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XV. SWIFT'S WORKS, edited by WALTER SCOTT, Esq. with a Life of the Author, Notes Critical and Illustrative, &c. &c. Nineteen Volumes Octavo, handsomely printed, with a few copies on Royal Paper.

☞ The present edition of this incomparable English Classic is offered to the public on a plan different from that adopted by former editors. In the Life of the Author, it is proposed to collate and combine the various information which has been given by Mr Sheridan, Lord Orrery, Dr Delany, Mr Pilkington, Dean Swift, Dr Johnson, and others, into one distinct and comprehensive narrative; which, it is hoped, may prove neither a libel or apology for Swift, nor a collection from the pleadings of those who have written either; but a plain, impartial, and connected biographical narrative. By the favour of distinguished friends in Ireland, the Editor hopes to obtain considerable light upon some passages in the Dean's life, which have hitherto perplexed his biographers. In preparing the text and notes, no labour or expense has been spared to procure original information. The Tale of a Tub, for example, is illustrated with the marginal notes of the learned Bentley, transcribed from manuscript jottings on his own copy. Although neither long nor numerous, they offer some curious elucidations of the author, and afford a singular instance of the equanimity with which the satire even of Swift was borne by the venerable scholar against whom it was so unadvisedly levelled. Some preliminary critical observations are offered on the various literary productions of the Dean of St Patrick's; and historical explanations and anecdotes accompany his political treatises. All those pieces which, though hitherto admitted into Swift's works, are positively ascertained not to be of his composition, are placed in the Appendix, or altogether retrenched. On the other hand, the editor is encouraged to believe, that, by accurate research, some gleanings may yet be recovered, which have escaped even the laudable and undeniable industry of Swift's last editor. So that, upon the whole, he hopes the present edition will be fully more complete than those of late years. The work will appear in the course of 1810.

XVI. RESEARCHES into the ORIGIN and AFFINITY of the GREEK and TEUTONIC LANGUAGES. By A. MURRAY, F. A. S. E. and Secretary for Foreign Correspondence. One Volume Quarto.

*** The immediate object of this work is, to illustrate the early state and connexion of these languages, on accurate and *philosophical* principles. The light which is thus thrown on the structure of the Greek tongue, gives a NEW and interesting form to the whole of classic philology; exhibits an extensive view of the process by which the mind invents and improves articulate speech; and leads to a development of the origin of the most antient European nations. The notices ascertained in the course of investigation depend, not on conjecture, but on a comparison of almost every European language with those to which it is respectively allied. In the train of inquiry pursued in the researches above mentioned, particular regard has been paid to the Oriental tongues; those having been examined which bear no affinity to the Teutonic, as well as those which appear to be related to it. For a plan and outline of the whole work, reference may be had to page 505 of an 'Account of the Life and Writings of James Bruce of Kinnaird Esq., Author of Travels to discover the Source of the Nile, in the Years 1768—1773,' published last year (1808.)

be $=\frac{1}{2a}$. Moreover, the times in which the ſame velocity will be extinguiſhed by different forces, acting uniformly, are inverſely as the forces, and gravity would extinguiſh the velocity 1 in the time $\frac{1}{g}$, =(in theſe meaſures) to $\frac{1}{\frac{u^2}{2a}}$, $=\frac{2a}{u^2}$. Therefore we have the following proportion $\frac{1}{2a}(=\mathrm{R}):\frac{u^2}{2a}(=g)=\frac{2a}{u^2}:2a$, and $2a$ is equal to E, the time in which the velocity 1 will be extinguiſhed by the uniform action of the reſiſtance competent to this velocity.

The velocity 1 would in this caſe be extinguiſhed after a motion uniformly retarded, in which the ſpace deſcribed is one half of what would be uniformly deſcribed during the ſame time with the conſtant velocity 1. Therefore the ſpace thus deſcribed by a motion which begins with the velocity 1, and is uniformly retarded by the reſiſtance competent to this velocity, is equal to the height through which *this* body muſt fall *in vacuo* in order to acquire *its* terminal velocity in air.

All theſe circumſtances may be conceived in a manner which, to ſome readers, will be more familiar and palpable. The terminal velocity is that where the reſiſtance of the air balances and is equal to the weight of the body. The reſiſtance of the air to any particular body is as the ſquare of the velocity; therefore let R be the whole reſiſtance to the body moving with the velocity 1, and r the reſiſtance to its motion with the terminal velocity u; we muſt have $r=\mathrm{R}\times u^2$, and this muſt be =W the weight. Therefore, to obtain the terminal velocity, divide the weight by the reſiſtance to the velocity 1, and the quotient is the ſquare of the terminal velocity, or $\frac{\mathrm{W}}{\mathrm{R}}=u^2$: And this is a very expeditious method of determining it, if R be previouſly known.

Then the common theorems give a, the fall neceſſary for producing this velocity *in vacuo* $=\frac{u^2}{2g}$, and the time of the fall $=\frac{u}{g}=e$, and $eu=2a$, = the ſpace uniformly deſcribed with the velocity u during the time of the fall, or its equal, the time of the extinction by the uniform action of the reſiſtance r; and, ſince r extinguiſhes it in the time e, R, which is u^2 times ſmaller, will extinguiſh it in the time u^2e, and R will extinguiſh the velocity 1, which is u times leſs than u, in the time ue, that is, in the time $2a$; and the body, moving uniformly during the time $2a$, =E, with the velocity 1, will deſcribe the ſpace $2a$; and, if the body begin to move with the velocity 1, and be uniformly oppoſed by the reſiſtance R, it will be brought to reſt when it has deſcribed the ſpace a; and the ſpace in which the reſiſtance to the velocity 1 will extinguiſh that velocity by its uniform action, is equal to the height through which that body muſt fall *in vacuo* in order to acquire its terminal velocity in air. And thus every thing is regulated by the time E in which the velocity 1 is extinguiſhed by the uniform action of the correſponding reſiſtance, or by $2a$, which is the ſpace uniformly deſcribed during this time, with the velocity 1. And E and $2a$ muſt be expreſſed by the ſame number. It is a number of units, of time, or of length.

35 The compariſon made general.

Having aſcertained theſe leading circumſtances for an unit of velocity, weight, and bulk, we proceed to deduce the ſimilar circumſtances for any other magnitude; and, to avoid unneceſſary complications, we ſhall always ſuppoſe the bodies to be ſpheres, differing only in diameter and denſity.

Firſt, then, let the velocity be increaſed in the ratio of 1 to v.

The reſiſtance will now be $\frac{v^2}{2a}$, $=r$.

The extinguiſhing time will be $\frac{\mathrm{E}}{v}$, $=e$, $=\frac{2a}{v}$, and $ev=2a$; ſo that the rule is general, that the ſpace along which *any* velocity will be extinguiſhed by the uniform action of the correſponding reſiſtance, is equal to the height neceſſary for communicating the terminal velocity to *that* body by gravity. For ev is twice the ſpace through which the body moves while the velocity v is extinguiſhed by the uniform reſiſtance.

In the 2d place, let the diameter increaſe in the proportion of 1 to d. The aggregate of the reſiſtance changes in the proportion of the ſurface ſimilarly reſiſted, that is, in the proportion of 1 to d^2. But the quantity of matter, or number of particles among which this reſiſtance is to be diſtributed, changes in the proportion of 1 to d^3. Therefore the retarding power of the reſiſtance changes in the proportion of 1 to $\frac{1}{d}$. When the diameter was 1, the reſiſtance to a velocity 1 was $\frac{1}{2a}$. It muſt now be $\frac{1}{2ad}$. The time in which this diminiſhed reſiſtance will extinguiſh the velocity 1 muſt increaſe in the proportion of the diminution of force, and muſt now be Ed, or $2ad$, and the ſpace uniformly deſcribed during this time with the initial velocity 1 muſt be $2ad$; and this muſt ſtill be twice the height neceſſary for communicating the terminal velocity w to *this* body. We muſt ſtill have $g=\frac{w^2}{2ad}$; and therefore $w^2=2gad$, and $w=\sqrt{2gad}=\sqrt{2ga}\sqrt{d}$. But $u=\sqrt{2ga}$. Therefore the terminal velocity w for this body is $=u\sqrt{d}$; and the height neceſſary for communicating it is ad. Therefore the terminal velocity varies in the ſubduplicate ratio of the diameter of the ball, and the fall neceſſary for producing it varies in the ſimple ratio of the diameter. The extinguiſhing time for the velocity v muſt now be $\frac{\mathrm{E}d}{v}$.

If, in the 3d place, the denſity of the ball be increaſed in the proportion of 1 to m, the number of particles among which the reſiſtance is to be diſtributed is increaſed in the ſame proportion, and therefore the retarding force of the reſiſtance is equally diminiſhed; and if the denſity of the air is increaſed in the proportion of 1 to n, the retarding force of the reſiſtance increaſes in the ſame proportion: hence we eaſily deduce theſe *general* expreſſions.

The terminal velocity $=u\sqrt{d\frac{m}{n}}=\sqrt{2gad\frac{m}{n}}$.

The producing fall *in vacuo* $=ad\frac{m}{n}$.

The

The retarding power of reſiſtance to any velocity $=$ r', $= \frac{v^2}{2\,a\,d\,\frac{m}{n}}$.

The extinguiſhing time for any velocity $v = \frac{E\,d\,m}{v\,n}$.

And thus we ſee that the chief circumſtances are regulated by the terminal velocity, or are conveniently referred to it.

36 Units neceſſary by which the quantities may be meaſured.

To render the deductions from theſe premiſes perſpicuous, and for communicating diſtinct notions or ideas, it will be proper to aſſume ſome convenient units, by which all theſe quantities may be meaſured; and, as this ſubject is chiefly intereſting in the caſe of military projectiles, we ſhall adapt our units to this purpoſe. Therefore, let a ſecond be the unit of time, a foot the unit of ſpace and velocity, an inch the unit of diameter of a ball or ſhell, and a pound avoirdupois the unit of preſſure, whether of weight or of reſiſtance; therefore g is 32 feet.

The great difficulty is to procure an abſolute meaſure of r, or u, or a; any one of theſe will determine the others.

37 Sir Iſaac Newton's endeavours in this way.

Sir Iſaac Newton has attempted to determine r by theory, and employs a great part of the ſecond book of the *Principia* in demonſtrating, that the reſiſtance to a ſphere moving with any velocity is to the force which would generate or deſtroy its whole motion in the time that it would uniformly move over $\frac{8}{3}$ of its diameter with this velocity as the denſity of the air is to the denſity of the ſphere. This is equivalent to demonſtrating that the reſiſtance of the air to a ſphere moving through it with any velocity, is equal to half the weight of a column of air having a great circle of the ſphere for its baſe, and for its altitude the height from which a body muſt fall *in vacuo* to acquire this velocity. This appears from Newton's demonſtration; for, let the ſpecific gravity of the air be to that of the ball as 1 to m; then, becauſe the times in which the ſame velocity will be extinguiſhed by the uniform action of different forces are inverſely as the forces, the reſiſtance to this velocity would extinguiſh it in the time of deſcribing $\frac{8}{3}md$, d being the diameter of the ball. Now 1 is to m as the weight of the diſplaced air to the weight of the ball, or as $\frac{2}{3}$ of the diameter of the ball to the length of a column of air of equal weight. Call this length a; a is therefore equal to $\frac{2}{3}\,m\,d$. Suppoſe the ball to fall from the height a in the time t, and acquire the velocity u. If it moved uniformly with this velocity during this time, it would deſcribe a ſpace $= 2\,a$, or $\frac{4}{3}\,m\,d$. Now its weight would extinguiſh this velocity, or deſtroy this motion, in the ſame time, that is, in the time of deſcribing $\frac{4}{3}\,m\,d$; but the reſiſtance of the air would do this in the time of deſcribing $\frac{8}{3}\,m\,d$; that is, in twice the time. The reſiſtance therefore is equal to half the weight of the ball, or to half the weight of the column of air whoſe height is the height producing the velocity. But the reſiſtances to different velocities are as the ſquares of the velocities, and therefore, as their producing heights; and, in general, the reſiſtance of the air to a ſphere moving with any velocity, is equal to the half weight of a column of air of equal ſection, and whoſe altitude is the height producing the velocity. The reſult of this inveſtigation has been acquieſced in by all Sir Iſaac Newton's commentators. Many faults have indeed been found with his reaſoning, and even with his principles; and it muſt be acknowledged that although this inveſtigation is by far the moſt ingenious of any in the *Principia*, and ſets his acuteneſs and addreſs in the moſt conſpicuous light, his reaſoning is liable to ſerious objections, which his moſt ingenious commentators have not completely removed. However, the concluſion has been acquieſced in, as we have already ſtated, but as if derived from other principles, or by more logical reaſoning. We cannot, however, ſay that the reaſonings or aſſumptions of theſe mathematicians are much better than Newton's: and we muſt add, that all the cauſes of deviation from the duplicate ratio of the velocities, and the cauſes of increaſed reſiſtance, which the later authors have valued themſelves for diſcovering and introducing into their inveſtigations, were pointed out by Sir Iſaac Newton, but purpoſely omitted by him, in order to facilitate the diſcuſſion *in re difficillima*. (See *Schol.* prop. 37. book ii.). 38

38 His reſult juſt, but his reaſoning erroneous.

It is known that the weight of a cubic foot of water is $62\frac{1}{2}$ pounds, and that the medium denſity of the air is $\frac{1}{840}$ of water; therefore, let a be the height producing the velocity (in feet), and d the diameter of the ball (in inches), and π the periphery of a circle whoſe diameter is 1; the reſiſtance of the air will be $= \frac{62\frac{1}{2}}{840} \times \frac{\pi}{4} \times \frac{1}{144} \times \frac{a}{2} \times d^2 = \frac{a\,d^2}{4928\frac{1}{2}}$ pounds, very nearly, $= \frac{v^2}{4928\frac{1}{2} \times 64} d^2$, $= \frac{v^2\,d^2}{315417}$ pounds.

We may take an example. A ball of caſt iron weighing 12 pounds, is $4\frac{1}{2}$ inches in diameter. Suppoſe this ball to move at the rate of $25\frac{1}{10}$ feet in a ſecond (the reaſon of this choice will appear afterwards). The height which will produce this velocity in a falling body is $9\frac{7}{8}$ feet. The area of its great circle is 0.11044 feet, or $\frac{11044}{100000}$ of one foot. Suppoſe water to be 840 times heavier than air, the weight of the air incumbent on this great circle, and $9\frac{7}{8}$ feet high, is 0.081151 pounds: half of this is 0.0405755 or $\frac{405755}{10000000}$, or nearly $\frac{1}{25}$ of a pound. This ſhould be the reſiſtance of the air to this motion of the ball.

39 Neceſſity of experiment.

In all matters of phyſical diſcuſſion, it is prudent to confront every theoretical concluſion with experiment. This is particularly neceſſary in the preſent inſtance, becauſe the theory on which this propoſition is founded is extremely uncertain. Newton ſpeaks of it with the moſt cautious diffidence, and ſecures the juſtneſs of the concluſions by the conditions which he aſſumes in his inveſtigation. He deſcribes with the greateſt preciſion the ſtate of the fluid in which the body muſt move, ſo as that the demonſtrations may be ſtrict, and leaves it to others to pronounce whether this is the real conſtitution of our atmoſphere. It muſt be granted that it is not; and that many other ſuppoſitions have been introduced by his commentators and followers, in order to ſuit his inveſtigation (for we muſt aſſert that little or nothing has been added to it) to the circumſtances of the caſe.

40 Newton's experiments.

Newton himſelf, therefore, attempted to compare his propoſitions with experiment. Some were made by dropping balls from the dome of St Paul's cathedral; and all theſe ſhowed as great a coincidence with his theory as they did with each other: but the irregularities

ties were too great to allow him to fay with precifion what was the refiftance. It appeared to follow the proportion of the fquares of the velocities with fufficient exactnefs; and though he could not fay that the refiftance was equal to the weight of the column of air having the height neceffary for communicating the velocity, it was always equal to a determinate part of it; and might be ftated $= n\,a$, n being a number to be fixed by numerous experiments.

One great fource of uncertainty in his experiments feems to have efcaped his obfervation: the air in that dome is almoft always in a ftate of motion. In the fummer feafon there is a very fenfible current of air downwards, and frequently in winter it is upwards: and this current bears a very great proportion to the velocity of the defcents. Sir Ifaac takes no notice of this.

He made another fet of experiments with pendulums; and has pointed out fome very curious and unexpected circumftances of their motions in a refifting medium. There is hardly any part of his noble work in which his addrefs, his patience, and his aftonifhing penetration, appear in greater luftre. It requires the utmoft intenfenefs of thought to follow him in thefe difquifitions; and we cannot enter on the fubject at prefent: fome notice will be taken of thefe experiments in the article *RESISTANCE of Fluids*. Their refults were much more uniform, and confirmed his general theory; and, as we have faid above, it has been acquiefced in by the firft mathematicians of Europe.

41
Inutility of the theory in practice.

But the deductions from this theory were fo inconfiftent with the obferved motions of military projectiles, when the velocities are prodigious, that no application could be made which could be of any fervice for determining the path and motion of cannon fhot and bombs; and although Mr John Bernoulli gave, in 1718, a moft elegant determination of the trajectory and motion of a body projected in a fluid which refifts in the duplicate ratio of the velocities (a problem which even Newton did not attempt), it has remained a dead letter. Mr Benjamin Robins, equally eminent for phyfical fcience and mathematical genius, was the firft who fufpected the true caufe of the imperfection of the ufually received theories; and in 1737 he publifhed a fmall tract, in which he fhowed clearly, that even the Newtonian theory of refiftance muft caufe a cannon ball, difcharged with a full allotment of powder, to deviate farther from the parabola, in which it would move *in vacuo*, than the parabola deviates from a ftraight line. But he farther afferted, on the authority of good reafoning, that in fuch great velocities the refiftance muft be much greater than this theory affigns; becaufe, befides the refiftance arifing from the *inertia* of the air which is put in motion by the ball, there muft be a refiftance arifing from a condenfation of the air on the anterior furface of the ball, and a rarefaction behind it: and there muft be a third refiftance, arifing from the ftatical preffure of the air on its anterior part, when the motion is fo fwift that there is a vacuum behind. Even thefe caufes of difagreement with the theory had been forefeen and mentioned by Newton (fee the Scholium to prop. 37. book ii. *Princip.*); but the fubject feems to have been little attended to. The eminent mathematicians had few opportunities of making experiments; and the profeffional men, who were in the fervice of princes, and had their countenance and aid in this matter, were generally too deficient in mathematical knowledge to make a proper ufe of their opportunities. The numerous and fplendid volumes which thefe gentlemen have been enabled to publifh by the patronage of fovereigns are little more than prolix extenfions of the fimple theory of Galileo. Some of them, however, fuch as St Remy, Antonini, and Le Blond, have given moft valuable collections of experiments, ready for the ufe of the profound mathematician.

42
The attempts of various mathematicians, &c.

43
Obfervations of Mr Robins on velocity and refiftance,

Two or three years after this firft publication, Mr Robins hit upon that ingenious method of meafuring the great velocities of military projectiles, which has handed down his name to pofterity with great honour. And having afcertained thefe velocities, he difcovered the prodigious refiftance of the air, by obferving the diminution of velocity which it occafioned. This made him anxious to examine what was the real refiftance to any velocity whatever, in order to afcertain what was the law of its variation; and he was equally fortunate in this attempt. His method of meafuring the refiftance has been fully defcribed in the article GUNNERY, N° 9, &c.

It appears (Robins's *Math. Works*, vol. i. page 205.) that a fphere of $4\frac{1}{2}$ inches in diameter, moving at the rate of $25\frac{1}{5}$ feet in a fecond, fuftained a refiftance of 0,04914 pounds, or $\frac{4914}{100000}$ of a pound. This is a greater refiftance than that of the Newtonian theory, which gave $\frac{405755}{10000000}$ in the proportion of 1000 to 1211, or very nearly in the proportion of five to fix in fmall numbers. And we may adopt as a rule in all moderate velocities, that the refiftance to a fphere is equal to $\frac{61}{100}$ of the weight of a column of air having the great circle of the fphere for its bafe, and for its altitude the height through which a heavy body muft fall *in vacuo* to acquire the velocity of projection.

This experiment is peculiarly valuable, becaufe the ball is precifely the fize of a 12 pound fhot of caft iron; and its accuracy may be depended on. There is but one fource of error. The whirling motion muft have occafioned fome whirl in the air, which would continue till the ball again paffed through the fame point of its revolution. The refiftance obferved is therefore probably fomewhat lefs than the true refiftance to the velocity of $25\frac{1}{5}$ feet, becaufe it was exerted in a relative velocity which was lefs than this, and is, in fact, the refiftance competent to this relative and fmaller velocity. —Accordingly, Mr Smeaton, a moft fagacious naturalift, places great confidence in the obfervations of a Mr Roufe of Leicefterfhire, who meafured the refiftance by the effect of the wind on a plane properly expofed to it. He does not tell us in what way the velocity of the wind was afcertained; but our deference for his great penetration and experience difpofes us to believe that this point was well determined. The refiftance obferved by Mr Roufe exceeds that refulting from Mr Robins's experiments nearly in the proportion of 7 to 10. Chevalier de Borda made experiments fimilar to thofe of Mr Robins, and his refults exceed thofe of Robins in the proportion of 5 to 6. Thefe differences are fo confiderable, that we are at a lofs what meafure to abide by. It is much to be regretted, that in a fubject fo interefting both to the philofopher and the man of the world, experiments have not been multiplied. Nothing would tend fo much to perfect the fcience of

44
and of Mr Roufe and De Borda.

45
They differ widely in their conclufions.

of gunnery; and indeed till this be done, all the labours of mathematicians are of no avail. Their investigations must remain an unintelligible cipher, till this key be supplied. It is to be hoped that Dr Charles Hutton of Woolwich, who has so ably extended Mr Robins's Examination of the Initial Velocities of Military Projectiles, will be encouraged to proceed to this part of the subject. We should wish to see, in the first place, a numerous set of experiments for ascertaining the resistances in moderate velocities; and, in order to avoid all error from the resistance and inertia of the machine, which is necessarily blended with the resistance of the ball, in Mr Robins's form of the experiment, and is separated with great uncertainty and risk of error, we would recommend a form of experiment somewhat different.

46 A new form of experiment recommended.

Let the axis and arm which carries the ball be connected with wheelwork, by which it can be put in motion, and gradually accelerated. Let the ball be so connected with a bent spring, that this shall gradually compress it as the resistance increases, and leave a mark of the degree of compression; and let all this part of the apparatus be screened from the air except the ball. The velocity will be determined precisely by the revolutions of the arm, and the resistance by the compression of the spring. The best method would be to let this part of the apparatus be made to slide along the revolving arm, so that the ball can be made to describe larger and larger circles. An intelligent mechanician will easily contrive an apparatus of this kind, held at any distance from the axis by a cord, which passes over a pulley in the axis itself, and is then brought along a perforation in the axis, and comes out at its extremity, where it is fitted with a swivel, to prevent it from snapping by being twisted. Now let the machine be put in motion. The centrifugal force of the ball and apparatus will cause it to fly out as far as it is allowed by the cord; and if the whole is put in motion by connecting it with some mill, the velocity may be most accurately ascertained. It may also be fitted with a bell and hammer like Gravesande's machine for measuring centrifugal forces. Now by gradually veering off more cord, the distance from the centre, and consequently the velocity and resistance increase, till the hammer is disengaged and strikes the bell.

Another great advantage of this form of the experiment is, that the resistance to very great velocities may be thus examined, which was impossible in Mr Robins's way. This is the great desideratum, that we may learn in what proportion of the velocities the resistances increase.

In the same manner, an apparatus, consisting of Dr Lynd's Anemometer, described in the article PNEUMATICS, N° 311, &c. might be whirled round with prodigious rapidity, and the fluid on it might be made clammy, which would leave a mark at its greatest elevation, and thus discover the resistance of the air to rapid notions.

Nay, we are of opinion that the resistance to very rapid motions may be measured directly in the conduit pipe of some of the great cylinder bellows employed in blast furnaces: the velocity of the air in this pipe is ascertained by the capacity of the cylinder and the strokes of the piston. We think it our duty to point out to such as have the opportunities of trying them methods which promise accurate results for ascertaining this most desirable point.

47 The result of Robins's experiments as yet most to be depended on.

We are the more puzzled what measure to abide by, because Mr Robins himself, in his Practical Propositions, does not make use of the result of his own experiments, but takes a much lower measure. We must content ourselves, however, with this experimental measure, because it is as yet the only one of which any account can be given, or well-founded opinion formed.

48 Applied to the formulæ.

Therefore, in order to apply our formulæ, we must reduce this experiment, which was made on a ball of $4\frac{1}{2}$ inches diameter, moving with the velocity of $25\frac{1}{5}$ feet per second, to what would be the resistance to a ball of one inch, having the velocity 1 foot. This will evidently give us $R = \frac{0,04914}{4,5^2 \times 25.2^2}$, being diminished in the duplicate ratio of the diameter and velocity. This gives us $R = 0,00000381973$ pounds, or $\frac{3.81973}{1000000}$ of a pound. The logarithm is 4,58204. The resistance here determined is the same whatever substance the ball be of; but the retardation occasioned by it will depend on the proportion of the resistance to the *vis insita* of the ball; that is, to its quantity of motion. This in similar velocities and diameters is as the density of the ball. The balls used in military service are of cast iron or of lead, whose specific gravities are 7,207 and 11,37 nearly, water being 1. There is considerable variety in cast iron, and this density is about the medium. These data will give us

	For Iron.	For Lead.
W, or weight of a ball 1 inch in diameter - - lbs.	0.13648	0.21533
Log. of W - -	9.13509	9.33310
E″ - -	1116″.6	1761″.6
Log. of E - -	3.04790	3.24591
u, or terminal velocity -	189.03	237.43
Log. *u* - - -	2.27653	2.37553
a, or producing height	558.3	880.8

These numbers are of frequent use in all questions on this subject.

Mr Robins gives an expeditious rule for readily finding *a*, which he calls F (see the article GUNNERY), by which it is made 900 feet for a cast iron ball of an inch diameter. But no theory of resistance which he professes to use will make this height necessary for producing the terminal velocity. His F therefore is an *empirical* quantity, analogous indeed to the producing height, but accommodated to his theory of the trajectory of cannon-shot, which he promised to publish, but did not live to execute. We need not be very anxious about this; for all our quantities change in the same proportion with R, and need only a correction by a multiplier or divisor, when R shall be accurately established.

We may illustrate the use of these formulæ by an example or two.

49 Examples of their use.

1. Then, to find the resistance to a 24 pound ball moving with the velocity of 1670 feet in a second, which is nearly the velocity communicated by 16 lbs. of powder. The diameter is 5,603 inches.

Log.

Log. R	- -	$+\bar{4}.58204$
Log. d^2	- - -	+1.49674
Log. 1670^2	- - -	+6.44548
Log. 334.4 lbs. $=r$	- -	2.52426

But it is found, by unequivocal experiments on the retardation of ſuch a motion, that it is 504 lbs. This is owing to the cauſes often mentioned, the additional reſiſtance to great velocities, ariſing from the condenſation of the air, and from its preſſure into the vacuum left by the ball.

2. Required the terminal velocity of this ball?

Log. R	- -	+4.58204
Log, d^2	- -	+1.49674
Log. reſiſt. to veloc. 1	-	$6.07878=a$
Log. W	- -	$1.38021=b$
Diff. of a and b, $=\log u^2$	-	5.30143
Log. 447.4 $=u$	-	2.65071

50 Table of terminal velocity according to Newton and Robins.

As the terminal velocity u, and its producing height a, enter into all computations of military projectiles, we have inſerted the following Table for the uſual ſizes of cannon-ſhot, computed both by the Newtonian theory of reſiſtance, and by the reſiſtances obſerved in Robins's experiments.

Lb. Ball.	Newton.		Robins.		Diam. Inch.
	u Term. Vel	2 a.	Term. Vel.	2 a.	
1	289.9	2626.4	263.4	2168.6	1.94
2	324.9	3298.5	295.2	2723.5	2.45
3	348.2	3788.2	316.4	3127.9	2.80
4	365.3	4170.3	331.9	3442.6	3.08
6	390.8	4472.7	355.1	3940.7	3.52
9	418.1	5463.5	379.9	4511.2	4.04
12	438.6	6010.6	398.5	4962.9	4.45
18	469.3	6883.3	426.5	5683.5	5.09
24	492.4	7576.3	447.4	6255.7	5.61
32	512.6	8024.8	465.8	6780.4	6.21
	540.5	9129.9	491.5	7538.3	6.75

51 Mr Muller's theory altogether erroneous.

Mr Muller, in his writings on this ſubject, gives a much ſmaller meaſure of reſiſtance, and conſequently a much greater terminal velocity: but his theory is a miſtake from beginning to end (See his *Supplement* to his *Treatiſe of Artillery* art. 150, &c.) In art. 148. he aſſumes an algebraic expreſſion for a principle of mechanical argument; and from its conſequence draws erroneous concluſions. He makes the reſiſtance of a cylinder one-third leſs than Newton *ſuppoſes* it; and his reaſon is falſe. Newton's meaſure is demonſtrated by his commentators Le Seur and Jaquier to be even a little too ſmall, upon his own principles, (Not. 277 Prop. 36. B. II.) Mr Muller then, without any ſeeming reaſon, introduces a new principle, which he makes the chief ſupport of his theory, in oppoſition to the theories of other mathematicians. The principle is falſe, and even abſurd, as we ſhall have occaſion to ſhow by and by. In conſequence, however, of this principle, he is enabled to compare the reſults with many experiments, and the agreement is very flattering. But we ſhall ſoon ſee that little dependence can be had on ſuch compariſons. We notice theſe things here, becauſe Mr Muller being head of the artillery ſchool in Britain, his publications have become a ſort of text-books. We are miſerably deficient in works on this ſubject, and muſt have recourſe to the foreign writers.

