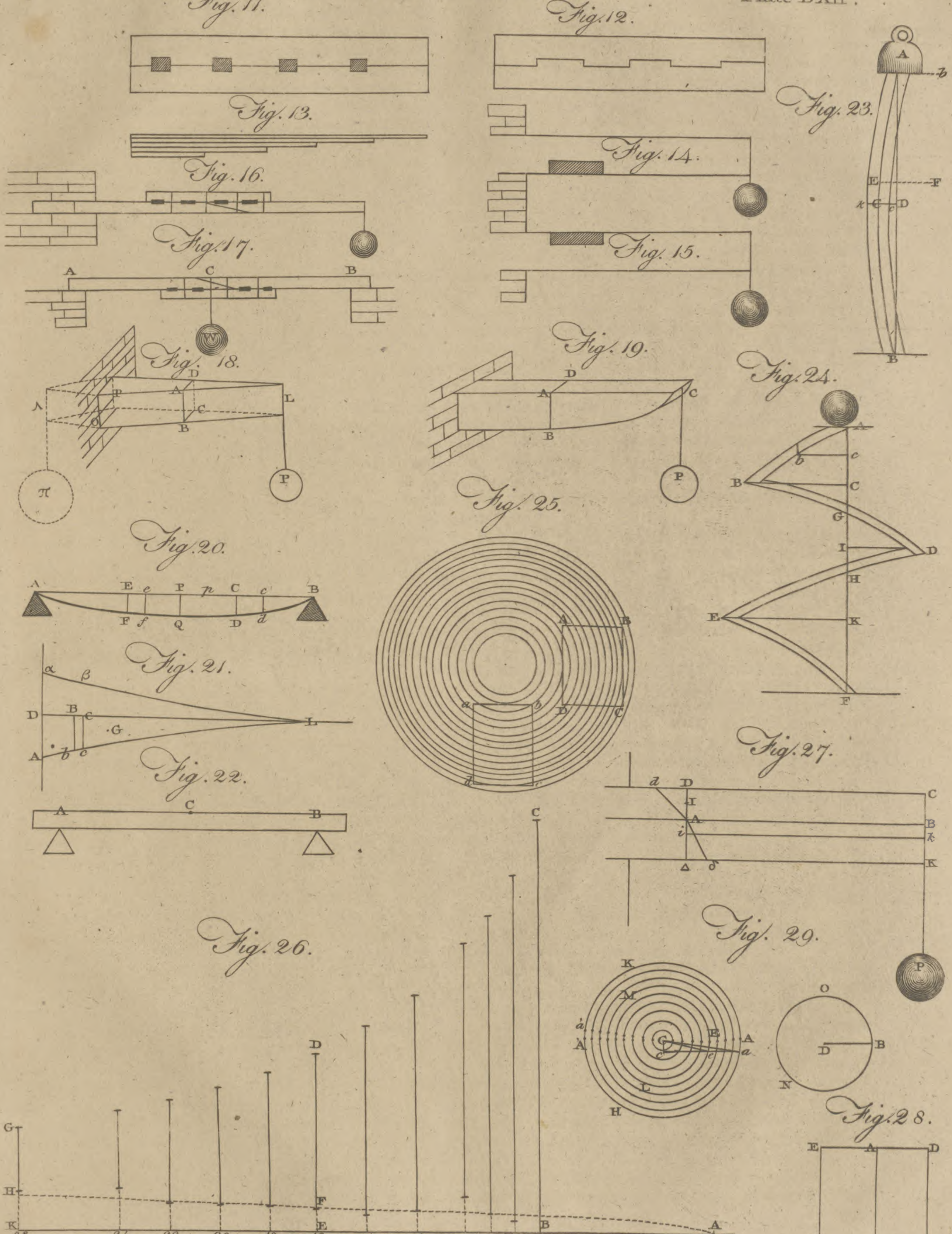


Fig. 9.



W. Train Sculp.t



W. Train Sculp.t

chirurgery. On which my wife told me, there was one that had the king's evil very grievoufly in the eyes, cheek, and throat; whereupon I told her, that fhe fhould now fee whether this was a bare fancy or imagination, as fhe thought it, or the dictates of God's Spirit on my heart. Then I laid my hands on the places affected, and prayed to God for Jefus fake to heal him; and bid the parent two or three days afterwards to bring the child to me again, which accordingly he did; and I then faw the eye was almoft quite whole; and the node, which was almoft as big as a pullet's egg, was fuppurated; and the throat ftrangely amended; and, to be brief (to God's glory I fpeak it) within a month difcharged itfelf quite, and was perfectly healed, and fo continues, God be praifed."

Then there came to him one Margaret Mackfhane of Ballinecly, in the parifh of Lifmore, who had been afflicted with the evil above feven years, in a much more violent degree; and foon after, his fame increafing, he cured the fame difeafe in many other perfons for three years. He did not meddle all this time with any other diftemper; till about the end of thefe three years, the ague growing epidemical, he found, as formerly, that there was beftowed on him the gift of curing that difeafe. He cured Colonel Phaire, of Cahirmony in the county of Corke, of an ague, and afterwards many other perfons of different diftempers, by ftroking; fo that his name was wonderfully cried up, as if fome divine perfon had been fent from above. January 1665-6, he came over to England, at the requeft of the earl of Orrery; in order to cure the lady of the lord-vifcount Conway, of Ragley in Warwickfhire, who had for many years laboured under a moft violent headache. He ftaid at Ragley three weeks or a month; and though he failed in his endeavours to relieve that lady, he cured vaft numbers of people in thofe parts and at Worcefter.

Though we are no friends to the marvellous, nor believe it poffible that either the king's evil or ague can be cured by ftroking or friction of any kind, whether gentle or fevere, we have no hefitation to acknowledge that many cures might be performed by Mr Greatrakes. Every reflecting perfon who reads the foregoing account which he gives of himfelf will fee that he was an enthufiaft, and believed himfelf guided by a particular revelation; and fuch is the credulity of mankind, that his pretenfions were readily admitted, and men crouded with eagernefs to be relieved of their difeafes. But it is well known to phyficians, that in many cafes the imagination has accomplifhed cures as wonderful as the force of medicine. It is owing chiefly to the influence of imagination that we have fo many accounts from people of veracity of the wonderful effects of quack medicines. We are perfectly affured that thefe medicines, by their natural operation, can never produce the effects afcribed to them; for there is no kind of proportion between the medicine and the effect produced, and often no connection between the medicine and the difeafe.

STROMATEUS, a genus of fifhes belonging to the order of apodes. See ICHTHYOLOGY *Index*.

STROMBOLI, the moft northern of the Lipari iflands. It is a volcano, which conftantly difcharges much fire and fmoke. It rifes in a conical form above the furface of the fea. On the eaft fide it has three or four little craters ranged near each other, not at the

fummit, but on the declivity, nearly at two-thirds of its height. But as the furface of the volcano is very rugged and interfected with hollow ways, it may be naturally concluded, that at the time of fome great eruption, the fummit and a part of this fide fell in, as muft have happened alfo to Vefuvius; confequently, the common chimney is at this day on the declivity, although always in the centre of the whole bafe. It is inhabited notwithftanding its fires; but care is taken to avoid the proximity of the crater, which is yet much to be feared. "I was affured (fays M. de Luc) by an Englifhman, who, like me, had the curiofity to vifit thefe ifles, that the fine weather having invited him and his company to land at Stromboli, they afcended a volcano, whofe craters at that time threw out nothing; but that while they were attentively viewing them, unapprehenfive of any danger, they were fuddenly faluted by fuch a furious difcharge, as to be obliged to retreat with precipitation, and not without one of the company being wounded by a piece of fcoria." Of all the volcanoes recorded in hiftory, Stromboli feems to be the only one that burns without ceafing. Etna and Vefuvius often lie quiet for many months, and even years, without the leaft appearance of fire; but Stromboli is ever at work, and for ages paft has been looked upon as the great lighthoufe of thefe feas. E. Long. 15. 45. N. Lat. 30. 0.

STROMBUS, a genus of fhell-fifh. See CONCHOLOGY *Index*.

STRONGOLI, a town of the kingdom of Naples, with a bifhop's fee. It is fituated on a rugged mountain, is about three miles from the fea, and feven north from St Severino. It is fuppofed to be the ancient *Petelia*, which made a confpicuous figure in the fecond Punic war by its obftinate refiftance againft Hannibal. Near its walls Marcellus the rival of Hannibal was flain in a fkirmifh. E. Long. 17. 26. N. Lat. 39. 20.

STRONTITES, or STRONTIAN EARTH, fo called from having been difcovered at Strontian in Scotland. See CHEMISTRY *Index*.

STROPHE, in ancient poetry, a certain number of verfes, including a perfect fenfe, and making the firft part of an ode. See POETRY, N° 130.

STRUMÆ, fcrophulous tumours arifing on the neck and throat, conftituting what is commonly called the *king's evil*. See MEDICINE *Index*.

STRUMPFIA, a genus of plants belonging to the clafs fyngenefia. See BOTANY *Index*.

STRUTHIO, a genus of birds belonging to the order of grallæ. See ORNITHOLOGY *Index*.

STRUTHIOLA, a genus of plants belonging to the clafs of tetrandria. See BOTANY *Index*.

STRYCHNOS, a genus of plants belonging to the clafs pentandria, and in the natural fyftem ranging under the 28th order, *luridæ*. See BOTANY *Index*.

STRYMON, in *Ancient Geography*, formerly *Conozus*; a river conftituting the ancient limits of Macedonia and Thrace; rifing in Mount Scombrus (Ariftotle). Authors differ as to the modern name of this river.

STRYPE, JOHN, was defcended from a German family, born at London, and educated at Cambridge. He was vicar of Low Layton in Effex, and diftinguifhed himfelf by his compilations of Lives and Memoirs; in which, as Dr Birch remarks, his fidelity and induftry will always give a value to his writings, however deftitute

tute they may be of the graces of ſtyle. He died in 1737, after having enjoyed his vicarage near 68 years.

STUART, DR GILBERT, was born at Edinburgh in the year 1742. His father Mr George Stuart was profeſſor of humanity in the univerſity, and a man of conſiderable eminence for his claſſical taſte and literature. For theſe accompliſhments he was probably indebted in no ſmall degree to his relation the celebrated Ruddiman, with whom both he and his ſon converſed familiarly, though they afterwards united to injure his fame.

Gilbert having finiſhed his claſſical and philoſophical ſtudies in the grammar-ſchool and univerſity, applied himſelf to juriſprudence, without following, or probably intending to follow, the profeſſion of the law. For that profeſſion he has been repreſented as unqualified by indolence; by a paſſion which at a very early period of life he diſplayed for general literature; or by boundleſs diſſipation:—and all theſe circumſtances may have contributed to make him relinquiſh purſuits in which he could hope to ſucceed only by patient perſeverance and ſtrict decorum of manners. That he did not waſte his youth in idleneſs, is, however, evident from An Hiſtorical Diſſertation concerning the Antiquity of the Britiſh Conſtitution, which he publiſhed before he had completed his twenty-ſecond year, and which had ſo much merit as to induce the univerſity of Edinburgh to confer upon the author, though ſo young a man, the degree of LL.D.

After a ſtudious interval of ſome years, he produced a valuable work, under the title of A View of Society in Europe, in its Progreſs from Rudeneſs to Refinement; or, Inquiries concerning the Hiſtory of Laws, Government, and Manners. He had read and meditated with patience on the moſt important monuments of the middle ages; and in this volume (which ſpeedily reached a ſecond edition) he aimed chiefly at the praiſe of originality and invention, and diſcovered an induſtry that is ſeldom connected with ability and diſcernment. About the time of the publication of the firſt edition of this performance, having turned his thoughts to an academical life, he aſked for the profeſſorſhip of public law in the univerſity of Edinburgh. According to his own account he had been promiſed that place by the miniſter, but had the mortification to ſee the profeſſorſhip beſtowed on another, and all his hopes blaſted by the influence of Dr Robertſon, whom he repreſented as under obligations to him.

To the writer of this article, who was a ſtranger to theſe rival candidates for hiſtorical fame, this part of the ſtory ſeems very incredible; as it is not eaſy to conceive how it ever could be in the power of Dr Stuart to render to the learned Principal any eſſential ſervice. It was believed indeed by the earl of Buchan, and by others, who obſerved that the illiberal jealouſy not unfrequent in the world of letters, was probably the ſource of this oppoſition; which entirely broke the intimacy of two perſons who, before that time, were underſtood to be on the moſt friendly footing with each other. Ingratitude, however, is as likely to have been the vice of Dr Stuart as of Dr Robertſon; for we have been told by a writer *, who, at leaſt in one inſtance, has completely proved what he affirms, that "ſuch was Gilbert Stuart's laxity of principle as a man, that he conſidered ingratitude as one of the moſt venial ſins; ſuch was his conceit as a writer, that he regarded no one's merits but his own; ſuch were his diſappointments, both as a writer and a man, that he allowed his peeviſhneſs to ſour into malice, and indulged his malevolence till it ſettled in corruption."

* *Chalmers in his Life of Ruddiman.*

Soon after this diſappointment, Dr Stuart went to London, where he became from 1768 to 1774 one of the writers of the Monthly Review. In 1772 Dr Adam, rector of the high-ſchool at Edinburgh, publiſhed a Latin Grammar, which he intended as an improvement of the famous Ruddiman's. Stuart attacked him in a pamphlet under the name of *Buſhby*, and treated him with much ſeverity. In doing this, he was probably actuated more by ſome perſonal diſlike of Dr Adam than by regard for the memory of his learned relation; for on other occaſions he ſhowed ſufficiently that he had no regard to Ruddiman's honour as a grammarian, editor, or critic.

In 1774 he returned to his native city, and began the Edinburgh Magazine and Review, in which he diſcuſſed the liberty and conſtitution of England, and diſtinguiſhed himſelf by an inquiry into the character of John Knox the reformer, whoſe principles he reprobated in the ſevereſt terms. About this time he reviſed and publiſhed Sullivan's Lectures on the Conſtitution of England. Soon after he turned his thoughts to the hiſtory of Scotland, and publiſhed Obſervations concerning its Public Law and Conſtitutional Hiſtory; in which he examined with a critical care the preliminary book to Dr Robertſon's Hiſtory. His next work was The Hiſtory of the Reformation; a book which deſerves praiſe for the eaſy dignity of the narrative, and for ſtrict impartiality. His laſt great work, The Hiſtory of Scotland from the Eſtabliſhment of the Reformation to the Death of Queen Mary, which appeared in 1782, has been very generally read and admired. His purpoſe was to vindicate the character of the injured queen, and expoſe the weakneſs of the arguments by which Dr Robertſon had endeavoured to prove her guilty: but though the ſtyle of this work is his own, it contains very little matter which was not furniſhed by Goodall and Tytler; and it is with the arms which theſe two writers put into his hands that Dr Stuart attacked his great antagoniſt.

In 1782 he once more viſited London, and engaged in the Political Herald and Engliſh Review; but the jaundice and dropſy increaſing on him, he returned by ſea to his native country, where he died in the houſe of his father on the 13th of Auguſt 1786.

In his perſon Dr Stuart was about the middle ſize and juſtly proportioned. His countenance was modeſt and expreſſive, ſometimes glowing with ſentiments of friendſhip, of which he was truly ſuſceptible, and at others darting that ſatire and indignation at folly and vice which appear in ſome of his writings. He was a boon companion; and, with a conſtitution that might have ſtood the ſhock of ages, he fell a premature martyr to intemperance. His talents were certainly great, and his writings are uſeful; but he ſeems to have been influenced more by paſſion than prejudice, and in his character there was not much to be imitated.

STUCCO, in building, a compoſition of white marble pulveriſed, and mixed with plaſter of lime; and the whole being ſifted and wrought up with water, is to be uſed like common plaſter: this is called by Pliny *marmoratum opus*, and *albarium opus*.

Stucco.

A patent has been granted to Mr B. Higgins for inventing a new kind of ſtucco, or water-cement, more firm and durable than any heretofore. Its compoſition, as extracted from the ſpecification ſigned by himſelf, is as follows: "Drift-ſand, or quarry (A) ſand, which conſiſts chiefly of hard quartoſe flat-faced grains with ſharp angles; which is the freeſt, or may be moſt eaſily freed by waſhing, from clay, ſalts, and calcareous, gypſeous, or other grains leſs hard and durable than quartz; which contains the ſmalleſt quantity of pyrites or heavy metallic matter inſeparable by waſhing; and which ſuffers the ſmalleſt diminution of its bulk in waſhing in the following manner—is to be preferred before any other. And where a coarſe and a fine ſand of this kind, and correſponding in the ſize of their grains with the coarſe and fine ſands hereafter deſcribed, cannot be eaſily procured, let ſuch ſand of the foregoing quality be choſen as may be ſorted and cleanſed in the following manner:

"Let the ſand be ſifted in ſtreaming clear water, through a ſieve which ſhall give paſſage to all ſuch grains as do not exceed one-ſixteenth of an inch in diameter; and let the ſtream of water and the ſifting be regulated ſo that all the ſand, which is much finer than the Lynn-ſand commonly uſed in the London glaſs-houſes, together with clay and every other matter ſpecifically lighter than ſand, may be waſhed away with the ſtream, whilſt the purer and coarſer ſand, which paſſes through the ſieve, ſubſides in a convenient receptacle, and whilſt the coarſe rubbiſh and rubble remain on the ſieve to be rejected.

"Let the ſand which thus ſubſides in the receptacle be waſhed in clean ſtreaming water through a finer ſieve, ſo as to be further cleanſed and ſorted into two parcels; a coarſer, which will remain in the ſieve which is to give paſſage to ſuch grains of ſand only as are leſs than one-thirtieth of an inch in diameter, and which is to be ſaved apart under the name of *coarſe ſand*; and a finer, which will paſs through the ſieve and ſubſide in the water, and which is to be ſaved apart under the name of *fine ſand*.—Let the coarſe and the fine ſand be dried ſeparately, either in the ſun or on a clean iron-plate, ſet on a convenient ſurface, in the manner of a ſand-heat (B).

"Let lime be choſen (C) which is ſtone-lime, which heats the moſt in ſlaking, and ſlakes the quickeſt when duly watered; which is the freſheſt made and cloſeſt kept; which diſſolves in diſtilled vinegar with the leaſt effervescence, and leaves the ſmalleſt reſidue inſoluble, and in this reſidue the ſmalleſt quantity of clay, gypſum, or martial matter.

"Let the lime choſen according to theſe important rules be put in a braſs-wired ſieve to the quantity of 14 pounds. Let the ſieve be finer than either of the foregoing; the finer, the better it will be: let the lime be ſlaked (D) by plunging it in a butt filled with ſoft water, and raiſing it out quickly and ſuffering it to heat and fume, and by repeating this plunging and raiſing alternately, and agitating the lime, until it be made to paſs through the ſieve into the water; and let the part of the lime which does not eaſily paſs through the ſieve be rejected: and let freſh portions of the lime be thus uſed, until as many (E) ounces of lime have paſſed through the ſieve as there are quarts of water in the butt. Let the water thus impregnated ſtand in the butt cloſely covered (F) until it becomes clear; and through wooden (G) cocks placed at different heights in the butt), let the clear liquor be drawn off as faſt (H) and as

(A) "This is commonly called *pit-ſand*.

(B) "The ſand ought to be ſtirred up continually until it is dried, and is then to be taken off; for otherwiſe the evaporation will be very ſlow, and the ſand which lies next the iron plate, by being overheated, will be diſcoloured.

(C) "The preference given to ſtone-lime is founded on the preſent practice in the burning of lime, and on the cloſer texture of it, which prevents it from being ſo ſoon injured by expoſure to the air as the more ſpongy chalk-lime is; not on the popular notion that ſtone-lime has ſomething in it whereby it excels the beſt chalk in the cementing properties. The gypſum contained in lime-ſtone remains unaltered, or very little altered, in the lime, after the burning; but it is not to be expected that clay or martial matter ſhould be found in their native ſtate in well-burned lime; for they concrete or vitrify with a part of the calcareous earth, and conſtitute the hard grains or lumps which remain undiſſolved in weak acids, or are ſeparable from the ſlaked lime by ſifting it immediately through a ſieve.

(D) "This method of impregnating the water with lime is not the only one which may be adopted. It is, however, preferred before others, becauſe the water clears the ſooner in conſequence of its being warmed by the ſlaking lime; and the gypſeous part of the lime does not diffuſe itſelf in the water ſo freely in this way as it does when the lime is ſlaked to fine powder in the common method, and is then blended with the water; for the gypſeous part of the lime ſlakes at firſt into grains rather than into fine powder, and will remain on the ſieve after the pure lime has paſſed through, long enough to admit of the intended ſeparation; but when the lime is otherwiſe ſlaked, the gypſeous grains have time to ſlake to a finer powder, and paſſing through the ſieve, diſſolve in the water along with the lime. I have imagined that other advantages attended this method of preparing the lime-water, but I cannot yet ſpeak of them with preciſion.

(E) "If the water contains no more acidulous gas than is uſually found in river or rain water, a fourth part of this quantity of lime, or leſs, will be ſufficient.

(F) "The calcareous cruſt which forms on the ſurface of the water ought not to be broken, for it aſſiſts in excluding the air, and preventing the abſorption of acidulous gas whereby the lime-water is ſpoiled.

(G) "Braſs-cocks are apt to colour a part of the liquor.

(H) "Lime-water cannot be kept many days unimpaired, in any veſſels that are not perfectly air-tight. If the liquor be drawn off before it clears, it will contain whiting, which is injurious; and if it be not inſtantly uſed as low as the lime subsides, for use. This clear liquor I call the *cementing liquor* (I). The freer the water is from saline matter, the better will be the cementing liquor made with it.

" Let 56 pounds of the aforesaid chosen lime be slaked, by gradually sprinkling on it, and especially on the unslaked pieces, the cementing liquor, in a close (K) clean place. Let the slaked part be immediately (L) sifted through the last-mentioned fine brass-wired sieve: Let the lime which passes be used instantly, or kept in air-tight vessels, and let the part of the lime which does not pass through the sieve be rejected (M).—This finer richer part of the lime which passes through the sieve I call *purified lime*.

" Let bone-ash be prepared in the usual manner, by grinding the whitest burnt bones, but let it be sifted, to be much finer than the bone-ash commonly sold for making cupels.

" The most eligible materials for making my cement being thus prepared, take 56 pounds of the coarse sand and 42 pounds of the fine sand; mix them on a large plank of hard wood placed horizontally; then spread the sand so that it may stand to the height of six inches, with a flat surface on the plank; wet it with the cementing liquor; and let any superfluous quantity of the liquor, which the sand in the condition described cannot retain, flow away off the plank. To the wettest sand add 14 pounds of the putrefied lime in several successive portions, mixing and beating them up together in the mean time with the instruments generally used in making fine mortar: then add 14 pounds of the bone-ash in successive portions, mixing and beating all together. The quicker and the more perfectly these materials are mixed and beaten together, and the sooner the cement thus formed is used, the better (N) it will be. This I call the *water-cement coarse-grained*, which is to be applied in building, pointing, plastering, stuccoing, or other work, as mortar and stucco now are; with this difference chiefly, that as this cement is shorter than mortar or common stucco, and dries sooner, it ought to be worked expeditiously in all cases; and in stuccoing, it ought to be laid on by sliding the trowel upwards on it; that the materials used along with this cement in building, or the ground on which it is to be laid in stuccoing, ought to be well wetted with the cementing liquor in the instant of laying on the cement; and that the cementing liquor is to be used when it is necessary to moisten the cement, or when a liquid is required to facilitate the floating of the cement.

" When such cement is required to be of a finer texture, take 98 pounds of the fine sand, wet it with the cementing liquor, and mix it with the purified lime and the bone-ash in the quantities and in the manner above described; with this difference only, that 15 pounds of lime, or (O) thereabouts, are to be used instead of 14 pounds, if the greater part of the sand be as fine as Lynn-sand. This I call *water-cement fine-grained*. It is to be used in giving the last coating, or the finish to any work intended to imitate the finer-grained stones or stucco. But it may be applied to all the uses of the water-cement coarse-grained, and in the same manner.

" When for any of the foregoing purposes of pointing, building, &c. such a cement is required much cheaper and coarser-grained, then much coarser clean sand than the foregoing coarse sand, or well-washed fine rubble, is to be provided. Of this coarse sand or rubble take 56 pounds, of the foregoing coarse sand 28 pounds, and of the fine sand 14 pounds; and after mixing these, and wetting them with the cementing liquor in the foregoing manner, add 14 pounds, or somewhat less, of the (P) purified lime, and then 14 pounds or somewhat less

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used after it is drawn limpid from the butt into open vessels, it will grow turbid again, and deposit the lime changed to whiting by the gas absorbed from the air. The calcareous matter which subsides in the butt resembles whiting the more nearly as the lime has been more sparingly employed; in the contrary circumstances, it approaches to the nature of lime; and in the intermediate state, it is fit for the common composition of the plasterers for inside stucco.

(I) " At the time of writing this specification, I preferred this term before that of lime-water, on grounds which I had not sufficiently examined.

(K) " The vapour which arises in the slaking of lime contributes greatly to the slaking of these pieces which lie in its way; and an unnecessary waste of the liquor is prevented, by applying it to the lime heaped in a pit or in a vessel, which may restrain the issue of the vapour, and direct it through the mass. If more of the liquor be used than is necessary to slake the lime, it will create error in weighing the slaked powder, and will prevent a part of it from passing freely through the sieve. The liquid is therefore to be used sparingly, and the lime which has escaped its action is to be sprinkled apart with fresh liquor.

(L) " When the aggregation of the lumps of lime is thus broken, it is impaired much sooner than it is in the former state, because the air more freely pervades it.

(M) " Because it consists of heterogeneous matter or of ill-burnt lime; which last will slake and pass through the sieve, if the lime be not immediately sifted after the slaking, agreeable to the text.

(N) " These proportions are intended for a cement made with sharp sand, for incrustation in exposed situations, where it is necessary to guard against the effects of hot weather and rain. In general, half this quantity of bone-ashes will be found sufficient; and although the incrustation in this latter case will not harden deeply so soon, it will be ultimately stronger, provided the weather be favourable.

" The injuries which lime and mortar sustain by exposure to the air, before the cement is finally placed in a quiescent state, are great; and therefore our cement is the worse for being long beaten, but the better as it is quickly beaten until the mixture is effected, and no longer.

(O) " The quantity of bone-ashes is not to be increased with that of the lime; but it is to be lessened as the exposure and purposes of the work will admit.

(P) " Because less lime is necessary, as the sand is coarser.

Stucco. lefs of the bone-afh, mixing them together in the manner already defcribed. When my cement is required to be white, white fand, white lime, and the whiteft bone-afh are to be chofen. Gray fand, and gray bone-afh formed of half-burnt bones, are to be chofen to make the cement gray; and any other colour of the cement is obtained, either by choofing coloured fand, or by the admixture of the neceffary quantity of coloured talc in powder, or of coloured, vitreous, or metallic powders, or other durable colouring ingredients commonly ufed in paint.

"To the end that fuch a water-cement as I have defcribed may be made as ufeful as it is poffible in all circumftances; and that no perfon may imagine that my claim and right under thefe letters-patent may be eluded by divers variations, which may be made in the foregoing procefs without producing any notable defect in the cement; and to the end that the principles of this art, as well as the art itfelf, of making my cement, may be gathered from this fpecification and perpetuated to the public; I fhall add the following obfervations:

"This my water-cement, whether the coarfe or fine grained, is applicable in forming artificial ftone, by making alternate layers of the cement and of flint, hard ftone, or brick, in moulds of the figure of the intended ftone, and by expofing the maffes fo formed to the open (Q) air to harden.

"When fuch cement is required for water (R) fences, two-thirds of the prefcribed quantity of bone-afhes are to be omitted; and in the place thereof an equal meafure of powdered terras is to be ufed; and if the fand employed be not of the coarfeft fort, more terras muft be added, fo that the terras fhall be by weight one-fixth part of the weight of the fand.

"When fuch a cement is required of the fineft grain (S) or in a fluid form, fo that it may be applied with a brufh, flint powder, or the powder of any quartofe or hard earthy fubftance, may be ufed in the place of fand; but in a quantity fmaller, as the flint or other powder is finer; fo that the flint-powder, or other fuch powder, fhall not be more than fix times the weight of the lime, nor lefs than four times its weight. The greater the quantity of lime within thefe limits, the more will the cement be liable to crack by quick drying, and *vice verfa*. Stucco.

"Where fuch fand as I prefer cannot be conveniently procured, or where the fand cannot be conveniently wafhed and forted, that fand which moft refembles the mixture of coarfe and fine fand above prefcribed, may be ufed as I have directed, provided due attention is paid to the quantity of the lime, which is to be greater (T) as the quantity is finer, and *vice verfa*.

"Where fand cannot be eafily procured, any durable ftony body, or baked earth grofsly powdered (U), and forted nearly to the fizes above prefcribed for fand, may be ufed in the place of fand, meafure for meafure, but not weight for weight, unlefs fuch grofs powder be as heavy fpecifically as fand.

"Sand may be cleanfed from every fofter, lighter, and lefs durable matter, and from that part of the fand which is too fine, by various methods preferable (X), in certain circumftances, to that which I have defcribed.

"Water may be found naturally free from fixable gas, felenite, or clay; fuch water may, without any notable inconvenience, be ufed in the place of the cementing liquor; and water approaching this ftate will not require fo much lime as I have ordered to make the cementing liquor; and a cementing liquor fufficiently ufeful may be made by various methods of mixing lime and water in the defcribed proportions, or nearly fo.

"When ftone-lime cannot be procured, chalk-lime, or fhell-lime, which beft refembles ftone-lime, in the characters above written of lime, may be ufed in the manner

(Q) "But they muft not be expofed to the rain until they are almoft as ftrong as frefh Portland ftone; and even then they ought to be fheltered from it as much as the circumftances will admit. Thefe ftones may be made very hard and beautiful, with a fmall expence of bone-afh, by foaking them, after they have dried thoroughly and hardened, in the lime liquor, and repeating this procefs twice or thrice, at diftant intervals of time. The like effect was experienced in incruftations.

(R) "In my experiments, mortar made with terras-powder, in the ufual method, does not appear to form fo ftrong a cement for water-fences as that made, according to the fpecification, with coarfe fand; and I fee no more reafon for avoiding the ufe of fand in terras-mortar, than there would be for rejecting ftone from the embankment. The bone-afhes meant in this place are the dark gray or black fort. I am not yet fully fatisfied about the operation of them in this inftance.

(S) "The qualities and ufes of fuch fine calcareous cement are recommended chiefly for the purpofe of fmoothing and finifhing the ftronger cruftaceous works, or for wafhing walls to a lively and uniform colour. For this laft intention, the mixture muft be as thin as new cream, and laid on brifkly with a brufh, in dry weather; and a thick and durable coat is to be made by repeated wafhing; but is not to be attempted by ufing a thicker liquor; for the coat made with this laft is apt to fcale, whilft the former endures the weather much longer than any other thin calcareous covering that has been applied in this way. Fine yellow-ochre is the cheapeft colouring ingredient for fuch wafh, when it is required to imitate Bath-ftone, or the warm-white ftones.

(T) "If fea-fand be well wafhed in frefh water, it is as good as any other round fand.

(U) "The cement made with thefe and the proper quantities of purified lime and lime-water, are inferior to the beft, as the grains of thefe powders are more perifhable and brittle than thofe of fand. They will not therefore be employed, unlefs for the fake of evafion, or for want of fand: in this latter cafe, the finer powder ought to be wafhed away.

(X) "This and the next paragraph is inferted with a view to evafions, as well as to fuggeft the eafier and cheaper methods which may be adopted in certain circumftances, by artifts who underftand the principles which I endeavoured to teach.

manner defcribed, except that fourteen pounds and a half of chalk-lime will be required in the place of fourteen pounds of ftone-lime. The proportion of lime which I have prefcribed above may be increafed without inconvenience, when the cement or ftucco is to be applied where it is not liable to dry quickly; and in the contrary circumftance, this proportion may be diminifhed; and the defect of lime in quantity or quality may be very advantageoufly fupplied (Y), by caufing a confiderable quantity of the cementing liquor to foak into the work, in fucceffive portions, and at diftant intervals of time, fo that the calcareous matter of the cementing liquor, and the matter attracted from the open air, may fill and ftrengthen the work.

"The powder of almoft every well-dried or burnt animal fubftance may be ufed inftead of bone-afh; and feveral earthy powders, efpecially the micaceous and the metallic; and the elixated afhes of divers vegetables whofe earth will not burn to lime; and the afhes of mineral fuel, which are of the calcareous kind, but will not burn to lime, will anfwer the ends of bone-afh in fome degree.

"The quantity of bone-afh defcribed may be leffened without injuring the cement, in thofe circumftances efpecially which admit the quantity of lime to be leffened, and in thofe wherein the cement is not liable to dry quickly. And the art of remedying the defects of lime may be advantageoufly practifed to fupply the deficiency of bone afh, efpecially in building, and in making artificial ftone with this cement."

STUD, in the manege, a collection of breeding horfes and mares.

STUDDING-SAILS, certain light fails extended, in moderate and fteady breezes, beyond the fkirts of the principal fails, where they appear as wings upon the yard-arms.

STUFF, *in Commerce*, a general name for all kinds of fabrics of gold, filver, filk, wool, hair, cotton, or thread, manufactured on the loom; of which number are velvets, brocades, mohairs, fatins, taffetas, cloths, ferges, &c.

STUKELY, DR WILLIAM, a celebrated antiquarian, defcended from an ancient family in Lincolnfhire, was born at Holbech in 1687, and educated in Bennet college, Cambridge. While an under-graduate, he often indulged a ftrong propenfity to drawing and defigning; but made phyfic his principal ftudy, and firft began to practife at Bofton in his native country. In 1717 he removed to London, where, on the recommendation of Dr Mead, he was foon after elected a fellow of the Royal Society; he was one of the firft who revived that of the antiquarians in 1718, and was their fecretary for many years during his refidence in town. In 1729 he took holy orders by the encouragement of Archbifhop Wake; and was foon after prefented by Lord-chancellor King with the living of All-Saints in Stamford. In 1741 he became one of the founders of the Egyptian fociety, which brought him acquainted with the benevolent duke of Montague, one of the members; who prevailed on him to leave Stamford, and prefented him to the living of St George the Martyr, Queen Square. He died of a ftroke of the palfy in 1765. In his phyfical capacity, his Differtation on the Spleen was well received; and his *Itinerarium Curiofum*, the firft fruit of his juvenile excurfions, was a good fpecimen of what was to be expected from his riper age. His great learning, and profound refearches into the dark remains of antiquity, enabled him to publifh many elaborate and curious works: his friends ufed to call him the *arch-druid* of his age. His difcourfes, intitled *Palæographia Sacra*, on the vegetable creation, befpeak him a botanift, philofopher, and divine.

STUM, in the wine-trade, denotes the unfermented juice of the grape after it has been feveral times racked off and feparated from its fediment. The cafks are for this purpofe well matched or fumigated with brimftone every time, to prevent the liquor from fermenting, as it would otherwife readily do, and become wine. See MUST.