We now proceed to conſider theſe motions through their whole courſe: and we ſhall firſt conſider them as affected by the reſiſtance only; then we ſhall conſider the perpendicular aſcents and deſcents of heavy bodies through the air; and, laſtly, their motion in a curvilineal trajectory, when projected obliquely. This muſt be done by the help of the abſtruſer parts of fluxionary mathematics. To make it more perſpicuous, we ſhall, by way of introduction, conſider the ſimply reſiſted rectilineal motions geometrically, in the manner of Sir Iſaac Newton. As we advance, we ſhall quit this track, and proſecute it algebraically, having by this time acquired diſtinct ideas of the algebraic quantities. 52 The motions conſidered through their whole courſe.

We muſt keep in mind the fundamental theorems of varied motions. 53 Preliminary obſervations.

1. The momentary variation of the velocity is proportional to the force and the moment of time jointly, and may therefore be repreſented by $\pm\dot{v}=f\dot{t}$, where $\dot{v}$ is the momentary increment or decrement of the velocity v, f the accelerating or retarding force, and $\dot{t}$ the moment or increment of the time t.

2. The momentary variation of the ſquare of the velocity is as the force, and as the increment or decrement of the ſpace jointly; and may be repreſented by $\pm v\dot{v}=f\dot{s}$ The firſt propoſition is familiarly known. The ſecond is the 39th of Newton's *Principia*, B. I. It is demonſtrated in the article Optics, and is the moſt extenſively uſeful propoſition in mechanics.

These things being premiſed, let the ſtraight line AC (fig. 5.) repreſent the initial velocity V, and let CO, perpendicular to AC, be the time in which this velocity would be extinguiſhed by the uniform action of the reſiſtance. Draw through the point A an equilateral hyperbola AeB, having OF, OCD for its aſſymptotes; then let the time of the reſiſted motion be repreſented by the line CB, C being the firſt inſtant of the motion. If there be drawn perpendicular ordinates $\varkappa e$, gf, DB, &c. to the hyperbola, they will be proportional to the velocities of the body at the inſtants $\varkappa$, g, D, &c. and the hyperbolic areas AC$\varkappa e$, ACgf, ACDB, &c. will be proportional to the ſpaces deſcribed during the times C$\varkappa$, Cg, CB, &c. 54 The motions as affected by reſiſtance only. Fig. 5.

For, ſuppoſe the time divided into an indefinite number of ſmall and equal moments, Cc, Dd, &c. draw the ordinates ac, bd, and the perpendiculars $b\beta$, $a\alpha$. Then, by the nature of the hyperbola, AC : ac = Oc : OC; and AC—ac : ac = Oc—OC : OC, that is, Aα : ac = Cc : OC, and Aα : Cc = ac : OC, = AC · ac : AC·OC; in like manner, Bβ : Dd = BD·bD : BD·OD. Now Dd = Cc, becauſe the moments of time were taken equal, and the rectangles AC·CO, BD·DO, are equal, by the nature of the hyperbola; therefore Aα : Bβ = AC · ac : BD · bd: but as the points c, d continually approach, and ultimately coincide with C, D, the ultimate ratio of AC · ac to BD·bd is that of AC^2 to BD^2; therefore the momentary decrements of AC

AC and BD are as AC^2 and BD^2. Now, becaufe the refiftance is meafured by the momentary diminution of velocity, thefe diminutions are as the fquares of the velocities; therefore the ordinates of the hyperbola and the velocities diminifh by the fame law; and the initial velocity was reprefented by AC: therefore the velocities at all the other inftants $\varkappa$, g, D, are properly reprefented by the correfponding ordinates. Hence,

1. Since the abfciffæ of the hyperbola are as the times, and the ordinates are as the velocities, the areas will be as the fpaces defcribed, and $AC\varkappa e$ is to $Acgf$ as the fpace defcribed in the time $C\varkappa$ to the fpace defcribed in the time Cg (1ft Theorem on varied motions).

2. The rectangle ACOF is to the area ACDB as the fpace formerly expreffed by $2a$, or E to the fpace defcribed in the refifting medium during the time CD: for AC being the velocity V, and OC the extinguifhing time e, this rectangle is $=eV$, or E, or $2a$, of our former difquifitions; and becaufe all the rectangles, fuch as ACOF, BDOG, &c. are equal, this correfponds with our former obfervation, that the fpace uniformly defcribed with any velocity during the time in which it would be uniformly extinguifhed by the correfponding refiftance is a conftant quantity, viz. that in which we always had $ev=E$, or $2a$.

3. Draw the tangent $A\varkappa$; then, by the hyperbola $C\varkappa=CO$: now $C\varkappa$ is the time in which the refiftance to the velocity AC would extinguifh it; for the tangent coinciding with the elemental arc Aa of the curve, the firft impulfe of the uniform action of the refiftance is the fame with the firft impulfe of its varied action. By this the velocity AC is reduced to ac. If this operated uniformly like gravity, the velocities would diminifh uniformly, and the fpace defcribed would be reprefented by the triangle $AC\varkappa$.

This triangle, therefore, reprefents the height through which a heavy body muft fall in vacuo, in order to acquire the terminal velocity.

4. The motion of a body refifted in the duplicate ratio of the velocity will continue without end, and a fpace will be defcribed which is greater than any affignable fpace, and the velocity will grow lefs than any that can be affigned; for the hyperbola approaches continually to the affymptote, but never coincides with it. There is no velocity BD fo fmall, but a fmaller ZP will be found beyond it; and the hyperbolic fpace may be continued till it exceeds any furface that can be affigned.

5. The initial velocity AC is to the final velocity BD as the fum of the extinguifhing time and the time of the retarded motion, is to the extinguifhing time alone: for AC : BD=OD (or OC+CD) : OC; or $V:v=e:e+t$.

6. The extinguifhing time is to the time of the retarded motion as the final velocity is to the velocity loft during the retarded motion: for the rectangles AFOC, BDOG are equal; and therefore AVGF and BVCD are equal, and VC : VA=VG : VB; therefore $t=e\frac{V-v}{v}$, and $e=t\frac{v}{V-v}$.

7. Any velocity is reduced in the proportion of m to n in the time $e\frac{m-n}{n}$. For, let AC : BD $=m:n$; then DO : CO$=m:n$, and DC : CO$=m-n:n$, and $DC=\frac{m-n}{n}CO$, or $t=e\frac{m-n}{n}$. Therefore any velocity is reduced to one half in the time in which the initial refiftance would have extinguifhed it by its uniform action.

55 Another mode of determining this motion.

Thus may the chief circumftances of this motion be determined by means of the hyperbola, the ordinates and abfciffæ exhibiting the relations of the times and velocities, and the areas exhibiting the relations of both to the fpaces defcribed. But we may render the conception of thefe circumftances infinitely more eafy and fimple, by expreffing them all by lines, inftead of this combination of lines and furfaces. We fhall accomplifh this purpofe by conftructing another curve LKP, having the line $ML\delta$, parallel to OD for its abfciffa, and of fuch a nature, that if the ordinates to the hyperbola AC, $e\varkappa$, fg, BD, &c. be produced till they cut this curve in L, p, n, K, &c. and the abfciffa in L, s, h, δ, &c. the ordinates sp, hn, δK, &c. may be proportional to the hyperbolic areas $eAC\varkappa$, $fACg$, δAcK. Let us examine what kind of curve this will be.

Make $OC:O\varkappa=O\varkappa:Og$; then Hamilton's *Conics*, IV. 14. Cor.), the areas $AC\varkappa e$, $e\varkappa gf$ are equal: therefore drawing ps, nt perpendicular to OM, we fhall have (by the affumed nature of the curve LpK), $Ms=st$; and if the abfciffa OD be divided into any number of fmall parts in geometrical progreffion (reckoning the commencement of them all from O), the axis Vi of this curve will be divided by its ordinates into the fame number of equal parts; and this curve will have its ordinates LM, ps, nt, &c. in geometrical progreffion, and its abfciffæ in arithmetrical progreffion.

Alfo, let KN, MV touch the curve in K and L, and let OC be fuppofed to be to Oc, as OD to Od, and therefore Cc to Dd as OC to OD; and let thefe lines Cc, Dd be indefinitely fmall; then (by the nature of the curve) Lo is equal to Kr: for the areas $aACc$, $bBDd$ are in this cafe equal. Alfo ko is to kr, as LM to KI, becaufe $cC:dD=CO:DO$:

$$\begin{aligned} \text{Therefore IN} : IK &= rK : rk \\ IK : ML &= rk : ol \\ ML : MV &= ol : oL \\ \text{and IN} : MN &= rK : oL. \end{aligned}$$

That is, the fubtangent IN, or MV, is of the fame magnitude, or is a conftant quantity in every part of the curve.

Laftly, the fubtangent IN, correfponding to the point K of the curve, is to the ordinate $K\delta$ as the rectangle BDOG or ACOF to the parabolic area BDCA.

For let $fghn$ be an ordinate very near to $BD\delta K$; and let hn cut the curve in n, and the ordinate KI in q; then we have

$$\begin{aligned} Kq : qn &= KI : IN, \text{ or} \\ Dg : qn &= DO : IN; \\ \text{but } BD : AC &= CO : DO; \\ \text{therefore } BD \cdot Dg : AC \cdot qn &= CO : IN. \end{aligned}$$

Therefore the fum of all the rectangles $BD.Dg$ is to the fum of all the rectangles $AC.qn$, as CO to IN; but

but the ſum of the rectangles BD . Dg is the ſpace ACDB; and, becauſe AC is given, the ſum of the rectangles AC . qn is the rectangle of AC and the ſum of all the lines qn; that is, the rectangle of AC and RL: therefore the ſpace ACDB : AC . RL = CO : IN, and ACDB × IN = AC . CO . RL; and therefore IN : RL = AC . CO : ACDB.

Hence it follows that QL expreſſes the area BVA, and in general, that the part of the line parallel to OM, which lies between the tangent KN and the curve LpK, expreſſes the correſponding area of the hyperbola which lies without the rectangle BDOG.

And now, by the help of this curve, we have an eaſy way of convincing and computing the motion of a body through the air. For the ſubtangent of our curve now repreſents twice the height through which the ball muſt fall in vacuo, in order to acquire the terminal velocity; and therefore ſerves for a ſcale on which to meaſure all the other repreſentatives of the motion.

56 The whole reduced to a ſimple arithmetical computation.

But it remains to make another obſervation on the curve LpK, which will ſave us all the trouble of graphical operations, and reduce the whole to a very ſimple arithmetical computation. It is of ſuch a nature, that when MI is conſidered as the abſciſſa, and is divided into a number of equal parts, and ordinates are drawn from the points of diviſion, the ordinates are a ſeries of lines in geometrical progreſſion, or are continual proportionals. Whatever is the ratio between the firſt and ſecond ordinate, there is the ſame between the ſecond and third, between the third and fourth, and ſo on; therefore the number of parts into which the abſciſſa is divided is the number of theſe equal ratios which is contained in the ratio of the firſt ordinate to the laſt: For this reaſon, this curve has got the name of the *logiſtic* or *logarithmic* curve; and it is of immenſe uſe in the modern mathematics, giving us the ſolution of many problems in the moſt ſimple and expeditious manner, on which the genius of the ancient mathematicians had been exerciſed in vain. Few of our readers are ignorant, that the numbers called *logarithms* are of equal utility in arithmetical operations, enabling us not only to ſolve common arithmetical problems with aſtoniſhing diſpatch, but alſo to ſolve others which are quite inacceſſible in any other way. Logarithms are nothing more than the numerical meaſures of the abſciſſa of this curve, correſponding to ordinates, which are meaſured on the ſame or any other ſcale by the natural numbers; that is, if MLδ be divided into equal parts, and from the points of diviſion lines be drawn parallel to MI, cutting the curve LpK, and from the points of interſection ordinates be drawn to MI, theſe will divide MI into portions, which are in the ſame proportion to the ordinates that the logarithms bear to their natural numbers.

In conſtructing this curve we were limited to no particular length of the line LR, which repreſented the ſpace ACDB; and all that we had to take care of was, that when OC, O$\varkappa$, Og were taken in geometrical progreſſion, Ms, Mt ſhould be in arithmetical progreſſion. The abſciſſæ having ordinates equal to ps, nt, &c. might have been twice as long, as is ſhown in the dotted curve which is drawn through L. All the lines which ſerve to meaſure the hyperbolic ſpaces would then have been doubled. But NI would alſo have been doubled, and our proportions would have ſtill held good; becauſe this ſubtangent is the ſcale of meaſurement of our figure, as E or 2a is the ſcale of meaſurement for the motions.

Since then we have tables of logarithms calculated for every number, we may make uſe of them inſtead of this geometrical figure, which ſtill requires conſiderable trouble to ſuit it to every caſe. There are two ſets of logarithmic tables in common uſe. One is called a table of hyperbolic or natural logarithms. It is ſuited to ſuch a curve as is drawn in the figure, where the ſubtangent is equal to that ordinate $\tau\upsilon$ which correſponds to the ſide πO of the ſquare $\pi\theta\lambda$O inſerted between the hyperbola and its aſſymptotes. This ſquare is the unit of ſurface, by which the hyperbolic areas are expreſſed; its ſide is the unit of length, by which the lines belonging to the hyperbola are expreſſed; $\tau\upsilon$ is = 1, or the unit of numbers to which the logarithms are ſuited, and then IN is alſo 1. Now the ſquare $\theta\pi$Oλ being unity, the area BACD will be ſome number; πO being alſo unity, OD is ſome number: Call it x. Then, by the nature of the hyperbola, OB : Oπ = $\pi\theta$: DB: That is, $x : 1 = 1 : \frac{1}{x}$, ſo that DB is $\frac{1}{x}$. Now calling Dd $\dot{x}$, the area BDdb, which is the fluxion (ultimately) of the hyperbolic area, is $\frac{\dot{x}}{x}$. Now in the curve LpK, MI has the ſame ratio to NI that BACD has to $\theta\lambda$Oπ: Therefore, if there be a ſcale of which NI is the unit, the number on this ſcale correſponding to MI has the ſame ratio to 1 which the number meaſuring BACD has to 1; and Ii, which correſponds to BDdb, is the fluxion (ultimately) of MI: Therefore, if MI be called the logarithm of x, $\frac{\dot{x}}{x}$ is properly repreſented by the fluxion of MI. In ſhort, the line MI is divided preciſely as the line of numbers on a Gunter's ſcale, which is therefore a line of logarithms; and the numbers called logarithms are juſt the lengths of the different parts of this line meaſured on a ſcale of equal parts. Therefore, when we meet with ſuch an expreſſion as $\frac{\dot{x}}{x}$ viz. the fluxion of a quantity divided by the quantity itſelf, we conſider it as the fluxion of the logarithm of that quantity, becauſe it is really ſo when the quantity is a number; and it is therefore ſtrictly true that the fluent of $\frac{\dot{x}}{x}$ is the hyperbolic logarithm of x.

Certain reaſons of convenience have given riſe to another ſet of logarithms; theſe are ſuited to a logiſtic curve whoſe ſubtangent is only $\frac{43429}{100000}$ of the ordinate $\tau\upsilon$, which is equal to the ſide of the hyperbolic ſquare, and which is aſſumed for the unit of number. We ſhall ſuit our applications of the preceding inveſtigation to both theſe, and ſhall firſt uſe the common logarithms whoſe ſubtangent is 0,43429.

The whole ſubject will be beſt illuſtrated by taking an example of the different queſtions which may be propoſed. 57 Illuſtrated by examples.

Recollect that the rectangle ACOF is = 2a, or $\frac{u^2}{g}$, or

E,

E, for a ball of caſt-iron one inch diameter, and if it has the diameter d, it is $\frac{u^2 d}{g}$, or $2ad$, or Ed.

I. It may be required to determine what will be the ſpace deſcribed in a given time t by a ball ſetting out with a given velocity V, and what will be its velocity v at the end of that time.

Here we have NI : MI=ACOF : BDCA; now NI is the ſubtangent of the logiſtic curve; MI is the difference between the logarithms of OD and OC; that is, the difference between the logarithms of $e+t$ and e; ACOF is $2ad$, or $\frac{u^2 d}{g}$, or Ed.

Therefore by common logarithms 0,43429 : log. $\overline{e+t}$ —log. $e = 2ad$: S,= ſpace deſcribed,

or 0,43429 : log. $\frac{e+t}{e} = 2ad$: S,

and S. $= \frac{2ad}{0,43429} \times \log. \frac{e+t}{e}$,

by hyperbolic logarithms $S = 2ad \times \log. \frac{e+t}{e}$.

Let the ball be a 12 pounder, and the initial velocity be 1600 feet, and the time 20 ſeconds. We muſt firſt find e, which is $\frac{2ad}{V}$.

Therefore, log. $2a$	- -	+ 3.03236
log. d (4, 5)	-	+ 0.65321
log. V. (1600)	-	— 3.20415
Log. of 3″,03,=e	- -	0.48145
And $e+t$ is 23″03, of which the log. is		1.36229
from which take the log. of e	-	0.48145
remains the log. of $\frac{e+t}{e}$	- -	0.88084

This muſt be conſidered as a common number by which we are to multiply $\frac{2ad}{0.43429}$.

Therefore add the logarithms of $2ad$		+ 3.68557
log. $\frac{e+t}{e}$	-	+ 9.94490
log. 0.43429	-	— 9.63778
Log. S. 9833 feet	- -	3.99269

For the final velocity,

OD : OC=AC : BD, or $e+t$: e=V : v.

23″,03 : 3″,03=1600 : $210\frac{1}{2}$,=v.

The ball has therefore gone 3278 yards, and its velocity is reduced from 1600 to 210.

It may be agreeable to the reader to ſee the gradual progreſs of the ball during ſome ſeconds of its motion.

T.	*S.*	*Diff.*	*V.*	*Diff.*
1″	1383		1203	397
2″	2456	1073	964	239
3″	3336	880	804	160
4″	4080	744	690	114
5″	4725	645	604	86
6″	5294	569	537	67

The firſt column is the time of the motion, the ſecond is the ſpace deſcribed, the third is the differences of the ſpaces, ſhowing the motion during each ſucceſſive ſecond; the fourth column is the velocity at the end of the time t; and the laſt column is the differences of velocity, ſhowing its diminution in each ſucceſſive ſecond. We ſee that at the diſtance of 1000 yards the velocity is reduced to one half, and at the diſtance of leſs than a mile it is reduced to one-third.

II. It may be required to determine the diſtance at which the initial velocity V is reduced to any other quantity v. This queſtion is ſolved in the very ſame manner, by ſubſtituting the logarithms of V and v for thoſe of $e+t$ and e; for AC : BD=OD : OC, and therefore log. $\frac{AC}{BD}$ = log. $\frac{OD}{OC}$, or log. $\frac{V}{v}$ = log. $\frac{e+t}{e}$.

Thus it is required to determine the diſtance in which the velocity 1780 of a 24 pound ball (which is the medium velocity of ſuch a ball diſcharged with 16 pounds of powder) will be reduced to 1500.

Here d is 5.68, and therefore the logarithm of $2ad$ is	- -	+3.78671
Log. $\frac{V}{v}$ = 0.07433, of which the log is		+8.87116
Log. 0.43429	- - -	—9.63778
Log. 1047,3 feet, or 349 yards		3.02009

This reduction will be produced in about $\frac{7}{8}$ of a ſecond.

III. Another queſtion may be to determine the time which a ball, beginning to move with a certain velocity, employs in paſſing over a given ſpace, and the diminution of velocity which it ſuſtains from the reſiſtance of the air.

We may proceed thus:

$2ad$: S=0,43429 : log. $\frac{e+t}{e}$, $= t$. Then to log. $\frac{e+t}{e}$ add log. e, and we obtain log. $e+t$, and $e+t$; from which if we take e we have t. Then to find v, ſay $e+t$: e=V : v.

58 We ſhall conclude theſe examples by applying this laſt rule to Mr Robins's experiment on a muſket bullet of $\frac{3}{4}$ of an inch in diameter, which had its velocity reduced from 1670 to 1425 by paſſing through 100 feet of air. This we do in order to diſcover the reſiſtance which it ſuſtained, and compare it with the reſiſtance to a velocity of 1 foot per ſecond.

Application of an experiment of Mr Robins. See *Robins's Math. Works*, vol. i. p. 135.

We muſt firſt aſcertain the firſt term of our analogy. The ball was of lead, and therefore $2a$ muſt be multiplied by d and by m, which expreſſes the ratio of the denſity of lead to that of caſt-iron. d is 0.75, and m is $\frac{11.37}{7.21} = 1.577$. Therefore

log. $2a$	3.03236
d	9.87506
m	0.19782
Log. $2adm$	3.10524

and $2adm$=1274.2.

Now 1274.2 : 100=0.43429 : 0.03408 = log. $\frac{e+t}{e}$.

But $e = \frac{2adm}{V}$ =0.763, and its logarithm=9.88252, which, added to 0.03408, gives 9.91660, which is the log. of $e+t$, =0.825, from which take e, and there remains

remains $t=$, 0''.062, or $\frac{62}{1000}$ of a ſecond, for the time of paſſage. Now, to find the remaining velocity, ſay 825 : .763=1670 : 1544, $=v$.

But in Mr Robins's experiment the remaining velocity was only 1425, the ball having loſt 245; whereas by this computation it ſhould have loſt only 126. It appears, therefore, that the reſiſtance is double of what it would have been if the reſiſtance increaſed in the duplicate proportion of the velocity. Mr Robins ſays it is nearly triple. But he ſuppoſes the reſiſtance to ſlow motions much ſmaller than his own experiment, ſo often mentioned, fully warrants.

The time e, in which the reſiſtance of the air would extinguiſh the velocity is 0''.763. Gravity, or the weight of the bullet, would have done it in $\frac{1670}{32}$ or 52''; therefore the reſiſtance is $\frac{52}{0.763}$ times, or nearly 68 times its weight, by this theory, or 5.97 pounds. If we calculate from Mr Robins's experiment, we muſt ſay log. $\frac{V}{v}$: 0.43429 = 100 : eV, which will be 630.23, and $e=\frac{630.23}{1670}=0''.3774$, and $\frac{52}{0.3774}$ gives 138 for the proportion of the reſiſtance to the weight, and makes the reſiſtance 12.07 pounds, fully double of the other.

It is to be obſerved, that with this velocity, which greatly exceeds that with which the air can ruſh into a void, there muſt be a ſtatical preſſure of the atmoſphere equal to 6¼ pounds. This will make up the difference, and allows us to conclude that the reſiſtance ariſing ſolely from the motion communicated to the air follows very nearly the duplicate proportion of the velocity.

The next experiment, with a velocity of 1690 feet, gives a reſiſtance equal to 157 times the weight of the bullet, and this bears a much greater proportion to the former than 1690^2 does to 1670^2, which ſhows, that although theſe experiments clearly demonſtrate a prodigious augmentation of reſiſtance, yet they are by no means ſuſceptible of the preciſion which is neceſſary for diſcovering the law of this augmentation, or for a good foundation of practical rules; and it is ſtill greatly to be wiſhed that a more accurate mode of inveſtigation could be diſcovered.

59 Recapitulation.

Thus we have explained, in great detail, the principles and the proceſs of calculation for the ſimple caſe of the motion of projectiles through the air. The learned reader will think that we have been unreaſonably prolix, and that the whole might have been compriſed in leſs room, by taking the algebraic method. We acknowledge that it might have been done even in a few lines. But we have obſerved, and our obſervation has been confirmed by perſons well verſed in ſuch ſubjects, that in all caſes where the fluxionary proceſs introduces the fluxion of a logarithm, there is a great want of diſtinct ideas to accompany the hand and eye. The ſolution comes out by a ſort of magic or legerdemain, we cannot tell either *how* or *why*. We therefore thought it our duty to furniſh the reader with diſtinct conceptions of the things and quantities treated of. For this reaſon, after ſhowing, in Sir Iſaac Newton's manner, how the ſpaces deſcribed in the retarded motion of a projectile followed the proportion of the hyperbolic areas, we ſhewed the nature of another curve, where lines could be found which increaſe in the very ſame manner as the path of the projectile increaſes; ſo that a point deſcribing the abſciſſa MI of this curve moves preciſely as the projectile does. Then, diſcovering that this line is the ſame with the line of logarithms on a Gunter's ſcale, we ſhewed how the logarithm of a number really repreſents the path or ſpace deſcribed by the projectile.

Having thus, we hope, enabled the reader to conceive diſtinctly the quantities employed, we ſhall leave the geometrical method, and proſecute the reſt of the ſubject in a more compendious manner.

60 Of the perpendicular aſcents of heavy projectiles.

We are, in the next place, to conſider the perpendicular aſcents and deſcents of *heavy* projectiles, where the reſiſtance of the air is combined with the action of gravity: and we ſhall begin with the deſcents.

Let u, as before, be the terminal velocity, and g the accelerating power of gravity: When the body moves with the velocity u, the reſiſtance is equal to g; and in every other velocity v, we muſt have $u^2 : v^2 = g : \frac{g v^2}{u^2}$, $=r$, for the reſiſtance to that velocity. In the deſcent the body is urged by gravity g, and oppoſed by the reſiſtance $\frac{g v^2}{u^2}$: therefore the remaining accelerating force, which we ſhall call f, is $g-\frac{g v^2}{u^2}$, or $\frac{g u^2-g v^2}{u^2}$, or $\frac{g(u^2-v^2)}{u^2}$, $=f$.

Now the fundamental theorem for varied motions is $f\dot{s}=u\dot{v}$, and $\dot{s}=\frac{v\dot{v}}{f}$, $=\frac{u^2}{g}\times\frac{v\dot{v}}{u^2-v^2}$, and $s=\frac{u^2}{g}\times\int\frac{v\dot{v}}{u^2-v^2}+C$. Now the fluent of $\frac{v\dot{v}}{u^2-v^2}$ is $=-$ hyperb. log. of $\sqrt{u^2-v^2}$. For the fluxion of $\sqrt{u^2-v^2}$ is $\frac{-v\dot{v}}{\sqrt{u^2-v^2}}$, and this divided by the quantity $\sqrt{u^2-v^2}$, of which it is the fluxion, gives preciſely $\frac{v\dot{v}}{u^2-v^2}$, which is therefore the fluxion of its hyperbolic logarithm. Therefore $S=-\frac{u^2}{g}\times L\sqrt{u^2-v^2}+C$. Where L means the hyperbolic logarithm of the quantity annexed to it, and λ may be uſed to expreſs its common logarithm. (See article Fluxions.)

The conſtant quantity C for completing the fluent is determined from this conſideration, that the ſpace deſcribed is o, when the velocity is o: therefore $C-\frac{u^2}{g}\times L\sqrt{u^2}=o$, and $C=\frac{u^2}{g}\times L\sqrt{u^2}$, and the complete fluent $S=\frac{u^2}{g}\times\overline{L\sqrt{u^2}-L\sqrt{u^2-v^2}}$, $=\frac{u^2}{g}\times L\sqrt{\frac{u^2}{u^2-v^2}}.=\frac{u^2}{0.43429\,g}\times\lambda\sqrt{\frac{u^2}{u^2-v^2}}$, or (putting M for 0.43429, the modulus or ſubtangent of the common logiſtic curve) $=\frac{u^2}{Mg}\times\lambda\sqrt{\frac{u^2}{u^2-v^2}}$.

This equation eſtabliſhes the relation between the ſpace fallen through, and the velocity acquired by the fall. We obtain by it $\frac{g\,S}{u^2} = L\sqrt{\frac{u^2}{u^2-v^2}}$, and $\frac{2g\,S}{u^2} = L.\frac{u^2}{u^2-v^2}$, or, which is ſtill more convenient for us, $\frac{M\times 2g\,S}{u^2} = \lambda\frac{u^2}{u^2-v^2}$, that is, equal to the logarithm of a certain number: therefore having found the natural number correſponding to the fraction $\frac{M\times 2g\,S}{u^2}$, conſider it as a logarithm, and take out the number correſponding to it: call this n. Then, ſince n is equal to $\frac{u^2}{u^2-v^2}$, we have $nu^2 - nv^2 = u^2$, and $nu^2 - u^2 = nv^2$, or $nv^2 = u^2 \times \overline{n-v}$, and $v^2 = \frac{u^2\times\overline{n-1}}{n}$.

To expedite all the computations on this ſubject, it will be convenient to have multipliers ready computed for $M\times 2g$, and its half,

viz. 27,794, whoſe log. is -	1.44396
and 13,897 - - -	1.14293

But v may be found much more expeditiouſly by obſerving that $\sqrt{\frac{u^2}{u^2-v^2}}$ is the ſecant of an arch of a circle whoſe radius is u, and whoſe ſine is v, or whoſe radius is unity and ſine $= \frac{v}{u}$: therefore, conſidering the above fraction as a logarithmic ſecant, look for it in the tables, and then take the ſine of the arc of which this is the ſecant, and multiply it by u; the product is the velocity required.

We ſhall take an example of a ball whoſe terminal velocity is 689⅓ feet, and aſcertain its velocity after a fall of 1848 feet. Here,

$u^2=475200$	and its log. -	$=5.67688$
$u=689\frac{1}{3}$	- - - -	2.83844
$g=32$	- - - - -	1.50515
$S=1848$	- - -	3.26670
Then log. 27,794	- -	+ 1.44396
log. S	- - -	+ 3.26670
log. u^2	- - -	— 5.67688
Log. of 0,10809 = log. n	-	9.03378

0,10809 is the logarithm of $1{,}2826 = n$, and $n-1 = 0{,}2826$, and $\frac{u^2\times\overline{n-1}}{n} = 323{,}6^2, = v^2$, and $v = 323{,}6$.

In like manner, 0,054045 (which is half of 0,10809) will be found to be the logarithmic ſecant of 28°, whoſe ſine 0,46947 multiplied by 689⅓ gives 324 for the velocity.

The proceſs of this ſolution ſuggeſts a very perſpicuous manner of conceiving the law of deſcent; and it may be thus expreſſed:

M is to the logarithm of the ſecant of an arch whoſe ſine is $\frac{v}{u}$, and radius 1, as $2a$ is to the height through which the body muſt fall in order to acquire the velocity v. Thus, to take the ſame example.

1. Let the height h be ſought which will produce the velocity 323,62, the terminal velocity of the ball being 689,44. Here $2a$, or $\frac{u^2}{g}$ is 14850, and $\frac{323{,}62}{689{,}34} = 0{,}46947$, which is the ſine of 28°. The logarithmic ſecant of this arch is 0,05407. Now M or 0,43429 : 0,05407 = 14850 : 1848, the height wanted.

2. Required the velocity acquired by the body by falling 1848 feet. Say 14850 : 1848 = 0,43429 : 0,05407. Look for this number among the logarithmic ſecants. It will be found at 28°, of which the logarithmic ſine is

garithmic ſine is - - -	9.67161
Add to this the log. of u - -	2.83844
The ſum - - -	2.51005

is the logarithm of 323,62, the velocity required.

We may obſerve, from theſe ſolutions, that the acquired velocity continually approaches to, but never equals, the terminal velocity. For it is always expreſſed by the ſine of an arch of which the terminal velocity is the radius. We cannot help taking notice here of a very ſtrange aſſertion of Mr Muller, late profeſſor of mathematics and director of the royal academy at Woolwich. 61 Erroneous aſſertion of Mr Muller. He maintains, in his Treatiſe on Gunnery, his Treatiſe of Fluxions, and in many of his numerous works, that a body cannot poſſibly move through the air with a greater velocity than this; and he makes this a fundamental principle, on which he eſtabliſhes a theory of motion in a reſiſting medium, which he aſſerts with great confidence to be the only juſt theory; ſaying, that all the inveſtigations of Bernoulli, Euler, Robins, Simpſon, and others, are erroneous. We uſe this ſtrong expreſſion, becauſe, in his criticiſms on the works of thoſe celebrated mathematicians, he lays aſide good manners, and taxes them not only with ignorance, but with diſhoneſty; ſaying, for inſtance, that it required no ſmall dexterity in Robins to confirm by his experiments a theory founded on falſe principles; and that Thomas Simpſon, in attempting to conceal his obligations to him for ſome valuable propoſitions, by changing their form, had ignorantly fallen into groſs errors.

Nothing can be more palpably abſurd than this aſſertion of Mr Muller. A blown bladder will have but a ſmall terminal velocity; and when moving with this velocity, or one very near it, there can be no doubt that it will be made to move much ſwifter by a ſmart ſtroke. Were the aſſertion true, it would be impoſſible for a portion of air to be put into motion through the reſt, for its terminal velocity is nothing. Yet this author makes this aſſertion a principle of argument, ſaying, that it is impoſſible that a ball can iſſue from the mouth of a cannon with a greater velocity than this; and that Robins and others are groſly miſtaken, when they give them velocities three or four times greater, and reſiſtances which are 10 or 20 times greater than is poſſible; and by thus compenſating his ſmall velocities by ſtill ſmaller reſiſtances, he confirms his theory by many experiments adduced in ſupport of the others. No reaſon whatever can be given for the aſſertion. Newton, or perhaps Huygens, was the firſt who obſerved that there was a limit to the velocity which gravity could communicate to a body; and this limit was found by his commentators to be a term to which it was vaſtly convenient to refer all its other motions. It therefore became

became an object of attention; and Mr Muller, through inadvertency, or want of diſcernment, has fallen into this miſtake, and with that arrogance and ſelf-conceit which mark all his writings, has made this miſtake a fundamental principle, becauſe it led him to eſtabliſh a novel ſet of doctrines on this ſubject. He was fretted at the ſuperior knowledge and talents of Mr Simpſon, his inferior in the academy, and was guilty of ſeveral mean attempts to hurt his reputation. But they were unſucceſsful.

62 Motion of a body projected downwards.

We might proceed to conſider the motion of a body projected downwards. While the velocity of projection is leſs than the terminal velocity, the motion is determined by what we have already ſaid: for we muſt compute the height neceſſary for acquiring this velocity in the air, and ſuppoſe the motion to have begun there. But if the velocity of projection be greater, this method fails. We paſs it over (though not in the leaſt more difficult than what has gone before), becauſe it is of mere curioſity, and never occurs in any intereſting caſe. We may juſt obſerve, that ſince the motion is ſwifter than the terminal velocity, the reſiſtance muſt be greater than the weight, and the motion will be retarded. The very ſame proceſs will give us for the ſpace deſcribed $S = \frac{u^2}{g} \times L\sqrt{\frac{V^2 - u^2}{v^2 - u^2}}\Big|$, V being the velocity of projection, greater than u. Now as this ſpace evidently increaſes continually (becauſe the body always falls), but does not become infinite in any finite time, the fraction $\frac{V^2 - u^2}{v^2 - u^2}$ does not become infinite; that is, v^2 does not become equal to u^2: therefore although the velocity V is continually diminiſhed, it never becomes ſo ſmall as u. Therefore u is a limit of diminution as well as of augmentation.

63 Relation between the time of deſcent and ſpace deſcribed, &c.

We muſt now aſcertain the relation between the time of the deſcent and the ſpace deſcribed, or the velocity acquired. For this purpoſe we may uſe the other fundamental propoſition of varied motions $f\dot{t} = \dot{v}$, which, in the preſent caſe, becomes $\frac{gu^2 - v^2}{u^2}\dot{t} = \dot{v}$; therefore $\dot{t} = \frac{u^2}{g} \times \frac{\dot{v}}{u^2 - v^2}, = \frac{u}{g} \times \frac{u\dot{v}}{u^2 - v^2}$, and $t = \frac{u}{g} \times \int \frac{u\dot{v}}{u^2 - v^2}$. Now (art. Fluxions) $\int \frac{u\dot{v}}{u^2 - v^2} = L\sqrt{\frac{u+v}{u-v}}$. Therefore $t = \frac{u}{g} \times L\sqrt{\frac{u+v}{u-v}}, = \frac{u}{Mg} \times \lambda\sqrt{\frac{u+v}{u-v}}$. This fluent needs no conſtant quantity to complete it, or rather $C = o$; for t muſt be $= o$ when $v = o$. This will evidently be the caſe: for then $L\sqrt{\frac{u+v}{u-v}}$ is $L\sqrt{\frac{u}{u}}$, $= L\ 1, = 0$.

But how does this quantity $\frac{u}{Mg} \times \lambda\sqrt{\frac{u+v}{u-v}}$ ſignify a time? Obſerve, that in whatever numbers, or by whatever units of ſpace and time, u and g are expreſſed, $\frac{u}{g}$ expreſſes the number of units of time in which the velocity u is communicated or extinguiſhed by gravity; and $L\sqrt{\frac{u+v}{u-v}}$, or $\frac{\lambda}{M}\sqrt{\frac{u+v}{u-v}}$, is always an abſtract number, multiplying this time.

We may illuſtrate this rule by the ſame example. In what time will the body acquire the velocity 323,62? Here $u + v = 1012{,}96$, $u - v = 365{,}72$; therefore $\lambda\sqrt{\frac{u+v}{u-v}} = 0{,}22122$, and $\frac{u}{g}$ (in feet and ſeconds) is 21″,542. Now, for greater perſpicuity, convert the equation $t = \frac{u}{Mg} \times \lambda\sqrt{\frac{u+v}{u-v}}$ into a proportion; thus $M : \lambda\sqrt{\frac{u+v}{u-v}} = \frac{u}{g} : t$, and we have 0,43429 : 0,22122 = 21″, 542 : 10″,973, the time required.

This is by far the moſt diſtinct way of conceiving the ſubject; and we ſhould always keep in mind that the numbers or ſymbols which we call logarithms are really parts of the line MI in the figure of the logiſtic curve, and that the motion of a point in this line is preciſely ſimilar to that of the body. The Marquis Poleni, in a diſſertation publiſhed at Padua in 1725, has with great ingenuity conſtructed logarithmics ſuited to all the caſes which can occur. Herman, in his *Phoronomia*, has borrowed much of Poleni's methods, but has obſcured them by an affectation of language geometrically preciſe, but involving the very obſcure notion of abſtract ratios.

It is eaſy to ſee that $\sqrt{\frac{u+v}{u-v}}$ is the cotangent of the $\frac{1}{2}$ complement of an arch, whoſe radius is 1, and whoſe ſine is $\frac{v}{u}$: For let KC (fig. 6.) be $= u$, and Fig. 6. BE $= v$; then KD $= u + v$, and DA $= u - v$. Join KB and BA, and draw CG parallel to KB. Now GA is the tangent of $\frac{1}{2}$ BA, $= \frac{1}{2}$ complement of HB. Then, by ſimilarity of triangles, GA : AC = AB : BK, $= \sqrt{AD} : \sqrt{DK} = \sqrt{u-v} : \sqrt{u+v}$ and $\frac{AC}{GA}$ (= cotan. $\frac{1}{2}$BA) $= \sqrt{\frac{u+v}{u-v}}$; therefore look for $\frac{v}{u}$ among the natural ſines, or for log. $\frac{v}{u}$ among the logarithmic ſines, and take the logarithmic cotangent of the half complement of the correſponding arch. This, conſidered as a common number, will be the ſecond term of our proportion. This is a ſhorter proceſs than the former.

By reverſing this proportion we get the velocity correſponding to a given time.

64 Fall of a body in air compared with that of one in vacuo.

To compare this deſcent of 1848 feet in the air with the fall of the body *in vacuo* during the ſame time, ſay $21''{,}542^2 : 10''{,}973^2 = 1848 : 1926{,}6$, which makes a difference of 79 feet.

Cor. 1. The time in which the body acquires the velocity u by falling through the air, is to the time of acquiring the ſame velocity by falling *in vacuo*, as u. $L\sqrt{\frac{u+v}{u-v}}$ to v: for it would acquire this velocity *in* vacuo

vacuo during the time $\frac{v}{g}$, and it acquires it in the air in the time $\frac{u}{g}\mathrm{L}\sqrt{\frac{u+v}{u-v}}$.

2. The velocity which the body acquires by falling through the air in the time $\frac{u}{g}\mathrm{L}\sqrt{\frac{u+v}{u-v}}$, is to the velocity which it would acquire *in vacuo* during the ſame time, as v to $u\mathrm{L}\sqrt{\frac{u+v}{u-v}}$: For the velocity which it would acquire *in vacuo* during the time $\frac{u}{g}$ $\mathrm{L}\sqrt{\frac{u+v}{u-v}}$ muſt be $u\,\mathrm{L}\sqrt{\frac{u+v}{u-v}}$ (becauſe in any time $\frac{w}{g}$ the velocity w is acquired.)

65 Time of the aſcent of a body projected perpendicularly.

In the next place, let a body, whoſe terminal velocity is u, be projected perpendicularly upwards, with any velocity V. It is required to determine the height to which it aſcends, ſo as to have any remaining velocity v, and the time of its aſcent; as alſo the height and time in which its whole motion will be extinguiſhed.

We have now $\frac{g(u^2+v^2)}{u^2}$ for the expreſſion of f; for both gravity and reſiſtance act now in the ſame direction, and retard the motion of the aſcending body: therefore $\frac{g(u^2+v^2)}{u^2}\dot{s}=-v\dot{v}$, and $\dot{s}=-\frac{u^2}{g}\times\frac{v\dot{v}}{u^2+v^2}$, and $s=-\frac{u^2}{g}\times\int\frac{v\dot{v}}{u^2+v^2}+C, =-\frac{u^2}{g}\times\mathrm{L}\sqrt{u^2+v^2}+$ C (ſee art. FLUXIONS). This muſt be $=o$ at the beginning of the motion, that is, when $v=V$, that is, $-\frac{u^2}{g}\times\mathrm{L}\sqrt{u^2+V^2}+C=o$, or $C=\frac{u^2}{g}\times\mathrm{L}\sqrt{u^2+v^2}$, and the complete fluent will be $s=\frac{u^2}{g}\times\mathrm{L}\sqrt{u^2+v^2}-\mathrm{L}\sqrt{u^2+v^2})=\frac{u^2}{g}\times\mathrm{L}\sqrt{\frac{u^2+V^2}{u^2+v^2}}, =\frac{u^2}{Mg}\times\lambda\sqrt{\frac{u^2+V^2}{u^2+v^2}}$

Let h be the greateſt height to which the body will riſe. Then $s=h$ when $v=o$; and $h=\frac{u^2}{g}\times\mathrm{L}\sqrt{\frac{u^2+V^2}{u^2}}, =\frac{u^2}{Mg}\times\lambda\sqrt{\frac{u^2+V^2}{u^2}}$. We have $\lambda\sqrt{\frac{u^2+V^2}{u^2+v^2}}=s\frac{mg}{u^2}$; therefore $\lambda\left(\frac{u^2+V^2}{u^2+v^2}\right)=\frac{2Mgs}{u^2}$. Therefore let n be the number whoſe common logarithm is $\frac{2Mgs}{u^2}$; we ſhall have $n=\frac{u^2+V^2}{u^2+v^2}$, and $v^2=\frac{u^2+V^2}{n}-u^2$; and thus we obtain the relation of s and v, as in the caſe of deſcents: but we obtain it ſtill eaſier by obſerving that $\sqrt{u^2+V^2}$ is the ſecant of an arch whoſe radius is u, and whoſe tangent is V, and that $\sqrt{u^2+v^2}$ is the ſecant of another arch of the ſame circle, whoſe tangent is v.

Let the ſame ball be projected upwards with the velocity 411,05 feet per ſecond. Required the whole height to which it will riſe?

Here $\frac{V}{u}$ will be found the tangent of $30.48\frac{1}{3}$, the logarithmic ſecant of which is 0,06606. This, multiplied by $\frac{u^2}{Mg}$, gives 2259 feet for the height. It would have riſen 2640 feet in a void.

Suppoſe this body to fall down again. We can compare the velocity of projection with the velocity with which it again reaches the ground. The aſcent and deſcent are equal: therefore $\sqrt{\frac{u^2+V^2}{u^2}}$, which multiplies the conſtant factor in the aſcent, is equal to $\sqrt{\frac{u^2}{u^2-v^2}}$, the multiplier in the deſcent. The firſt is the ſecant of an arch whoſe tangent is V; the other is the ſecant of an arch whoſe ſine is v. Theſe ſecants are equal, or the arches are the ſame; therefore the velocity of projection is to the final returning velocity as the tangent to the ſine, or as the radius to the coſine of the arch. Thus ſuppoſe the body projected with the terminal velocity, or $V=u$; then $v=\frac{u}{\sqrt{2}}$. If $V=689$, $v=487$. 66 Velocity of projection compared with that with which it reaches the ground.

We muſt in the laſt place aſcertain the relation of the ſpace and the time.

Here $\frac{g(u^2+v^2)}{u^2}\dot{t}=-\dot{v}$, and $\dot{t}=-\frac{u^2}{g}\times\frac{\dot{v}}{u^2+v^2}, =-\frac{u}{g}\times\frac{u\dot{v}}{u^2+v^2}$ and $t=\frac{-u}{g}\times\int\frac{u\dot{v}}{u^2+v^2}+C$. Now (art. FLUXIONS) $\int\frac{u\dot{v}}{u^2+v^2}$ is an arch whoſe tangent $=\frac{v}{u}$ and radius 1; therefore $t=-\frac{u}{g}\times\text{arc. tan.}\frac{v}{u}+C$. This muſt be $=o$ when $v=V$, or $C-\frac{u}{g}\times\text{arc. tan.}\frac{V}{u}=o$, and $C=\frac{u}{g}\times\text{arc. tan.}\frac{V}{g}$, and the complete fluent is $t=\frac{u}{g}\times\left(\text{arc. tan.}\frac{V}{u}-\text{arc. tan.}\frac{v}{u}\right)$. The quantities within the brackets expreſs a portion of the arch of a circle whoſe radius is unity; and are therefore abſtract numbers, multiplying $\frac{u}{g}$, which we have ſhown to be the number of units of time in which a heavy body falls *in vacuo* from the height a, or in which it acquires the velocity u.

We learn from this expreſſion of the time, that however great the velocity of projection, and the height to which this body will riſe, may be, the time of its aſcent is limited. It never can exceed the time of falling from the height a *in vacuo* in a greater proportion than that of a quadrantal arch to the radius, nearly the proportion of 8 to 5. A 24 pound iron ball cannot continue riſing above 14 ſeconds, even if the reſiſtance to quick motions did not increaſe faſter than the ſquare of the velocity. It probably will attain its greateſt height in leſs than 12 ſeconds, let its velocity be ever ſo great. 67 Time of aſcent limited.

In the preceding example of the whole aſcent, $v=o$, and

and the time $t = \frac{u}{g} \times$ arc. tan. $\frac{V}{u}$, or $\frac{u}{g}$ arc. $30^{\circ}.\,48'$. Now $30^{\circ}.48' = 1848'$, and the radius 1 contains 3438; therefore the arch $= \frac{1848}{3438}, = 0{,}5376$; and $\frac{u}{g} = 21'',54$. Therefore $t = 21'',54 \times 0{,}5376, = 11'',58$, or nearly $11\frac{1}{2}$ seconds. The body would have risen to the same height in a void in $10\frac{3}{4}$ seconds.

68 This time compared in bodies projected in air and in vacuo.

Cor. 1. The time in which a body, projected in the air with any velocity V, will attain its greatest height, is to that in which it would attain its greatest height *in vacuo*, as the arch whose tangent expresses the velocity is to the tangent; for the time of the ascent in the air is $\frac{u}{g} \times$ arch; the time of the ascent *in vacuo* is $\frac{V}{g}$. Now $\frac{V}{u}$ is $=$ tan. and $V = u \times$ tan. and $\frac{V}{g} = \frac{u}{g} \times$ tan.

Fig. 6.

It is evident, by inspecting fig. 6. that the arch AI is to the tangent AG as the sector ICA to the triangle GCA; therefore the time of attaining the greatest height in the air is to that of attaining the greatest height *in vacuo* (the velocities of projection being the same), as the circular sector to the corresponding triangle.

If therefore a body be projected upwards with the terminal velocity, the time of its ascent will be to the time of acquiring this velocity *in vacuo* as the area of a circle to the area of the circumscribed square.

2. The height H to which a body will rise in a void, is to the height h to which it would rise through the air when projected with the same velocity V as $M \cdot V^2$ to $v^2 \times \lambda \frac{u^2 + V^2}{u^2}$: for the height to which it will rise *in vacuo* is $\frac{V^2}{2g}$, and the height to which it rises in the air is $\frac{u^2}{Mg} \lambda \sqrt{\frac{u^2 + V^2}{u^2}}$; therefore $H : h = \frac{V^2}{2g}$:

$$\frac{u^2}{Mg} \lambda \sqrt{\frac{u^2 + V^2}{u^2}}, = V^2 : \frac{u^2}{M} \times |2 \lambda \sqrt{\frac{u^2 + V^2}{u^2}}, = V^2 :$$

$$\frac{u^2}{M} \times \lambda \frac{u^2 + V^2}{u^2}, = M \cdot V^2 : u^2 \times \lambda \frac{u^2 + V^2}{u^2}.$$

Therefore if the body be projected with its terminal velocity, so that $V = u$, the height to which it will rise in the air is $\frac{30103}{43429}$ of the height to which it will rise *in vacuo*, or $\frac{5}{7}$ in round numbers.

We have been thus particular in treating of the perpendicular ascents and descents of heavy bodies through the air, in order that the reader may conceive distinctly the quantities which he is thus combining in his algebraic operations, and may see their connection in nature with each other. We shall also find that, in the present state of our mathematical knowledge, this simple state of the case contains almost all that we can determine with any confidence. On this account it were to be wished that the professional gentlemen would make many experiments on these motions. There is no way that promises so much for assisting us in forming accurate notions of the air's resistance. Mr Robins's method with the pendulum is impracticable with great shot; and the experiments which have been generally resorted to for this purpose, viz. the ranges of shot and shells on a horizontal plane, are so complicated in themselves, that the utmost mathematical skill is necessary for making any inferences from them; and they are subject to such irregularities, that they may be brought to support almost any theory whatever on this subject. But the perpendicular flights are affected by nothing but the initial velocity and the resistance of the air; and a considerable deviation from their intended direction does not cause any sensible error in the consequences which we may draw from them for our purpose.

69 Necessity of further experiments.

But we must now proceed to the general problem, to determine the motion of a body projected in any direction, and with any velocity. Our readers will believe beforehand that this must be a difficult subject, when they see the simplest cases of rectilineal motion abundantly abstruse: it is indeed so difficult, that Sir Isaac Newton has not given a solution of it, and has thought himself well employed in making several approximations, in which the fertility of his genius appears in great lustre. In the tenth and subsequent propositions of the second book of the *Principia*, he shows what state of density in the air will comport with the motion of a body in any curve whatever: and then, by applying this discovery to several curves which have some similarity to the path of a projectile, he finds one which is not very different from what we may suppose to obtain in our atmosphere. But even this approximation was involved in such intricate calculations, that it seemed impossible to make any use of it. In the second edition of the *Principia*, published in 1713, Newton corrects some mistakes which he had committed in the first, and carries his approximations much farther, but still does not attempt a direct investigation of the path which a body will describe in our atmosphere. This is somewhat surprising. In prop. 14. &c. he shows how a body, actuated by a centripetal force, in a medium of a density varying according to certain laws, will describe an eccentric spiral, of which he assigns the properties, and the law of description. Had he supposed the density constant, and the difference between the greatest and least distances from the centre of centripetal force exceedingly small in comparison with the distances themselves, his spiral would have coincided with the path of a projectile in the air of uniform density, and the steps of his investigation would have led him immediately to the complete solution of the problem. For this is the real state of the case. A heavy body is not acted on by equal and parallel gravity, but by a gravity inversely proportional to the square of the distance from the centre of the earth, and in lines tending to that centre nearly; and it was with the view of simplifying the investigation, that mathematicians have adopted the other hypothesis.

70 Of oblique projection.

71 This problem not solved by Newton.

Soon after the publication of this second edition of the *Principia*, the dispute about the invention of the fluxionary calculus became very violent, and the great promoters of that calculus upon the continent were in the habit of proposing difficult problems to exercise the talents of the mathematician. Challenges of this kind frequently passed between the British and foreigners.

72 Disputes among British and foreign mathematicians.

Dr

Dr Keill of Oxford had keenly eſpouſed the claim of Sir Iſaac Newton to this invention, and had engaged in a very acrimonious altercation with the celebrated John Bernoulli of Baſle. Bernoulli had publiſhed in the *Acta Eruditorum Lipſiæ* an inveſtigation of the law of forces, by which a body moving in a reſiſting medium might deſcribe any propoſed curve, reducing the whole to the ſimpleſt geometry. This is perhaps the moſt elegant ſpecimen which he has given of his great talents. Dr Keill propoſed to him the particular problem of the trajectory and motion of a body moving through the air, as one of the moſt difficult. Bernoulli very ſoon ſolved the problem in a way much more general than it had been propoſed, viz. without any limitation either of the law of reſiſtance, the law of the centripetal force, or the law of denſity, provided only that they were regular, and capable of being expreſſed algebraically. Dr Brook Taylor, the celebrated author of the Method of Increments, ſolved it at the ſame time, in the limited form in which it was propoſed. Other authors ſince that time have given other ſolutions. But they are all (as indeed they muſt be) the ſame in ſubſtance with Bernoulli's. Indeed they are all (Bernoulli's not excepted) the ſame with Newton's firſt approximations, modified by the ſteps introduced into the inveſtigation of the ſpiral motions mentioned above; and we ſtill think it moſt ſtrange that Sir Iſaac did not perceive that the *variation of curvature*, which he introduced in that inveſtigation, made the whole difference between his approximations and the complete ſolution. This we ſhall

73 Bernoulli's ſolution. point out as we go along. And we now proceed to the problem itſelf, of which we ſhall give Bernoulli's ſolution, reſtricted to the caſe of uniform denſity and a reſiſtance proportional to the ſquare of the velocity. This ſolution is more ſimple and perſpicuous than any that has ſince appeared.

Problem. To determine the trajectory, and all the circumſtances of the motion of a body projected

Fig. 7. through the air from A (fig. 7.) in the direction AB, and reſiſted in the duplicate ratio of the velocity.

Let the arch AM be put $=z$, the time of deſcribing it t, the abſciſſa AP$=x$, the ordinate PM $=y$. Let the velocity in the point M$=v$, and let MN$=\dot{z}$, be deſcribed in the moment $\dot{t}$; let r be the reſiſtance of the air, g the force of gravity, meaſured by the velocity which it will generate in a ſecond; and let a be the height through which a heavy body muſt fall *in vacuo* to acquire the velocity which would render the reſiſtance of the air equal to its gravity: ſo that we have $r=\frac{v^2}{2a}$; becauſe, for any velocity u, and producing height h, we have $g=\frac{u^2}{2h}$.

Let Mm touch the curve in M; draw the ordinate pNm, and draw Mo, Nn perpendicular to Np and Mm. Then we have MN$=\dot{z}$, and M$o=\dot{x}$, alſo mo is ultimately $=\dot{y}$ and Mm is ultimately $=$ MN or $\dot{z}$. Laſtly, let us ſuppoſe $\dot{x}$ to be a conſtant quantity, the elementary ordinates being ſuppoſed equidiſtant.

74 Action of gravity in a given time. The action of gravity during the time $\dot{t}$ may be meaſured by mN, which is half the ſpace which it would cauſe the body to deſcribe uniformly in the time $\dot{t}$ with the velocity which it generates in that time. Let this be reſolved into nN, by which it deflects the body into a curvilineal path, and mn, by which it retards the aſcent and accelerates the deſcent of the body along the tangent. The reſiſtance of the air acts ſolely in retarding the motion, both in aſcending and deſcending, and has no deflective tendency. The whole action of gravity then is to its accelerating or retarding tendency as mN to mn, or (by ſimilarity of triangles) as mM to mo. Or $\dot{z}:\dot{y}=g:\frac{g\dot{y}}{\dot{z}}$, and the whole retardation in the aſcent will be $r+\frac{g\dot{y}}{\dot{z}}$. The ſame fluxionary ſymbol will expreſs the retardation during the deſcent, becauſe in the deſcent the ordinates decreaſe, and $\dot{y}$ is a negative quantity.

The diminution of velocity is $-\dot{v}$. This is proportional to the retarding force and to the time of its action jointly, and therefore $-\dot{v}=\overline{r+\frac{g\dot{y}}{\dot{z}}}\times\dot{t}$; but the time $\dot{t}$ is as the ſpace $\dot{z}$ divided by the velocity v; therefore $-\dot{v}=r+\frac{g\dot{y}}{\dot{z}}\times\frac{\dot{z}}{v},=-\frac{r\dot{z}+g\dot{y}}{v}$, and $-v\dot{v}=-r\dot{z}-g\dot{y}=\frac{v^2\dot{z}}{2a}-g\dot{y}$. Becauſe mN is the deflection by gravity, it is as the force g and the ſquare of the time $\dot{t}$ jointly (the momentary action being held as uniform). We have therefore mN, or $-\ddot{y}=g\dot{t}^2$. (Obſerve that mN is in fact only the half of $-\ddot{y}$; but g being twice the fall of a heavy body in a ſecond, we have $-\ddot{y}$ ſtrictly equal to $g\dot{t}^2$). But $\dot{t}^2=\frac{\dot{z}^2}{v^2}$; therefore $-\ddot{y}=\frac{g\dot{z}^2}{v^2}$, and $v^2=\frac{g\dot{z}^2}{-\ddot{y}}$, and $-v^2\ddot{y}=g\dot{z}^2$. The fluxion of this equation is $-v^2\dddot{y}-2v\ddot{y}\dot{v}=2g\dot{z}\ddot{z}$; but, becauſe $\dot{z}:\dot{y}=m\text{M}:mo,=m\text{N}:mn,=\ddot{y}:\ddot{z}$, we have $\dot{z}\ddot{z}=\dot{y}\ddot{y}$. Therefore $2g\dot{y}\ddot{y}=2g\dot{z}\ddot{z},=-v^2\dddot{y}-2v\ddot{y}\dot{v}$, and $-2v\dot{v}\ddot{y}=v^2\dddot{y},-2g\dot{y}\ddot{y}$, and $-v\dot{v}=\frac{v^2\dddot{y}}{2\ddot{y}}-g\dot{y}$. But we have already $-v\dot{v}=\frac{v^2\dot{z}}{2a}-g\dot{y}$; therefore $\frac{v^2\dddot{y}}{\ddot{y}}=\frac{v^2\dot{z}}{a}$, and finally $\frac{\dddot{y}}{\ddot{y}}=\frac{\dot{z}}{a}$, or $a\dddot{y}=\dot{z}\ddot{y}$, for the fluxionary equation of the curve.

If we put this into the form of a proportion, we have $a:\dot{z}=\ddot{y}:\dddot{y}$. Now this evidently eſtabliſhes a relation between the length of the curve and its variation of curvature; and between the curve itſelf and its evoluta, which are the very circumſtances introduced by Newton 75 Relation between the length of the curve and its variation of curvature.

Newton into his investigation of the spiral motions. And the equation $\frac{\dot{z}}{a} = \frac{\dddot{y}}{\ddot{y}}$ is evidently an equation connected with the logarithmic curve and the logarithmic spiral. But we must endeavour to reduce it to a lower order of fluxions, before we can establish a relation between z, x, and y.

Let p express the ratio of $\dot{y}$ to $\dot{x}$, that is, let p be $= \frac{\dot{y}}{\dot{x}}$, or $p\dot{x} = \dot{y}$. It is evident that this expresses the inclination of the tangent at M to the horizon, and that p is the tangent of this inclination, radius being unity. Or it may be considered merely as a number, multiplying $\dot{x}$, so as to make it $= \dot{y}$. We now have $\dot{y}^2 = p^2\dot{x}^2$, and since $\dot{z}^2 = \dot{x}^2 + \dot{y}^2$, we have $\dot{z}^2 = \dot{x}^2 + p^2\dot{x}^2$, $= \overline{1+p^2} \times \dot{x}^2$, and $\dot{z} = \dot{x}\sqrt{1+p^2}$.

Moreover, because we have supposed the abscissa x to increase uniformly, and therefore $\dot{x}$ to be constant, we have $\ddot{y} = \dot{x}\dot{p}$, and $\dddot{y} = \dot{x}\ddot{p}$. Now let q express the ratio of $\dot{p}$ to $\dot{x}$, that is, make $\frac{\dot{p}}{\dot{x}} = q$, or $q\dot{x} = \dot{p}$. This gives us $\dot{x}\dot{q} = \ddot{p}$, and $\dot{x}^2\dot{q} = \dot{x}\ddot{p}, = \dddot{y}$.