STUPIDITY. The Greek word μωροτης correfponds moft with our Englifh word *ftupidity* or *foolifhnefs*, when ufed to exprefs that ftate of mind in which the intellects are defective. The immediate caufes are faid to be, a deficiency of vital heat, or a defect in the brain. Stupid children fometimes become fprightly youths; but if ftupidity continues to the age of puberty, it is hardly ever removed. If ftupidity follows upon a violent paffion, an injury done to the head, or other evident caufe, and if it continues long, it becomes incurable. But the ftupidity which confifts in a lofs of memory, and fucceeds a lethargy, fpontaneoufly ceafes when the lethargy is cured.

STUPOR, a numbnefs in any part of the body, whether occafioned by ligatures obftructing the blood's motion, by the palfy, or the like.

STUPPA, or STUPE, in *Medicine*, is a piece of cloth dipped in fome proper liquor, and applied to an affected part.

STURDY, a diftemper to which cattle are fubject, called alfo the *turning evil*. See FARRIERY *Index*.

STURGEON. See ACCIPENSER, ICHTHYOLOGY *Index*.

STURMIUS, JOHN, a learned philologer and rhetorician, was born at Sleida in Eifel near Cologne in 1507. He ftudied at firft in his native country with the fons of Count de Manderfcheid, whofe receiver his father was. He afterwards purfued his ftudy at Liege in the college of St Jerom, and then went to Louvain in 1524. Five years he fpent there, three in learning and two in teaching. He fet up a printing-prefs with Rudger Refcius profeffor of the Greek tongue, and printed feveral Greek authors. He went to Paris in 1529, where he was highly efteemed, and read public lectures on the Greek and Latin writers, and on logic. He married there, and kept a great number of boarders: but as he liked what were called the *new opinions*, he was more than once in danger; and this undoubtedly was the reafon why he removed to Strafburg in 1537, in order to take poffeffion of the place offered him by the magiftrates. The year following he opened a fchool, which became

(Y) "This practice is noticed, as the remedy which may be ufed for the defects arifing from evafive meafures, and as the method of giving fpongy incruftations containing bone-afhes the greateft degree of hardnefs."

became famous, and by his means obtained of Maximilian II. the title of an univerſity in 1566. He was very well ſkilled in polite literature, wrote Latin with great purity, and was a good teacher. His talents were not confined to the ſchool; for he was frequently intruſted with deputations in Germany and foreign countries, and diſcharged theſe employments with great honour and diligence. He ſhowed extreme charity to the refugees on account of religion: He not only laboured to aſſiſt them by his advice and recommendations; but he even impoveriſhed himſelf for them. He died in his 82d year, after he had been for ſome time blind. He publiſhed many books; the principal of which are, 1. *Partitiones Dialecticæ.* 2. *De Educatione Principum.* 3. *De Nobilitate Anglicana.* 4. *Linguæ Latinæ reſolvendæ Ratio.* 5. Excellent Notes on Ariſtotle's and Hermogenes's Rhetoric, &c.

He ought not to be confounded with *John Sturmius*, a native of Mechlin, and phyſician and profeſſor of mathematics at Louvain, who alſo wrote ſeveral works.

STURNUS, the STARLING; a genus of birds belonging to the order of paſſeres. See ORNITHOLOGY *Index.*

STYE, or STYTHE, in the eye. See CRITHE.

STYLE, a word of various ſignifications, originally deduced from *ſtylos*, a kind of bodkin wherewith the ancients wrote on plates of lead, or on wax, &c. and which is ſtill uſed to write on ivory-leaves and paper prepared for that purpoſe, &c.

STYLE, in dialling, denotes the gnomon or cock of a dial raiſed on the plane thereof to project a ſhadow.

STYLE, in *Botany*. See BOTANY.

STYLE, in language, is the peculiar manner in which a man expreſſes his conceptions. It is a picture of the ideas which riſe in his mind, and of the order in which they are there produced.

The qualities of a good ſtyle may be ranked under two heads; perſpicuity and ornament. It will readily be admitted, that perſpicuity ought to be eſſentially connected with every kind of writing; and to attain it, attention muſt be paid, firſt to ſingle words and phraſes, and then to the conſtruction of ſentences. When conſidered with reſpect to words and phraſes, it requires theſe three qualities; purity, propriety, and preciſion. When conſidered with regard to ſentences, it requires a clear arrangement of the words and unity in the ſenſe; to which, if ſtrength and harmony be added, the ſtyle will become ornamented.

One of the moſt important directions to be obſerved by him who wiſhes to form a good ſtyle, is to acquire clear and preciſe ideas on the ſubject concerning which he is to write or ſpeak. To this muſt be added frequency of compoſition, and an acquaintance with the ſtyle of the beſt authors. A ſervile imitation, however, of any author is carefully to be avoided; for he who copies, can hardly avoid copying faults as well as beauties. A ſtyle cannot be proper unleſs it be adapted to the ſubject, and likewiſe to the capacity of our hearers, if we are to ſpeak in public. A ſimple, clear, and unadorned ſtyle, ſuch as that of Swift, is fitteſt for intricate diſquiſition; a ſtyle elegant as Addiſon's, or impetuous like Johnſon's, is moſt proper for fixing the attention on truths, which, though known, are too much neglected. We muſt not be inattentive to the ornaments of ſtyle, if we wiſh that our labours ſhould be read and admired; but he is a contemptible writer, who looks not beyond the dreſs of language, who lays not the chief ſtreſs upon his matter, and who does not regard ornament as a ſecondary and inferior recommendation. For further obſervations on the different kinds of ſtyle, ſee ORATORY, N° 99, &c.

STYLE, in *Juriſprudence*, the particular form or manner of proceeding in each court of juriſdiction, agreeable to the rules and orders eſtabliſhed therein: thus we ſay, the ſtyle of the court of Rome, of chancery, of parliament, of the privy-council, &c.

STYLE, in *Muſic*, denotes a peculiar manner of ſinging, playing, or compoſing; being properly the manner that each perſon has of playing, ſinging, or teaching; which is very different both in reſpect of different geniuſes, of countries, nations, and of the different matters, places, times, ſubjects, paſſions, expreſſions, &c. Thus we ſay, the ſtyle of Paleſtrina, of Lully, of Corelli, of Handel, &c.; the ſtyle of the Italians, French, Spaniards, &c.

Old STYLE, the Julian method of computing time, as the

New STYLE is the Gregorian method of computation. See KALENDAR.

STYLEPHORUS CHORDATUS, a genus of fiſhes belonging to the order of apodes. See ICHTHYOLOGY *Index*, and Tranſactions of the Linnæan Society, vol. i.

STYLET, a ſmall dangerous kind of poniard which may be concealed in the hand, chiefly uſed in treacherous aſſaſſinations. The blade is uſually triangular, and ſo ſmall that the wound it makes is almoſt imperceptible.

STYLITES, PILLAR SAINTS, in eccleſiaſtical hiſtory, an appellation given to a kind of ſolitaries, who ſtood motionleſs upon the tops of pillars, raiſed for this exerciſe of their patience, and remained there for ſeveral years, amidſt the admiration and applauſe of the ſtupid populace. Of theſe we find ſeveral mentioned in ancient writers, and even as low as the twelfth century, when they were totally ſuppreſſed.

The founder of the order was St Simeon Stylites, a famous anchoret in the fifth century, who firſt took up his abode on a column ſix cubits high; then on a ſecond of twelve cubits, a third of twenty-two, a fourth of thirty-ſix, and on another of forty cubits, where he thus paſſed thirty-ſeven years of his life. The tops of theſe columns were only three feet in diameter, and were defended by a rail that reached almoſt to the girdle, ſomewhat reſembling a pulpit. There was no lying down in it. The faquirs, or devout people of the Eaſt, imitate this extraordinary kind of life to this day.

STYLOCERALOIDES,
STYLO-GLOSSUS,
STYLO-Hyoidæus,
STYLO-Pharyngæus,
STYLOIDES,
} The names of different muſcles in the human body. See *Table of the Muſcles* under ANATOMY.

STYLOSANTHES, a genus of plants belonging to the *diadelphia* claſs, and in the natural method ranking under the 32d order, *Papilionaceæ*. See BOTANY *Index*.

STYPTIC, in *Pharmacy*, a medicine which by its aſtringency ſtops hæmorrhagies, &c. See MATERIA MEDICA *Index*.

STYRAX, the STORAX-TREE, a genus of plants belonging to the claſs *decandria*, and in the natural ſyſtem ranging

Styx, Suabia.

ranging under the 18th order, *bicornes*. See BOTANY and MATERIA MEDICA *Index*.

STYX, in *Fabulous Hiſtory*, a celebrated river of hell, round which it flows nine times. The gods held the waters of the Styx in ſuch veneration, that to ſwear by them was reckoned an oath altogether inviolable. If any of the gods had perjured themſelves, Jupiter obliged them to drink the waters of the Styx, which lulled them for one whole year into a ſenſeleſs ſtupidity, for the nine following years they were deprived of the ambroſia and the nectar of the gods, and after the expiration of the years of their puniſhment, they were reſtored to the aſſembly of the deities, and to all their original privileges. It is ſaid that this veneration was ſhown to the Styx, becauſe it received its name from the nymph Styx, who with her three daughters aſſiſted Jupiter in his war againſt the Titans.

Tranſactions of the Royal Society of Edinburgh, vol. ii.

Styx was a river which it was neceſſary for departed ſhades to paſs before they could enter the infernal regions; and it was the office of Charon to ferry them over in a boat which was kept for that purpoſe. The ghoſts of thoſe who had not been honoured with the rites of ſepulture were obliged to wander an hundred years before Charon could admit them into his boat to convey them before the judges of Hades. What could have given riſe to this fable of Charon and his boat, it is not very material to inquire. Mythological writers have ſaid, that the Greeks learned it from the Egyptians, which is indeed probable enough; that the Egyptians framed both this, and ſome other fables relating to the dead, from certain cuſtoms peculiar to their country; that in particular there was, not far from Memphis, a famous burying-place, to which the dead bodies were conveyed in a boat acroſs the lake Acheruſia; and that Charon was a boatman who had long officiated in that ſervice. The learned Dr Blackwell ſays, in his life of Homer, that, in the old Egyptian language, *Charoni* ſignified "ferryman."

SUABIA, a circle of Germany, bounded on the north by the circle of Franconia and that of the Lower Rhine; on the weſt by the circle of the Lower Rhine and Alſace; on the ſouth by Switzerland; and on the eaſt by the circle of Bavaria. Of all the circles of the empire, Suabia is the moſt divided; it contains four eccleſiaſtic and thirteen lay principalities, nineteen independent prelacies and abbeys, twenty-ſix earldoms and lordſhips, and thirty-one free cities. The prime directors of the circle, as they are termed, were formerly the biſhop of Conſtance and the duke of Wirtemberg. But this circle has ſuffered ſimilar changes with neighbouring ſtates.

Baron Rieſbeck's Travels through Germany, vol. i.

The mixture of the various forms of government and religious ſects; the oppreſſion exerciſed by the great on the poor; the game conſtantly played by the emperor, who poſſeſſes many pieces of detached country in Suabia, which depend not on the circle, and can, in conſequence of his privileges as archduke of Auſtria, extend his poſſeſſions in it by various ways; are circumſtances (ſays Baron Rieſbeck) which give the cultivation of the country, and the character of the inhabitants, a moſt extraordinary caſt. In ſeveral of the poſt towns where you ſtop, you ſee the higheſt degree of cultivation in the midſt of the moſt ſavage wildneſs; a great degree of knowledge and poliſh of manners, mixed with the groſſeſt ignorance and ſuperſtition; traces of liberty, under the deepeſt oppreſſion; national pride, together with the contempt and neglect of the native country; in ſhort, all the ſocial qualities in ſtriking contraſt and oppoſition to each other. Thoſe parts of Suabia which belong to the great potentates, ſuch as Wirtemberg, Auſtria, and Baden, are certainly the moſt improved. The whole of Suabia may comprehend about nine hundred German ſquare miles, and two millions of people. More than half of theſe are ſubjects of the three above mentioned princes, though they are not proprietors of near one half of the lands.

Suabia ‖ Subduple Ratio.

SUARES, FRANCIS, a Jeſuit, was born in Granada on the 5th of January 1548. He was a profeſſor of theology at Alcala, Salamanca, Rome, and Coimbra in Portugal. He died at Liſbon in 1617 with the greateſt reſignation; "I never thought (ſaid he) that it was ſo eaſy to die." His memory was aſtoniſhing, he could repeat the whole of his voluminous works by heart. His writings fill 23 folio volumes, and are moſtly on theological and moral ſubjects. His Treatiſe of Laws has been reprinted in this country. His Defence of the Catholic Faith againſt the Errors of England was written at the requeſt of Pope Paul V. This book was publicly burnt at London by order of James I. When Suares heard it, he is ſaid to have exclaimed, "O that I too could ſeal with my blood the truths which I have defended with my pen!"

SUBAH, the general name of the viceroyſhips, or greater governments, into which the Mogul empire was divided, conſiſting of ſeveral provinces. The juriſdiction of a ſubahdar, the ſame as ſubahſhip, ſubaedaree, or nizamut.

SUBAHDAR, the viceroy, lord-lieutenant, or governor, holding a ſubah; the ſame as nabob or nazim. Alſo the black commander of a company of ſeapoys.

SUBALTERN, a ſubordinate officer, or one who diſcharges his poſt under the command and ſubject to the direction of another; ſuch are lieutenants, ſublieutenants, cornets, and enſigns, who ſerve under the captain.

SUBCLAVIAN, in *Anatomy*, is applied to any thing under the armpit or ſhoulder, whether artery, nerve, vein, or muſcle.

SUBDEACON, an inferior miniſter, who anciently attended at the altar, prepared the ſacred veſſels, delivered them to the deacons in time of divine ſervice, attended the doors of the church during communion-ſervice, went on the biſhop's embaſſies with his letters or meſſages to foreign churches, and was inveſted with the firſt of the holy orders. They were ſo ſubordinate to the ſuperior rulers of the church, that, by a canon of the council of Laodicea, they were forbidden to ſit in the preſence of a deacon without his leave. According to the canons, a perſon muſt be twenty-two years of age to be promoted to the order of ſubdeacon. See DEACON.

SUBDOMINANT, in *Muſic*, a name given by M. Rameau to the fourth note of the tone, which of conſequence is the ſame interval from the tonic when deſcending as the dominant in riſing. This denomination ariſes from the affinity which this author finds by inverſion between the minor mode of the ſubdominant and the major mode of the tonic.

SUBDUPLE RATIO, is when any number or quantity is contained in another twice. Thus 3 is ſaid to be ſubduple of 6, as 6 is duple of 3. See RATIO.

SUBDUPLICATE

Subduplicate ‖ Subornation.

SUBDUPLICATE RATIO of any two quantities, is the ratio of their ſquare roots.

SUBER, the CORK-TREE. See QUERCUS, BOTANY *Index*.

SUBJECT, a perſon under the rule and dominion of a ſovereign prince or ſtate.

SUBJECT is alſo uſed for the matter of an art or ſcience, or that which it conſiders, or whereon it is employed: thus the human body is the ſubject of medicine.

SUBINFEUDATION, was where the inferior lords, in imitation of their ſuperiors, began to carve out and grant to others minuter eſtates than their own, to be held of themſelves; and were ſo proceeding downwards *in infinitum*, till the ſuperior lords obſerved, that by this method of ſubinfeudation they loſt all their feodal profits, of wardſhips, marriages, and eſcheats, which fell into the hands of theſe meſne or middle lords, who were the immediate ſuperiors of the terre-tenant, or him who occupied the land. This occaſioned the ſtat. of Weſtm. 3. or *quia emptores*, 18. Edw. I. to be made; which directs, that, upon all ſales or feoffments of lands, the feoffee ſhall hold the ſame, not of his immediate feoffer, but of the chief lord of the fee of whom ſuch feoffer himſelf held it. And from hence it is held, that all manors exiſting at this day muſt have exiſted by immemorial preſcription; or at leaſt ever ſince the 18 Edw. I. when the ſtatute of *quia emptores* was made.

Blackſt. Commentary, vol. ii.

SUBITO, in the Italian muſic, is uſed to ſignify that a thing is to be performed quickly and haſtily: thus we meet with *volti ſubito*, turn over the leaf quickly.

SUBJUNCTIVE, in *Grammar*. See GRAMMAR.

SUBLIMATE, a chemical preparation, conſiſting of quickſilver united with muriatic acid. See MERCURY, CHEMISTRY *Index*.

SUBLIMATION, in *Chemiſtry*, the condenſing and collecting, in a ſolid form, by means of veſſels aptly conſtructed, the fumes of bodies raiſed from them by the application of a proper heat.

SUBLIME, or SUBLIMITY. See the article GRANDEUR and SUBLIMITY.

SUBLINGUAL ARTERY. See ANATOMY.

SUBLINGUAL Glands, in *Anatomy*, two glands under the tongue, placed one on each ſide thereof.

SUBMULTIPLE, in *Geometry*, &c. A ſubmultiple number, or quantity, is that which is contained a certain number of times in another, and which, therefore, repeated a certain number of times, becomes exactly equal thereto. Thus 3 is a ſubmultiple of 21. In which ſenſe a ſubmultiple coincides with an aliquot part.

SUBMULTIPLE Ratio, is that between the quantity contained and the quantity containing. Thus the ratio of 3 to 21 is ſubmultiple. In both caſes ſubmultiple is the reverſe of multiple: 21, *e. gr.* being a multiple of 3, and the ratio of 21 to 3 a multiple ratio.