By these substitutions our former equation $a\dddot{y} = \dot{z}\ddot{y}$ changes to $a\dot{x}^2\dot{q} = \dot{x}\sqrt{\overline{1+p^2}}\,\dot{x}\dot{p}$, or $a\dot{q} = \dot{p}\sqrt{1+p^2}$, and, taking the fluent on both sides, we have $aq = \int \dot{p}\sqrt{1+p^2} + C$, C being the constant quantity required for completing the fluent according to the limiting conditions of the case. Now $\dot{x} = \frac{\dot{p}}{q}$, and $\frac{1}{q} = \int, \frac{a}{\dot{p}\sqrt{\overline{1+p^2}} + C}$. Therefore $\dot{x} = \int, \frac{a\dot{p}}{p\sqrt{\overline{1+p^2}} + C}$

Also, since $\dot{y} = p\dot{x}, = \frac{p\dot{p}}{q}$, we have $y = \int, \frac{ap\dot{p}}{p\sqrt{\overline{1+p^2}} + C}$.

Also $\dot{z} = \dot{x}\sqrt{1+p^2} = \frac{a\dot{p}\sqrt{1+p^2}}{\int, \dot{p}\sqrt{\overline{1+p^2}} + C}$.

The values of $\dot{x}$, $\dot{y}$, $\dot{z}$, give us

$$x = \int, \frac{a\dot{p}}{\int, \dot{p}\sqrt{\overline{1+p^2}} + C}, = a\int \frac{\dot{p}}{\int p\sqrt{\overline{1+p^2}} + C}.$$

$$y = \int \frac{ap\dot{p}}{\int, \dot{p}\sqrt{\overline{1+p^2}} + C}, = a\int \frac{p\dot{p}}{\int \dot{p}\sqrt{\overline{1+p^2}} + C}.$$

$$z = \int, \frac{a\sqrt{\overline{1+p^2}}\,\dot{p}}{\int, \dot{p}\sqrt{\overline{1+p^2}} + C}, = a\int, \frac{\dot{p}\sqrt{1+p^2}}{\int, \dot{p}\sqrt{\overline{1+p^2}} + C}.$$

The process therefore of describing the trajectory is, 1st, To find q in terms of p by the area of the curve whose abscissa is p and the ordinate is $\sqrt{1+p^2}$.

2d, We get x by the area of another curve whose abscissa is p, and the ordinate is $\frac{1}{q}$.

3d, We get y by the area of a third curve whose abscissa is p, and the ordinate is $\frac{p}{q}$.

The problem of the trajectory is therefore completely solved, because we have determined the ordinate, abscissa, and arch of the curve for any given position of its tangent. It now only remains to compute the magnitudes of these ordinates and abscissæ, or to draw them by a geometrical construction. But in this consists the difficulty. The areas of these curves, which express the lengths of x and y, can neither be computed nor exhibited geometrically, by any accurate method *yet* discovered, and we must content ourselves with approximations. These render the description of the trajectory exceedingly difficult and tedious, so that little advantage has as yet been derived from the knowledge we have got of its properties. It will however greatly assist our conception of the subject to proceed some length in this construction; for it must be acknowledged that very few distinct notions accompany a mere algebraic operation, especially if in any degree complicated, which we confess is the case in the present question. 75 To compute the magnitude of the ordinate and abscissa.

Let B m NR (fig. 8.) be an equilateral hyperbola, of which B is the vertex, BA the semitransverse axis, which we shall assume for the unity of length. Let AV be the semiconjugate axis = BA, = unity, and AS the assymptote, bisecting the right angle BAV. Let PN, pn be two ordinates to the conjugate axis, exceedingly near to each other. Join BP, AN, and draw Bβ, Nν perpendicular to the assymptote, and BC parallel to AP. It is well known that BP is equal to NP. Therefore $PN^2 = BA^2 + AP^2$. Now since BA = 1, if we make AP = p of our formulæ, PN is $\sqrt{1+p^2}$, and Pp is $= \dot{p}$, and the area BAPNB $= \int, \dot{p}\sqrt{\overline{1+p^2}}$: That is to say, the number $\int, \dot{p}\sqrt{1+p^2}$ (for it is a number) has the same proportion to unity of number that the area BAPNB has to BCVA, the unit of surface. This area consists of two parts, the triangle APN, and the hyperbolic sector ABN. APN $= \frac{1}{2}$ AP $\times$ PN, $= \frac{1}{2}p\sqrt{1+p^2}$, and the hyperbolic sector ABN = BN$\nu\beta$, which is equivalent to the hyperbolic logarithm of the number represented by Aν when Aβ is unity. Therefore it is equal to $\frac{1}{2}$ the logarithm of $p + \sqrt{1+p^2}$. Hence we see by the bye that $\int, \dot{p}\sqrt{1+p^2} = \frac{1}{2}p\sqrt{1+p^2} + \frac{1}{2}$ hyperbolic logarithm $\overline{p + \sqrt{1+p^2}}$. Plate CCCCXLII. Fig. 8.

Now let AMD be another curve, such that its ordinates Vm, PD, &c. may be proportional to the areas ABmV, ABNP, and may have the same proportion to AB, the unity of length, which these areas have to ABCV, the unity of surface. Then VM : VC = VmBA : VCBA, and PD : Pδ = PNBA : VCBA, &c. These ordinates will now represent $\int, \dot{p}\sqrt{1+p^2}$ with reference to a linear unit, as the areas to the hyperbola represented it in reference to a superficial unit.

Again,

Again, in every ordinate make PD : Pδ = Pδ : PO, and thus we obtain a reciprocal to PD, or to $\int, \dot p\sqrt{1+p^2}$, or equivalent to $\int, \frac{1}{\dot p\sqrt{1+p^2}}$. This will evidently be $\frac{\dot x}{a\dot p}$, and PO op will be $\frac{\dot x}{a}$, and the area contained between the lines AF, AW, and the curve GEOH, and cut off by the ordinate PO, will represent $\frac{x}{a}$.

Lastly, make PO : PQ = AV : AP, $= 1 : p$; and then PQ qp will represent $\frac{\dot y}{a}$, and the area ALEQP will represent $\frac{y}{a}$.

But we must here observe, that the fluents expressed by these different areas require what is called the *correction* to accommodate them to the circumstances of the case. It is not indifferent from what ordinate we begin to reckon the areas. This depends on the initial direction of the projectile, and that point of the abscissa AP must be taken for the commencement of all the areas which gives a value of p suited to the initial direction. Thus, if the projection has been made from
Fig. 7. A (fig. 7.) at an elevation of 45°, the ratio of the fluxions $\dot x$ and $\dot y$ is that of equality; and therefore the
Fig. 8. point E of fig. 8. where the two curves intersect and have a common ordinate, evidently corresponds to this condition. The ordinate EV passes through V, so that AV or p = AB, = 1, = tangent 45°, as the case requires. The values of x and of y corresponding to any other point of the trajectory, such as that which has AP for the tangent of the angle which it makes with the horizon, are now to be had by computing the areas VEOP, VEQP.

Another curve might have been added, of which the ordinates would exhibit the fluxions of the arch of the trajectory $\dot z = \frac{a\dot p\sqrt{1+p^2}}{\int, \dot p\sqrt{1+p^2}|+C}$ and of which the area would exhibit the arch itself. And this would have been very easy, for it is $\dot z = a\frac{\dot p\sqrt{1+p^2}}{\int, \dot p\sqrt{1+p^2}|+C}$, which is evidently the fluxion of the hyperbolic logarithm of $\int, \dot p\sqrt{1+p^2}|$. But it is needless, since $\dot z = \dot x\sqrt{1+p^2}$, and we have already got $\dot x$. It is only increasing PO in the ratio of BA to BP.

77 Consequences of knowing the form of the trajectory.

And thus we have brought the investigation of this problem a considerable length, having ascertained the *form* of the trajectory. This is surely done when the ratio of the arch, absciss, and ordinate, and the position of its tangent, is determined in every point. But it is still very far from a solution, and much remains to be done before we can make any practical application of it. The only general consequence that we can deduce from the premises is, that in every case where the resistance in any point bears the same proportion to the force of gravity, the trajectory will be similar. Therefore, two balls, of the same density, projected in the same direction, will describe similar trajectories if the velocities are in the subduplicate ratio of the diameters. This we shall find to be of considerable practical importance. But let us now proceed to determine the velocity in the different points of the trajectory, and the time of describing its several portions.

78 To determine the velocity in different points.

Recollect, therefore, that $v^2 = \frac{-g\dot z^2}{\ddot y}$, and that $\dot z^2 = \dot x^2\overline{1+p^2}$ and $\ddot y = \dot x\dot p$. This gives $v^2 = \frac{-g\dot x\,\overline{1+p^2}}{\dot p}$. But $\dot p = q\dot x$. Therefore $v^2 = \frac{-g\times\overline{1+p^2}}{q}$, $= \frac{-ag\,\overline{1+p^2}}{\int, \dot p\sqrt{1+p^2}+C}$, and $v = \sqrt{\frac{-g\,\overline{1+p^2}}{q}}$, $= \frac{\sqrt a\sqrt{-g}\sqrt{1+p^2}}{\sqrt{\int\dot p\sqrt{1+p^2}|+C}}$.

Also $\dot t$ was found $= \frac{\dot z}{v}$, $= \frac{\dot x\sqrt{1+p^2}}{v}$, $= \frac{\dot p\sqrt{1+p^2}}{qv}$. If we now substitute for v its value just found, we obtain $\dot t = \frac{\dot p}{\sqrt{-gq}}$, and $t = \int\frac{\dot p}{\sqrt{-gq}}$, $= \int\frac{\dot p\sqrt a}{\sqrt{-g\int\dot p\sqrt{1+p^2}|+C}}$, $= \frac{\sqrt a}{\sqrt{-g}}\times\int\frac{\dot p}{\sqrt{\int\dot p\sqrt{1+p^2}|+C}}$.

79 Difficulty of accommodating the formulæ to particular cases.

The greatest difficulty still remains, viz. the accommodating these formulæ, which appear abundantly simple, to the particular cases. It would seem at first sight, that all trajectories are similar; since the ratio of the fluxions of the ordinate and abscissa corresponding to any particular angle of inclination to the horizon seems the same in them all: but a due attention to what has been hitherto said on the subject will show us that we have as yet only been able to ascertain the velocity in the point of the trajectory, which has a certain inclination to the horizon, indicated by the quantity p, and the time (reckoned from some assigned beginning) when the projectile is in that point.

To obtain absolute measures of these quantities, the term of commencement must be fixed upon. This will be expressed by the constant quantity C, which is assumed for completing the fluent of $\dot p\sqrt{1+p^2}$, which is the basis of the whole construction. We there found $q = \frac{\int, \dot p\sqrt{1+p^2}}{a}$. This fluent is in general $q = \frac{C+\int, \dot p\sqrt{1+p^2}}{a}$, and the constant quantity C is to be accommodated to some circumstances of the case. Different authors have selected different circumstances. Euler, 80 Euler's method the simplest.

Euler, in his Commentary on Robins, and in a dissertation in the Memoirs of the Academy of Berlin published in 1753, takes the vertex of the curve for the beginning of his abscissa and ordinate. This is the simplest method of any, for C must then be so chosen that the whole fluent may vanish when $p=o$, which is the case in the vertex of the curve, where the tangent is parallel to the horizon. We shall adopt this method.

Fig. 9.

Therefore, let AP (fig. 9.) $=x$, PM$=y$, AM$=z$. Put the quantity C which is introduced into the fluent equal to $\frac{n}{a}$. It is plain that n must be a number; for it must be homologous with $\dot{p}\sqrt{1+p^2}$, which is a number. For brevity's sake let us express the fluent of $\dot{p}\sqrt{1+p^2}$ by the single letter P; and thus we shall have $x=a\times\int\frac{\dot{p}}{n+\mathrm{P}}$, $y=a\times\int\frac{p\dot{p}}{n+\mathrm{P}}$, $z=a\times\int\frac{\dot{p}\sqrt{1+p^2}}{n+\mathrm{P}}$. And $v^2=\frac{-ag\,(1+p^2)}{n+\mathrm{P}}$. Now the height h necessary for communicating any velocity v is $\frac{v^2}{2g}=\frac{-ag\,(1+p^2)}{2g\,(n+\mathrm{P})}$, $=\frac{-\frac{1}{2}a\,(1+p^2)}{n+p}$. And lastly, $t=\frac{\sqrt{a}}{\sqrt{g}}\int\frac{\dot{p}}{\sqrt{n+\mathrm{P}}}$.

These fluents, being all taken so as to vanish at the vertex, where the computation commences, and where p is $=o$ (the tangent being parallel to the horizon), we obtain in this case $h=\frac{\frac{1}{2}a}{n}$, $=\frac{a}{2n}$, and $n=\frac{a}{2h}$.

Hence we see that the circumstance which modifies all the curves, distinguishing them from each other, is the velocity (or rather its square) in the highest point of the curve. For h being determined for any body whose terminal velocity is u, n is also determined; and this is the modifying circumstance. Considering it geometrically, it is the area which must be cut off from the area DMAP of fig. 8. in order to determine the ordinates of the other curves.

We must farther remark, that the values now given relate only to that part of the area where the body is descending from the vertex. This is evident; for, in order that y may increase as we recede from the vertex, its fluxion must be taken in the opposite sense to what it was in our investigation. *There* we supposed y to increase as the body ascended, and then to diminish during the descent; and therefore the fluxion of y was first positive and then negative.

The same equations, however, will serve for the ascending branch CNA of the curve, only changing the sign of P; for if we consider y as decreasing during the ascent, we must consider q as expressing $\frac{-\dot{p}}{\dot{x}}$, and therefore P, or $\int\dot{p}\sqrt{1+p^2}$, which is $=\frac{q}{a}$, must be taken negatively. Therefore, in the ascending branch, we have AQ or x (increasing as we recede from A) $=a\times\int\frac{\dot{p}}{n-\mathrm{P}}$, QN or $y=a\times\int\frac{p\dot{p}}{n-p}$, AN or $z=a\times\int\frac{\dot{p}\sqrt{1+p^2}}{n-\mathrm{P}}$, $t=\frac{\sqrt{a}}{\sqrt{g}}\times\int\frac{\dot{p}}{\sqrt{1-\mathrm{P}}}$, and the height producing the velocity at N$=\frac{\frac{1}{2}a\,(1+p^2)}{n-\mathrm{P}}$.

81 Remarkable property of the curve or trajectory.

Hence we learn by the bye, that in no part of the ascending branch can the inclination of the tangent be such that P shall be greater than n; and that if we suppose P equal to n in any point of the curve, the velocity in that point will be infinite. That is to say, there is a certain assignable elevation of the tangent which cannot be exceeded in a curve which has this velocity in the vertex. The best way for forming a conception of this circumstance in the nature of the curve, is to invert the motion, and suppose an accelerating force, equal and opposite to the resistance, to act on the body in conjunction with gravity. It must describe the same curve, and this branch ANC must have an assymptote LO, which has this limiting position of the tangent. For, as the body descends in this curve, its velocity increases to infinity by the joint action of gravity and this *accelerating* force, and yet the tangent never approaches so near the perpendicular position as to make P$=n$. This remarkable property of the curve was known to Newton, as appears by his approximations, which all lead him to curves of a hyperbolic form, having one assymptote inclined to the horizon. Indeed it is pretty obvious: For the resistance increasing faster than the velocity, there is no velocity of projection so great but that the curve will come to deviate so from the tangent, that in a finite time it will become parallel to the horizon. Were the resistance proportional to the velocity, then an infinite velocity would produce a rectilineal motion, or rather a deflection from it less than any that can be assigned.

82 On what its form and magnitude depends.

We now see that the particular form and magnitude of this trajectory depends on two circumstances, a and n. a affects chiefly the magnitude. Another circumstance might indeed be taken in, viz. the diminution of the accelerating force of gravity by the statical effect of the air's gravity. But, as we have already observed, this is too trifling to be attended to in military projectiles.

$\frac{\dot{y}}{\dot{x}}$ was made equal to $\dot{p}$. Therefore the radius of curvature, determined by the ordinary methods, is $\frac{\dot{x}\,(1+p^2)\,(\sqrt{1+p^2})}{\dot{p}}$ *, and, because $\frac{\dot{x}}{\dot{p}}$ is $=\frac{a}{n+\mathrm{P}}$ for the descending branch of the curve, the radius of curvature at M is $\frac{a\times\overline{1+p^2}\times\sqrt{1+p^2}}{n+\mathrm{P}}$, and, in the ascending branch at N, it is $\frac{a\times\overline{1+p^2}\times\sqrt{1+p^2}}{n-\mathrm{P}}$. On both sides therefore, when the velocity is infinitely great, and P by this means supposed to equal or exceed n, the radius of curvature is also infinitely great. We also see that the two branches are unlike each other, and that when p is the same in both, that is, when the tangent is equally inclined to the horizon, the radius of curvature, the ordinate, the abscissa, and the arch, are all greater in the ascending branch. This is pretty obvious.

* *Simpson's Fluxions*, § 68, &c.

vicus. For as the reſiſtance acts entirely in diminiſhing the velocity, and does not affect the deflection occaſioned by gravity, it muſt allow gravity to incurvate the path ſo much the more (with the ſame inclination of its line of action) as the velocity is more diminiſhed. The curvature, therefore, in thoſe points which have the ſame inclination of the tangent, is greateſt in the deſcending branch, and the motion is ſwifteſt in the aſcending branch. It is otherwiſe in a void, where both ſides are alike. Here u becomes infinite, or there is no terminal velocity; and n alſo becomes infinite, being $=\frac{a}{2h}$.

It is therefore in the quantity P, or $\int \dot{p}\sqrt{1+p^2}$, that the difference between the trajectory in a void and in a reſiſting medium conſiſts; it is this quantity which expreſſes the accumulated change of the ratio of the increments of the ordinate and abſciſs. In vacuo the ſecond increment of the ordinate is conſtant when the firſt increment of the abſciſſa is ſo, and the whole increment of the ordinate is as $1+p$. And this difference is ſo much the greater as P is greater in reſpect of n. P is nothing at the vertex, and increaſes along with the angle MTP; and when this is a right angle, P is infinite. The trajectory in a reſiſting medium will come therefore to deviate infinitely from a parabola, and may even deviate farther from it than the parabola deviates from a ſtraight line. That is, the diſtance of the body in a given moment from that point of its parabolic path where it would have been in a void, is greater than the diſtance between that point of the parabola from the point of the ſtraight line where it would have been, independent of the action of gravity. This muſt happen whenever the reſiſtance is greater than the weight of the body, which is generally the caſe in the beginning of the trajectory in military projectiles; and this (were it now neceſſary) is enough to ſhow the inutility of the parabolic theory.

83 Several properties of it aſcertained.

Although we have no method of deſcribing this trajectory, which would be received by the ancient geometers, we may aſcertain ſeveral properties of it, which will aſſiſt us in the ſolution of the problem. In particular, we can aſſign the abſolute length of any part of it by means of the logiſtic curve. For becauſe P $=\int \dot{p}\sqrt{1+p^2}$, we have $\dot{p}\cdot\sqrt{1+p^2}=\dot{P}$, and therefore z, which was $=a\times\int\frac{\dot{p}\sqrt{1+p^2}}{\int\dot{p}\sqrt{1+p^2}}+C$, or $=a\times\int\frac{\dot{P}}{n+P}$, may be expreſſed by logarithms; or $z=a\times$ hyp. log. of $\frac{n+P}{n}$, ſince at the vertex A, where z muſt be $=0$, P is alſo $=0$.

Being able, in this way, to aſcertain the length AM of the curve (counted from the vertex), correſponding to any inclination p of the tangent at its extremity M, we can aſcertain the length of any portion of it, ſuch as Mm, by firſt finding the length of the part Am, and then of the part AM. This we do more expeditiouſly thus: Let p expreſs the poſition of the tangent in M, and q its poſition at m; then AM $=a\times\log.\frac{n+P}{n}$ and Am $=a\times\log.\frac{n+Q}{n}$, and therefore M$m$ is $=a\times\log.\frac{n+Q}{n+P}$. Thus we can find the values of a great number of ſmall portions, and the inclination of the tangents at their extremities. Then to each of theſe portions we can aſſign its proportion of the abſciſſa and ordinate, without having recourſe to the values of x and y. For the portion of abſciſs correſponding to the arch Mm, whoſe middle point is inclined to the horizon in the angle b, will be Mm × coſine b, and the correſponding portion of the ordinate will be Mm × ſin. b. Then we obtain the velocity in each part of the curve by the equation $h=\frac{\frac{1}{2}a\times\overline{1+p^2}}{n+p}$; or, more directly the velocity v at M will be $=\sqrt{ag}\frac{\sqrt{1+p^2}}{\sqrt{n+P}}$. Laſtly, divide the length of the little arch by this, and the quotient will be the time of deſcribing Mm very nearly. Add all theſe together, and we obtain the whole time of deſcribing the arch AM, but a little too great, becauſe the motion in the ſmall arch is not perfectly uniform. The error, however, may be as ſmall as we pleaſe, becauſe we may make the arch as ſmall as we pleaſe; and for greater accuracy, it will be proper to take the p by which we compute the velocity, a medium between the p for the beginning and that for the end of the arch.

84 Euler's method preferred.

This is the method followed by Euler, who was one of the moſt expert analyſts, if not the very firſt, in Europe. It is not the moſt elegant, and the methods of ſome other authors, who approximate directly to the areas of the curves which determine the values of x and y, have a more ſcientific appearance; but they are not ultimately very different: For, in ſome methods, theſe areas are taken piecemeal, as Euler takes the arch; and by the methods of others, who give the value of the areas by Newton's method of deſcribing a curve of the parabolic kind through any number of given points, the ordinates of theſe curves, which expreſs $\dot{x}$ and $\dot{y}$, muſt be taken ſingly, which amounts to the ſame thing, with the great diſadvantage of a much more complicated calculus, as any one may ſee by comparing the expreſſions of $\dot{x}$ and $\dot{y}$ with the expreſſion of $\dot{z}$. As to thoſe methods which approximate directly to the areas or values of x and y by an infinite ſeries, they all, without exception, involve us in moſt complicated expreſſions, with coefficients of ſines and tangents, and ambiguous ſigns, and engage us in a calculation almoſt endleſs. And we know of no ſeries which converges faſt enough to give us tolerable accuracy, without ſuch a number of terms as is ſufficient to deter any perſon from the attempt. The calculation of the arches is very moderate, ſo that a perſon tolerably verſant in arithmetical operations may compute an arch with its velocity and time in about five minutes. We have therefore no heſitation in preferring this method of Euler's to all that we have ſeen, and therefore proceed to determine ſome other circumſtances which render its application more general.

If

85 Its application made more general.

If there were no resistance, the smallest velocity would be at the vertex of the curve, and it would immediately increase by the action of gravity conspiring (in however small degree) with the motion of the body. But in a resisting medium, the velocity at the vertex is diminished by a quantity to which the acceleration of gravity in that point bears no assignable proportion. It is therefore diminished, upon the whole, and the point of smallest velocity is a little way beyond the vertex. For the same reasons, the greatest curvature is a little way beyond the vertex. It is not very material for our present purpose to ascertain the exact positions of those points.

The velocity in the descending branch augments continually: but it cannot exceed a certain limit, if the velocity at the vertex has been less than the terminal velocity; for when the curve is infinite, p is also infinite, and $h=\frac{\frac{1}{2}ap^2}{P}$, because n in this case is nothing in respect of P, which is infinite; and because p is infinite, the number hyp. log. $\overline{p\times\sqrt{1+p^2}}$, though infinite, vanishes in comparison with $p+\sqrt{1+p^2}$; so that in this case $P=\frac{1}{2}p^2$, and $h=a$, and $v=$ the terminal velocity.

If, on the other hand, the velocity at the vertex has been greater than the terminal velocity, it will diminish continually, and when the curve has become infinite, v will be equal to the terminal velocity.

In either case we see that the curve on this side will have a perpendicular assymptote. It would require a long and pretty intricate analysis to determine the place of this assymptote, and it is not material for our present purpose. The place and position of the other assymptote LO is of the greatest moment. It evidently distinguishes the kind of trajectory from any other. Its position depends on this circumstance, that if p marks the position of the tangent, $n—P$, which is the denominator of the fraction expressing the square of the velocity, must be equal to nothing, because the velocity is infinite: therefore, in this place, $P=n$, or $n=\frac{1}{2}p\sqrt{1+p^2}+\frac{1}{2}\log.\overline{p+\sqrt{1+p^2}}$. In order, therefore, to find the point L, where the assymptote LO cuts the horizontal line AL, put $P=n$, then will $AL=x-\frac{yx}{y}, =a\times\left(\int\frac{p}{n-P}-\frac{1}{p}\int\frac{pp}{n-P}\right)$.

Through the whole of this article $\int$ means *fluent*.

It is evident that the logarithms used in these expressions are the natural or hyperbolic. But the operations may be performed by the common tables, by making the value of the arch Mm of the curve $=\frac{a}{M}\times\log.\frac{n+Q}{n+P}$ &c. where M means the subtangent of the common logarithms, or 0,43429; also the time of describing this arch will be expeditiously had by taking a medium μ between the values of $\frac{\sqrt{1+p^2}}{\sqrt{n+P}}$ and $\frac{\sqrt{1+q^2}}{\sqrt{n+Q}}$, and making the time $=\frac{\sqrt{a}}{M\alpha\sqrt{g}}\times\log.\frac{n+Q}{n+P}$.

86 Mode of applying this process in practice.

Such then is the process by which the form and magnitude of the trajectory, and the motion in it, may be determined. But it does not yet appear how this is to be applied to any question in practical artillery. In this process we have only learned how to compute the motion from the vertex in the descending branch till the ball has acquired a particular direction, and the motion to the vertex from a point of the ascending branch where the ball has another direction, and all this depending on the greatest velocity which the body can acquire by falling, and the velocity which it has in the vertex of the curve. But the usual question is, "What will be the motion of the ball projected in a certain direction with a certain velocity?"

The mode of application is this: Suppose a trajectory computed for a particular terminal velocity, produced by the fall a, and for a particular velocity at the vertex, which will be characterized by n, and that the velocity at that point of the ascending branch where the inclination of the tangent is 30° is 900 feet per second. Then, we are certain, that if a ball, whose terminal velocity is that produced by the fall a, be projected with the velocity of 900 feet per second, and an elevation of 30°, it will describe this very trajectory, and the velocity and time corresponding to every point will be such as is here determined.

Now this trajectory will, in respect to form, answer an infinity of cases: for its characteristic is the proportion of the velocity in the vertex to the terminal velocity. When this proportion is the same, the number n will be the same. If, therefore, we compute the trajectories for a sufficient variety of these proportions, we shall find a trajectory that will nearly correspond to any case that can be proposed; and an approximation sufficiently exact will be had by taking a proportional medium between the two trajectories which come nearest to the case proposed.

87 Computed tables or trajectories.

Accordingly, a set of tables or trajectories have been computed by the English translator of Euler's Commentary on Robins's Gunnery. They are in number 18, distinguished by the position of the assymptote of the ascending branch. This is given for 5°, 10°, 15°, &c. to 85°, and the whole trajectory is computed as far as it can ever be supposed to extend in practice. The following table gives the value of the number n corresponding to each position of the assymptote.

OLB	n	OLB	n
0	0,00000	45	1,14779
5	0,08760	50	1,43236
10	0,17724	55	1,82207
15	0,27712	60	2,39033
20	0,37185	65	3,29040
25	0,48269	70	4,88425
30	0,60799	75	8,22357
35	0,75382	80	17,54793
40	0,92914	85	67,12291

Since the path of a projectile is much less incurvated, and more rapid in the ascending than in the descending branch, and the difference is so much the more remarkable in great velocities; it must follow, that the range on a horizontal or inclined plane depends most on the ascending branch: therefore the greatest range will not be made with that elevation which bisects the angle of position, but with a lower elevation; and the deviation from the bisecting elevation will be greater as the initial

 velocities

velocities are greater. It is very difficult to frame an exact rule for determining the elevation which gives the greatest range. We have subjoined a little table which gives the proper elevations (nearly) corresponding to the different initial velocities.

It was computed by the following approximation, which will be found the same with the series used by Newton in his Approximation.

Let e be the angle of elevation, a the height producing the terminal velocity, h the height producing the initial velocity, and c the number whose hyperbolic logarithm is 1 (i. e. the number 2,718). Then,

$$y = x \times \left(\text{tan. } e + \frac{a}{2\,h.\ \text{cof. } e}\right) - \frac{a^2}{2h}\left(C^{\frac{x}{a.\ \text{cof.}\ e.}} - 1\right),$$

&c. Make $y = v$, and take the maximum by varying e, we obtain $\overline{\text{Sin.}^{\frac{1}{2}} e + \frac{a \text{ fin. } e}{2\,h}} =$ hyperbol. log. $\left(1 + \frac{2\,h}{a \text{ fine } e}\right)$, which gives us the angle e.

The numbers in the first column, multiplied by the terminal velocity of the projectile, give us the initial velocity; and the numbers in the last column, being multiplied by the height producing the terminal velocity, and by 2,3026, give us the greatest ranges. The middle column contains the elevation. The table is not computed with scrupulous exactness, the question not requiring it. It may, however, be depended on within one part of 2000.

To make use of this table, divide the initial velocity by the terminal velocity u, and look for the quotient in the first column. Opposite to this will be found the elevation giving the greatest range; and the number in the last column being multiplied by $2{,}3026 \times a$ (the height producing the terminal velocity) will give the range.

TABLE of Elevations giving the greatest Range.

Initial vel. / u	Elevation.	Range. / $2{,}3026\,a$
0,6909	43°.40′	0,1751
0,7820	43 .20	0,2169
0,8645	42 .50	0,2548
1,3817	41 .40	0,4999
1,5641	40 .20	0,5789
1,7291	40 .10	0,6551
2,0726	39 .50	0,7877
2,3461	37 .20	0,8967
2,5936	35 .50	0,9752
2,7635	35 .—	1,0319
3,1281	34 .40	1,1411
3,4544	34 .20	1,2298
3,4581	34 .20	1,2277
3,9101	33 .50	1,3371
4,1452	33 .30	1,3901
4,3227	33 .30	1,4274
4,6921	31 .50	1,5050
4,8631	31 .50	1,5341

88 Advantage to be derived from the solution of the problem.

Such is the solution which the present state of our mathematical knowledge enables us to give of this celebrated problem. It is exact in its principle, and the application of it is by no means difficult, or even operose. But let us see what advantage we are likely to derive from it.

In the first place, it is very limited in its application. There are few circumstances of general coincidence, and almost every case requires an appropriated calculus. Perhaps the only general rules are the two following:

1. Balls of equal density, projected with the same elevation, and with velocities which are as the square-roots of their diameters, will describe similar curves.— This is evident, because, in this case, the resistance will be in the ratio of their quantities of motion. Therefore all the homologous lines of the motion will be in the proportion of the diameters.

2. If the initial velocities of balls projected with the same elevation are in the inverse subduplicate ratio of the whole resistances, the ranges, and all the homologous lines of their track, will be inversely as those resistances.

These theorems are of considerable use: for by means of a proper series of experiments on one ball projected with different elevations and velocities, tables may be constructed which will ascertain the motions of an infinity of others.

89 Shown from various considerations to be very little.

But when we take a retrospective view of what we have done, and consider the conditions which were assumed in the solution of the problem, we shall find that much yet remains before it can be rendered of great practical use, or even satisfy the curiosity of the man of science. The resistance is all along supposed to be in the duplicate ratio of the velocity; but even theory points out many causes of deviation from this law, such as the pressure and condensation of the air, in the case of very swift motions; and Mr Robins's experiments are sufficient to show us that the deviations must be exceedingly great in such cases. Mr Euler and all subsequent writers have allowed that it may be three times greater, even in cases which frequently occur; and Euler gives a rule for ascertaining with tolerable accuracy what this increase and the whole resistance may amount to. Let H be the height of a column of air whose weight is equivalent to the resistance taken in the duplicate ratio of the velocity. The whole resistance will be expressed by $H + \frac{H^2}{28845}$. This number 28845 is the height in feet of a column of air whose weight balances its elasticity. We shall not at present call in question his reasons for assigning this precise addition. They are rather reasons of arithmetical conveniency than of physical import. It is enough to observe, that if this measure of the resistance is introduced into the process of investigation, it is totally changed; and it is not too much to say, that with this complication it requires the knowledge and address of a Euler to make even a partial and very limited approximation to a solution.— Any law of the resistance, therefore, which is more complicated than what Bernoulli has assumed, namely, that of a simple power of the velocity, is abandoned by all the mathematicians, as exceeding their abilities; and they have attempted to avoid the error arising from the assumption of the duplicate ratio of the velocity, either by supposing the resistance throughout the whole trajectory to be greater than what it is in general, or they have divided the trajectory into different portions, and assigned different resistances to each, which vary,

vary, through the whole of that portion, in the duplicate ratio of the velocities. By this kind of patchwork they make up a trajectory and motion which corresponds, in some tolerable degree, with what? With an accurate theory? No; but with a series of experiments. For, in the first place, every theoretical computation that we make, proceeds on a supposed initial velocity; and this cannot be ascertained with any thing approaching to precision, by any theory of the action of gunpowder that we are yet possessed of. In the next place, our theories of the resisting power of the air are entirely established on the experiments on the flights of shot and shells, and are corrected and amended till they tally with the most approved experiments we can find. We do not learn the ranges of a gun by theory, but the theory by the range of the gun. Now the variety and irregularity of all the experiments which are appealed to are so great, and the acknowledged difference between the resistance to slow and swift motions is also so great, that there is hardly any supposition which can be made concerning the resistance, that will not agree in its results with many of those experiments. It appears from the experiments of Dr Hutton of Woolwich, in 1784, 1785, and 1786, that the shots frequently deviated to the right or left of their intended track 200, 300, and sometimes 400 yards. This deviation was quite accidental and anomalous, and there can be no doubt but that the shot deviated from its intended and *supposed* elevation as much as it deviated from the intended vertical plane, and this without any opportunity of measuring or discovering the deviation. Now, when we have the whole range from one to three to choose among for our measure of resistance, it is evident that the confirmations which have been drawn from the ranges of shot are but feeble arguments for the truth of any opinion. Mr Robins finds his measures fully confirmed by the experiments at Metz and at Minorca. Mr Muller finds the same. Yet Mr Robins's measure both of the initial velocity and of the resistance are at least treble of Mr Muller's; but by compensation they give the same results. The Chevalier Borda, a very expert mathematician, has adduced the very same experiments in support of his theory, in which he abides by the Newtonian measure of the resistance, which is about $\frac{1}{3}$ of Mr Robins's, and about $\frac{3}{4}$ of Muller's.

90 Cause of its inutility.

What are we to conclude from all this? Simply this, that we have hardly any knowledge of the air's resistance, and that even the solution given of this problem has not as yet greatly increased it. Our knowledge consists only in those experiments, and mathematicians are attempting to patch up some notion of the motion of a body in a resisting medium, which shall tally with them.

There is another essential defect in the conditions assumed in the solution. The density of the air is supposed uniform; whereas we are certain that it is less by one-fifth or one-sixth towards the vertex of the curve, in many cases which frequently occur, than it is at the beginning and end of the flight. This is another latitude given to authors in their assumptions of the air's resistance. The Chevalier de Borda has, with considerable ingenuity, accommodated his investigation to this circumstance, by dividing the trajectory into portions, and, without much trouble, has made one equation answer them all. We are disposed to think that his solution of the problem (in the Memoirs of the Academy of Paris for 1769) corresponds better with the physical circumstances of the case than any other. But this process is there delivered in too concise a manner to be intelligible to a person not perfectly familiar with all the resources of modern analysis. We therefore preferred John Bernoulli's, because it is elementary and rigorous.

91 Necessity of attending to experiments.

After all, the practical artillerist must rely chiefly on the records of experiments contained in the books of practice at the academies, or those made in a more public manner. Even a perfect theory of the air's resistance can do him little service, unless the force of gunpowder were uniform. This is far from being the case even in the same powder. A few hours of a damp day will make a greater difference than occurs in any theory; and, in service, it is only by trial that every thing is performed. If the first shell fall very much short of the mark, a little more powder is added; and, in cannonading, the correction is made by varying the elevation.

We hope to be forgiven by the eminent mathematicians for these observations on their theories. They by no means proceed from any disrespect for their labours. We are not ignorant of the almost insuperable difficulty of the task, and we admire the ingenuity with which some of them have contrived to introduce into their analysis reasonable substitutions for those terms which would render the equations intractable. But we must still say, upon their own authority, that these are but ingenious guesses, and that experiment is the touchstone by which they mould these substitutions; and when they have found a coincidence, they have no motive to make any alteration. Now, when we have such a latitude for our measure of the air's resistance, that we may take it of any value, from one to three, it is no wonder that compensations of errors should produce a coincidence; but where is the coincidence? The theorist *supposes* the ball to set out with a certain velocity, and his theory gives a certain range: and this range agrees with observation—but how? Who knows the velocity of the ball in the experiment? This is concluded from a theory incomparably more uncertain than that of the motion in a resisting medium.

The experiments of Mr Robins and Dr Hutton show, in the most incontrovertible manner, that the resistance to a motion exceeding 1100 feet in a second, is almost *three times* greater than in the duplicate ratio to the resistance to moderate velocities. Euler's translator, in his comparison of the author's trajectories with experiment supposes it to be *no* greater. Yet the coincidence is very great. The same may be said of the Chevalier de Borda's. Nay, the same may be said of Mr Robins's own practical rules: for he makes his F, which corresponds to our a, almost double of what these authors do, and yet his rules are confirmed by practice. Our observations are therefore well founded.

92 The theory is still of some use in practice,

But it must not be inferred from all this, that the physical theory is of no use to the practical artillerist. It plainly shows him the impropriety of giving the projectile an enormous velocity. This velocity is of no effect after 200 or 300 yards at farthest, because it is so rapidly reduced by the prodigious resistance of the air. Mr Robins has deduced several practical maxims of the greatest importance from what we already know of this subject, and which could hardly have been even conjectured without this knowledge. See GUNNERY.

And

93 and may be brought to greater perfection.

And it must still be acknowledged, that this branch of physical science is highly interesting to the philosopher; nor should we despair of carrying it to greater perfection. The defects arise almost entirely from our ignorance of the law of variation of the air's resistance. Experiments may be contrived much more conducive to our information here than those commonly resorted to. The oblique flights of projectiles are, as we have seen, of very complicated investigation, and ill fitted for instructing us; but numerous and well contrived experiments on the perpendicular ascents are of great simplicity, being affected by nothing but the air's resistance. To make them instructive, we think that the following plan might be pursued. Let a set of experiments be premised for ascertaining the initial velocities. Then let shells be discharged perpendicularly with great varieties of density and velocity, and let nothing be attended to but the height and the time; even a considerable deviation from the perpendicular will not affect either of these circumstances, and the effect of this circumstance can easily be computed. The height can be ascertained with sufficient precision for very valuable information by their light or smoke. It is evident that these experiments will give *direct* information of the air's retarding force; and every experiment gives us two measures, viz. the ascent and descent: and the comparison of the times of ascent and descent, combined with the observed height in one experiment made with a great initial velocity, will give us more information concerning the air's resistance than 50 ranges. If we should suppose the resistance as the square of the velocity, this comparison will give in each experiment an exact determination of the initial and final velocities, which no other method can give us. These, with experiments on the *time* of horizontal flights, with known initial velocities, will give us more instruction on this head than any thing that has yet been done; and till something of this kind is carefully done, we presume to say that the motion of bodies in a resisting medium will remain in the hands of the mathematicians as a matter of curious speculation. In the mean time, the rules which Mr Robins has delivered in his Gunnery are very simple and easy in their use, and seem to come as near the truth as any we have met with. He has not informed us upon what principles they are founded, and we are disposed to think that they are rather empirical than scientific. But we profess great deference for his abilities and penetration, and doubt not but that he had framed them by means of as scientific a discussion as his knowledge of this new and difficult subject enabled him to give it.

94 Tables calculated on the preceding principles.

We shall conclude this article, by giving two or three tables, computed from the principles established above, and which serve to bring into one point of view the chief circumstances of the motion in a resisting medium. Although the result of much calculation, as any person who considers the subject will readily see, they must not be considered as offering any very accurate results; or that, in comparison with one or two experiments, the differences shall not be considerable. Let any person peruse the published registers of experiments which have been made with every attention, and he will see such enormous irregularities, that all expectations of perfect agreement with them must cease. In the experiments at Woolwich in 1735, which were continued for several days, not only do the experiments of one day differ among themselves, but the mean of all the experiments of one day differs from the mean of all the experiments of another no less than one fourth of the whole. The experiments in which the greatest regularity may be expected, are those made with great elevations. When the elevation is small, the range is more affected by a change of velocity, and still more by any deviation from the supposed or intended direction of the shot.

The first table shows the distance in yards to which a ball projected with the velocity 1600 will go, while its velocity is reduced one-tenth, and the distance at which it drops 16 feet from the line of its direction. This table is calculated by the resistance observed in Mr Robins's experiments. The first column is the weight of the ball in pounds. The second column remains the same whatever be the initial velocity; but the third column depends on the velocity. It is here given for the velocity which is very usual in military service, and its use is to assist us in directing the gun to the mark.—If the mark at which a ball of 24 pounds is directed is 474 yards distant, the axis of the piece must be pointed 16 feet higher than the mark. These deflections from the line of direction are nearly as the squares of the distances.

I.	II.	III.
2	92	420
4	121	428
9	159	456
18	200	470
32	272	479

The next table contains the ranges in yards of a 2 pound shot, projected at an elevation of 45°, with the different velocities in feet per second, expressed in the first column. The second column contains the distances to which the ball would go in vacuo in a horizontal plane; and the third contains the distances to which it will go through the air. The fourth column is added, to show the height to which it rises in the air; and the fifth shows the ranges corrected for the diminution of the air's density as the bullet ascends, and may therefore be called the *corrected range*.

I.	II.	III.	IV.	V.
200	416	349	106	360
400	1664	1121	338	1150
600	3740	1812	606	1859
800	6649	2373	866	2435
1000	10300	2845	1138	2919
1200	14961	3259	1378	3343
1400	20364	3640	1606	3734
1600	26597	3950	1814	4050
1800	33663	4235	1992	4345
2000	41559	4494	2168	4610
2200	50286	4720	2348	4842
2400	59846	4917	2460	5044
2600		5106	2630	5238
2800		5293	2762	5430
3000		5455	2862	5596
3200				5732

Fig. 1.

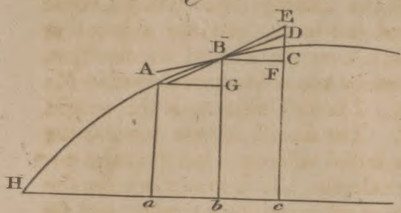

Fig. 2.

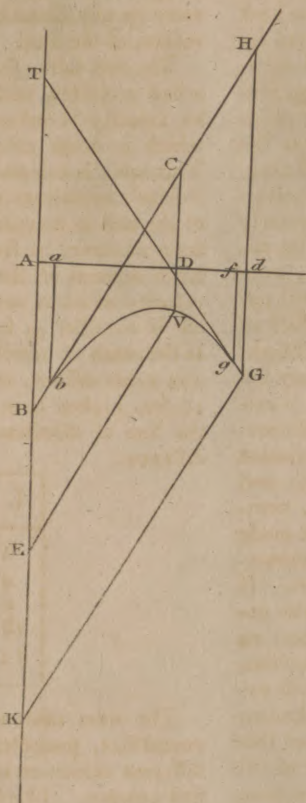

Fig. 3.

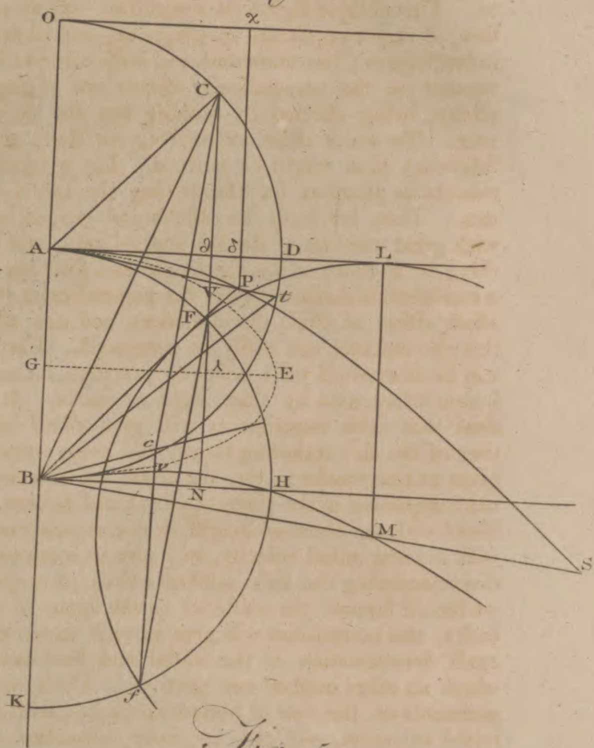

Fig. 4.

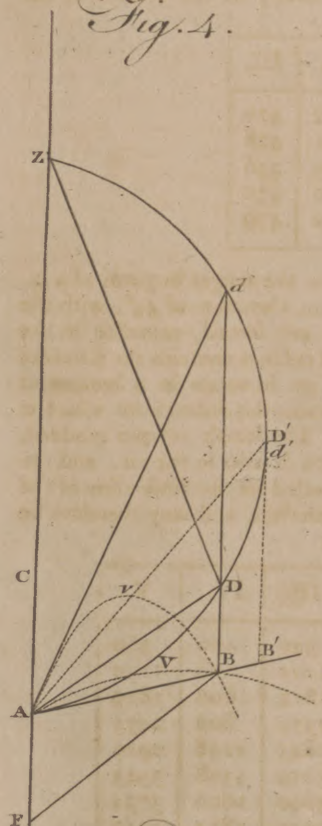

Fig. 5.

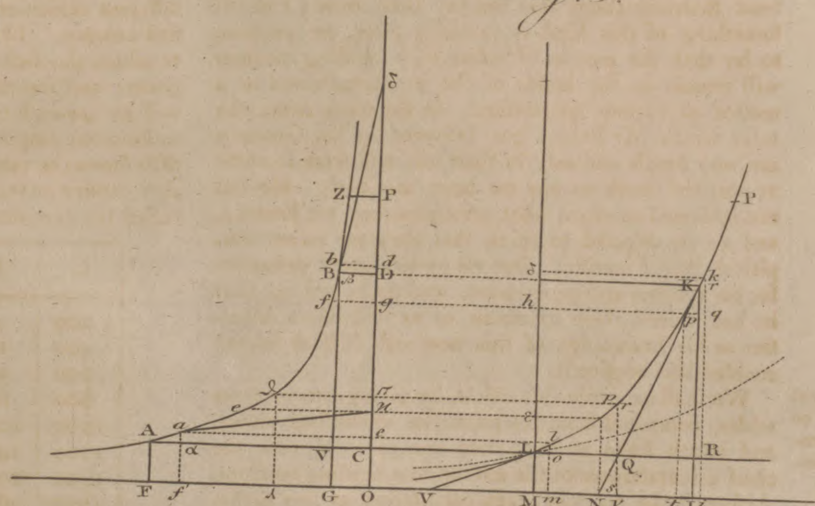

Fig. 6.

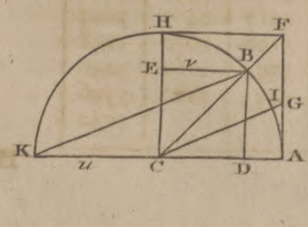

Fig. 7.

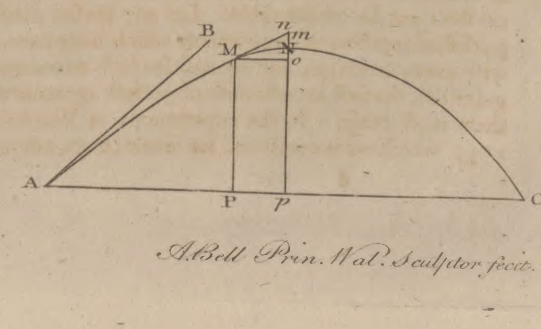

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Fig. 8.

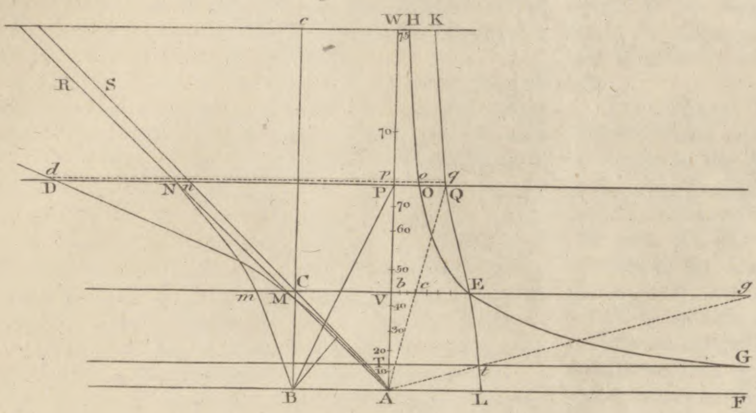


Fig. 9.

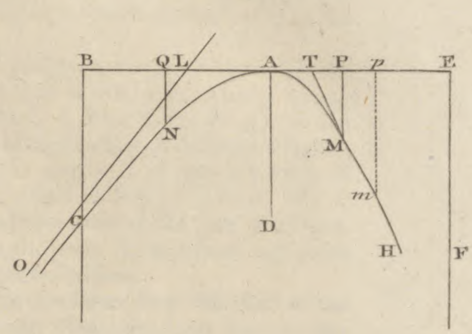
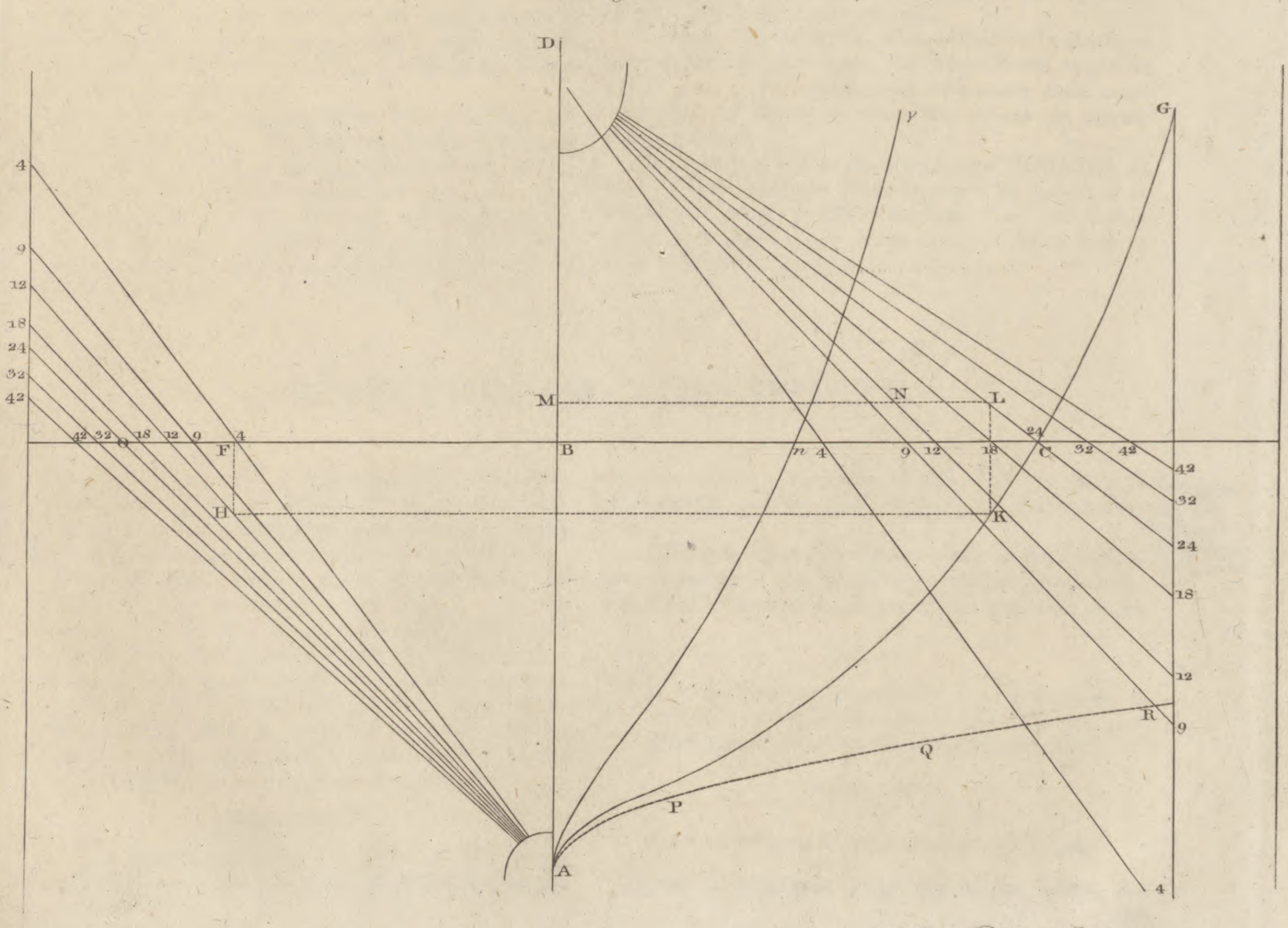


Fig. 10.



A. Bell Prin. Wal. Sculptor fecit.

95 Use of the last table. The initial velocities can never be pushed as far as we have calculated for in this table; but we mean it for a table of more extensive use than appears at first sight. Recollect, that while the proportion of the velocity at the vertex to the terminal velocity remains the same, the curves will be similar: therefore, if the initial velocities are as the square-roots of the diameters of the balls, they will describe similar curves, and the ranges will be as the diameters of the balls.

Therefore, to have the range of a 12 pound shot, if projected at an elevation of 45, with the velocity 1500; suppose the diameter of the 12 pounder to be d, and that of the 24 pounder D; and let the velocities be v and V: Then say, $\sqrt{d}:\sqrt{D}=1500$, to a fourth proportional V. If the 24 pounder be projected with the velocity V, it will describe a curve similar to that described by the 12 pounder, having the initial velocity 1500. Therefore find (by interpolation) the range of the 24 pounder, having the initial velocity V. Call this R. Then $D:d=R:r$, the range of the 12 pounder which was wanted, and which is nearly 3380 yards.

We see by this table the immense difference between the motions through the air and in a void. We see that the ranges through the air, instead of increasing in the duplicate ratio of the initial velocities, really increase slower than those velocities in all cases of military service; and in the most usual cases, viz. from 800 to 1600, they increase nearly as the square-roots of the velocities.

A set of similar tables, made for different elevations, would almost complete what can be done by theory, and would be much more expeditious in their use than Mr Euler's Trajectories, computed with great labour by his English translator.

The same table may also serve for computing the ranges of bomb-shells. We have only to find what must be the initial velocity of the 24 pound shot which corresponds to the proposed velocity of the shell. This must be deduced from the diameter and weight of the shell, by making the velocity of the 24 pounder such, that the ratio of its weight to the resistance may be the same as in the shell.

That the reader may see with one glance the relation of those different quantities, we have given this table, expressed in a figure (fig. 10). The abscissa, or axis DA, is the scale of the initial velocities in feet per second, measured on a scale of 400 equal parts in an inch. The ordinates to the curve ACG express the yards of the range on a scale containing 800 yards in an inch. The ordinates to the curve $A\,x\,y$ express (by the same scale) the height to which the ball rises in the air. Fig. 10. 96 Relation of the different quantities in it.

The ordinate BC (drawn through the point of the abscissa which corresponds to the initial velocity 2000) is divided in the points 4, 9, 12, 18, 24, 32, 42, in the ratio of the diameters of cannon-shot of different weights; and the same ordinate is produced on the other side of the axis, till BO be equal to BA; and then BO is divided in the subduplicate ratio of the same diameters. Lines are drawn from the point A, and from any point D of the abscissa, to these divisions.

We see distinctly by this figure how the effect of the initial velocity gradually diminishes, and that in very great velocities the range is very little increased by its augmentation. The dotted curve APQR, shows what the ranges in vacuo would be.

By this figure may the problems be solved. Thus, to find the range of the 12 pounder, with the initial velocity 1500. Set off 1500 from B to F; draw FH parallel to the axis, meeting the line 12A in H; draw the ordinate HK; draw KL parallel to the axis, meeting 24 B in L; draw the ordinate LM, cutting 12 B in N. MN is the range required.

If curves, such as ACG, were laid down in the same manner for other elevations, all the problems might be solved with great dispatch, and with much more accuracy than the theory by which the curves are drawn can pretend to.

Note, that fig. 10. as given on Plate CCCCXLII. *is one-half less than the scale according to which it is described; but the practical mathematician will find no difficulty in drawing the figure on the enlarged scale to correspond to the description.*

PROJECTION OF THE SPHERE.

Stereographic Projection of the Sphere. THE PROJECTION of the SPHERE is a perspective representation of the circles on the surface of the sphere; and is variously denominated according to the different positions of the eye and plane of projection.

There are three principal kinds of projection; the *stereographic*, the *orthographic*, and *gnomic*. In the stereographic projection the eye is supposed to be placed on the surface of the sphere; in the orthographic it is supposed to be at an infinite distance; and in the gnomic projection the eye is placed at the centre of the sphere. Other kinds of projection are, the *globular*, *Mercator's*, *scenographic*, &c. for which see the articles GEOGRAPHY, NAVIGATION, PERSPECTIVE, &c.

DEFINITIONS.

1. The plane upon which the circles of the sphere are described, is called the *plane of projection*, or the *primitive circle*. The pole of this circle is the *pole of projection*, and the place of the eye is the *projecting point*.

2. The *line of measures* of any circle of the sphere is that diameter of the primitive, produced indefinitely, which passes through the centre of the projected circle.

AXIOM.

The projection, or representation of any point, is where the straight line drawn from it to the projecting point intersects the plane of projection.

SECTION I.

Of the Stereographic Projection of the Sphere.

IN the stereographic projection of the sphere, the eye

Stereographic Projection of the Sphere. eye is placed on the surface of the sphere in the pole of the great circle upon which the sphere is to be projected. The projection of the hemisphere opposite to the eye falls within the primitive, to which the projection is generally limited; it, however, may be extended to the other hemisphere, or that wherein the eye is placed, the projection of which falls without the primitive.

As all circles in this projection are projected either into circles or straight lines, which are easily described, it is therefore more generally understood, and by many preferred to the other projections.

PROPOSITION I. THEOREM I.

Every great circle which passes through the projecting point is projected into a straight line passing through the centre of the primitive; and every arch of it, reckoned from the other pole of the primitive, is projected into its semitangent.

Plate CCCCXLIII. Fig. 1. Let ABCD (fig. 1.) be a great circle passing through A, C, the poles of the primitive, and intersecting it in the line of common section BED, E being the centre of the sphere. From A, the projecting point, let there be drawn straight lines AP, AM, AN, AQ, to any number of points P, M, N, Q, in the circle ABCD: these lines will intersect BED, which is in the same plane with them. Let them meet it in the points *p*, *m*, *n*, *q*; then *p*, *m*, *n*, *q*, are the projections of P, M, N, Q: hence the whole circle ABCD is projected into the straight line BED, passing through the centre of the primitive.

Again, because the pole C is projected into E, and the point M into *m*; therefore the arch CM is projected into the straight line E *m*, which is the semitangent of the arch CM to the radius AE. In like manner, the arch CP is projected into its semitangent, E *p*, &c.

COROLLARIES.

1. Each of the quadrants contiguous to the projecting point is projected into an indefinite straight line, and each of those that are remote into a radius of the primitive.

2. Every small circle which passes through the projecting point is projected into that straight line which is its common section with the primitive.

3. Every straight line in the plane of the primitive, and produced indefinitely, is the projection of some circle on the sphere passing through the projecting point.

4. The projection of any point in the surface of the sphere, is distant from the centre of the primitive, by the semitangent of the distance of that point from the pole opposite to the projecting point.

PROPOSITION II. THEOREM II.

Every circle on the sphere which does not pass through the projecting point is projected into a circle.

If the given circle be parallel to the primitive, then a straight line drawn from the projecting point to any point in the circumference, and made to revolve about the circle, will describe the surface of a cone; which being cut by the plane of projection parallel to the base, the section will be a circle. See *CONIC Sections*.