SUBORDINARIES. See HERALDRY, Chap. III. Sect. II.

SUBORDINATION, a relative term, expreſſing an inferiority betwixt one perſon and another.

SUBORNATION, in *Law*, a ſecret, underhand, preparing, inſtructing, or bringing in a falſe witneſs; and from hence *ſubornation of perjury* is the preparing or corrupt alluring to perjury. The puniſhment for this crime was formerly death, then baniſhment or cutting out the tongue, afterwards forfeitures of goods; and it is now a fine and impriſonment, and never more to be received as evidence. The ſtatute 2 Geo. II. c. 25. ſuperadded a power for the court to order the offender to be ſent to the houſe of correction for a term not exceeding ſeven years, or be tranſported for the ſame period.

Subornation ‖ Subſcription.

SUBPOENA, in *Law*, a writ whereby common perſons are called into chancery, in ſuch caſes where the common law hath provided an ordinary remedy; and the name of it proceeds from the words therein, which charge the party called to appear at the day and place affirmed, *ſub pœna centum librarum*, &c. The ſubpœna is the leading proceſs in the courts of equity; and by ſtatute, when a bill is filed againſt any perſon, proceſs of ſubpœna ſhall be taken out to oblige the defendant to appear and anſwer the bill, &c.

SUBPOENA ad teſtificandum, a writ or proceſs to bring in witneſſes to give their teſtimony. If a witneſs on being ſerved with this proceſs does not appear, the court will iſſue an attachment againſt him; or a party, plaintiff or defendant, injured by his non-attendance, may maintain an action againſt the witneſs. See *Blackſt. Com.* vol. viii. p. 369.

SUBPOENA, in *Equity*, a proceſs in equity, calling on a defendant to appear and anſwer to the complainant's bill. See ſtatute 5th Geo. II. c. 25. which enacts, that where the party cannot be found to be ſerved with a ſubpœna, and abſconds (as is believed) to avoid being ſerved, a day ſhall be appointed him to appear to the bill of the plaintiff; which is to be inſerted in the London Gazette, read in the pariſh church where the defendant laſt lived, and fixed up at the Royal Exchange: and if the defendant doth not appear upon that day, the bill ſhall be taken *pro confeſſo*.

SURREPTITIOUS, a term applied to a letter, licence, patent, or other act, fraudulently obtained of a ſuperior, by concealing ſome truth which, had it been known, would have prevented the conceſſion or grant.

SUBROGATION, or SURROGATION, in the civil law, the act of ſubſtituting a perſon in the place, and intitling him to the rights, of another. In its general ſenſe, ſubrogation implies a ſucceſſion of any kind, whether of a perſon to a perſon, or of a perſon to a thing.

There are two kinds of ſubrogation: the one *conventional*, the other *legal*. *Conventional* ſubrogation is a contract whereby a creditor transfers his debt, with all appurtenances thereof, to the profit of a third perſon. *Legal* ſubrogation is that which the law makes in favour of a perſon who diſcharges an antecedent creditor; in which caſe there is a legal tranſlation of all rights of the ancient creditor to the perſon of the new one.

SUBSCRIPTION, in general, ſignifies the ſignature put at the bottom of a letter, writing, or inſtrument.

In commerce, it is uſed for the ſhare or intereſt which particular perſons take in a public ſtock or a trading company, by writing their names, and the ſhares they require, in the books or regiſter thereof.

SUBSCRIPTION to articles of faith is required of the clergy of every eſtabliſhed church, and of ſome churches not eſtabliſhed. Whether ſuch ſubſcription ſerves any good purpoſe, in a religious or theological view, is a very doubtful queſtion. It may be neceſſary in an eſtabliſhment, as a teſt of loyalty to the prince, and of attachment to the conſtitution, civil and eccleſiaſtical, but it cannot

 produce

produce uniformity of opinion. As all language is more or less ambiguous, it becomes difficult, if not impossible, to determine in what sense the words of long established creeds are to be interpreted; and we believe that the clergy of the churches of England and Scotland seldom consider themselves as fettered by the Thirty-nine Articles, or the Confession of Faith, when composing instructions either for their respective parishes or for the public at large. See INDEPENDENTS.

SUBSCRIPTION, in the commerce of books, signifies an engagement to take a certain number of copies of a book, intended to be printed, and a reciprocal obligation of the bookseller or publisher to deliver the said copies, on certain terms. These subscriptions, which had their rise in England about the middle of the 17th century, were lately very frequent in France and Holland, and are now very common among ourselves.

SUBSEQUENT, something that comes after another, particularly with regard to the order of time.

SUBSIDY, in *Law*, signifies an aid or tax granted to the king by parliament, for the necessary occasions of the kingdom; and is to be levied on every subject of ability, according to the rate or value of his lands or goods: but this word, in some of our statutes, is confounded with that of customs. See TAX.

SUBSTANCE, the subjects to which we suppose qualities belong. Thus gold is the substance to which the qualities of ductility, yellowness, density, &c. belong. See METAPHYSICS, n° 145.

SUBSTANTIAL, in the schools, something belonging to the nature of substance.

SUBSTANTIVE, in *Grammar*. See GRAMMAR.

SUBSTITUTE, a person who officiates for another in his absence.

SUBSTITUTION, in the *Civil Law*, a disposition of a testament, whereby the testator substitutes one heir for another, who has only the usufruct, and not the property or the thing, left him.

SUBSTRACTION, or SUBTRACTION, in *Arithmetic*, the second rule, or rather operation, in arithmetic, whereby we deduct a less number from a greater, to learn their precise difference. See ARITHMETIC and ALGEBRA.

SUBTANGENT OF A CURVE, the line that determines the intersection of a tangent with the axis; or that determines the point wherein the tangent cuts the axis prolonged.

SUBTENSE, formed from *sub* "under," and *tendo* "I stretch," in *Geometry*, a right line which is opposite to an angle, and drawn between the two extremities of the arch which measures that angle.

SUBTERRANEOUS, whatever is under ground: thus naturalists speak of subterraneous fires, subterraneous damps, &c.

SUBTERRANEOUS Cavern. See QUARRIES.

SUBTILE, in *Physics*, an appellation given to whatever is extremely small, fine, and delicate; such as the animal spirits, the effluvia of odorous bodies, &c. are supposed to be.

SUBULARIA, ROUGH-LEAVED ALYSSON, or *Awlwort*, a genus of plants belonging to the class tetradynamia, and in the natural order ranging under the 39th order, *siliquosæ*. See BOTANY *Index*.

SUBULATED, something shaped like an awl.

SUCCEDANEUM, in *Pharmacy*, denotes a drug substituted in the place of another.

SUCCESSION, in *Metaphysics*, the idea which we get by reflecting on the ideas that follow one another in our mind; and from the succession of ideas we get the idea of *time*. See METAPHYSICS, N° 93. and 209.

SUCCESSION, in *Law*. See DESCENT.

SUCCESSION to the Crown. See *HEREDITARY Right*.—From the days of Egbert, the first sole monarch of England, even to the present, the four cardinal maxims mentioned in that article have ever been held constitutional canons of succession. It is true, as Sir William Blackstone observes, this succession, through fraud or force, or sometimes through necessity, when in hostile times the crown descended on a minor or the like, has been very frequently suspended; but has generally at last returned back into the old hereditary channel, though sometimes a very considerable period has intervened. And even in those instances where this succession has been violated, the crown has ever been looked upon as hereditary in the wearer of it. Of which the usurpers themselves were so sensible, that they for the most part endeavoured to vamp up some feeble show of a title by descent, in order to amuse the people, while they gained the possession of the kingdom. And, when possession was once gained, they considered it as the purchase or acquisition of a new estate of inheritance, and transmitted, or endeavoured to transmit it, to their own posterity by a kind of hereditary right of usurpation. (See Black. Com. vol. i. 197—217.). From the historical view there given, it appears that the title to the crown is at present hereditary, though not quite so absolutely hereditary as formerly: and the common stock or ancestor, from whom the descent must be derived, is also different. Formerly the common stock was King Egbert; then William the Conqueror; afterwards, in James I.'s time, the two common stocks united; and so continued till the vacancy of the throne in 1688: now it is the Princess Sophia in whom the inheritance was vested by the new king and parliament. Formerly, the descent was absolute, and the crown went to the heir without any restriction: but now, upon the new settlement, the inheritance is conditional: being limited to such heirs only, of the body of the Princess Sophia, as are Protestant members of the church of England, and are married to none but Protestants.

And in this due medium consists the true constitutional notion of the right of succession to the imperial crown of these kingdoms. The extremes between which it steers are each of them equally destructive of those ends for which societies were formed and kept on foot. Where the magistrate, upon every succession, is elected by the people, and may by the express provision of the laws be deposed (if not punished) by his subjects, this may sound like the perfection of liberty, and look well enough when delineated on paper; but in practice will be ever productive of tumult, contention, and anarchy. And, on the other hand, divine indefeasible hereditary right, when coupled with the doctrine of unlimited passive obedience, is surely of all constitutions the most thoroughly slavish and dreadful. But when such an hereditary right as our laws have created and vested in the royal stock, is closely interwoven with those liberties which are equally the inheritance of the subject; this union

union will form a constitution, in theory the most beautiful of any, in practice the most approved, and, we trust, in duration the most permanent.

In France the succession to the monarchy was limited to heirs male (see SALIC); but in Navarre the crown was inherited by the heir of line, whether male or female. The case stands thus: Philip the Fourth, king of France, surnamed *the Fair*, in the year 1285 espoused Jane queen of Navarre in her own right; and as king consort of this latter kingdom added the title of Navarre to his former one of France. Louis X. son and heir of Philip and Jane (surnamed *Hutin* or the *Boisterous*), succeeded to both crowns. By Margaret his first wife, who had been crowned queen of Navarre, he left one daughter, Joan or Jane. His second wife Clementina was pregnant at the time of his decease, and was delivered of a posthumous son, whom most of the French annalists recognize as John I. of France, though he lived no longer than three weeks. On his death the kingdom of France passed to Philip V. (surnamed *the Long*), and that of Navarre (to which the Salic law could by no construction extend) to Joanna the only child and heir of Louis and Margaret. From Joanna, in lineal succession, the kingdom of Navarre passed to Jane d'Albret, mother of Henry IV. of France, and wife of Anthony of Vendosme, who as king consort wore the crown of Navarre. On the accession of Henry to the kingdom of France, the two monarchies were united, and the four succeeding princes assumed the joint titles.

SUCCINIC ACID, an acid extracted from amber by sublimation in a gentle heat, and which rises in a concrete form into the neck of the subliming vessel. See CHEMISTRY *Index*.

SUCCINUM, AMBER, in *Mineralogy*, a species of bitumen classed under the inflammable substances. See MINERALOGY *Index*.

SUCCORY. See CICHORIUM, BOTANY *Index*.

SUCCOTH, in *Ancient Geography*, a town which lay between the brook Jabbok and the river Jordan, where Jacob fixed his tents. There was another Succoth, where the Israelites first encamped after their departure from Rameses towards the Red sea. Succoth signifies *tents*.

SUCCUBUS, a term used by some writers for a dæmon who assumes the shape of a woman, and as such lies with a man; in which sense it stands opposed to *incubus*, which was a dæmon in form of a man, that lies with a woman. But the truth is, the succubus is only a species of the nightmare. See MEDICINE, N° 329.

SUCCULA, in *Mechanics*, an axis or cylinder, with staves in it to move it round; but without any tympanum or peritrochium.

SUCCULENT PLANTS, among botanists, such whose leaves are thick and full of juice.

SUCKER. See CYCLOPTERUS, ICHTHYOLOGY *Index*.

SUCKERS, in *Gardening*, the same with OFFSETS.

SUCKING-FISH. See ECHENEIS, ICHTHYOLOGY *Index*.

SUCKLING, SIR JOHN, an English poet and dramatic writer, was the son of Sir John Suckling, comptroller of the household to King Charles I. and born at Witham in Essex in 1613. He discovered an uncommon propensity to the acquiring of languages, insomuch that he is reported to have spoken Latin at five years of age, and to have written it at nine. When he grew up, he travelled; but seems to have affected nothing more than the character of a courtier and fine gentleman; which he so far attained, that he was allowed to have the peculiar happiness of making every thing he did become him. In his travels he made a campaign under the great Gustavus Adolphus; and his loyalty, if not his valour, appeared in the beginning of our civil wars; for, after his return to England, he raised a troop of horse for the king's service entirely at his own charge; and mounted them so completely and richly, that they are said to have cost him 12,000l. This troop, with Sir John at its head, behaved so ill in the engagement with the Scots, upon the English borders, in 1639, as to occasion the famous lampoon composed by Sir John Mennis; "Sir John he got him an ambling nag," &c. This ballad, which was set to a brisk tune, was much sung by the parliamentarians, and continues to be sung to this day. This disastrous expedition, and the ridicule that attended it, was supposed to have hastened his death; being seized by a fever, of which he died, at 28 years of age. He was a sprightly wit, and an easy versifier, but no great poet. His works, consisting of a few poems, letters, and plays, have nevertheless gone through several editions.

SUCTION, the act of sucking or drawing up a fluid, as air, water, milk, or the like, by means of the mouth and lungs; or, in a similar manner, by artificial means. See PNEUMATICS and HYDRODYNAMICS.

SUDATORY, a name given by the ancient Romans to their hot or sweating rooms; sometimes also called *Laconica*.

SUDEROE. See *FERRO-Islands*.

SUDORIFIC, an appellation given to any medicine that causes or promotes sweat.

SUESSIONES, a branch of the Remi, a people of Gallia Belgica (Pliny); called sometimes *Suessones*, in the lower age *Suessi*; situated between the Remi to the east, the Nervii to the north, the Veromandui to the west, and the Meldæ to the south, in the tract now called *le Soissonois*.—*Suessiones*, *Suessones*, and *Suessonæ*, the name of their city in the lower age; thought to have been formerly called *Noviodunum* (Cæsar), is now called *Soissons*.

SUET, SEVUM, or *Sebum*, in *Anatomy*, the solid fat found in several animals, as sheep, oxen, &c. but not in the human species. See the article FAT.—It is of the sevum that tallow is made.

SUETONIUS TRANQUILLUS, CAIUS, a famous Latin historian, was born at Rome, and became secretary to the emperor Adrian, about the 118th year of the Christian era; but that post was taken from him three years after, when several persons fell under that prince's displeasure for not showing the empress Sabina all the respect she deserved. During his disgrace he composed many works, which are lost. Those now extant are his History of the XII first Emperors, and a part of his treatise of the Illustrious Grammarians and Rhetoricians. Pliny the Younger was his intimate friend, and persuaded him to publish his books. His History of the XII Roman Emperors has been much commended by most of our polite scholars. He represents, in a continued series of curious and interesting particulars, without any digressions or reflections, the actions of the emperors, without omitting their vices, which he exposes with all their

their deformity, and with the ſame freedom mentions the good qualities of the very ſame perſons; but the horrid diſſoluteneſs and obſcene actions he relates of Tiberius, Caligula, Nero, &c. have made ſome ſay, that he wrote the lives of the emperors with the ſame licentiouſneſs with which they lived. The edition of this hiſtory procured by Grævius at Utrecht in 1672, with the excellent Commentaries of Torrentius and Caſaubon, and the notes of ſome other learned critics, is much eſteemed. Burman alſo publiſhed an edition in 2 vols. 4to, with notes.

SUEVI, the Catti or Chatti of Cæſar (Strabo), placed on the Rhine: the reaſon of Cæſar's calling them thus does not appear, though conſiderably diſtant from the proper Suevi or Alemanni.

SUEVI, (Tacitus), a common name of the people ſituated between the Elbe and the Viſtula, diſtinguiſhed otherwiſe by particular names; as in Ptolemy, *Suevi Angeli, Suevi Sennones.*

SUEVUS, in *Ancient Geography*, a river of Germany, thought to be the ſame with the Viadrus or Oder, emptying itſelf at three mouths into the Baltic, the middlemoſt of which is called *Swine* or *Swene;* which laſt comes nearer the name *Suevus.*

SUEZ, a ſmall ſea-port town, ſituated near the northern extremity of the Red ſea, and about 30 hours journey eaſt from Cairo. The country around it is a ſandy plain, without the ſmalleſt ſpot of verdure. The only water which can be drunk is brought from El-Naba, or the ſpring, at the diſtance of three hours journey; and it is ſo brackiſh, that without a mixture of rum it is inſupportable to Europeans. The town itſelf is a collection of miſerable ruins, the khans being the only ſolid buildings; yet from March till June, the ſeaſon when the Jidda and Yambo fleet arrives, the town becomes crowded; but after its departure nobody remains except the governor, who is a Mamlouk, 12 or 14 perſons who form his houſehold, and the garriſon. The fortreſs is a defenceleſs heap of ruins, which the Arabs conſider as a citadel, becauſe it contains ſix braſs four-pounders, and two Greek gunners, who turn their heads aſide when they fire. The harbour is a wretched quay, where the ſmalleſt boats are unable to reach the ſhore, except at the higheſt tides. There, however, the merchandiſe is embarked, to convey it over the banks of ſand to the veſſels which anchor in the road. This road, ſituated a league from the town, is ſeparated from it by a ſhore which is left dry at low water; it has no works for its defence, ſo that the veſſels which M. Volney tells us he has ſeen there, to the number of 28 at a time, might be attacked without oppoſition; for the ſhips themſelves are incapable of reſiſtance, none having any other artillery than four ruſty ſwivels.

Volney's Travels, vol. i.