But if the circle MN (fig. 2.) be not parallel to the primitive circle BD, let the great circle ABCD, passing through the projecting point, cut it at right angles in the diameter MN, and the primitive in the diameter BD. Through M, in the plane of the great circle, let MF be drawn parallel to BD; let AM, AN be joined, and meet BD in *m*, *n*. Then, because AB, AD are quadrants, and BD, MF parallel, the arch AM is equal to AF, and the angle AMF or A *mn* is equal to ANM. Hence the conic surface described by the revolution of AM about the circle MN is cut by the primitive in a subcontrary position; therefore the section is in this case likewise a circle. Fig. 2.

COROLLARIES.

1. The centres and poles of all circles parallel to the primitive have their projection in its centre.

2. The centre and poles of every circle inclined to the primitive have their projections in the line of measures.

3. All projected great circles cut the primitive in two points diametrically opposite; and every circle in the plane of projection, which passes through the extremities of a diameter of the primitive, or through the projections of two points that are diametrically opposite on the sphere, is the projection of some great circle.

4. A tangent to any circle of the sphere, which does not pass through the projecting point, is projected into a tangent to that circle's projection; also, the circular projections of tangent circles touch one another.

5. The extremities of the diameter, on the line of measures of any projected circle, are distant from the centre of the primitive by the semitangents of the least and greatest distances of the circle on the sphere, from the pole opposite to the projecting point.

6. The extremities of the diameter, on the line of measures of any projected great circle, are distant from the centre of the primitive by the tangent and cotangent of half the great circle's inclination to the primitive.

7. The radius of any projected circle is equal to half the sum, or half the difference of the semitangents of the least and greatest distances of the circle from the pole opposite to the projecting point, according as that pole is within or without the given circle.

PROPOSITION III. THEOREM III.

An angle formed by two tangents at the same point in the surface of the sphere, is equal to the angle formed by their projections.

Let FGI and GH (fig. 3.) be the two tangents, and A the projecting point; let the plane AGF cut the sphere in the circle AGL, and the primitive in the line BML. Also, let MN be the line of common section of the plane AGH with the primitive: then the angle FGH=LMN. If the plane FGH be parallel to the primitive BLD, the proposition is manifest. If not, through any point K in AG produced, let the plane FKH, parallel to the primitive, be extended to meet FGH in the line FH. Then, because the plane AGF meets the two parallel planes BLD, FKH, the lines of common section LM, FK are parallel; therefore Fig. 3.

Stereographic Projection of the Sphere.

fore the angle AML=AKF. But since A is the pole of BLD, the chords, and consequently the arches AB AL, are equal, and the arch ABG is the sum of the arches AL, BG; hence the angle AML is equal to an angle at the circumference standing upon AG, and therefore equal to AGI or FGK; consequently the angle FGK=FKG, and the side FG=FK. In like manner HG=HK: hence the triangles GHF, KHF are equal, and the angle FGH=FKH=LMN.

Corollaries.

1. An angle contained by any two circles of the sphere is equal to the angle formed by their projections. For the tangents to these circles on the sphere are projected into straight lines, which either coincide with, or are tangents to, their projections on the primitive.

2. An angle contained by any two circles of the sphere is equal to the angle formed by the radii of their projections at the point of intersection.

Proposition IV. Theorem IV.

The centre of a projected great circle is distant from the centre of the primitive; the tangent of the inclination of the great circle to the primitive, and its radius, is the secant of its inclination.

Fig. 4. Let MNG (fig. 4.) be the projection of a great circle, meeting the primitive in the extremities of the diameter MN, and let the diameter BD, perpendicular to MN, meet the projection in F, G. Bisect FG in H, and join NH. Then, because any angle contained by two circles of the sphere is equal to the angle formed by the radii of their projections at the point of intersection; therefore the angle contained by the proposed great circle and the primitive is equal to the angle ENH, of which EH is the tangent, and NH the secant, to the radius of the primitive.

Corollaries.

1. All circles which pass through the points M, N are the projections of great circles, and have their centres in the line BG; and all circles which pass through the points F, G, are the projections of great circles, and have their centres in the line HI, perpendicular to BG.

2. If NF, NH be continued to meet the primitive in L, F; then BL is the measure of the great circle's inclination to the primitive; and MT=2BL.

Proposition V. Theorem V.

The centre of projection of a less circle perpendicular to the primitive, is distant from the centre of the primitive, the secant of the distance of the less circle from its nearest pole; and the radius of projection is the tangent of that distance.

Fig. 5. Let MN (fig. 5.) be the given less circle perpendicular to the primitive, and A the projecting point. Draw AM, AN to meet the diameter BD produced in G and H; then GH is the projected diameter of the less circle: bisect GH in C, and C will be its centre; join NE, NC. Then because AE, NI are parallel, the angle INE=NEA; but NEA=2NMA =2NHG=NCG: hence ENC=INE+INC=NCG +INC=a right angle; and therefore NC is a tangent to the primitive at N; but the arch ND is the distance of the less circle from its nearest pole D: hence NC is the tangent, and EC the secant of the distance of the less circle from its pole to the radius of the primitive.

Proposition VI. Theorem VI.

The projection of the poles of any circle, inclined to the primitive, are, in the line of measures, distant from the centre of the primitive, the tangent, and cotangent, of half its inclination.

Let MN (fig. 6.) be a great circle perpendicular to the primitive ABCD, and A the projecting point; then P, *p* are the poles of MN, and of all its parallels *m n*, &c. Let AP, A *p* meet the diameter BD in F *f*, which will therefore be the projected poles of MN and its parallels. The angle BEM is the inclination of the circle MEN, and its parallels, to the primitive: and because BC and MP are quadrants, and MC common to both; therefore PC=BM: and hence PEC is also the inclination of MN and its parallels. Now EF is the tangent of EAF, or of half the angle PEC the inclination; and E *f* is the tangent of the angle EA *f*; but EA *f* is the complement of EAF, hence E *f* is the cotangent of half the inclination. Fig. 6.

Corollaries.

1. The projection of that pole which is nearest to the projecting point is without the primitive, and the projection of the other within.

2. The projected centre of any circle is always between the projection of its nearest pole and the centre of the primitive; and the projected centres of all circles are contained between their projected poles.

Proposition VII. Theorem VII.

Equal arches of any two great circles of the sphere will be intercepted between two other circles drawn on the sphere through the remote poles of those great circles.

Let AGB, CFD (fig. 7.) be two great circles of the sphere, whose remote poles are E, P; through which draw the great circle PBEC, and less circle PGE, intersecting the great circles AGB, CFD, in the points B, G, and D, F; then the arch BG is equal to the arch DF. Fig. 7.

Because E is the pole of the circle AGB, and P the pole of CFD, therefore the arches EB, PD are equal; and since BD is common to both, hence the arch ED is equal to the arch PB. For the same reason, the arches EF, PG are equal; but the angle DEF is equal to the angle BPG: hence these triangles are equal, and therefore the arch DF is equal to the arch BG.

Proposition VIII. Theorem VIII.

If from either pole of a projected great circle, two straight lines be drawn to meet the primitive and the projection, they will intercept similar arches of these circles.

Stereographic Projection of the Sphere.

On the plane of projection AGB (fig. 7.) let the great circle CFD be projected into *c f d*, and its pole P into *p*; through *p* draw the straight lines *p d*, *p f*, then are the arches GB, *f d* similar.

Since *p d* lies both in the plane AGB and APBE, it is in their common section, and the point B is also in their common section; therefore *p d* passes through the point B. In like manner it may be shown that the line *p f* passes through G. Now the points D, F are projected into *d*, *f*: hence the arches FD, *f d* are similar; but GB is equal to FD, therefore the intercepted arch of the primitive GB is similar to the projected arch *f d*.

Corollary.

Hence, if from the angular point of a projected spherical angle two straight lines be drawn through the projected poles of the containing sides, the intercepted arch of the primitive will be the measure of the spherical angle.

Proposition IX. Problem I.

To describe the projection of a great circle through two given points in the plane of the primitive.

Let P and B be given points, and C the centre of the primitive.

Fig. 8. 1. When one point P (fig. 8.) is the centre of the primitive, a diameter drawn through the given points will be the great circle required.

Fig. 9. 2. When one point P (fig. 9.) is in the circumference of the primitive. Through P draw the diameter PD; and an oblique circle described through the three points P, B, D, will be the projection of the required great circle.

3. When the given points are neither in the centre nor circumference of the primitive. Through either of
Fig. 10. the given points P (fig. 10.) draw the diameter ED, and at right angles thereto draw the diameter FG. From F through P draw the straight line FPH, meeting the circumference in H: draw the diameter HI, and draw the straight line FIK, meeting ED produced in D; then an arch, terminated by the circumference, being described through the three points, P, B, K, will be the great circle.

Proposition X. Problem II.

To describe the representation of a great circle about any given point as a pole.

Let P be the given pole, and C the centre of the primitive.

1. When P (fig. 8.) is in the centre of the primitive, then the primitive will be the great circle required.

Fig. 11. 2. When the pole P (fig. 11.) is in the circumference of the primitive. Through P draw the diameter PE, and the diameter AB drawn at right angles to PE will be the projected great circle required.

3. When the given pole is neither in the centre nor circumference of the primitive. Though the pole P
Plate CCCCXLIV. (fig. 12.) draw the diameter AB, and draw the diameter DE perpendicular to AB; through E and P draw the straight line EPF, meeting the circumference in F. Make FG equal to FD; through E and G draw the straight line EGH, meeting the diameter AB produced if necessary in H; then from the centre H, with the radius HE, describe the oblique circle DIE, and it will be the projection of the great circle required.

Or, make DK equal to FA; join EK, which intersects the diameter AB in I; then through the three points, D, I, E, describe the oblique circle DIE.

Proposition XI. Problem III.

To find the poles of a great circle.

1. When the given great circle is the primitive, its centre is the pole.

2. To find the pole of the right circle ACB (fig. 11.) Draw the diameter PE perpendicular to the given circle AB; and its extremities P, E are the poles of the circle ACB.

3. To find the pole of the oblique circle DEF (fig. 13.) Join DF, and perpendicular thereto draw the diameter AB, cutting the given oblique circle DEF in E. Draw the straight line FEG, meeting the circumference in G. Make GI, GH, each equal to AD; then FI being joined, cuts the diameter AB in P, the lower pole; through F and H draw the straight line FH *p*, meeting the diameter AB produced in *p*, which will be the opposite or exterior pole. Fig. 13.

Proposition XII. Problem IV.

To describe a less circle about any given point as a pole, and at any given distance from that pole.

1. When the pole of the less circle is in the centre of the primitive; then from the centre of the primitive, with the semitangent of the distance of the given circle from its pole, describe a circle, and it will be the projection of the less circle required.

2. If the given pole is in the circumference of the primitive, from C (fig. 14.), the centre of the primitive, set off CE the secant of the distance of the less circle from its pole P; then from the centre E, with the tangent of the given distance, describe a circle, and it will be the less circle required. Or, make PG, PF each equal to the chord of the distance of the less circle from its pole. Through B, G, draw the straight line BGD meeting CP produced in D: bisect GD in H, and draw HE perpendicular to GD; and meeting PD in E, then E is the centre of the less circle. Fig. 14.

3. When the given pole is neither in the centre nor circumference of the primitive. Through P (fig. 15.), the given pole, and C the centre of the primitive, draw the diameter AB, and draw the diameter DE perpendicular to AB; join EP, and produce it to meet the primitive in *p*; make *p* F, *p* G, each equal to the chord of the distance of the less circle from its pole; join EF which intersects the diameter AB in H; from E through G draw the straight line EGI, meeting the diameter AB produced in I; bisect HI in K: Then a circle described from the centre K, at the distance KH or KI, will be the projection of the less circle. Fig. 15.

Proposition XIII. Problem V.

To find the poles of a given less circle.

The poles of a less circle are also those of its parallel great

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great circle. If therefore the parallel great circle be given, then its poles being found by Prob. III. will be those of the less circle. But if the parallel great circle be not given, let HMIN (fig. 15.) be the given less circle. Through its centre, and C the centre of the primitive, draw the line of measures IAHB; and draw the diameter DE perpendicular to it, also draw the straight line EHF meeting the primitive in F; make F p equal to the chord of the distance of the less circle from its pole; join E p, and its intersection P with the diameter AB is the interior pole. Draw the diameter p CL through E and L, draw EL q meeting the diameter AB produced in q; then q is the external pole. Or thus: Join EI intersecting the primitive in G; join also EH, and produce it to meet the primitive in F; bisect the arch GF in p; from E to p draw the straight line EP p, and P is the pole of the given less circle.

Fig. 15.

Proposition XIV. Problem VI.

To measure any arch of a great circle.

1. Arches of the primitive are measured on the line of chords.

2. Right circles are measured on the line of semitangents, beginning at the centre of the primitive. Thus, the measure of the portion AC (fig. 16.) of the right circle DE, is found by applying it to the line of semitangents. The measure of the arch DB is found by subtracting that of BC from 90°: the measure of the arch AF, lying partly on each side of the centre, is obtained by adding the measures of AC and CF. Lastly, To measure the part AB, which is neither terminated at the centre or circumference of the primitive, apply CA to the line of semitangents; then CB, and the difference between the measures of these arches, will be that of AB.

Fig. 16.

Or thus: Draw the diameter GH perpendicular to DE; then from either extremity, as D, of this diameter, draw lines through the extremities of the arch intended to be measured; and the intercepted portion of the primitive applied to the line of chords will give the measure of the required arch. Thus IK applied to the line of chords will give the measure of AB.

3. To measure an arch of an oblique circle: draw lines from its pole through the extremities of the arch to meet the primitive, then the intercepted portion of the primitive applied to the line of chords will give the measure of the arch of the oblique circle. Thus, let AB (fig. 17.), be an arch of an oblique circle to be measured, and P its pole; from P draw the lines PAD, PBE meeting the primitive in B and E; then the arch DE applied to the line of chords will give the measure of the arch of the oblique circle AB.

Fig. 17.

Proposition XV. Problem VII.

To measure any arch of a less circle.

Fig. 18.

Let DEG (fig. 18.) be the given less circle, and DE the arch to be measured: find its internal pole P; and describe the circle AFI parallel to the primitive, and whose distance from the projecting point may be equal to the distance of the given less circle from its pole P: then join PD, PE, which produce to meet the parallel circle in A and F. Now AF applied to a line of chords will give the measure of the arch DE of the given less circle.

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Proposition XVI. Problem VIII.

To measure any spherical angle.

1. If the angle is at the centre of the primitive, it is measured as a plane angle.

2. When the angular point is in the circumference of the primitive; let A (fig. 19.) be the angular point, and ABE an oblique circle inclined to the primitive. Through P, the pole of ABE, draw the line AP p meeting the circumference in p: then the arch E p is the measure of the angle BAD, and the arch AF p is the measure of its supplement BAF: also p F is the measure of the angle BAC, and p ED that of its supplement.

Fig. 19.

3. If the angular point is neither at the centre nor circumference of the primitive. Let A (fig. 20.) be the angular point, and DAH, or GAF, the angle to be measured, P the pole of the oblique circle DAF, and p the pole of GAH: then from A, through the points P p, draw the straight lines APM, A p N, and the arch MN will be the measure of the angle DAH; and the supplement of MN will be the measure of the angle HAF or DAG.

Fig. 20.

Proposition XVII. Problem IX.

To draw a great circle perpendicular to a projected great circle, and through a point given in it.

Find the pole of the given circle, then a great circle described through that pole and the given point will be perpendicular to the given circle. Hence if the given circle be the primitive, then a diameter drawn through the given point will be the required perpendicular. If the given circle is a right one, draw a diameter at right angles to it; then though the extremities of this diameter and the given point describe an oblique circle, and it will be perpendicular to that given. If the given circle is inclined to the primitive, let it be represented by BAD (fig. 21.), whose pole is P, and let A be the point through which the perpendicular is to be drawn: then, by Prob. I. describe a great circle through the points P and A, and it will be perpendicular to the oblique circle BAD.

Fig. 21.

Proposition XVIII. Problem X.

Through a point in a projected great circle, to describe another great circle to make a given angle with the former, provided the measure of the given angle is not less than the distance between the given point and circle.

Let the given circle be the primitive, and let A (fig 19.) be the angular point. Draw the diameters AE, DF perpendicular to each other; and make the angle CAG equal to that given, or make CG equal to the tangent of the given angle; then from the centre G, with the distance GC, describe the oblique circle ABE, and it will make with the primitive an angle equal to that given.

If the given circle be a right one, let it be APB (fig. 22.) and let P be the given point. Draw the diameter GH

Fig. 22.

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GH perpendicular to AB; join GP, and produce it to *a*; make H *b* equal to twice A *a*: and G *b* being joined intersects AB in C. Draw CD perpendicular to AB, and equal to the cotangent of the given angle to the radius PC; or make the angle CPD equal to the complement of that given: then from the centre D, with the radius DP, describe the great circle FPE, and the angle APF, or BPE, will be equal to that given.

Fig. 23. If APB (fig. 23.) is an oblique circle. From the angular point P, draw the lines PG, PC through the centres of the primitive and given oblique circle. Through C, the centre of APB, draw GCD at right angles to PG; make the angle GPD equal to that given; and from the centre D, with the radius DP, describe the oblique circle FPE, and the angle APF, or BPE, will be equal to that proposed.

Proposition XIX. Problem XI.

Any great circle cutting the primitive being given, to describe another great circle which shall cut the given one in a proposed angle, and have a given arch intercepted between the primitive and given circles.

Plate CCCCXLV Fig. 24. If the given circle be a right one, let it be represented by APC (fig. 24.); and at right angles thereto draw the diameter BPM; make the angle BPF equal to the complement of the given angle, and PF equal to the tangent of the given arch; and from the centre of the primitive with the secant of the same arch describe the arch G*g*. Through F draw FG parallel to AC, meeting G*g* in G; then from the centre G, with the tangent PF, describe an arch *n o*, cutting APC in I, and join GI. Through G, and the centre P, draw the diameter HK; draw PL perpendicular to HK, and IL perpendicular to GI, meeting PL in L; then L will be the centre of the circle HIK, which is that required.

Fig. 25. But if the given great circle be inclined to the primitive, let it be ADB (fig. 25.), and E its centre: make the angle BDF equal to the complement of that given, and DF equal to the tangent of the given arch, as before. From P, the centre of the primitive, with the secant of the same arch, describe the arch G*g*, and from E, the centre of the oblique circle, with the extent EF, describe an arch intersecting G*g* in G. Now G being determined, the remaining part of the operation is performed as before.

When the given arch exceeds 90°, the tangent and secant of its supplement are to be applied on the line DF the contrary way, or towards the right; the former construction being reckoned to the left.

Proposition XX. Problem XII.

Any great circle in the plane of projection being given, to describe another great circle, which shall make given angles with the primitive and given circles.

Fig. 26. Let ADC (fig. 26.) be the given circle, and Q its pole. About P the pole of the primitive, describe an arch *m n*, at the distance of as many degrees as are in the angle which the required circle is to make with the primitive. About Q the pole of the circle ADC, and at a distance equal to the measure of the angle which the required circle is to make with the given circle ADC, describe an arch *o n*, cutting *m n* in *n*. Then about *n* as a pole, describe the great circle EDF, cutting the primitive and given circle in E and D, and it will be the great circle required.

Scholium.

It will hence be an easy matter to construct all the various spherical triangles. The reader is, however, referred to the article *Spherical Trigonometry*, for the method of constructing them agreeably to this projection; and also for the application to the resolution of problems of the sphere. For the method of projecting the sphere upon the plane of the meridian, and of the horizon, according to the stereographic projection, see the article Geography.

SECTION II.

Of the Orthographic Projection of the Sphere.

The orthographic projection of the sphere, is that in which the eye is placed in the axis of the plane of projection, at an infinite distance with respect to the diameter of the sphere; so that at the sphere all the visual rays are assumed parallel, and therefore perpendicular to the plane of projection.

Hence the orthographic projection of any point is where a perpendicular from that point meets the plane of projection: and the orthographic representation of any object is the figure formed by perpendiculars drawn from every point of the object to the plane of projection.

This method of projection is used in the geometrical delineation of eclipses, occultations, and transits. It is also particularly useful in various other projections, such as the analemma. See Geography, &c.

Proposition I. Theorem I.

Every straight line is projected into a straight line. If the given line be parallel to the plane of projection, it is projected into an equal straight line; but if it is inclined to the primitive, then the given straight line will be to its projection in the ratio of the radius to the cosine of inclination.

Let AB (fig. 27.) be the plane of projection, and let CD be a straight line parallel thereto: from the extremities C, D of the straight line CD, draw the lines CE, DF perpendicular to AB; then by 3. of xi. of Eucl. the intersection EF, of the plane CEFD, with the plane of projection, is a straight line: and because the straight lines CD, EF are parallel, and also CE, DF; therefore, by 34. of i. of Eucl. the opposite sides are equal; hence the straight line CD, and its projection EF, are equal. Again, let GH be the proposed straight line, inclined to the primitive; then the lines GE, HF being drawn perpendicular to AB, the intercepted portion EF will be the projection of GH. Through G draw GI parallel to AB, and the angle IGH will be equal to the inclination of the given line to the plane of projection. Now GH being the radius, GI, or its equal EF, will be the cosine of IGH; hence the given line GH is to its projection EF as radius to the cosine or inclination. Fig. 27.

Corollaries.

Orthographic projection of the Sphere.

COROLLARIES.

1. A straight line perpendicular to the plane of projection is projected into a point.

2. Every straight line in a plane parallel to the primitive is projected into an equal and parallel straight line.

3. A plane angle parallel to the primitive is projected into an equal angle.

4. Any plane rectilineal figure parallel to the primitive is projected into an equal and similar figure.

5. The area of any rectilineal figure is to the area of its projection as radius to the cosine of its inclination.

PROPOSITION II. THEOREM II.

Every great circle, perpendicular to the primitive, is projected into a diameter of the primitive; and every arch of it, reckoned from the pole of the primitive, is projected into its sine.

Fig. 28. Let BFD (fig. 28.) be the primitive, and ABCD a great circle perpendicular to it, passing through its poles A, C; then the diameter EED, which is their line of common section, will be the projection of the circle ABCD. For if from any point, as G, in the circle ABC, a perpendicular GH fall upon BD, it will also be perpendicular to the plane of the primitive: therefore H is the projection of G. Hence the whole circle is projected into BD, and any arch AG into EH equal to GI its sine.

COROLLARIES.

1. Every arch of a great circle, reckoned from its intersection with the primitive, is projected into its versed sine.

2. Every less circle perpendicular to the primitive is projected into its line of common section with the primitive, which is also its own diameter; and every arch of the semicircle above the primitive, reckoned from the middle point, is projected into its sine.

3. Every diameter of the primitive is the projection of a great circle; and every chord the projection of a less circle.

4. A spherical angle at the pole of the primitive is projected into an equal angle.

PROPOSITION III. THEOREM III.

A circle parallel to the primitive is projected into a circle equal to itself, and concentric with the primitive.

Fig. 29. Let the less circle FIG (fig. 29.) be parallel to the plane of the primitive BND. The straight line HE, which joins their centres, is perpendicular to the primitive; therefore E is the projection of H. Let any radii HI and IN perpendicular to the primitive be drawn. Then IN, HE being parallel, are in the same plane; therefore IH, NE, the lines of common section of the plane IE, with two parallel planes, are parallel; and the figure IHEN is a parallelogram. Hence NE = IH, and consequently FIG is projected into an equal circle KNL, whose centre is E.

COROLLARY.

The radius of the projection is the cosine of the distance of the parallel circle from the primitive, or the sine of its distance from the pole of the primitive.

PROPOSITION IV. THEOREM IV.

An inclined circle is projected into an ellipse, whose transverse axis is the diameter of the circle.

1. Let ELF (fig. 30.) be a great circle inclined to the primitive EBF, and EF their line of common section. From the centre C, and any other point K, in EF, let the perpendicular CB, KI be drawn in the plane of the primitive, and CL, KN, in the plane of the great circle, meeting the circumference in L, N. Let LG, ND be perpendicular to CB, KI; then G, D are the projections of L, N. And because the triangles LCG, NKD are equiangular, $CL^2:CG^2::NK^2:DK^2$: or $EC^2 : CG^2 :: EKF : DK^2$: therefore the points G, D are in the curve of an ellipse, of which EF is the transverse axis, and CG the semiconjugate axis. Fig. 30.

COROLLARIES.

1. In a projected great circle, the semiconjugate axis is the cosine of the inclination of the great circle to the primitive.

2. Perpendiculars to the transverse axis intercept corresponding arches of the projection and the primitive.

3. The eccentricity of the projection is the sine of the inclination of the great circle to the primitive.

Case 2. Let AQB (fig. 31.) be a less circle, inclined to the primitive, and let the great circle LBM, perpendicular to both, intersect them in the lines AB, LM. From the centre O, and any other point N in the diameter AB, let the perpendiculars TOP, NQ, be drawn in the plane of the less circle, to meet its circumference in T, P, Q. Also, from the points A, N, O, B, let AG, NI, OC, BH, be drawn perpendicular to LM; and from P, Q, T, draw PE, QD, TF, perpendicular to the primitive; then G, I, C, H, E, D, F, are the projections of these points. Because OP is perpendicular to LMB, and OC, PE, being perpendicular to the primitive, are in the same plane, the plane COPE is perpendicular to LBM. But the primitive is perpendicular to LBM; therefore the common section EC is perpendicular to LBM, and to LM. Hence CP is a parallelogram, and EC = OP. In like manner, FC, DI, are proved perpendicular to LM, and equal to OT, NQ. Thus ECF is a straight line, and equal to the diameter PT. Let QR, DK be parallel to AB, LM; then RO = NQ = DI = KC, and PR × RT = EK × KF. But AO : CG :: NO : CI; therefore $AO^2 : CG^2 :: QR^2 : DK^2$: and $EC^2 : CG^2 :: EKF : DK^2$. Fig. 31.

COROLLARIES.

1. The transverse axis is to the conjugate as radius to the cosine of the circle's inclination to the primitive.

2. Half the transverse axis is the cosine of half the sum of the greatest and least distances of the less circle from the primitive.

3. The extremities of the conjugate axis are in the line of measures, distant from the centre of the primitive by the cosines of the greatest and least distances of the less circle from the primitive.

4. If

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4. If from the extremities of the conjugate axis of any elliptical projection perpendiculars be drawn (in the fame direction if the circle do not interfect the primitive, but if otherwife in oppofite directions), they will interfect an arch of the primitive, whofe chord is equal to the diameter of the circle.

Proposition V. Theorem V.

The projected poles of an inclined circle are in its line of meafures diftant from the centre of the primitive the fine of the inclination of the circle to the primitive.

Fig. 32. Let ABCD (fig. 32.) be a great circle, perpendicular both to the primitive and the inclined circle, and interfecting them in the diameters AC, MN. Then ABCD paffes through the poles of the inclined circle; let thefe be P, Q; and let P*p*, Q*q*, be perpendicular to AC; *p*, *q* are the projected poles; and it is evident that *p* O = fine of BP, or MA, the inclination.

Corollaries.

1. The centre of the primitive, the centre of the projection, the projected poles, and the extremities of the conjugate axis, are all in one and the fame ftraight line.

2. The diftance of the centre of projection from the centre of the primitive, is to the cofine of the diftance of the circle from its own pole, as the fine of the circle's inclination to the primitive is to the radius.

Proposition VI. Problem I.

To defcribe the projection of a circle perpendicular to the primitive, and whofe diftance from its pole is equal to a given quantity.

Fig. 33. Let PA *p* B (fig. 33.) be the primitive circle, and P, *p* the poles of the right circle to be projected. Then if the circle to be projected is a great circle, draw the diameter AB at right angles to the axis P*p*, and it will be that required. But if the required projection is that of a lefs circle, make PE, PF each equal to the chord of the diftance of the lefs circle from its pole; join EF, and it will be the projection of the lefs circle required.

Proposition VII. Problem II.

Through a given point in the plane of the primitive to defcribe the projection of a great circle, having a given inclination to the primitive.

1. When the given inclination is equal to a right angle, a ftraight line drawn through the centre of the primitive, and the given point, will be the projection required.

2. When the given inclination is lefs than a right angle, and the given point in the circumference of the primitive. Fig. 34. Let R (fig. 34.) be a point given in the circumference of the primitive, through which it is required to draw the projection of a great circle, inclined to the primitive in an angle meafured by the arch QP of the primitive.

Through the given point R draw the diameter RCS, and draw GC*g* at right angles to it. Make the arch GV of the primitive equal to QP, and draw VA at right angles to GC; and in G*g*, towards the oppofite parts of C, take CB equal to AC; then, with the greater axis RS, and lefs axis AB, defcribe an ellipfe, and it will be the projection of the oblique circle required.

3. When the diftance of the given point from the primitive is equal to the cofine of the given inclination.

Every thing remaining as in the preceding cafe; let A be the given point, and AC the cofine of an arch GV, equal to the given arch QP; then drawing the diameter RCS at right angles to ACB, the ellipfe defcribed with the given axis RS, AB will be the projection of the inclined circle.

4. When the diftance of the given point from the centre of the primitive is lefs than the femidiameter of the primitive, but greater than the cofine of the given inclination.

Let D be the given point, through which draw the diameter IC *i*; and at the point D draw DL perpendicular to DC meeting the primitive in L; alfo draw LK, making with LD the angle DLK equal to the complement of the given inclination. Let LK meet DC in K; then will DK be lefs than DC. On DC as a diameter defcribe a circle, and make DH equal to DK; through H draw a diameter of the primitive RCS, and defcribe an ellipfe through the points R, D, S, and it will be the projection of the inclined circle. *Walker on the Sphere*, p. 159.

Proposition VIII. Problem III.

Through two given points in the plane of the primitive to defcribe the projection of a great circle.

1. If the two given points and the centre of the primitive be in the fame ftraight line, then a diameter of the primitive being drawn through thefe points will be the projection of the great circle required.

2. When the two given points are not in the fame ftraght line with the centre of the primitive; and one of them is in the circumference of the primitive.

Let DR (fig. 34.) be the two given points, of which R is in the circumference of the primitive. Draw the diameters RCS, and GC *g*, FDH perpendicular to it, meeting the primitive in G *g* F. Divide GC, *g* C, in A, B, in the fame proportion as FH is divided in D; and defcribe the ellipfe whofe axes are RS, AB, and centre C; and it will be the projection required.

3. When the given points are within the primitive, and not in the fame ftraight line with its centre.

Let D, E (fig. 35.) be the two given points; Fig. 35. through C the centre of the primitive draw the ftraight lines ID, KE *i*; draw DL perpendicular to I *i*, and EO perpendicular to K *k*, meeting the primitive in L, O. Through E, and towards the fame parts of C, draw EP parallel to DC, and in magnitude a fourth proportional to LD, DC, OE. Draw the diameter CP meeting the primitive in R, S, and defcribe an ellipfe through the points D and R, or S, and it will alfo pafs through E. This ellipfe will be the projection of the propofed inclined circle.

Proposition IX. Problem IV.

To defcribe the projection of a lefs circle parallel to the primitive, its diftance from the pole of the primitive being given.

From

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From the pole of the primitive, with the fine of the given diftance of the circle from its pole, defcribe a circle, and it will be the projection of the given lefs circle.

Proposition X. Problem V.

About a given point as a projected pole to defcribe the projection of an inclined circle, whofe diftance from its pole is given.

Fig. 36. Let P (fig. 36.) be the given projected pole, through which draw the diameter G*g*, and draw the diameter H*b* perpendicular thereto. From P draw PL perpendicular to GP meeting the circumference in L; through which draw the diameter L*l*. Make LT, LK each equal to the chord of the diftance of the lefs circle from its pole, and join TK, which interfects L*l*, in Q. From the points T, Q, K, draw the lines FA, QS, KB, perpendicular to G*g*; and make OR, OS, each equal to QT, or QK. Then an ellipfe defcribed through the points A, S, B, R will be the projection of the propofed lefs circle.

Proposition XI. Problem VI.

To find the poles of a given projected circle.

1. If the projected circle be parallel to the primitive, the centre of the primitive will be its pole.

2. If the circle be perpendicular to the primitive, then the extremities of a diameter of the primitive drawn at right angles to the ftraight line reprefenting the projected circle, will be the poles of that circle.

3. When the projected circle is inclined to the primitive.

Fig. 37. Let ARBS (fig. 36, 37,) be the elliptical projection of any oblique circle; through the centre of which, and C the centre of the primitive, draw the line of meafures CBA, meeting the ellipfe in B, A; and the primitive in G, *g*. Draw CH, BK, AT perpendicular to G*g*, meeting the primitive in H, K, T. Bifect the arch KT in L, and draw LP perpendicular to G*g*; then P will be the projected pole of the circle, of which ARBS is the projection.

Proposition XII. Problem VII.

To meafure any portion of a projected circle, and converfely.

1. When the given projection is that of a great circle.

Fig. 38. Let ADBE (fig. 38.) be the given great circle, either perpendicular or inclined to the primitive, of which the portion DE is to be meafured, and let M*m* be the line of meafures of the given circle. Through the points D, E, draw the lines EG, DF parallel to M*m*; and the arch FG of the primitive will be the meafure of the arch DE of the great circle, and converfely.

2. When the projection is that of a lefs circle parallel to the primitive.

Plate CCCCXLVI. Fig. 39. Let DE (fig. 39.) be the portion to be meafured, of the lefs circle DEH parallel to the primitive. From the centre C draw the lines CD, CE, and produce them to meet the primitive in the points B, F. Then the intercepted portion BF of the primitive will be the meafure of the given arch DE of the lefs circle DEH.

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3. If the given lefs circle, of which an arch is to be meafured, is perpendicular to the primitive.

Let ADEB (fig. 40.) be the lefs circle, of which the meafure of the arch DE is required. Through C, the centre of the primitive, draw the line of meafures M*m*, and from the interfection O of the given right circle, and the line of meafures, with the radius OA, or OB, defcribe the femicircle AFGB; through the points D, E, draw the lines DF, EG parallel to the line of meafures, and the arch FG will be the meafure of DE, to the radius AO. In order to find a fimilar arch in the circumference of the primitive, join OF, OG, and at the centre C of the primitive, make the angle *m*CH equal to FOG, and the arch *m*H to the radius C*m* will be the meafure of the arch DE. Fig. 40.

4. When the great projection is of a lefs circle inclined to the primitive.

Let RDS (fig. 41.) be the projection of a lefs circle inclined to the primitive, and DE a portion of that circle to be meafured. Through O the centre of the projected circle, and C the centre of the primitive, draw the line of meafures M*m*; and from the centre O, with the radius OR, or OS, defcribe the femicircle RGFS; through the points D, E draw the lines DF, EG parallel to the line of meafures, and FG will be the meafure of the arch DE to the radius OR, or OS. Join OF, OG, and make the angle *m*CH equal to FOG, and the arch *m* H of the primitive will be the meafure of the arch DE of the inclined circle RDS. Fig. 41.

The converfe of this propofition, namely, to cut off an arch from a given projected circle equal to a given arch of the primitive, is obvious.

The above operation would be greatly fhortened by ufing the line of fines in the fector.

It feems unneceffary to infift farther on this projection, efpecially as the reader will fee the application of it to the projection of the fphere on the planes of the *Meridian*, *Equator*, and *Horizon*, in the article Geography; and to the delineation of *Eclipfes* in the article Astronomy. The *Analemma*, Plate CCXXXV. in the article Geography, is alfo according to this projection; and the method of applying it to the folution of aftronomical problems is there exemplified.

SECTION III.

Of the Gnomonic Projection of the Sphere.

In this projection the eye is in the centre of the fphere, and the plane of projection touches the fphere in a given point parallel to a given circle. It is named *gnomonic*, on account of its being the foundation of dialling: the plane of projection may alfo reprefent the plane of a dial, whofe centre being the projected pole, the femiaxis of the fphere will be the ftile or gnomon of the dial.

As the projection of great circles is reprefented by ftraight lines, and lefs circles parallel to the plane of projection are projected into concentric circles: therefore many problems of the fphere are very eafily refolved. Other problems, however, become more intricate on account of fome of the circles being projected into ellipfes, parabolas, and hyperbolas.

Proposition

Gnomonic Projection of the Sphere.

PROPOSITION I. THEOREM I.

Every great circle is projected into a straight line perpendicular to the line of measures; and whose distance from the circle is equal to the cotangent of its inclination, or to the tangent of its nearest distance from the pole of the projection.

Fig. 42. Let BAD (fig. 42.) be the given circle, and let the circle CBED be perpendicular to BAD, and to the plane of projection; whose intersection CF with this last plane will be the line of measures. Now since the circle CBED is perpendicular both to the given circle BAD and to the plane of projection, the common section of the two last planes produced will therefore be perpendicular to the plane of the circle CBED produced, and consequently to the line of measures: hence the given circle will be projected into that section; that is, into a straight line passing through d, perpendicular to Cd. Now Cd is the cotangent of the angle CdA, the inclination of the given circle, or the tangent of the arch CD to the radius AC.

COROLLARIES.

1. A great circle perpendicular to the plane of projection is projected into a straight line passing through the centre of projection: and any arch is projected into its correspondent tangent.

2. Any point, as D, or the pole of any circle, is projected into a point d, whose distance from the pole of projection is equal to the tangent of that distance.

3. If two great circles be perpendicular to each other, and one of them passes through the pole of projection, they will be projected into two straight lines perpendicular to each other.

4. Hence if a great circle be perpendicular to several other great circles, and its representation pass through the centre of projection; then all these circles will be represented by lines parallel to one another, and perpendicular to the line of measures, for representation of that first circle.

PROPOSITION II. THEOREM II.

If two great circles intersect in the pole of projection, their representations will make an angle at the centre of the plane of projection, equal to the angle made by these circles on the sphere.

For since both these circles are perpendicular to the plane of projection, the angle made by their intersections with this plane is the same as the angle made by these circles.

PROPOSITION III. THEOREM III.

Any less circle parallel to the plane of projection is projected into a circle whose centre is the pole of projection, and its radius is equal to the tangent of the distance of the circle from the pole of projection.

Let the circle PI (fig. 42.) be parallel to the plane GF, then the equal arches PC, CI are projected into the equal tangents GC, CH; and therefore C the point of contact and pole of the circle PI and of the projection, is the centre of the representation G, H.

COROLLARY.

If a circle be parallel to the plane of projection, and 45 degrees from the pole, it is projected into a circle equal to a great circle of the sphere; and therefore may be considered as the primitive circle, and its radius the radius of projection.

PROPOSITION IV. THEOREM IV.

A less circle not parallel to the plane of projection is projected into a conic section, whose transverse axis is in the line of measures; and the distance of its nearest vertex from the centre of the plane of projection is equal to the tangent of its nearest distance from the pole of projection; and the distance of the other vertex is equal to the tangent of the greatest distance.

Any less circle is the base of a cone whose vertex is at A (fig. 43.); and this cone being produced, its intersection with the plane of projection will be a conic section. Thus the cone DAF, having the circle DF for its base, being produced, will be cut by the plane of projection in an ellipse whose transverse diameter is df; and Cd is the tangent of the angle CAD, and Cf the tangent of CAF. In like manner, the cone AFE, having the side AE parallel to the line of measures df, being cut by the plane of projection, the section will be a parabola, of which f is the nearest vertex, and the point into which E is projected is at an infinite distance. Also the cone AFG, whose base is the circle FG, being cut by the plane of projection, the section will be a hyperbola; of which f is the nearest vertex; and GA being produced gives d the other vertex. Fig. 43.

COROLLARIES.

1. A less circle will be projected into an ellipse, a parabola, or hyperbola, according as the distance of its most remote point is less, equal to, or greater than, 90 degrees.

2. If H be the centre, and K k, l the focus of the ellipse, hyperbola, or parabola; then $HK=\frac{Ad-Af}{2}$ for the ellipse; $Hk=\frac{Ad+Af}{2}$ for the hyperbola; and fn being drawn perpendicular to AE $fl=\frac{nE+Ff}{2}$ for the parabola.

PROPOSITION V. THEOREM V.

Let the plane TW (fig. 44.) be perpendicular to the plane of projection TV, and BCD a great circle of the sphere in the plane TW. Let the great circle BED be projected into the straght line bek. Draw CQS perpendicular to bk, and Cm parallel to it and equal to CA, and make QS equal to Qm; then any angle QSt is the measure of the arch Qt of the projected circle. Fig. 44.

Join AQ: then because Cm is equal to CA, the angle QCm equal to QCA, each being a right angle, and the side QC common to both triangles; therefore Qm, or its equal QS, is equal QA. Again, since the plane ACQ is perpendicular to the plane TV, and bQ to

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to the interfection CQ; therefore b Q is perpendicular both to AQ and QS: hence, fince AQ and QS are equal, all the angles at S cut the line b Q in the fame points as the equal angles at A. But by the angles at A the circle BED is projected into the line b Q. Therefore the angles at S are the meafures of the parts of the projected circle b Q; and S is the dividing centre thereof.

Corollaries.

1. Any great circle b Q t is projected into a line of tangents to the radius SQ.

2. If the circle b C pafs through the centre of projection, then the projecting point A is the dividing centre thereof, and C b is the tangent of its correfpondent arch CB to CA the radius of projection.

Proposition VI. Theorem VI.

Fig. 44. Let the parallel circle GLH (fig. 44.) be as far from the pole of projection C as the circle FNI is from its pole; and let the diftance of the poles C, P be bifected by the radius AO: and draw b AD perpendicular to AO; then any ftraight line b Q t drawn through b will cut off the arches h l, F n equal to each other in the reprefentations of thefe equal circles in the plane of projection.

Let the projections of the lefs circles be defcribed. Then, becaufe BD is perpendicular to AO, the arches BO, DO are equal; but fince the lefs circles are equally diftant each from its refpective pole, therefore the arches FO, OH are equal; and hence the arch BF is equal to the arch DH. For the fame reafon the arches BN, DL are equal; and the angle FBN is equal to the angle LDH; therefore, on the fphere, the arches FN, HL are equal. And fince the great circle BNLD is projected into the ftraight line b Q n l, &c. therefore n is the projection of N, and l that of L; hence f n, h l, the projections of FN, HL refpectively, are equal.

Proposition VII. Theorem VII.

Fig. 45. If F n k, h l g, (fig. 45.) be the projections of two equal circles, whereof one is as far from its pole P as the other from its pole C, which is the centre of projection; and if the diftance of the projected poles C, p be divided in o, fo that the degrees in C o, o p be equal, and the perpendicular o S be erected to the line of meafures g h. Then the line p n, C l drawn from the poles C, p, through any point Q in the line o S, will cut off the arches F n, h l equal to each other, and to the angle QC p.

The great circle A o perpendicular to the plane of the primitive is projected into the ftraight line o S perpendicular to g h, by Prop. i. cor. 3. Let Q be the projection of q; and fince p Q, CQ are ftraight lines, they are therefore the reprefentations of the arches P q, C q of great circles. Now fince P q C is an ifofceles fpherical triangle, the angles PCQ, CPQ are therefore equal; and hence the arches P q, C q produced will cut off equal arches from the given circles FI, GH, whofe reprefentations F n, h l are therefore equal: and fince the angle QC p is the meafure of the arch h l, it is alfo the meafure of its equal F n.

Corollary.

Hence, if from the projected pole of any circle a perpendicular be erected to the line of meafures, it will cut off a quadrant from the reprefentation of that circle.

Proposition VIII. Theorem VIII.

Let F n k (fig. 45.) be the projection of any circle FI, Fig. 45. and p the projection of its pole P. If C g be the cotangent of CAP, and g B perpendicular to the line of meafures g C, let CAP be bifected by A o, and the line o B drawn to any point B, and alfo p B cutting F n k in d; then the angle g o B is the meafures of the arch F d.

The arch PG is a quadrant, and the angle $g\,o\,A = PA + o\,AP = g\,AC + o\,AP = g\,AC + CA\,o = g\,A\,o$; therefore $g\,A = g\,o$; confequently o is the dividing centre of g B, the reprefentation of GA; and hence, by Prop. v. the angle g o B is the meafure of g B. But fince p g reprefents a quadrant, therefore p is the pole of g B; and hence the great circle p d B paffing through the pole of the circles g B and F n will cut off equal arches in both, that is, F d = g B = angle g o B.

Corollary.

The angle g o B is the meafure of the angle g p B. For the triangle g p B reprefents a triangle on the fphere, wherein the arch which g B reprefents is equal to the angle which the angle p reprefents; becaufe g p is a quadrant: therefore g o B is the meafure of both.

Proposition IX. Problem I.

To draw a great circle through a given point, and whofe diftance from the pole of projection is equal to a given quantity.

Let ADB (fig. 46.) be the projection, C its pole or Fig. 46. centre, and P the point through which a great circle is to be drawn: through the points P, C draw the ftraight line PCA, and draw CE perpendicular to it: make the angle CAE equal to the given diftance of the circle from the pole of projection C; and from the centre C, with the radius CE, defcribe the circle EFG: through P draw the ftraight line PIK, touching the circle EFG in I, and it will be the projection of the great circle required.

Proposition X. Problem II.

To draw a great circle perpendicular to a great circle which paffes through the pole of projection, and at a given diftance from that pole.

Let ADB (fig. 46.) be the primitive, and CI the given circle: draw CL perpendicular to CI, and make the angle CLI equal to the given diftance: then the ftraight line KP, drawn through I parallel to CL, will be the required projection.

Proposition XI. Problem III.

At a given point in a projected great circle, to draw another great circle to make a given angle with the former; and, converfely, to meafure the angle contained between two great circles.

Let P (fig. 47.) be the given point in the given great Fig. 47. circle

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circle PB, and C the centre of the primitive: through the points P, C draw the straight line PCG; and draw the radius of the primitive CA perpendicular thereto; join PA; to which draw AG perpendicular: through G draw BGD at right angles to GP, meeting PB in B; bisect the angle CAP by the straight line AO; join BO, and make the angle BOD equal to that given; then DP being joined, the angle BPD will be that required.

If the measure of the angle BPD be required, from the points B, D draw the lines BO, DO, and the angle BOD is the measure of BPD.

PROPOSITION XII. PROBLEM IV.

To describe the projection of a less circle parallel to the plane of projection, and at a given distance from its pole.

Fig. 46. Let ADB (fig. 46.) be the primitive, and C its centre: set the distance of the circle from its pole, from B to H, and from H to D; and draw the straight line AED, intersecting CE perpendicular to BC, in the point E: with the radius CE describe the circle EFG, and it is the projection required.

PROPOSITION XIII. PROBLEM V.

To draw a less circle perpendicular to the plane of projection.

Plate CCCCXLVII. Fig. 48. Let C (fig. 48.) be the centre of projection, and TI a great circle parallel to the proposed less circle: at C make the angles ICN, TCO each equal to the distance of the less circle from its parallel great circle TI; let CL be the radius of projection, and from the extremity L draw LM perpendicular thereto; make CV equal to LM; or CF equal to CM: then with the vertex V and assymptotes CN, CO describe the hyperbola WVK†; or, with the focus F and CV describe the hyperbola, and it will be the perpendicular circle described.

† See *Conic Sections*.

PROPOSITION XIV. PROBLEM VI.

To describe the projection of a less circle inclined to the plane of projection.

Fig. 49. Draw the line of measures dp (fig. 49.); and at C, the centre of projection, draw CA perpendicular to dp, and equal to the radius of projection: with the centre A, and radius AC, describe the circle DCFG; and draw RAE parallel to dp: then take the greatest and least distances of the circle from the pole of projection, and set them from C to D and F respectively, for the circle DF; and from A, the projecting point, draw the straight lines AFf, and ADd; then df will be the transverse axis of the ellipse: but if D fall beyond the line RE, as at G, then from G draw the line GADd, and df is the transverse axis of an hyperbola: and if the point D fall in the line RE, as at E, then the line AE will not meet the line of measures, and the circle will be projected into a parabola whose vertex is f: bisect df in H, the centre, and for the ellipse take half the difference of the lines Ad, Af, which laid from H will give K the focus: for the hyperbola, half the sum of Ad, Af being laid from H, will give k its focus: then with the transverse axis df, and focus K, or k, describe the ellipse dMf, or hyperbola fm, which will be the projection of the inclined circle: for the parabola, make EQ equal to Ff, and draw fn perpendicular to AQ, and make fk equal to one half of nQ: then with the vertex f, and focus k, describe the parabola fm, for the projection of the given circle FE.

PROPOSITION XV. PROBLEM VII.

To find the pole of a given projected circle.

Let DMF (fig. 50.) be the given projected circle whose line of measures is DF, and C the centre of projection; from C draw the radius of projection CA, perpendicular to the line of measures, and A will be the projecting point: join AD, AF, and bisect the angle DAF by the straight line AP; hence P is the pole. If the given projection be an hyperbola, the angle fAG (fig. 49.), bisected, will give its pole in the line of measures; and in a parabola, the angle fAE bisected will give its pole. Fig. 50.

PROPOSITION XVI. PROBLEM VIII.

To measure any portion of a projected great circle, or to lay off any number of degrees thereon.

Let EP (fig. 51.) be the great circle, and IP a portion thereof to be measured: draw ICD perpendicular to IP; let C be the centre, and CB the radius of projection, with which describe the circle EBD; make IA equal to IB; then A is the dividing centre of EP; hence AP being joined, the angle IAP is the measure of the arch IP. Fig. 51.

Or, if IAP be made equal to any given angle, then IP is the correspondent arch of the projection.

PROPOSITION XVII. PROBLEM IX.

To measure any arch of a projected less circle, or to lay off any number of degrees on a given projected less circle.

Let Fn (fig. 52.) be the given less circle, and P its pole: from the centre of projection C draw CA perpendicular to the line of measures GH, and equal to the radius of projection; join AP, and bisect the angle CAP by the straight line AO, to which draw AD perpendicular: describe the circle GlH, as far distant from the pole of projection C as the given circle is from its pole P; and through any given point n, in the projected circle Fn, draw Dnl, then Hl is the measure of the arch Fn. Fig. 52.

Or let the measure be laid from H to l, and the line Dl joined will cut off Fn equal thereto.

PROPOSITION XVIII. PROBLEM X.

To describe the gnomonic projection of a spherical triangle, when three sides are given; and to find the measures of either of its angles.

Let ABC (fig. 53.) be a spherical triangle whose three sides are given: draw the radius CD (fig. 54.) perpendicular to the diameter of the primitive EF; and at the point D make the angles CDA, CDG, ADI, equal respectively to the sides AC, BC, AB, of the spherical triangle ABC (fig. 53.), the lines DA, DG intersecting the diameter EF, produced if necessary in the points A and G: make DI equal to DG; then from the centre C, with the radius CG, describe an arch; and from A, with the distance AI, describe another arch, intersecting the former in B; join AB, CB, and ACB will be the projection of the spherical triangle (fig. 53.); and the rectilineal angle ACB is the measure of the spherical angle ACB (fig. 53.). Fig. 53. Fig. 54.

PROPOSITION

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Proposition XIX. Problem XI.

The three angles of a spherical triangle being given, to project it, and to find the measures of the sides.

Fig. 55. Let ABC (fig. 55.) be the spherical triangle of which the angles are given: construct another spherical triangle EFG, whose sides are the supplements of the given angles of the triangle ABC; and with the sides of this supplemental triangle describe the gnomonic projection, &c. as before.

It may be observed, that the supplemental triangle EFG has also a supplemental part EF*g*; and when the sides GE, GF, which are substituted in place of the angles A, B, are obtuse, their supplements *g* E, *g* F are to be used in the gnomonic projection of the triangle.

Proposition XX. Problem XII.

Given two sides, and the included angle of a spherical triangle, to describe the gnomonic projection of that triangle, and to find the measures of the other parts.

Fig. 56. Let the sides AC, CB, and the angle ACB (fig. 53.), be given; make the angles CDA, CDG (fig. 56.) equal respectively to the sides AC, CB (fig. 53.); also make the angle ACB (fig. 56.) equal to the spherical angle ACB (fig. 53.), and CB equal to CG, and ABC will be the projection of the spherical triangle.

To find the measure of the side AB: from C draw CL perpendicular to AB, and CM parallel thereto, meeting the circumference of the primitive in M; make LN equal to LM; join AN, BN, and the angle ANB will be the measure of the side AB.

To find the measure of either of the spherical angles, as BAC: from D draw DK perpendicular to AD, and make KH equal to KD: from K draw KI perpendicular to CK, and let AB produced meet KI in I, and join HI: then the rectilineal angle KHI is the measure of the spherical angle BAC. By proceeding in a similar manner, the measure of the other angle will be found.

Proposition XXI. Problem XIII.

Two angles and the intermediate side given, to describe the gnomonic projection of the triangle; and to find the measures of the remaining parts.

Let the angles CAB, ACB, and the side AC of the spherical triangle ABC (fig. 53.), be given: make the angle CDA (fig. 56.) equal to the measure of the given side AC (fig. 53.); and the angle ACB (fig. 56.) equal to the angle ACB (fig. 53.); produce AC to H, draw DK perpendicular to AD, and make KH equal to KD; draw KI perpendicular to CK, and make the angle KHI equal to the spherical angle CAB: from I, the intersection of KI, HI, to A draw IA, and let it intersect CB in B, and ACB will be the gnomonic projection of the spherical triangle ACB (fig. 53.). The unknown parts of this triangle may be measured by last problem.

Proposition XXII. Problem XIV.

Two sides of a spherical triangle, and an angle opposite to one of them given, to describe the projection of the triangle; and to find the measure of the remaining parts.

Let the sides AC, CB, and the angle BAC of the spherical triangle ABC (fig. 53.) be given: make the angles CDA, CDG (fig. 56.) equal respectively to the measures of the given sides AC, BC: draw DK perpendicular to AD, make KH equal to DK, and the angle KHI equal to the given spherical angle BAC: draw the perpendicular KI, meeting HI in I; join AI; and from the centre C, with the distance CG, describe the arch GB, meeting AI in B, join CB, and ABC will be the rectilineal projection of the spherical triangle ABC (fig. 53.) and the measures of the unknown parts of the triangle may be found as before.

Proposition XXIII. Problem XV.

Given two angles, and a side opposite to one of them, to describe the gnomonic projection of the triangle, and to find the measures of the other parts.

Let the angles A, B, and the side BC of the triangle ABC (fig. 55.) be given: let the supplemental triangle EFE be formed, in which the angles E, F, G, are the supplements of the sides BC, CA, AB, respectively, and the sides EF, FG, GE, the supplements of the angles C, A, B. Now at the centre C (fig. 56.) make the angles CDA, CDK equal to the measures of the sides GE, GF respectively, being the supplements of the angles B and A; and let the lines DA, DK intersect the diameter of the primitive EF in the points A and K: draw DG perpendicular to AD, make GH equal to DG, and at the point H make the angle GHI equal to the angle E, or to its supplement; and let EI, perpendicular to CH, meet HI in I, and join AI: then from the centre C, with the distance CG, describe an arch intersecting AI in B; join CB, and ABC will be the gnomonic projection of the given triangle ABC (fig. 55.): the supplement of the angle ACB (fig. 56.) is the measure of the side AB, (fig. 55.); the measures of the other parts are found as before.

It has already been observed, that this method of projection has, for the most part, been applied to dialling only. However from the preceding propositions, it appears that all the common problems of the sphere may be more easily resolved by this than by either of the preceding methods of projection; and the facility with which these problems are resolved by this method has given it the preference in dialling. It may not perhaps be amiss, in this place, to give a brief illustration of it in this particular branch of science.

In an horizontal dial, the centre of projection Z (fig. 57.) represents the zenith of the place for which the dial is to be constructed; ZA the perpendicular height of the style: the angle ZPA, equal to the given latitude, determines the distance ZP of the zenith from the pole; and AP the edge of the style, which by its shadow gives the hour: the angle ZAP, equal also to the latitude, gives the distance of the equator EQ from the zenith: let E *a* be equal to EA, and *a* will be the dividing point of the equator. Hence if the angles E *a* I, E *a* II, &c. E *a* XI, E *a* X, &c. be made equal to 15°, 30°, &c. the equator will be divided into hours; Fig. 57.

 and

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and lines drawn from P to these points of division will be hour lines.

If the dial is either vertical, or inclined to the horizon, then the point Z will be the zenith of that place whose horizon is parallel to the plane of the dial: ZE will be that latitude of the place; and the hours on the former dial will now be changed into others, by a quantity equal to the difference of longitude between the given place and that for which the dial is to be constructed. Thus, if it is noon when the shadow of the style falls on the line *P* X, then the difference of meridians is the angle E *a* X, or 30°. Hence, when a dial is to be constructed upon a given plane, either perpendicular or inclined to the horizon, the declination and inclination of that place must be previously found.

In an erect direct south dial, its zenith Z is the south point of the horizon, ZP is the distance of this point from the pole, and ZE its distance from the equator. If the dial is directed to the north, Z represents the north point of the horizon; PZ the distance of Z from the pole under the horizon; and ZE the elevation of the equator above the horizon.

If the dial is an erect east or west dial, the zenith Z is the east or west points of the horizon accordingly, and the pole P is at an infinite distance, for the angle ZAP is a right angle; and therefore the line AP will not meet the meridian PZ. The line ZA produced is the equator, and is divided into hours by lines perpendicular to it.

If the plane of the dial is parallel to the equator, its zenith Z coincides with one of the poles of the equator P; and hence the hour lines of this dial are formed by drawing lines from the point Z, containing angles equal to 15°.

In the preceding methods of projection of the sphere, equal portions of a great circle on the sphere are represented by unequal portions in the plane of projection, and this inequality increases with the distance from the centre of projection. Hence, in projections of the earth, those places towards the circumference of the projection are very much distorted. In order to avoid this inconveniency, M. de la Hire * proposed, that the eye should be placed in the axis produced at the distance of the sine of 45° beyond the pole: In this case arches of the sphere and their projections are very nearly proportional to each other. Hence in a map of the earth agreeable to this construction, the axis, instead of being divided into a line of semitangents, is divided equally, in like manner as the circumference. The map of the world is constructed agreeable to this method of projection.

* *Hist. de l'Academie Royal des Scien.* 1701. See the article *Geography*.

PRO PRO

Projection || Prolate.

PROJECTION, in *Perspective*, denotes the appearance, or representation of an object on the perspective plane.

The projection of a point is a point through which an optic ray passes from the objective point through the plane to the eye; or it is the point wherein the plane cuts the optic ray.

And hence may be easily conceived what is meant by the projection of a line, a plane, or a solid.

Projection, in Alchemy, the casting of a certain imaginary powder, called *powder of projection*, into a crucible, or other vessel, full of some prepared metal, or other matter; which is to be hereby presently transmuted into gold.

Powder of Projection, or of the philosophers stone, is a powder supposed to have the virtue of changing any quantity of an imperfect metal, as copper or lead, into a more perfect one, as silver or gold, by the admixture of a little quantity thereof.

The mark to which alchemists directed all their endeavours, was to discover this powder of projection. See *Philosophers Stone*, and Chemistry, *History of*.

PROJECTURE, in *Architecture*, the outjetting and prominency, or embossing, which the mouldings and other members have beyond the naked wall, column, &c.

PROLAPSUS, in *Surgery*, a prolapsion or falling out of any part of the body from its natural situation: thus we say, *prolapsus intestini*, "a prolapsion of the intestine," &c. See Surgery.

PROLATE, in *Geometry*, an epithet applied to a spheroid produced by the revolution of a semi-ellipsis about its larger diameter. See Spheroid.

Prolegomena || Prolific.

PROLEGOMENA, in *Philology*, certain preparatory observations or discourses prefixed to a book, &c. containing something necessary for the reader to be apprised of, to enable him the better to understand the book, or to enter deeper into the science, &c.

PROLEPSIS, a figure in *Rhetoric*, by which we anticipate or prevent what might be objected by the adversary. See Oratory, N° 80.

PROLEPTIC, an epithet applied to a periodical disease which anticipates, or whose paroxysm returns sooner and sooner every time; as is frequently the case in agues.

PROLIFER flos, (*proles*, "an offspring;" and *fero*, "to bear);" a prolific flower, or a flower which from its own substance produces another; a singular degree of luxuriance, to which full flowers are chiefly incident. See Botany.

PROLIFIC, something that has the qualities necessary for generating.