Suez has always been, notwithſtanding its local diſadvantages, a place of great trade, on account of its geographical ſituation. It was by the gulf of Suez that the commodities of India were formerly conveyed to Europe, till the diſcovery of the paſſage by the Cape of Good Hope converted that trade into a new channel. As the iſthmus of Suez, which ſeparates the Red ſea from the Mediterranean, is not more than 57 miles, it has been frequently propoſed to join theſe two ſeas together by a canal. As there are no mountains nor remarkable inequalities of ſurface, this plan would at firſt view appear eaſy to be executed. But though the difference of levels would not prevent a junction, the great difficulty ariſes from the nature of the correſponding coaſts of the Mediterranean and the Red ſea, which are of a low and ſandy ſoil, where the waters form lakes, ſhoals, and moraſſes, ſo that veſſels cannot approach within a conſiderable diſtance. It will therefore be found ſcarcely poſſible to dig a permanent canal amid theſe ſhifting ſands: not to mention, that the ſhore is deſtitute of harbours, which muſt be entirely the work of art. The country beſides has not a drop of freſh water, and to ſupply the inhabitants, it muſt be brought as far as from the Nile.

The beſt and only method therefore of effecting this junction, is that which has been already ſucceſsfully practiſed at different times; which is, by making the river itſelf the medium of communication, for which the ground is perfectly well calculated; for Mount Mokattum ſuddenly terminating in the latitude of Cairo, forms only a low and ſemicircular mound, round which is a continued plain from the banks of the Nile as far as the point of the Red ſea. The ancients, who early underſtood the advantage to be derived from this ſituation, adopted the idea of joining the two ſeas by a canal connected with the river. Strabo * obſerves, that this was firſt executed under Seſoſtris, who reigned about the time of the Trojan war; and this work was ſo conſiderable as to occaſion it to be remarked, "that it was 100 cubits (or 170 feet) wide, and deep enough for large veſſels." After the Greeks conquered the country, it was reſtored by the Ptolemies, and again renewed by Trajan. In ſhort, even the Arabs themſelves followed theſe examples. "In the time of Omar ebn-el-Kattab (ſays the hiſtorian El Makin), the cities of Mecca and Medina ſuffering from famine, the caliph ordered Amrou governor of Egypt to cut a canal from the Nile to Kolzoum, that the contributions of corn and barley appointed for Arabia might be conveyed that way."

* Lib. xvii.

This canal is the ſame which runs at preſent to Cairo, and loſes itſelf in the country to the north-eaſt of Berket-el-Hadj, or the Lake of the Pilgrims.

The place on the weſt coaſt of the gulf of Suez, where the children of Iſrael are ſuppoſed to have entered it, is called *Badea*, about ſix miles to the north of Cape Korondel, on the other ſide of the gulf, as we are informed in a letter from the ingenious Edward Wortley Montague, F. R. S. to Dr Watſon, containing an account of his journey from Cairo to the Written Mountains in the deſert of Sinai. Oppoſite to Badea is a ſtrong current which ſets to the oppoſite ſhore, about ſouth-eaſt, with a whirlpool called *Birque Pharaone*, the *well* or *pool of Pharaoh*, being the place where his hoſt is ſaid to have been deſtroyed. We are told by the ſame gentleman, that the Egyptian ſhore from Suez to Badea is ſo rocky and ſteep, that there was no entering upon the gulf but at one of theſe two places.

The Britiſh nation, we believe, never attempted to carry on commerce with any of the ports of the Red ſea beyond Jidda, till, on the ſuggeſtion of Mr Bruce, in 1776, ſome Britiſh merchants at Bengal equipped two or three veſſels for Suez, laden with piece-goods of Bengal and coaſt manufactures. The command of the veſſels was committed to Captain Greig, a meritorious ſeaman; and the management of the goods was entruſted to Mr Straw, a gentleman diſtinguiſhed for his mercantile knowledge. The ſale turned out to advantage; but such great expences were incurred in making presents to the bey of Cairo and Suez, as to consume the whole profits gained by the sale of the cargo. The great purpose of the expedition was, however, accomplished, as a firman was obtained from the government of Cairo to trade by the way of Suez. In consequence of this, three ships went to Suez the following year, and as many in 1778. The opening of this trade alarmed the jealousy of the East India Company; they applied to our government, and orders were given to relinquish this promising commerce. These orders reached Egypt sooner than Bengal, and the consequence was fatal to the unfortunate adventurers who visited Suez that year (1779). By a plan concerted between the beys, a large body of Bedouin Arabs attacked the caravan passing from Suez to Cairo with goods valued at 12 lacks of rupees. The goods were plundered, the Europeans were stripped and left naked in the desert, exposed to the burning rays of the sun, without a drop of water to quench their thirst, or food to support life. Most of them died, and some of their bodies were afterwards found mangled and disfigured by wolves. We have been favoured with a particular account of the sufferings of our countrymen by a correspondent, which, we are sorry, we have not room to insert. Those who wish to obtain a more full account may consult the Annual Register for 1781 or 1782.

SUFFETULA, in *Ancient Geography*, a town of Africa, in the dominions of Carthage; probably so called from Suffetes, the title of the magistrates of that city. It is now called *Spaitla*, in the kingdom of Tunis, and has many elegant remains of antiquity. There are three temples in a great measure entire; one of them of the Composite order, the other two Corinthian. "A beautiful and perfect capital of the Composite order (says Mr Bruce), the only perfect one that now exists, is designed in all its parts in a very large size; and with the detail of the rest of the ruin, is a precious monument of what that order was, now in the collection of the king." The town itself (he says) is situated in the most beautiful spot in Barbary, surrounded by great numbers of juniper-trees, and watered by a pleasant stream, which sinks under the earth at that place, without appearing any more.

SUFFOCATION, the privation of the function of respiration or breathing. See the articles DROWNING, HANGING, &c.

SUFFOLK, a county of England. Its name is contracted from *Southfolk*, so called from its situation in regard to Norfolk. It is bounded on the west by Cambridge-shire; on the south by Essex, from which it is parted by the river Stour; on the east by the German ocean; and on the north by Norfolk, separated from it by the Lesser Ouse and the Waveney. From west to east it is 52 miles in length, about 20 at a medium in breadth, and 196 in circumference. It contains 22 hundreds, 29 market-towns, 575 parishes, upwards of 34,000 houses, and 210,431 inhabitants. The whole is divided into two parts, viz. the Liberty of St Edmund, and the Geldable; the former of which contains the west parts of the county, and the other the east; and there is a grand jury for each at the assizes. The air is reckoned as wholesome and pleasant as any in the kingdom, nor is it otherwise upon the sea coast, which is dry and sandy, and free from salt marshes. The soil, except to the west and upon the sea-coast, is very rich, being a compound of clay and marle. Towards the sea there are large heaths and tracts of sand; but these produce hemp, rye, and pease, and feed great flocks of sheep. About Newmarket the soil is much the same; but in high Suffolk or the woodlands, besides wood, there are very rich pastures, where abundance of cattle are fed. In other parts of the county, as about Bury, there is plenty of corn. As this county is noted for the richness of its pastures, so is it for butter and cheese, especially the former, which is said to be remarkably good; so that being packed up in firkins, it is sold for all uses both by sea and land, and conveyed to many parts of England, especially to London. The inland parts of the county are well supplied with wood for fuel, and those upon the sea-coast with coals from Newcastle. The manufactures of the county are chiefly woollen and linen cloth. It lies in the diocese of Norwich, has two archdeacons, viz. of Sedbury and Suffolk; gives title of earl to a branch of the Howards; sends two members to parliament for the county, and two for each of the following places, Ipswich, Dunwich, Orford, Aldborough, Sudbury, Eye, and St Edmund's-Bury. The county is extremely well watered by the following rivers, which either traverse its borders, or run across into the German ocean, viz. the Lesser Ouse, the Waveney, the Blithe, the Deben, the Orwell or Gipping, and the Stour.

Gough's edition of Camden's Britannia.

SUFFRAGAN, an appellation given to simple bishops with regard to archbishops, on whom they depend, and to whom appeals lie from the bishops courts.

Suffragan is likewise the appellation given to a bishop, who is occasionally appointed to reside in a town or village, and assist the diocesan.

SUFFRAGE, denotes a vote given in an assembly, where something is deliberated on, or where a person is elected to an office or benefice.

SUFFRUTEX, among botanists, denotes an undershrub, or the lowest kind of woody plants, as lavender.

SUGAR, a solid sweet substance obtained from the juice of the sugar-cane; or, according to chemists, an essential salt, capable of crystallization, of a sweet and agreeable flavour, and contained in a greater or less quantity in almost every species of vegetables, but most abundant in the sugar-cane.

1 Value of sugar.

As the sugar-cane is the principal production of the West Indies, and the great source of their riches; as it is so important in a commercial view, from the employment which it gives to seamen, and the wealth which it opens for merchants; and besides now is become a necessary of life—it may justly be esteemed one of the most valuable plants in the world. The quantity consumed in Europe is estimated at nine millions sterling, and the demand would probably be greater if it could be sold at a reduced price. Since sugar then is reckoned so precious a commodity, it must be an object of desire to all persons of curiosity and research, to obtain some general knowledge of the history and nature of the plant by which it is produced, as well as to understand the process by which the juice is extracted and refined. We will therefore first inquire in what countries it originally flourished, and when it was brought into general use, and became an article of commerce.

From the few remains of the Grecian and Roman authors which have survived the ravages of time, we can find no proofs that the juice of the sugar-cane was known

at

Sugar.

2 was probably known to the ancient Jews.

at a very early period. There can be no doubt, however, that in thoſe countries where it was indigenous its value was not long concealed. It is not improbable that it was known to the ancient Jews; for there is ſome reaſon to ſuppoſe, that the Hebrew word קנה, which occurs frequently in the Old Teſtament, and is by our tranſlators rendered ſometimes *calamus* and ſometimes *ſweet-cane*, does in fact mean the ſugar-cane. The firſt paſſage in which we have obſerved it mentioned is Exod. xxx. 23. where Moſes is commanded to make an ointment with myrrh, cinnamon, kené, and caſſia. Now the kené does not appear to have been a native of Egypt nor of Judea; for in Jeremiah vi. 20. it is mentioned as coming from a far country. "To what purpoſe cometh there to me incenſe from Sheba and the ſweet-cane from a far country?" This is not true of the calamus aromaticus, which grows ſpontaneouſly in the Levant, as well as in many parts of Europe. If the cinnamon mentioned in the paſſage of Exodus quoted above was true cinnamon, it muſt have come from the Eaſt Indies, the only country in the world from which cinnamon is obtained. There is no difficulty therefore in ſuppoſing, that the ſugar-cane was exported from the ſame country. If any credit be due to etymology, it confirms the opinion that kené denotes the ſugar-cane; for the Latin word *canna* and the Engliſh word *cane* are evidently derived from it. It is alſo a curious fact, that *ſachar* or *ſheker* *, in Hebrew, ſignifies *inebriation*, from which the Greek word σακχαρ, "ſugar," is undoubtedly to be traced.

3 Account of it by Greek and Roman authors.

The ſugar-cane was firſt made known to the weſtern parts of the world by the conqueſts of Alexander the Great. Strabo † relates that Nearchus his admiral found it in the Eaſt Indies in the year before Chriſt 325. It is evidently alluded to in a fragment of Theophraſtus, preſerved in Photius. Varro, who lived A. C. 68, deſcribes it in a fragment quoted by Iſidorus ‡ as a fluid preſſed from reeds of a large ſize, which was ſweeter than honey §. Dioſcorides, about the year 35 before Chriſt, ſays "that there is a kind of honey called *ſaccharon*, which is found in India and Arabia Felix. It has the appearance of ſalt, and is brittle when chewed. If diſſolved in water, it is beneficial to the bowels and ſtomach, is uſeful in diſeaſes of the bladder and kidneys, and, when ſprinkled on the eye, removes thoſe ſubſtances that obſcure the ſight." This is the firſt account we have of its medical qualities. Galen often preſcribed it as a medicine. Lucan relates, that an oriental nation in alliance with Pompey uſed the juice of the cane as a common drink.

Quique bibunt tenera dulces ab arundine ſuccos.
Lib. iii. 237.

Pliny ſays it was produced in Arabia and India, but that the beſt came from the latter country. It is alſo mentioned by Arrian, in his Periplus of the Red ſea, by the name of Σακχαρ (*ſachar*) as an article of commerce from India to the Red ſea. Ælian *, Tertullian †, and Alexander Aphrodiſæus ‡, mention it as a ſpecies of honey procured from canes (A).

* שכר.

† Lib. xv.

‡ Lib. xvii. cap. 3.

§ *Matthioli Dios.* cap. lxxv.

* *Nat. Hiſt.*

† *De Judicio Dei.*

‡ Lib. ii. Prob. 79.

4 Is a native of the Eaſt Indies.

That the ſugar-cane is an indigenous plant in ſome parts of the Eaſt Indies, we have the ſtrongeſt reaſon to believe; for Thunberg found it in Japan, and has accordingly mentioned it as a native of that country in his *Flora Japonica*, publiſhed in 1784. Oſbeck alſo found it in China in 1751. It may indeed have been tranſplanted from ſome other country; but as it does not appear from hiſtory that the inhabitants of Japan or China ever carried on any commerce with remote nations, it could only be conveyed from ſome neighbouring country. Marco Polo, a noble Venetian, who travelled into the eaſt about the year 1250, found ſugar in abundance in Bengal. Vaſco de Gama, who doubled the Cape of Good Hope in 1497, relates, that a conſiderable trade in ſugar was then carried on in the kingdom of Calicut. On the authority of Dioſcorides and Pliny, too, we ſhould be diſpoſed to admit, that it is a native of Arabia, did we not find, on conſulting Niebuhr's Travels, that that botaniſt has omitted it when enumerating the moſt valuable plants of that country. If it be a ſpontaneous production of Arabia, it muſt ſtill flouriſh in its native ſoil. Mr Bruce found it in Upper Egypt. If we may believe the relation of Giovan Lioni, a conſiderable trade was carried on in ſugar in Nubia in 1500: it abounded alſo at Thebes, on the Nile, and in the northern parts of Africa, about the ſame period.

5 Introduced into Europe probably during the cruſades.

There is reaſon to believe that the ſugar-cane was introduced into Europe during the cruſades; expeditions which however romantic in their plan, and unſucceſsful in their execution, were certainly productive of many advantages to the nations of Europe. Albertus Aquenſis, a monkiſh writer, obſerves, that the Chriſtian ſoldiers in the Holy Land frequently derived refreſhment and ſupport during a ſcarcity of proviſions by ſucking the canes. This plant flouriſhed alſo in the Morea, and in the iſlands of Rhodes and Malta; from which it was tranſported into Sicily. The date of this tranſaction it is not eaſy to aſcertain; but we are ſure that ſugar was cultivated in that iſland previous to the year 1166; for Lafitau the Jeſuit, who wrote a hiſtory of the Portugueſe diſcoveries, mentions a donation made that year to the monaſtery of St Bennet, by William the ſecond, king of Sicily, of a mill for grinding ſugar-canes, with all its rights, members, and appurtenances.

From Sicily, where the ſugar-cane ſtill flouriſhes on the ſides of Mount Hybla, it was conveyed to Spain, Madeira, the Canary and Cape de Verd iſlands, ſoon after they were diſcovered in the 15th century.

D'Orville's Travels.

6 Suppoſed by ſome not a native of America or the Weſt Indies.

An opinion has prevailed, that the ſugar-cane is not a native of the weſtern continent, or its adjacent iſlands the Weſt Indies, but was conveyed thither by the Spaniards or Portugueſe ſoon after the diſcovery of America by Columbus. From the teſtimony of Peter Martyr, in the third book of his firſt decade, compoſed during Columbus's ſecond voyage, which commenced in 1493 and ended in 1495, it appears, that the ſugar-cane was known at that time in Hiſpaniola. It may be ſaid, that it was brought thither by Columbus; but for this aſſertion we have found no direct evidence; and though we had

(A) For a more minute account of the hiſtory of ſugar in the early and middle ages, a paper of the Mancheſter Tranſactions, in Volume IV. by Dr Falconer, may be conſulted.

Sugar. had direct evidence, this would not prove that the ſugar-cane was not an indigenous plant of the Weſt Indies. There are authors of learning who, after inveſtigating this ſubject with attention, do not heſitate to maintain, that it is a native both of the iſlands and of the continent of America.

P. Labat has ſupported this opinion with much appearance of truth *; and, in particular, he appeals to the teſtimony of Thomas Gage, an Engliſhman, who viſited New Spain in 1625. Gage enumerates ſugar-canes among the proviſions with which the Charaibes of Guadaloupe ſupplied his ſhip. "Now (ſays Labat) it is a fact that the Spaniards had never cultivated an inch of ground in the ſmaller Antilles. Their ſhips commonly touched at thoſe iſlands indeed for wood and water; and they left ſwine in the view of ſupplying with freſh proviſions ſuch of their countrymen as might call there in future; but it would be abſurd in the higheſt degree to ſuppoſe, that they would plant ſugar-canes, and at the ſame time put hogs aſhore to deſtroy them.

* Tom. iii. c. xv.

7 This opinion oppoſed by Labat.

"Neither had the Spaniards any motive for beſtowing this plant on iſlands which they conſidered as of no kind of importance, except for the purpoſe that has been mentioned; and to ſuppoſe that the Charaibes might have cultivated, after their departure, a production of which they knew nothing, betrays a total ignorance of the Indian diſpoſition and character.

8 From teſtimony.

"But (continues Labat) we have ſurer teſtimony, and ſuch as proves, beyond all contradiction, that the ſugar-cane is the natural production of America. For, beſides the evidence of Francis Ximenes, who, in a Treatiſe on American Plants, printed at Mexico, aſſerts, that the ſugar-cane grows without cultivation, and to an extraordinary ſize, on the banks of the river Plate, we are aſſured by Jean de Lery, a Proteſtant miniſter, who was chaplain in 1556 to the Dutch garriſon in the fort of Coligny, on the river Janeiro, that he himſelf found ſugar-canes in great abundance in many places on the banks of that river, and in ſituations never viſited by the Portugueſe. Father Hennepen and other voyagers bear teſtimony in like manner to the growth of the cane near the mouth of the Miſſiſſippi; and Jean de Laet to its ſpontaneous production in the iſland of St Vincent. It is not for the plant itſelf, therefore, but for the ſecret of making ſugar from it, that the Weſt Indies are indebted to the Spaniards and Portugueſe; and theſe to the nations of the eaſt."

Such is the reaſoning of Labat, which the learned Lafitau has pronounced incontrovertible; and it is greatly ſtrengthened by recent diſcoveries, the ſugar-cane having been found in many of the iſlands of the Pacific ocean by our late illuſtrious navigator Captain Cook.

9 Deſcription of the ſugar cane.

The ſugar-cane, or ſaccharum officinarum of botaniſts, is a jointed reed, commonly meaſuring (the flag part not included) from three feet and a half to ſeven feet in height, but ſometimes riſing to 12 feet. When ripe it is of a fine ſtraw colour inclining to yellow, producing leaves or blades, the edges of which are finely and ſharply ſerrated, and terminating in an arrow decorated with a panicle. The joints in one ſtalk are from 40 to 60 in number, and the ſtalks riſing from one root are ſometimes very numerous. The young ſhoot aſcends from the earth like the point of an arrow; the ſhaft of which ſoon breaks, and the two firſt leaves, which had been incloſed within a quadruple ſheath of ſeminal leaves, riſe to a conſiderable height (B).

10 Soil moſt favourable to its growth.

As the cane is a rank ſucculent plant, it muſt require a ſtrong deep ſoil to bring it to perfection, perhaps indeed no ſoil can be too rich for this purpoſe. The ſoil which experience has found to be moſt favourable to the cultivation of it in the Weſt Indies is the dark gray loam of St Chriſtopher's, which is ſo light and porous as to be penetrable by the ſlighteſt application of the hoe. The under ſtratum is gravel from 8 to 12 inches deep. Canes planted in particular ſpots in this iſland have been known to yield 8000 pounds of Muſcovado ſugar from a ſingle acre. The average produce of the iſland for a ſeries of years has been 16,000 hogſheads of 16 cwt. which is one-half only of the whole cane-land, or 8500 acres. When annually cut, it gives nearly two hogſheads of 16 cwt. per acre for the whole of the land in ripe canes.

Next to the aſhy loam of St Chriſtopher's is the ſoil which in Jamaica is called *brick-mould;* not as reſembling a brick in colour, but as containing ſuch a due mixture of clay and ſand as is ſuppoſed to render it well adapted for the uſe of the kiln. It is a deep, warm, and mellow, hazel earth, eaſily worked; and though its ſurface ſoon grows dry after rain, the under ſtratum retains a conſiderable degree of moiſture in the drieſt weather; with this advantage too, that even in the wetteſt ſeaſon it ſeldom requires trenching. Plant-canes, by which is meant canes of the firſt growth, have been known in very fine ſeaſons to yield two tons and a half of ſugar per acre. After this may be reckoned the black mould of ſeveral varieties. The beſt is the deep black earth of Barbadoes, Antigua, and ſome other of the windward iſlands; but there is a ſpecies of this mould in Jamaica that is but little, if any thing inferior to it, which abounds with limeſtone and flint on a ſubſtratum of ſoapy marle. Black mould on clay is more common; but

Edward's Hiſtory of the Weſt Indies, vol. ii.

(B) "A field of canes, when ſtanding, in the month of November, when it is in arrow or full bloſſom (ſays Mr Beckford in his deſcriptive Account of the Iſland of Jamaica), is one of the moſt beautiful productions that the pen or pencil can poſſibly deſcribe. It in common riſes from three to eight feet or more in height; a difference of growth that very ſtrongly marks the difference of ſoil or the varieties of culture. It is when ripe of a bright and golden yellow; and where obvious to the ſun, is in many parts very beautifully ſtreaked with red: the top is of a darkiſh green; but the more dry it becomes, from either an exceſs of ripeneſs or a continuance of drought, of a ruſſet yellow, with long and narrow leaves depending; from the centre of which ſhoots up an arrow like a ſilver wand from two to ſix feet in height; and from the ſummit of which grows out a plume of white feathers, which are delicately fringed with a lilac dye; and indeed is, in its appearance, not much unlike the tuft that adorns this particular and elegant tree."

Sugar.

but as the mould is generally ſhallow, and the clay ſtiff and retentive of water, this laſt ſort of land requires great labour, both in ploughing and trenching, to render it profitable. When manured and properly pulverized, it becomes very productive. It is unneceſſary to attempt a minute deſcription of all the other ſoils which are found in theſe iſlands. There is, however, a peculiar ſort of land on the north ſide of Jamaica, chiefly in the pariſh of Trelawney, that cannot be paſſed over unnoticed, not only on account of its ſcarcity but its value; few ſoils producing finer ſugars, or ſuch *as anſwer ſo well in the pan;* an expreſſion ſignifying a greater return of refined ſugar than common. The land alluded to is generally of a red colour; the ſhades of which, however, vary conſiderably from a deep chocolate to a rich ſcarlet; in ſome places it approaches to a bright yellow, but it is everywhere remarkable, when firſt turned up, for a gloſſy or ſhining ſurface, and if wetted ſtains the fingers like paint.

11 Proper ſeaſon for planting it.

As in every climate there is a ſeaſon more favourable for vegetation than others, it is of great importance that plants for ſeed be committed to the ground at the commencement of this ſeaſon. As the cane requires a great deal of moiſture to bring it to maturity, the propereſt ſeaſon for planting it is in the months of September and October, when the autumnal rains commence, that it may be ſufficiently luxuriant to ſhade the ground before the dry weather ſets in. Thus the root is kept moiſt, and the crop is ripe for the mill in the beginning of the enſuing year. Canes planted in the month of November, or later in the ſeaſon, loſe the advantage of the autumnal rains; and it often happens that dry weather in the beginning of the enſuing year retards their vegetation until the vernal or May rains ſet in, when they ſprout both at the roots and the joints; ſo that by the time they are cut the field is loaded with unripe ſuckers inſtead of ſugar-canes. A January plant, however, commonly turns out well; but canes planted very late in the ſpring, though they have the benefit of the May rains, ſeldom anſwer expectation; for they generally come in unſeaſonably, and throw the enſuing crops out of regular rotation. They are therefore frequently cut before they are ripe; or if the autumnal ſeaſon ſets in early, are cut in wet weather, which has probably occaſioned them to ſpring afreſh; in either caſe the effect is the ſame: The juice is unconcocted, and all the ſap being in motion, the root is deprived of its natural nouriſhment, to the great injury of the ratoon. The chief objection to a fall plant is this, that the canes become rank and top-heavy, at a period when violent rains and high winds are expected, and are therefore frequently lodged before they are fit to be cut.

12 Method of planting

The ſugar-cane is propagated by the top-ſhoots, which are cut from the tops of the old canes. The uſual method of planting in the Weſt Indies is this: The quantity of land intended to be planted, being cleared of weeds and other incumbrances, is firſt divided into ſeveral plats of certain dimenſions, commonly from 15 to 20 acres each; the ſpaces between each plat or diviſion are left wide enough for roads, for the conveniency of carting, and are called *intervals*. Each plat is then ſubdivided, by means of a line and wooden pegs, into ſmall ſquares of about three feet and a half. Sometimes indeed the ſquares are a foot larger; but this circumſtance makes but little difference. The negroes are then placed in a row in the firſt line, one to a ſquare, and directed to dig out with their hoes the ſeveral ſquares, commonly to the depth of five or ſix inches. The mould which is dug up being formed into a bank at the lower ſide, the excavation or cane-hole ſeldom exceeds 15 inches in width at the bottom, and two feet and a half at the top. The negroes then fall back to the next line, and proceed as before. Thus the ſeveral ſquares between each line are formed into a trench of much the ſame dimenſions with that which is made by the plough. An able negro will dig from 100 to 120 of theſe holes for his day's work of ten hours; but if the land has been previouſly ploughed and lain fallow, the ſame negro will dig nearly double the number in the ſame time (c).

The cane-holes or trench being now completed, whether by the plough or by the hoe, and the cuttings ſelected for planting, which are commonly the tops of the canes that have been ground for ſugar (each cutting containing five or ſix gems), two of them are ſufficient for a cane hole of the dimenſions deſcribed. Theſe, being placed longitudinally in the bottom of the hole, are covered with mould about two inches deep; the reſt of the bank being intended for future uſe. In 12 or 14 days the young ſprouts begin to appear; and as ſoon as they riſe a few inches above the ground, they are, or ought to be, carefully cleared of weeds, and furniſhed with an addition of mould from the banks. This is uſually performed by the hand. At the end of four or five months the banks are wholly levelled, and the ſpaces between the rows carefully hoe-ploughed. Frequent cleanings, while the canes are young, are indeed ſo eſſentially neceſſary, that no other merit in an overſeer can compenſate for the want of attention in this particular. A careful manager will remove at the ſame time all the lateral ſhoots or ſuckers that ſpring up after the canes begin to joint, as they ſeldom come to maturity, and draw nouriſhment from the original plants.

13 and cleaning it.

14 The plough might be uſed with advantage.

" In the cultivation of other lands, in Jamaica eſpecially (ſays Mr Edwards, the elegant hiſtorian of the Weſt Indies, whoſe ſuperior excellence has induced us frequently to refer to him in the courſe of this article), the plough has been introduced of late years, and in ſome few caſes to great advantage; but it is not every ſoil or ſituation that will admit the uſe of the plough; ſome lands being much too ſtony, and others too ſteep; and I am ſorry I have occaſion to remark, that a practice

(c) As the negroes work at this buſineſs very unequally, according to their different degrees of bodily ſtrength, it is ſometimes the practice to put two negroes to a ſingle ſquare; but if the land has not had the previous aſſiſtance of the plough, it commonly requires the labour of 50 able negroes for 13 days to hole 20 acres. In Jamaica, ſome gentlemen, to eaſe their own ſlaves, have this laborious part of the planting-buſineſs performed by job-work. The uſual price for holing and planting is 6l. currency per acre (equal to 4l. 7s. ſterling). The coſt of falling and clearing heavy wood-land is commonly as much more.

Sugar.

tice commonly prevails in Jamaica, on properties where this auxiliary is uſed, which would exhauſt the fineſt lands in the world. It is that of ploughing, then croſs-ploughing, round-ridging, and harrowing the ſame lands from year to year, or at leaſt every other year, without affording manure: accordingly it is found that this method is utterly deſtructive of the ratoon or ſecond growth, and altogether ruinous. It is indeed aſtoniſhing that any planter of common reading or obſervation ſhould be paſſive under ſo pernicious a ſyſtem. Some gentlemen, however, of late manage better: their practice is to break up ſtiff and clayey land, by one or two ploughings, early in the ſpring, and give it a ſummer's fallow. In the autumn following, being then mellow and more eaſily worked, it is holed and planted by manual labour after the old method, which has been already deſcribed. But in truth, the only advantageous ſyſtem of ploughing in the Weſt Indies is to confine it to the ſimple operation of holing, which may certainly be performed with much greater facility and diſpatch by the plough than by the hoe; and the relief which, in the caſe of ſtiff and dry ſoils, is thus given to the negroes, exceeds all eſtimation, in the mind of a humane and provident owner. On this ſubject I ſpeak from practical knowledge. At a plantation of my own, the greateſt part of the land which is annually planted is neatly and ſufficiently laid into cane-holes, by the labour of one able man, three boys, and eight oxen, with the common ſingle-wheeled plough. The ploughſhare indeed is ſomewhat wider than uſual; but this is the only difference, and the method of ploughing is the ſimpleſt poſſible. By returning the plough back along the furrow, the turf is alternately thrown to the right and to the left, forming a trench ſeven inches deep, about two feet and a half wide at the top, and one foot wide at the bottom. A ſpace of 18 or 20 inches is left between each trench, on which the mould being thrown by the ſhare, the banks are properly formed, and the holing is complete. Thus the land is not exhauſted by being too much expoſed to the ſun; and in this manner a field of 20 acres is holed with one plough, and with great eaſe, in 13 days. The plants are afterwards placed in the trench as in the common method, where manual labour alone is employed.

Edwards's Hiſtory of the Weſt Indies, vol. ii.

15 Canes named according to the age of their roots.

In moſt parts of the Weſt Indies it is uſual to hole and plant a certain proportion of the cane-land, commonly one-third, in annual rotation. Canes of the firſt year's growth are called *plant canes*, as has been already obſerved. The ſpouts that ſpring from the roots of the canes that have been previouſly cut for ſugar are called *ratoons;* the firſt yearly returns from their roots are called *firſt ratoons;* the ſecond year's growth *ſecond ratoons.*

16 Manures employed.

Mr Edwards informs us, that the manure generally uſed is a compoſt formed, 1ſt, Of the vegetable aſhes drawn from the fires of the boiling and ſtill houſes. 2dly, Feculencies diſcharged from the ſtill houſe, mixed up with rubbiſh of buildings, white-lime, &c. 3dly, Refuſe, or field-traſh (*i. e.*), the decayed leaves and ſtems of the canes; ſo called in contradiſtinction to cane-traſh, reſerved for fuel. 4thly, Dung, obtained from the horſe and mule ſtables, and from moveable pens, or ſmall incloſures made by poſts and rails, occaſionally ſhifted upon the lands intended to be planted, and into which the cattle are turned at night. 5thly, Good mould, collected from gullies and other waſte places, and thrown into the cattle-pens.

Sugar.

17 The ſugar-cane deſtroyed by monkeys,

The ſugar-cane is liable to be deſtroyed by monkeys, rats, and inſects. The upland plantations ſuffer greatly from monkeys; theſe creatures, which now abound in the mountainous parts of St Chriſtopher's, were firſt brought thither by the French, when they poſſeſſed half that iſland; they come down from the rocks in ſilent parties by night, and having poſted centinels to give the alarm if any thing approaches, they deſtroy incredible quantities of the cane, by their gambols as well as their greedineſs. It is in vain to ſet traps for theſe creatures, however baited; and the only way to protect the plantation, and deſtroy them, is to ſet a numerous watch, well armed with fowling-pieces, and furniſhed with dogs. The negroes will perform this ſervice cheerfully, for they are very fond of monkeys as food. The celebrated Father Labat ſays, they are very delicious, but the white inhabitants of St Kitt's never eat them.

Grainger's Hiſtory of the ſugar-cane.

18 rats,

The low-land plantations ſuffer as much by rats as thoſe on the mountains do from monkeys; but the rats, no more than the monkeys, are natives of the place; they came with the ſhipping from Europe, and breed in the ground under looſe rocks and buſhes: the field negroes eat them greedily, and they are ſaid to be publicly ſold in the markets at Jamaica. To free the plantations from theſe vermin, the breed of wild cats ſhould be encouraged, and ſnakes ſuffered to multiply unmoleſted; they may alſo be poiſoned with arſenic, and the raſped root of the caſſava made into pellets, and plentifully ſcattered over the grounds. This practice, however, is dangerous; for as the rats when thus poiſoned become exceeding thirſty, they run in droves to the neighbouring ſtreams, which they poiſon as they drink, and the cattle grazing on the banks of theſe polluted waters have frequently periſhed by drinking after them: It is ſafer therefore to make the pellets of flour, kneaded with the juice of the nightſhade, the ſcent of which will drive them away though they will not eat it. There is an Eaſt Indian animal called *mungoes*, which bears a natural antipathy to rats; if this animal was introduced into our ſugar iſlands, it would probably extirpate the whole race of theſe noxious vermin. The *formica omnivora* of Linnæus, the carnivorous ant, which is called in Jamaica the *raffle's ant*, would ſoon clear a ſugar plantation of rats.

19 and inſects.

The ſugar-cane is alſo ſubject to a diſeaſe which no foreſight can obviate, and for which human wiſdom has hitherto in vain attempted to find a remedy. This diſeaſe is called the *blaſt*, and is occaſioned by a ſpecies of *aphis*. When this happens, the fine, broad, green blades become ſickly, dry, and withered; ſoon after they appear ſtained in ſpots; and if theſe ſpots are carefully examined, they will be found to contain innumerable eggs of an inſect like a bug, which are ſoon quickened, and cover the plants with the vermin: the juice of the canes thus affected becomes ſour, and no future ſhoot iſſues from the joints. Ants alſo concur with the bugs to ſpoil the plantation, and againſt theſe evils it is hard to find a remedy.

20 Time at which the crop ripens

The crops of ſugar-canes do not ripen preciſely at the ſame period in all the colonies. In the Daniſh, Spaniſh, and Dutch ſettlements, they begin in January, and continue till October. This method does not imply any fixed ſeaſon for the maturity of the ſugar-cane. The plant, Sugar. *Raynal's History of the East and West Indies, vol. iv.* plant, however, like others, must have its progress; and it hath been justly observed to be in flower in the months of November and December. It must necessarily follow, from the custom these nations have adopted of continuing to gather their crops for 10 months without intermission, that they cut some canes which are not ripe enough, and others that are too ripe, and then the fruit hath not the requisite qualities. The time of gathering them should be at a fixed season, and probably the months of March and April are the fittest for it; because all the sweet fruits are ripe at that time, while the sour ones do not arrive at a state of maturity till the months of July and August.

The English cut their canes in March and April; but they are not induced to do this on account of their ripeness. The drought that prevails in their islands renders the rains which fall in September necessary to their planting; and as the canes are 18 months in growing, this period always brings them to the precise point of maturity (D).

21 a season of festivity. *Edwards, vol. iv. p. 226.* "The time of crop in the sugar islands (says Mr Edwards) is the season of gladness and festivity to man and beast. So palatable, salutary, and nourishing, is the juice of the cane, that every individual of the animal creation, drinking freely of it, derives health and vigour from its use. The meagre and sickly among the negroes exhibit a surprising alteration in a few weeks after the mill is set in action. The labouring horses, oxen, and mules, though almost constantly at work during this season, yet, being indulged with plenty of the green tops of this noble plant, and some of the scummings from the boiling-house, improve more than at any other period of the year. Even the pigs and poultry fatten on the refuse. In short, on a well-regulated plantation, under a humane and benevolent director, there is such an appearance during crop-time of plenty and busy cheerfulness, as to soften, in a great measure, the hardships of slavery, and induce a spectator to hope, when the miseries of life are represented as insupportable, that they are sometimes exaggerated through the medium of fancy."

22 The canes when cut are sent to the mill. The plants being cut, the branches at the top are given to the cattle for food; the top-shoot, which is full of eyes, is preserved for planting. The canes are cut into pieces about a yard long, tied up in bundles, and carried in carts to the mill, where they are bruised, and the juice is extracted from them. The mill consists principally of three upright iron-plated rollers or cylinders, from 30 to 40 inches in length, and from 20 to 25 inches in diameter; and the middle one, to which the moving power is applied, turns the other two by means of cogs. Between these rollers, the canes (being previously cut short, and tied into bundles) are twice compressed; for having passed through the first and second rollers, they are turned round the middle one by a circular piece of frame-work or screen, called in Jamaica the *Dumb-returner*, and forced back through the second and third; an operation which squeezes them completely dry, and sometimes even reduces them to powder. The cane juice is received in a leaden bed, and thence conveyed into a vessel called the *receiver*. The refuse, or macerated rind of the cane (which is called *cane-trash*, in contradistinction to *field-trash*), serves for fuel to boil the liquor.

The juice as it flows from the mill, taken at a medium, contains eight parts of pure water, one part of sugar, and one part consisting of coarse oil and mucilaginous gum, with a portion of essential oil. 23 The juice extracted from them.

As this juice has a strong disposition to fermentation, it must be boiled as soon as possible. There are some water-mills that will grind with great ease canes sufficient for 30 hogsheads of sugar in a week. It is necessary to have boiling vessels, or clarifiers, that will correspond in dimensions to the quantity of juice flowing from the receiver. These clarifiers are commonly three in number, and are sometimes capable of containing 1000 gallons each; but it is more usual to see them of 300 or 400 gallons each. Besides the clarifiers which are used for the first boiling, there are generally four coppers or boilers. The clarifiers are placed in the middle or at one end of the boiling-house. If at one end, the boiler called the *teache* is placed at the other, and several boilers (generally three) are ranged between them. The teache is ordinarily from 70 to 100 gallons, and the boilers between the clarifiers and teache diminish in size from the first to the last. Where the clarifiers are in the middle, there is usually a set of three boilers of each side, which constitute in effect a double boiling-house. On very large estates this arrangement is found useful and necessary. The objection to so great a number is the expence of fuel; to obviate which, in some degree, the three boilers on each side of the clarifiers are commonly hung to one fire. 24 Vessels used for purifying it are,

The juice runs from the receiver along a wooden gutter lined with lead into the boiling-house, where it is received into one of the clarifiers. When the clarifier is filled, a fire is lighted, and a quantity of Bristol quicklime in powder, which is called *temper*, is poured into the vessel. The use of the lime is to unite with the superabundant acid, which, for the success of the process, it is necessary to get rid of. The quantity sufficient to separate the acid must vary according to the strength of the quicklime and the quality of the liquor. Some planters allow a pint of lime to every 100 gallons of liquor; but Mr Edwards thinks that little more than half the quantity is a better medium proportion, and even then, that it ought to be dissolved in boiling water, that as little of it as possible may be precipitated. The heat is suffered gradually to increase till it approaches within a few degrees of the heat of boiling water, that the impurities 25 The clarifier,

(D) The account given in the text concerning the time when the sugar-canes are collected, we have taken from the Abbé Raynal's History of the Trade and Settlements of the East and West Indies; but Mr Cazaud observes, that in February, March, and April, all the canes, whatever be their age, are as ripe as the nature of the soil ever allows them to be. He says farther, that the dryness of the weather, and not the age of the canes, which increases from January to April, is the cause that in January 400 gallons of juice commonly yield 48 gallons of sugar and molasses, one with another; in February from 56 to 64; in March from 64 to 72; in April sometimes 80; after which period the sugar ferments, and even burns, when the refiner is not very expert at his business. *Philosoph. Transact. vol. lxix.*

purities may be thoroughly ſeparated. But if the liquor were ſuffered to boil with violence, the impurities would again incorporate with it. It is known to be ſufficiently heated when the ſcum begins to riſe in bliſters, which break into white froth, and appear generally in about 40 minutes. The fire is then ſuddenly extinguiſhed by means of a damper, which excludes the external air, and the liquor is allowed to remain about an hour undiſturbed, during which period the impurities are collected in ſcum on the ſurface. The juice is then drained off either by a ſyphon or a cock; the ſcum being of a tenacious gummy nature, does not flow out with the liquor, but remains behind in the clarifier. The liquid juice is conveyed from the clarifier by a gutter into the evaporating boiler, commonly termed the *grand copper;* and if it has been obtained from good canes it generally appears tranſparent.

26
and four coppers.

In the evaporating boiler, which ſhould be large enough to receive the contents of the clarifier, the liquor is allowed to boil; and as the ſcum riſes it is taken off. The ſcumming and evaporation are continued till the liquor becomes finer and thicker, and ſo far diminiſhed in bulk that it may be eaſily contained in the ſecond copper. When put into the ſecond copper, it is nearly of the colour of Madeira wine; the boiling and ſcumming are continued, and if the impurities be conſiderable, a quantity of lime-water is added. This proceſs is carried on till the liquor be ſufficiently diminiſhed in quantity to be contained in the third copper. After being purified a third time, it is put into the fourth copper, which is called the *teache*, where it is boiled and evaporated till it is judged ſufficiently pure to be removed from the fire. In judging of the purity of the liquor, many of the negroes (ſays Mr Edwards) gueſs ſolely by the eye (which by long habit they do with great accuracy), judging by the appearance of the grain on the back of the ladle: but the practice moſt in uſe is to judge by what is called the *touch;* i. e. taking up with the thumb a ſmall portion of the hot liquor from the ladle; and, as the heat diminiſhes, drawing with the fore-finger the liquid into a thread. This thread will ſuddenly break, and ſhrink from the thumb to the ſuſpended finger, in different lengths, according as the liquor is more or leſs boiled. The proper boiling height for ſtrong muſcovado ſugar is generally determined by a thread of a quarter of an inch long. It is evident, that certainty in this experiment can be attained only by long habit, and that no verbal precepts will furniſh any degree of ſkill in a matter depending wholly on conſtant practice.

27
After being clarified it is cooled, granulated, and freed from its melaſſes.

The juice being thus purified by paſſing through the clarifier and four coppers, it is poured into coolers, which are uſually ſix in number. The removal from the teache to the cooler is called *ſtriking*. The cooler is a ſhallow wooden veſſel ſeven feet long, from five to ſix wide, about 11 inches deep, and capable of containing a hogſhead of ſugar. As the liquor cools, the ſugar grains, that is, collects into an irregular maſs of imperfect cryſtals, ſeparating itſelf from the melaſſes. It is then removed from the cooler, and conveyed to the curing-houſe, where the melaſſes drain from it. For receiving them there is a large ciſtern, the ſloping ſides of which are lined with boards. Directly above the ciſtern a frame of joiſt-work without boarding is placed, on which empty hogſheads without heads are ranged. The bottoms of theſe hogſheads are pierced with 8 or 10 holes, in each of which the ſtalk of a plantain leaf is fixed ſo as to project ſix or eight inches below the joiſts, and riſe a little above the top of the hogſhead. The hogſheads being filled with the contents of the cooler, conſiſting of ſugar and melaſſes, the melaſſes being liquid, drain through the ſpungy ſtalk, and drop into the ciſtern. After the melaſſes are drained off, the ſugar becomes pretty dry and fair, and is then called *muſcovado* or *raw ſugar*.

We have deſcribed the proceſs for extracting ſugar, which is generally adopted in the Britiſh Weſt India iſlands, according to the lateſt improvements; and have been anxious to preſent it to our readers in the ſimpleſt and moſt perſpicuous form, that it might be intelligible to every perſon; and have therefore avoided to mention the obſervations and propoſed amendments of thoſe who have written on this ſubject. Had we done ſo, we ſhould have ſwelled the preſent article to too great a ſize, without accompliſhing the purpoſe which we hav in view; for our intention is not to inſtruct the planters, but to give a diſtinct account of the moſt approved methods which the planters have generally adopted. But though we judge it uſeleſs to trouble our readers with all the little varieties in the proceſs which different perſons employ, we flatter ourſelves it will not be diſagreeable to learn by what methods the French make their ſugar purer and whiter than ours. A quantity of ſugar from the cooler is put into conical pans or earthen pots, called by the French *formes*, having a ſmall perforation at the apex, which is kept cloſed. Each cone, reverſed on its apex, is ſupported in another earthen veſſel. The ſyrup is ſtirred together, and then left to cryſtallize. At the end of 15 or 16 hours, the hole in the point of each cone is opened, that the impure ſyrup may run out. The baſe of theſe ſugar loaves is then taken out, and white pulverized ſugar ſubſtituted in its ſtead; which being well preſſed down, the whole is covered with clay moiſtened with water. This water filters through the maſs, carrying the ſyrup with it which was mixed with the ſugar, but which by this management flows into a pot ſubſtituted in the place of the firſt. This ſecond fluid is called *fine ſyrup*. Care is taken to moiſten and keep the clay to a proper degree of ſoftneſs as it becomes dry. The ſugar loaves are afterwards taken out, and dried in a ſtove for eight or ten days; after which they are pulverized, packed, and exported to Europe, where they are ſtill farther purified. The reaſon aſſigned why this proceſs is not univerſally adopted in the Britiſh ſugar iſlands is this, that the water which dilutes and carries away the melaſſes diſſolves and carries with it ſo much of the ſugar, that the difference in quality does not pay for the difference in quantity. The French planters probably think otherwiſe, upwards of 400 of the plantations of St Domingo having the neceſſary apparatus for claying and actually carrying on the ſyſtem.

28
Method of purifying uſed by the French.

Chaptal's Chemiſtry, vol. iii.

29
The art of refining ſugar introduced by a Venetian.

The art of refining ſugar was firſt made known to the Europeans by a Venetian, who is ſaid to have received 100,000 crowns for the invention. This diſcovery was made before the new world was explored; but whether it was an invention of the perſon who firſt communicated it, or whether it was conveyed from China, where it had been known for a conſiderable time before, cannot now perhaps be accurately aſcertained. We find no

Anderſon's Origin of Commerce.

mention made of the refining of ſugar in Britain till the year 1659, though it probably was practiſed ſeveral years before. For in the Portugueſe iſland of St Thomas in 1624 there were 74 ſugar ingenios, each having upwards of 200 ſlaves. The quantity of raw ſugar imported into England in 1778 amounted to 1,403,995 cwts.; the quantity imported into Scotland in the ſame year was 117,285 cwts.; the whole quantity imported into Great Britain in 1787 was 1,926,741 cwts.

30 In refining it is mixed with lime-water and bullock's blood, and expoſed to heat.

The ſugar which undergoes the operation of refining in Europe is either raw ſugar, ſometimes called *muſcovado* or *caſſonado*, which is raw ſugar in a purer ſtate. The raw ſugar generally contains a certain quantity of melaſſes as well as earthy and feculent ſubſtances. The caſſonado, by the operation of earthing, is freed from its melaſſes. As the intention of refining theſe ſugars is to give them a higher degree of whiteneſs and ſolidity, it is neceſſary for them to undergo other proceſſes. The firſt of theſe is called *clarification.* It conſiſts in diſſolving the ſugar in a certain proportion of lime-water, adding a proper quantity of bullock's blood, and expoſing it to heat in order to remove the impurities which ſtill remain. The heat is increaſed very gradually till it approach that of boiling water. By the aſſiſtance of the heat, the animal matter which was thrown in coagulates, at the ſame time that it attracts all the ſolid feculent and earthy matter, and raiſes it to the ſurface in the appearance of a thick foam of a browniſh colour. As the feculencies are never entirely removed by a firſt proceſs, a ſecond is neceſſary. The ſolution is therefore cooled to a certain degree by adding ſome water; then a freſh quantity of blood, but leſs conſiderable than at firſt, is poured in. The fire is renewed, and care is taken to increaſe the heat gently as before. The animal ſubſtance ſeizes on the impurities which remain, collects them on the ſurface, and they are then ſkimmed off. The ſame operation is repeated a third and even a fourth time, but no addition is made to the liquor except water. If the different proceſſes have been properly conducted, the ſolution will be freed from every impurity, and appear tranſparent. It is then conveyed by a gutter into an oblong baſket about 16 inches deep, lined with a woollen cloth; and after filtering through this cloth, it is received in a ciſtern or copper which is placed below.

31 Then freed from its remaining impurities by evaporation.

The ſolution being thus clarified, it undergoes a ſecond general operation called *evaporation.* Fire is applied to the copper into which the ſolution was received, and the liquid is boiled till it has acquired the proper degree of conſiſtency. A judgement is formed of this by taking up a ſmall portion of the liquid and drawing it into a thread. When, after this trial, it is found ſufficiently viſcous, the fire is extinguiſhed, and the liquid is poured into coolers. It is then ſtirred violently by an inſtrument called an *oar*, from the reſemblance it bears to the oar of a boat. This is done in order to diminiſh the viſcoſity, and promote what is called the *granulation*, that is, the forming of it into grains or imperfect cryſtals. When the liquid is properly mixed and cooled, it is then poured into moulds of the form of a ſugar loaf. Theſe moulds are ranged in rows. The ſmall ends, which are loweſt, are placed in pots; and they have each of them apertures ſtopped up with linen for filtering the ſyrup, which runs from the moulds into the pots. The liquor is then taken out ſlowly in ladlefuls from the coolers, and poured into the moulds.

32 Afterwards poured into moulds, where the ſyrup is drained from it.

When the moulds are filled, and the contents ſtill in a fluid ſtate, it is neceſſary to ſtir them, that no part may adhere to the moulds, and that the ſmall cryſtals which are juſt formed may be equally diffuſed through the whole maſs. When the ſugar is completely cryſtallized, the linen is taken away from the apertures in the moulds, and the ſyrup, or that part which did not cryſtallize, deſcends into the pots in which the moulds are placed. After this purgation the moulds are removed and fixed in other pots, and a ſtratum of fine white clay diluted with water is laid on the upper part of the loaf. The water deſcending through the ſugar by its own weight, mixes with the ſyrup which ſtill remains in the body of the loaf, and waſhes it away. When the clay dries, it is taken off, and another covering of moiſt clay put in its place; and if it be not then ſufficiently waſhed, a third covering of clay is applied.

33 Laſtly expoſed to a certain degree of heat.

After the loaves have ſtood ſome days in the moulds, and have acquired a conſiderable degree of firmneſs and ſolidity, they are taken out, and carried to a ſtove, where they are gradually heated to the 50° of Reaumur (64° of Fahrenheit), in order to diſſipate any moiſture which may be ſtill confined in them. After remaining in the ſtove eight days, they are taken out; and after cutting off all diſcolouring ſpecks, and the head if ſtill wet, they are wrapped in blue paper, and are ready for ſale. The ſeveral ſyrups collected during the different parts of the proceſs, treated in the ſame manner which we have juſt deſcribed, afford ſugars of inferior quality; and the laſt portion, which no longer affords any ſugar, is ſold by the name of *melaſſes.*

34 In what the beauty of ſugar conſiſts; how farther refined.

The beauty of refined ſugar, when formed into loaves, conſiſts in whiteneſs, joined to a ſmallneſs of grain; in being dry, hard, and ſomewhat tranſparent. The proceſs which we have deſcribed above refers to ſugar once refined; but ſome more labour is neceſſary to produce double refined ſugar. The principal difference in the operation is this, the latter is clarified by white of eggs inſtead of blood, and freſh water in place of lime-water.

35 How ſugar candy is made.

Sugar-candy is the true eſſence of the cane formed into large cryſtals by a ſlow proceſs. When the ſyrup is well clarified, it is boiled a little, but not ſo much as is done for the proof mentioned in the proceſs for making common ſugar. It is then placed in old moulds, having their lower ends ſtopped with linen, and croſſed at little diſtances with ſmall twigs to retain the ſugar as it cryſtallizes. The moulds are then laid in a cool place. In proportion as the ſyrup cools cryſtals are formed. In about nine or ten days the moulds are carried to the ſtove, and placed in a pot; but the linen is not removed entirely, ſo that the ſyrup falls down ſlowly in drops. When the ſyrup has dropped away, and the cryſtals of the ſugar-candy are become dry, the moulds are taken from the ſtove and broken in pieces, to diſengage the ſugar, which adheres ſtrongly to the ſides of the moulds. If the ſyrup has been coloured with cochineal, the cryſtals take a ſlight taint of red; if indigo has been mixed, they aſſume a bluiſh colour. If it be deſired to have the candy perfumed, the eſſence of flowers or amber may be dropped into the moulds along with the ſyrup.

Having now given ſome account of the method uſually employed for refining ſugar, it will not be improper

Sugar. proper to say a few things concerning its nature and its uses.

36 Chemical qualities of sugar. Sugar is soluble in water, and in a small degree in alcohol. When united with a small portion of water, it becomes fusible; from which quality the art of preserving is indebted for many of its preparations. It is phosphoric and combustible; when exposed to fire emitting a blue flame if the combustion be slow, and a white flame if the combustion be rapid. By distillation it produces a quantity of phlegm, acid, oil, gas, and charcoal. Bergman, in treating sugar with the nitrous acid, obtained a new acid now known by the name of the *oxalic acid*: but he has omitted to mention the principles of which sugar is composed. Lavoisier, however, has supplied this omission; and after many experiments has assigned three principles in sugar, hydrogen, oxygen, and carbone. If the juice expressed from the sugar-cane be left to itself, it passes into the acetous fermentation; and during the decomposition of the sugar, which is continued for three or four months, a great quantity of glutinous matter is separated. This matter when distilled gives a portion of ammoniac. If the juice be exposed to the spirituous fermentation, a wine is obtained analogous to cyder. If this wine, after being kept in bottles a-year, be distilled, we obtain a portion of *eau de vie*.

37 Its uses in medicine, &c. The uses to which sugar are applied are indeed numerous and important: It can be made so solid as in the art of preserving to receive the most agreeable colours and the greatest variety of forms. It can be made so fluid as to mix with any soluble substance.—It preserves the juice and substance of fruits in all countries and in all seasons. It affords a delicious seasoning to many kinds of food. It is useful in pharmacy, for it unites with medicines, and removes their disagreeable flavour: it is the basis of all syrups. M. Macquer has shown in a very satisfactory manner how useful sugar would be if employed in fermenting wines. Sugar has also been found a remedy for the scurvy, and a valuable article of food in cases of necessity. M. Imbert de Lennes, first surgeon to the late duke of Orleans, published the following story in the *Gazette de Santé*, which confirms this assertion. A vessel laden with sugar bound from the West Indies was becalmed in its passage for several days, during which the stock of provisions was exhausted. Some of the crew were dying of the scurvy, and the rest were threatened with a still more terrible death. In this emergency recourse was had to the sugar. The consequence was, the symptoms of the scurvy went off, the crew found it a wholesome and substantial aliment, and returned in good health to France.

38 Affords the greatest quantity of nourishment of any kind of food. "Sugar (says Dr Rush) affords the greatest quantity of nourishment in a given quantity of matter of any substance in nature; of course it may be preserved in less room in our houses, and may be consumed in less time, than more bulky and less nourishing aliment. It has this peculiar advantage over most kinds of aliment, that it is not liable to have its nutritious qualities affected by time or the weather; hence it is preferred by the Indians in their excursions from home. They mix a certain quantity of maple sugar, with an equal quantity of Indian corn, dried and powdered, in its milky state. This mixture is packed in little baskets, which are frequently wetted in travelling, without injuring the sugar. A few spoonfuls of it mixed with half a pint of spring water afford them a pleasant and strengthening meal. From the degrees of strength and nourishment which are conveyed into animal bodies by a small bulk of sugar, it might probably be given to horses with great advantage, when they are used in places or under circumstances which make it difficult or expensive to support them with more bulky or weighty aliment. A pound of sugar with grass or hay has supported the strength and spirits of a horse during a whole day's labour in one of the West-India islands. A larger quantity given alone has fattened horses and cattle, during the war before last in Hispaniola, for a period of several months, in which the exportation of sugar, and the importation of grain, were prevented by the want of ships.

Transactions of the American Philosophical Society, vol. iii.

39 An excellent antidote against worms. "The plentiful use of sugar in diet is one of the best preventives that has ever been discovered of the diseases which are produced by worms. Nature seems to have implanted a love for this aliment in all children, as if it were on purpose to defend them from those diseases. Dr Rush knew a gentleman in Philadelphia, who early adopted this opinion, and who, by indulging a large family of children in the use of sugar, has preserved them all from the diseases usually occasioned by worms.

40 and probably against the plague and other malignant fevers. "Sir John Pringle has remarked, that the plague has never been known in any country where sugar composes a material part of the diet of the inhabitants. Dr Rush thinks it probable that the frequency of malignant fevers of all kinds has been lessened by this diet, and that its more general use would defend that class of people who are most subject to malignant fevers from being so often affected by them.

"In the numerous and frequent disorders of the breast, which occur in all countries where the body is exposed to a variable temperature of weather, sugar affords the basis of many agreeable remedies. It is useful in weaknesses, and acrid defluxions upon other parts of the body. Many facts may be adduced in favour of this assertion. Dr Rush mentions only one, which, from the venerable name of the person whose case furnished it, cannot fail of commanding attention and credit. Upon my inquiring of Dr Franklin, at the request of a friend (says our respectable author), about a year before he died, whether he had found any relief from the pain of the stone from the blackberry jam, of which he took large quantities, he told me that he had, but that he believed the medicinal part of the jam resided wholly in the sugar; and as a reason for thinking so, he added, that he often found the same relief by taking about half a pint of a syrup, prepared by boiling a little brown sugar in water, just before he went to bed, that he did from a dose of opium. It has been supposed by some of the early physicians of our country, that the sugar obtained from the maple-tree is more medicinal than that obtained from the West India sugar-cane; but this opinion I believe is without foundation. It is preferable in its qualities to the West India sugar only from its superior cleanliness.

41 Has given relief from the pain of the stone.

42 Not hurtful to the teeth. "Cases may occur in which sugar may be required in medicine, or in diet, by persons who refuse to be benefited, even indirectly by the labour of slaves. In such cases the innocent maple sugar will always be preferred. It has been said, that sugar injures the teeth; but this opinion now has so few advocates, that it does not deserve a serious refutation."

In

4

Sugar.

In the account which we have given above of the method of cultivating and manufacturing ſugar, we have had in our eye the plantations in the Weſt Indies, where ſlaves alone are employed; but we feel a peculiar pleaſure in having it in our power to add a ſhort deſcription of the method uſed in the Eaſt Indies, becauſe there ſugar is manufactured by free men, on a plan which is much more economical than what is followed in the Weſt Indies. The account which we mean to give is an extract from the report of the committee of Privy-council for trade on the ſubject of the African ſlave-trade, drawn up by Mr Botham. We ſhall give it in the author's own words.

43 Sugar manufactured in the Eaſt Indies by free men,

"Having been for two years in the Engliſh and French Weſt India iſlands, and ſince conducted ſugar eſtates in the Eaſt Indies; before the abolition of the ſlave-trade was agitated in parliament, it may be deſirable to know that ſugar of a ſuperior quality and inferior price to that in our iſlands is produced in the Eaſt Indies; that the culture of the cane, the manufacture of the ſugar and arrack, is, with theſe material advantages, carried on by free people. China, Bengal, the coaſt of Malabar, all produce quantities of ſugar and ſpirits; but as the moſt conſiderable growth of the cane is carried on near Batavia, I ſhall explain the improved manner in which ſugar eſtates are there conducted. The proprietor of the eſtate is generally a wealthy Dutchman, who has erected on it ſubſtantial mills, boiling and curing houſes. He rents this eſtate to a Chineſe, who reſides on it as a ſuperintendant; and this renter (ſuppoſing the eſtate to conſiſt of 300 or more acres) relets it to free men in parcels of 50 or 60 on theſe conditions: "That they ſhall plant it in canes, and receive ſo much per pecul of 133½ pounds for every pecul of ſugar that the canes ſhall produce."

44 of a ſuperior quality and at a lower price.

45 How ſugar eſtates are managed at Batavia.

When crop time comes on, the ſuperintendant collects a ſufficient number of perſons from the adjacent towns or villages, and takes off his crop as follows. To any ſet of tradeſmen who bring their carts and buffaloes he agrees to give ſuch a price per pecul to cut all his crop of canes, carry them to the mill and grind them. A ſecond to boil them per pecul. A third to clay them and baſket them for market per pecul. So that by this method of conducting a ſugar eſtate the renter knows to a certainty what the produce of it will coſt him per pecul. He has not any permanent or unneceſſary expence; for when the crop is taken off, the taſkmen return to their ſeveral purſuits in the towns and villages they came from; and there only remain the cane planters who are preparing the next year's crop. This like all other complex arts, by being divided into ſeveral branches, renders the labour cheaper and the work more perfectly done.

Only clayed ſugars are made at Batavia; theſe are in quality equal to the beſt ſort from the Weſt Indies, and are ſold ſo low from the ſugar eſtates as eighteen ſhillings ſterling per pecul of 133½libs. This is not the ſelling price to the trader at Batavia, as the government there is arbitrary, and ſugar ſubject to duties impoſed at will. The Shabander exacts a dollar per pecul on all ſugar exported. The price of common labour is from 9d. to 10d. per day. By the method of carrying on the ſugar eſtates, the taſkmen gain conſiderably more than this not only from working extraordinary hours, but from being conſidered artiſts in their ſeveral branches. They do not make ſpirits on the ſugar eſtates. The melaſſes is ſent for ſale to Batavia, where one diſtillery may purchaſe the produce of an hundred eſtates. Here is a vaſt ſaving and reduction of the price of ſpirits; not as in the Weſt Indies, a diſtillery, for each eſtate; many centre in one, and arrack is ſold at Batavia from 21 to 25 rixdollars per leaguer of 160 gallons; ſay 8d. per gallon."

The SUGAR MAPLE, (the *acer ſaccharinum* of Linnæus), as well as the ſugar-cane, produces a great quantity of ſugar. This tree grows in great numbers in the weſtern counties of all the middle ſtates of the American union. Thoſe which grow in New York and Pennſylvania yield the ſugar in a greater quantity than thoſe which grow on the waters of the Ohio.—Theſe trees are generally found mixed with the beech, hemlock, white and water aſh, the cucumber tree, linden, aſpen, butter nut, and wild cherry trees. They ſometimes appear in groves covering five or ſix acres in a body, but they are more commonly interſperſed with ſome or all of the foreſt trees which have been mentioned. From 30 to 50 trees are generally found upon an acre of ground. They grow only in the richeſt ſoils, and frequently in ſtony ground. Springs of the pureſt water abound in their neighbourhood. They are, when fully grown, as tall as the white and black oaks, and from two to three feet in diameter. They put forth a beautiful white bloſſom in the ſpring before they ſhow a ſingle leaf. The colour of the bloſſom diſtinguiſhes them from the acer rubrum, or the common maple, which affords a bloſſom of a red colour. The wood of the ſugar maple-tree is extremely inflammable, and is preferred upon that account by hunters and ſurveyors for fire-wood. Its ſmall branches are ſo much impregnated with ſugar as to afford ſupport to the cattle, horſes, and ſheep of the firſt ſettlers, during the winter, before they are able to cultivate forage for that purpoſe. Its aſhes afford a great quantity of potaſh, exceeded by few, or perhaps by none, of the trees that grow in the woods of the United States. The tree is ſuppoſed to arrive at its full growth in the woods in twenty years.

46 Deſcription of the ſugar maple.

Tranſactions of the American Philoſophical Society, vol. iii.

It is not injured by tapping; on the contrary, the oftener it is tapped, the more ſyrup is obtained from it. In this reſpect it follows a law of animal ſecretion. A ſingle tree had not only ſurvived, but flouriſhed after forty-two tappings in the ſame number of years. The effects of a yearly diſcharge of ſap from the tree, in improving and increaſing the ſap, are demonſtrated from the ſuperior excellence of thoſe trees which have been perforated in an hundred places, by a ſmall wood-pecker which feeds upon the ſap. The trees, after having been wounded in this way, diſtil the remains of their juice on the ground, and afterwards acquire a black colour. The ſap of theſe trees is much ſweeter to the taſte than that which is obtained from trees which have not been previouſly wounded, and it affords more ſugar.

47 The oftener this tree is tapped the more ſyrup is obtained from it.

From twenty-three gallons and one quart of ſap, procured in twenty-four hours from only two of theſe dark coloured trees, Arthur Noble, Eſq. of the ſtate of New York, obtained four pounds and thirteen ounces of good grained ſugar.

48 What quantity of ſap will produce a certain quantity of ſugar.

A tree of an ordinary ſize yields in a good ſeaſon from twenty to thirty gallons of ſap, from which are made from five to ſix pounds of ſugar. To this there are ſometimes

Sugar.

times remarkable exceptions. Samuel Lowe, Eſq. a juſtice of peace in Montgomery county, in the ſtate of New York, informed Arthur Noble, Eſq. that he had made twenty pounds and one ounce of ſugar between the 14th and 23d of April, in the year 1789, from a ſingle tree that had been tapped for ſeveral ſucceſſive years before.

49 This quantity might be increaſed by culture.

From the influence which culture has upon foreſt and other trees, it has been ſuppoſed, that by tranſplanting the ſugar maple-tree into a garden, or by deſtroying ſuch other trees as ſhelter it from the rays of the ſun, the quantity of the ſap might be increaſed, and its quality much improved. A farmer in Northampton county, in the ſtate of Pennſylvania, planted a number of theſe trees above twenty years ago in his meadow, from three gallons of the ſap of which he obtains every year a pound of ſugar. It was obſerved formerly, that it required five or ſix gallons of the ſap of the trees which grow in the woods to produce the ſame quantity of ſugar.

50 The ſap diſtils from the wood in the ſpring months.

The ſap diſtils from the wood of the tree. Trees which have been cut down in the winter for the ſupport of the domeſtic animals of the new ſettlers, yield a conſiderable quantity of ſap as ſoon as their trunks and limbs feel the rays of the ſun in the ſpring of the year. It is in conſequence of the ſap of theſe trees being equally diffuſed through every part of them, that they live three years after they are girdled, that is, after a circular inciſion is made through the bark into the ſubſtance of the tree for the purpoſe of deſtroying it. It is remarkable that graſs thrives better under this tree in a meadow, than in ſituations expoſed to the conſtant action of the ſun. The ſeaſon for tapping the trees is in February, March, and April, according to the weather which occurs in theſe months.

51 Is increaſed by warm days and froſty nights.

Warm days and froſty nights are moſt favourable to a plentiful diſcharge of ſap. The quantity obtained in a day from a tree is from five gallons to a pint, according to the greater or leſs heat of the air. Mr Lowe informed Arthur Noble, Eſq. that he obtained near three and twenty gallons of ſap in one day (April 14. 1789.) from the ſingle tree which was before mentioned. Such inſtances of a profuſion of ſap in ſingle trees are however not very common.

52 How the ſap is drained from the tree.

There is always a ſuſpenſion of the diſcharge of ſap in the night if a froſt ſucceed a warm day. The perforation in the tree is made with an axe or an auger. The latter is preferred from experience of its advantages. The auger is introduced about three quarters of an inch, and in an aſcending direction (that the ſap may not be frozen in a ſlow current in the mornings or evenings), and is afterwards deepened gradually to the extent of two inches. A ſpout is introduced about half an inch into the hole made by this auger, and projects from three to twelve inches from the tree. The ſpout is generally made of the ſumach or elder, which uſually grows in the neighbourhood of the ſugar trees. The tree is firſt tapped on the ſouth ſide; when the diſcharge of its ſap begins to leſſen, an opening is made on the north ſide, from which an increaſed diſcharge takes place. The ſap flows from four to ſix weeks, according to the temperature of the weather. Troughs large enough to contain three or four gallons made of white pine, or white aſh, or of dried water aſh, aſpen, linden, poplar, or common maple, are placed under the ſpout to receive the ſap, which is carried every day to a large receiver, made of either of the trees before mentioned. From this receiver it is conveyed, after being ſtrained, to the boiler.

Sugar ‖ Sugillation.

53 Is reduced to ſugar by three modes.

We underſtand that there are three modes of reducing the ſap to ſugar; by evaporation, by freezing, and by boiling; of which the latter is moſt general, as being the moſt expeditious. We are farther aſſured, that the profit of the maple tree is not confined to its ſugar. It affords moſt agreeable melaſſes, and an excellent vinegar. The ſap which is ſuitable for theſe purpoſes is obtained after the ſap which affords the ſugar has ceaſed to flow, ſo that the manufactories of theſe different products of the maple tree, by ſucceeding, do not interfere with each other. The melaſſes may be made to compoſe the baſis of a pleaſant ſummer beer. The ſap of the maple is moreover capable of affording a ſpirit; but we hope this precious juice will never be proſtituted to this ignoble purpoſe. Should the uſe of ſugar in diet become more general in this country (ſays Dr Ruſh) it may tend to leſſen the inclination or ſuppoſed neceſſity for ſpirits, for I have obſerved a reliſh for ſugar in diet to be ſeldom accompanied by a love for ſtrong drink.

54 Sugar procured from many other vegetables.

There are ſeveral other vegetables raiſed in our own country which afford ſugar; as beet-roots, ſkirrets, parſneps, potatoes, celeri, red cabbage ſtalks, the young ſhoots of Indian wheat. The ſugar is moſt readily obtained from theſe, by making a tincture of the ſubject in rectified ſpirit of wine; which, when ſaturated by heat, will depoſit the ſugar upon ſtanding in the cold.

SUGAR of Milk. See MILK, CHEMISTRY *Index*.

Acid of SUGAR. See CHEMISTRY *Index*.

SUGILLATION, in *Medicine*, an extravaſation of blood in the coats of the eye, which at firſt appears of a reddiſh colour, and afterwards livid or black. If the diſorder is great, bleeding and purging are proper, as are alſo diſcutients.

END OF THE NINETEENTH VOLUME.

DIRECTIONS FOR PLACING THE PLATES OF VOLUME XIX.

PART I.

PART II.