The prolific powers of some individuals among mankind are very extraordinary.—Instances have been found where children, to the number of six, seven, eight, nine, and sometimes sixteen, have been brought forth after one pregnancy. The wife of Emmanuel Gago, a labourer near Valladolid, was delivered, the 14th of June 1779, of five girls, the two first of whom were baptized: the other three were born in an hour after; two of them were baptized; but the last, when it came into the world, had every appearance of death. The celebrated Tarsin was brought to bed in the seventh month of her pregnancy, at Argenteuil near Paris, 17th July 1779, of three boys, each 14 inches and a half long, and of a girl 13 inches: they were all four baptized, but did not live 24 hours.

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Fig. 1.

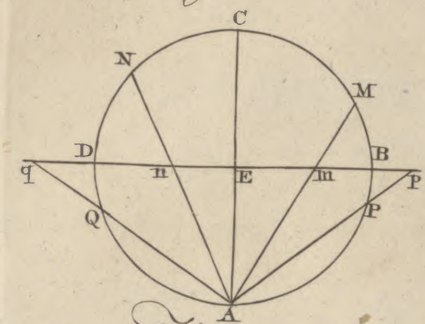


Fig. 2.

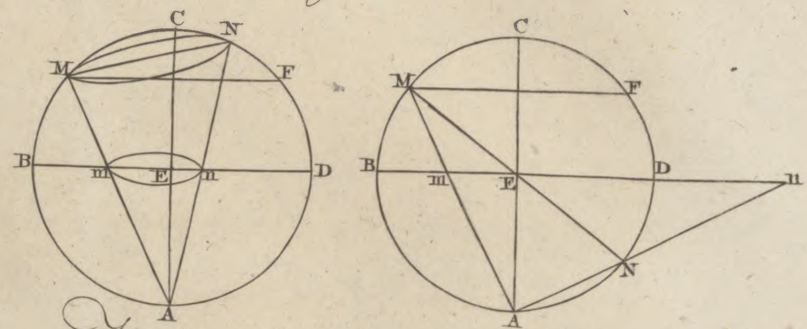
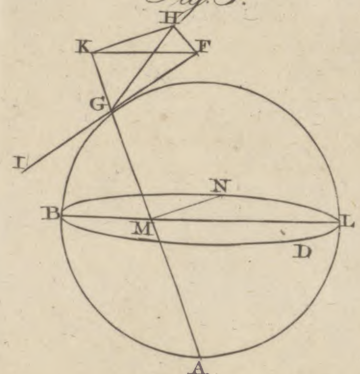


Fig. 3.



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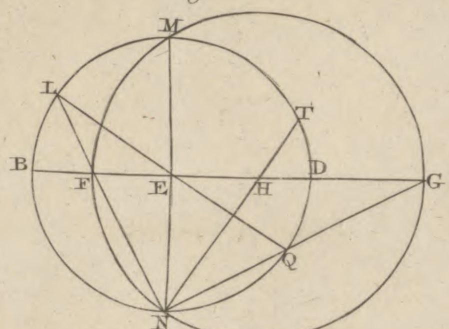


Fig. 5.

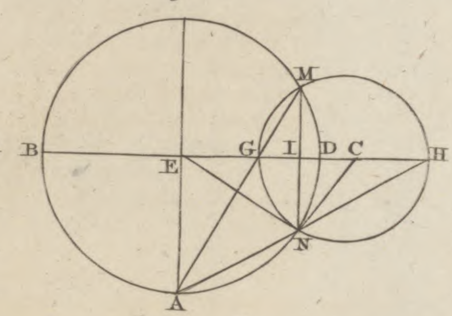


Fig. 6.

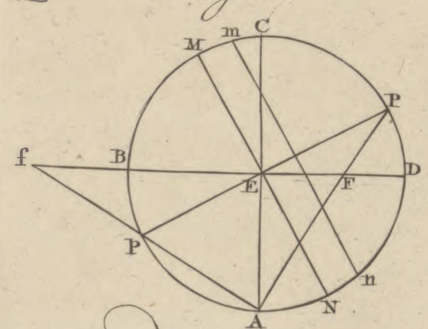


Fig. 7.

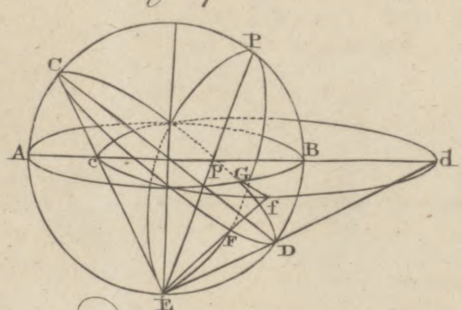


Fig. 8.

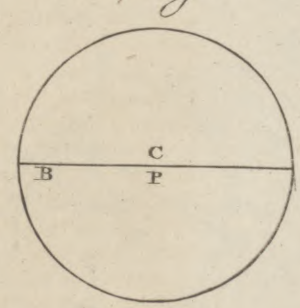


Fig. 9.

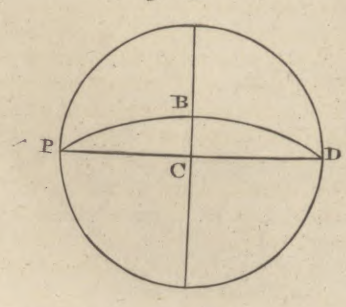


Fig. 10.

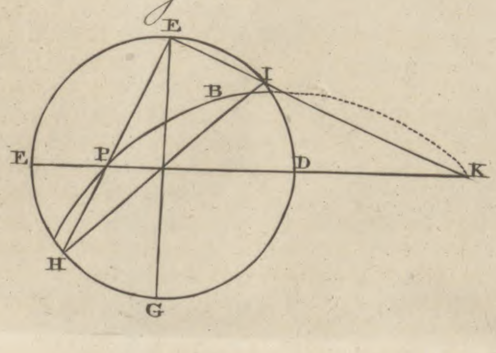
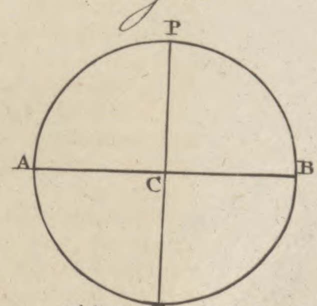


Fig. 11.



A. Bell Prin. Wal. Sculptor fecit

Fig. 12.

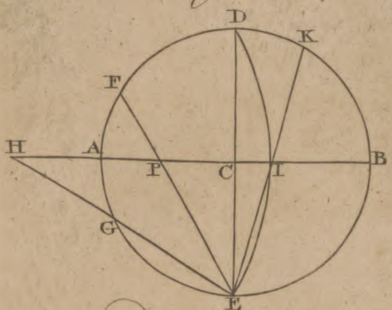


Fig. 13.

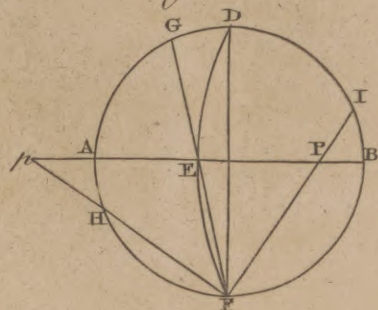
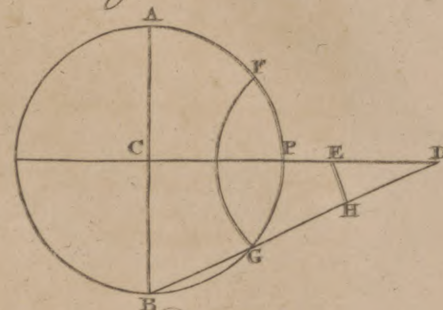


Fig. 14.



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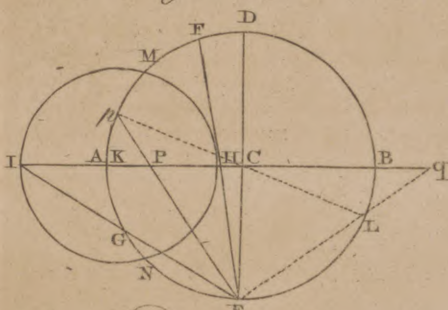

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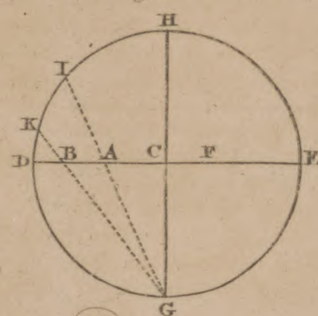

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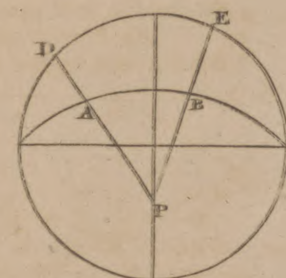

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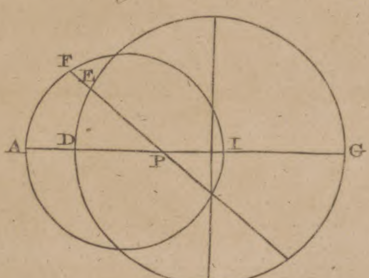

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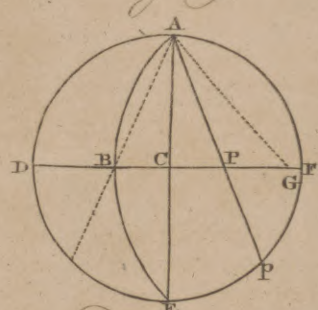

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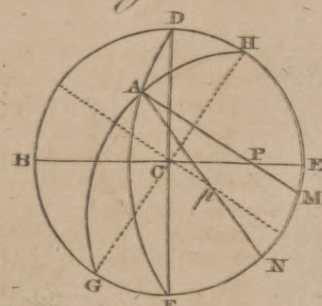

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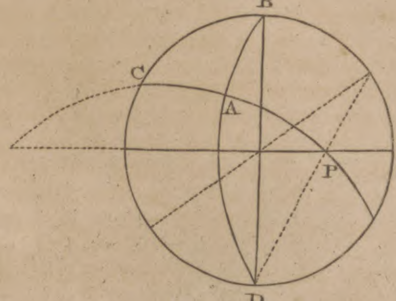

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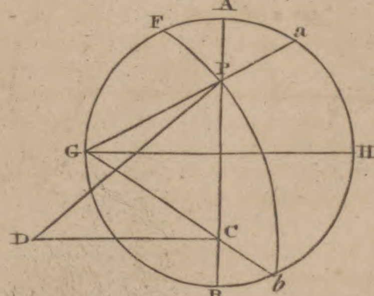

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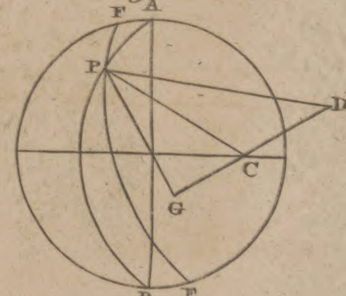

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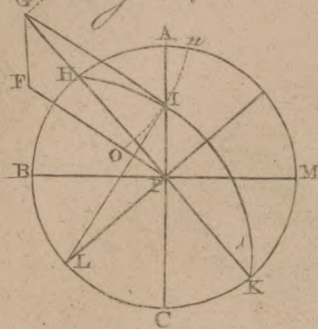

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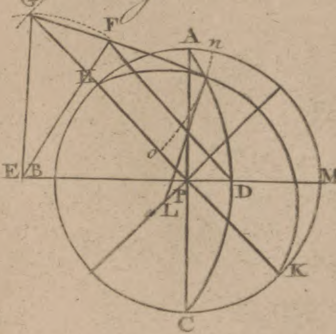

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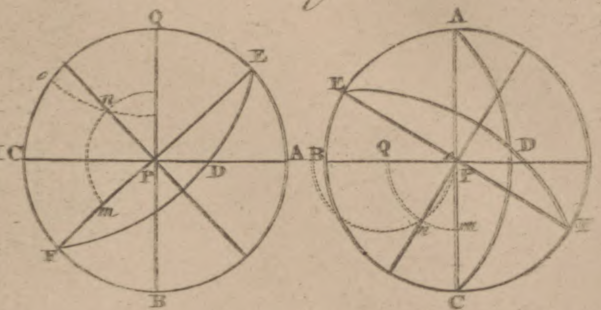

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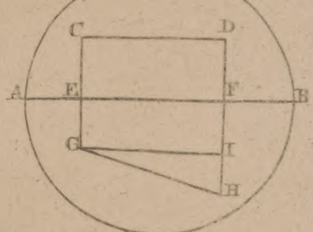

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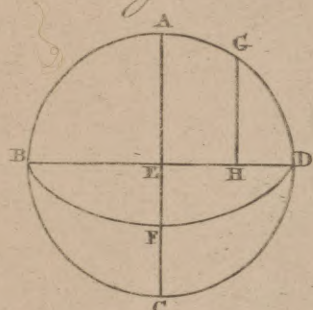

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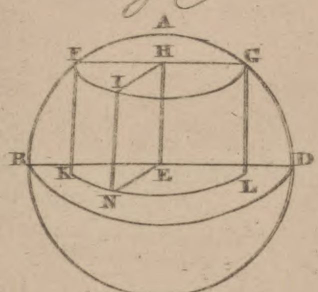

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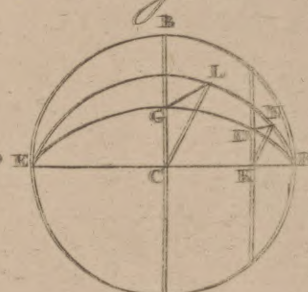

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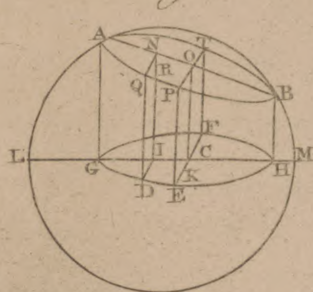

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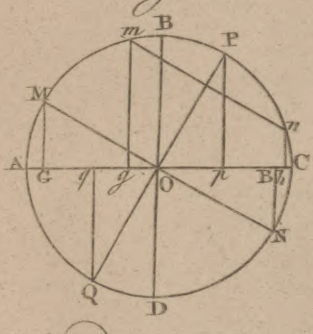

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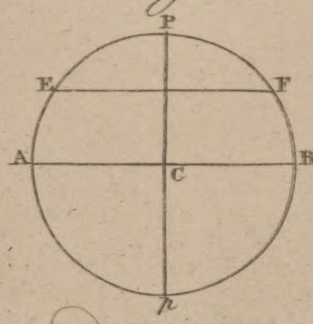

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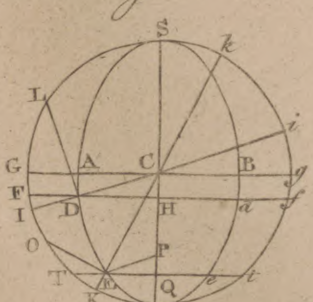

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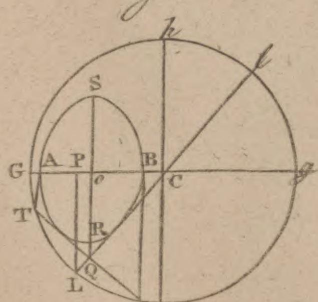

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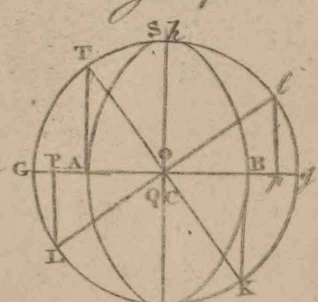

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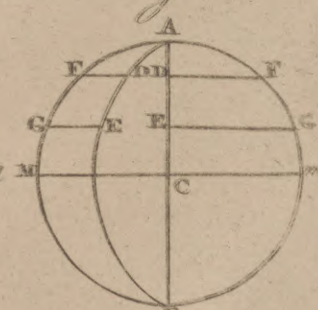

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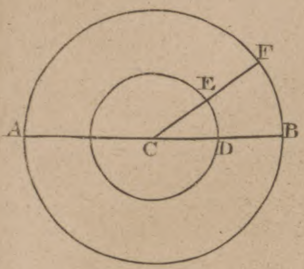

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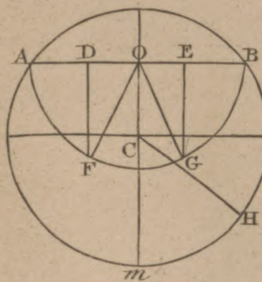

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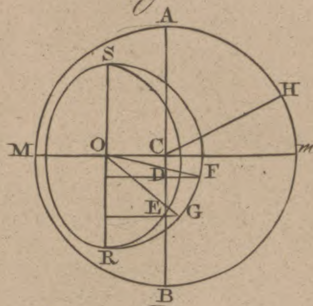

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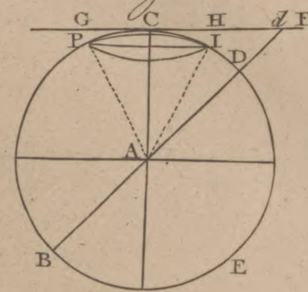

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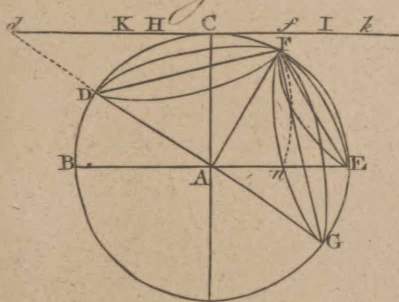

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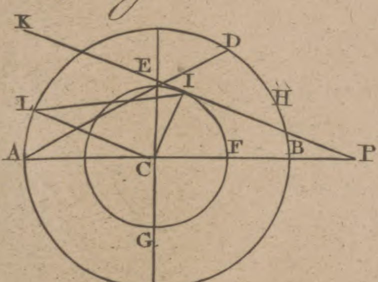

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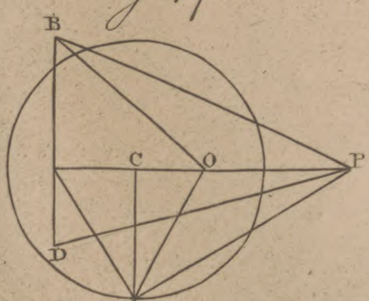

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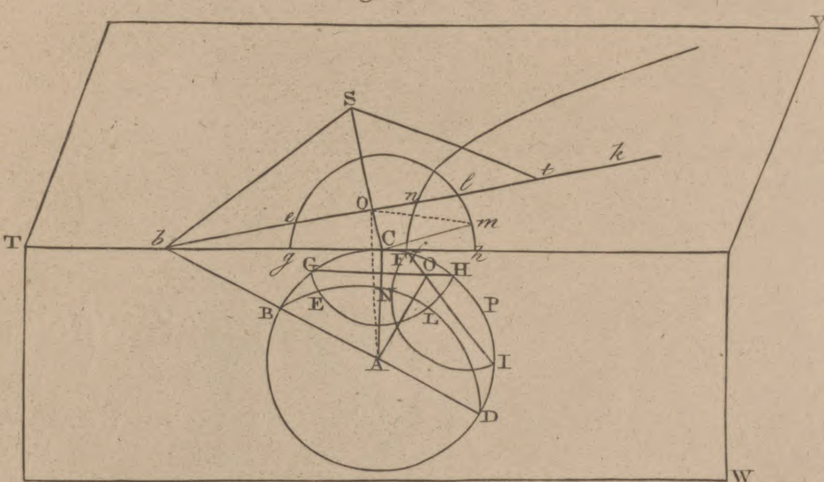

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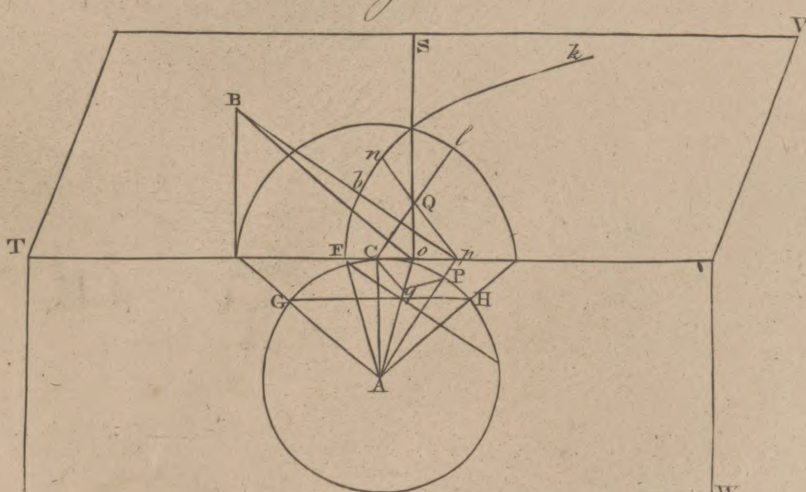

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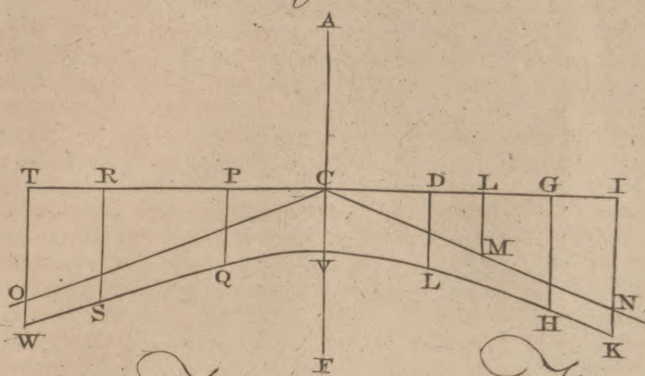

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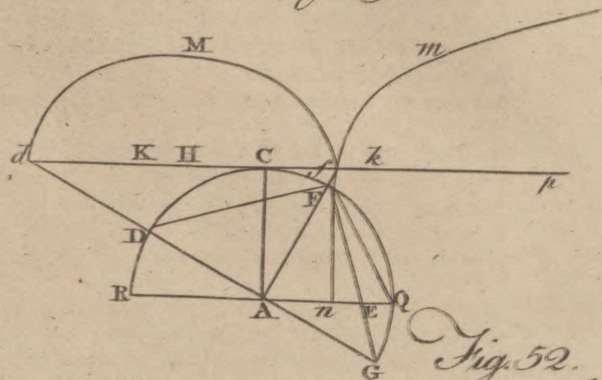

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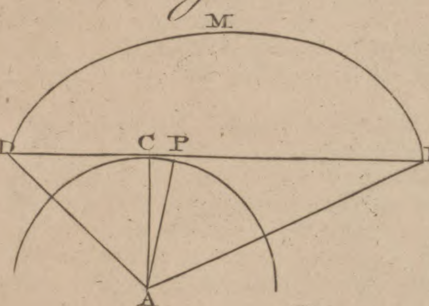

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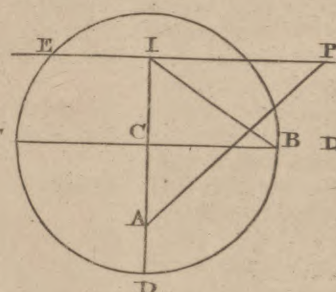

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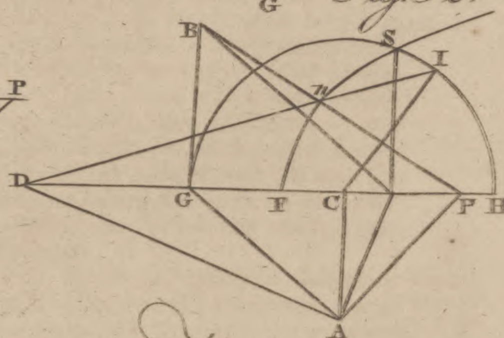

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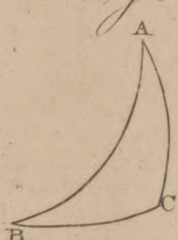

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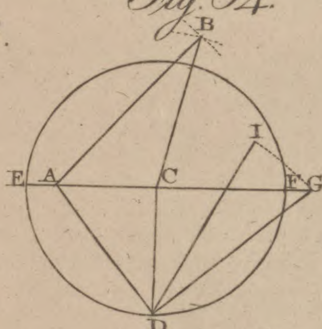

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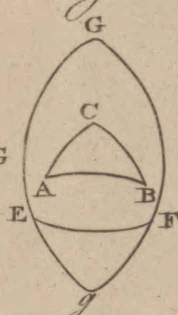

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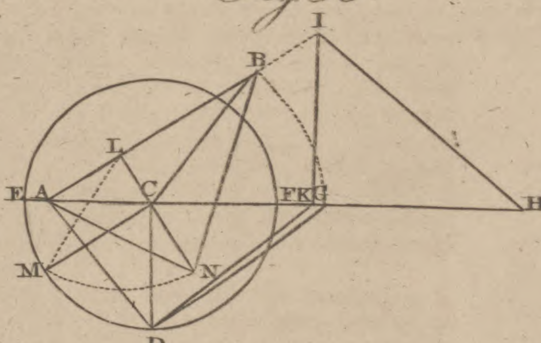

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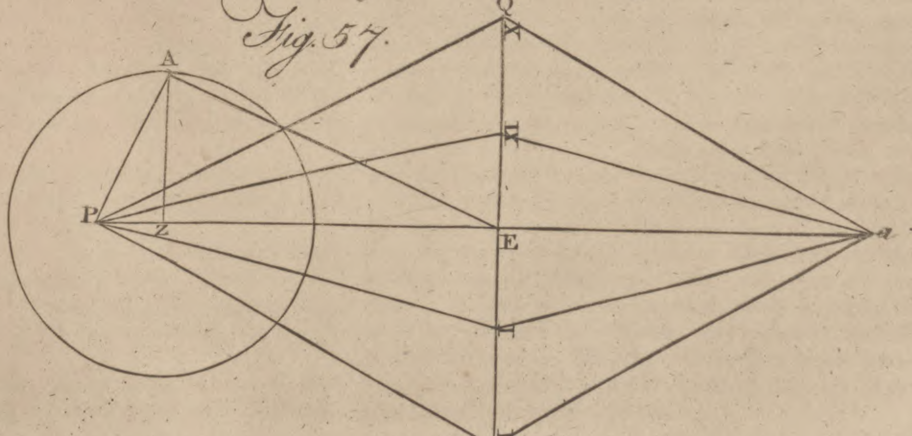

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Prolific || Promise.

The public papers for the month of June 1779 made mention of one Maria Ruiz, of the diſtrict of Lucena in Andaluſia, who was ſucceſſively delivered of 16 boys, without any girls; and ſeven of them were ſtill alive on the 17th of Auguſt thereafter. The following, though a recent fact, is almoſt incredible: In the year 1755, a Muſcovite peaſant, named *James Kyrloff*, and his wife, were preſented to the empreſs of Ruſſia. This peaſant had been twice married, and was then 70 years of age. His firſt wife was brought to bed 21 times; namely, four times of four children each time; ſeven times of three, and ten times of two; making in all 57 children, who were then alive. His ſecond wife, who accompanied him, had already been delivered ſeven times, once of three children, and ſix times of twins, which made 15 children for her ſhare. Thus the Muſcovite patriarch had already had 72 children by two marriages. We are aſſured that the ſultan Muſtapha III. had iſſue by his concubines 580 male children. What number of female children he had, and whether there were twins of both ſexes, we are not informed. Theſe facts ſuppoſe great fecundity; and whatever credit is given them, we muſt conſider as entirely fabulous what is reported concerning a counteſs of Holland who was delivered of 365 children, of a very ſmall ſize.

PROLIXITY in diſcourſe, the fault of entering into too minute a detail, or being too long, preciſe, and circumſtantial, even to a degree of tedioufneſs.

PROLOCUTOR of the convocation, the ſpeaker or chairman of that aſſembly. See CONVOCATION.

PROLOGUE, in dramatic poetry, a diſcourſe addreſſed to the audience before the drama or play begins. The original intention was to advertiſe the audience of the ſubject of the piece, and to prepare them to enter more eaſily into the action, and ſometimes to make an apology for the poet.

PROMETHEUS, the ſon of Japetus, ſuppoſed to have been the firſt diſcoverer of the art of ſtriking fire by flint and ſteel; which gave riſe to the fable of his ſtealing fire from heaven: A renowned warrior; but whoſe hiſtory is involved in fable. He flouriſhed about 1687 B. C. The poetical account is, that he formed a man of clay of ſuch exquiſite workmanſhip, that Pallas, charmed with his ingenuity, offered him whatever in heaven could contribute to finiſh his deſign; and for this purpoſe took him up with her to the celeſtial manſions, where he ſtole ſome fire from the chariot of the ſun, which he uſed to animte his image. At this theft Jupiter was ſo enraged, that he ordered Vulcan to chain him down on Mount Caucaſus, and ſent an eagle or vulture to prey on his liver; which every night was renewed, in proportion to the quantity eaten up in the day-time, until at laſt he was delivered by Hercules, who killed the vulture.

PROMETHEUS, in *Ancient Aſtronomy*, was the name of a conſtellation of the northern hemiſphere, now called *Hercules, Engonaſin*. See ASTRONOMY.

1 Promiſe defined.

PROMISE, in ordinary caſes, is a declaration of ſome intention to be put in execution; but in morals is a ſolemn aſſeveration by which one pledges his veracity that he ſhall perform, or cauſe to be performed, the thing which he mentions.

As ſuch a declaration excites expectations in the minds of thoſe to whom it is made; and as to fruſtrate theſe expectations might rouſe indignation, and be followed by conſequences injurious to the perſon, the character, or intereſt, of him who made it—it becomes a matter of prudence in the promiſer to keep his word. And farther, as a certain degree of confidence is found neceſſary to the very exiſtence of civil ſociety, and as others may have acted on the faith of his promiſe, it is now not a matter of prudence only to keep his word—it is a duty which he owes to all who have ſpent their time, their money, or their labour, in conſequence of thoſe expectations which he has warranted them to entertain.

Promiſe. 2 How it comes to be binding.

It, then, being conſonant to ſound reaſon, neceſſary to the exiſtence of civil ſociety, and in general the intereſt of both the promiſer and promiſee, that the words of the promiſe ſhould be fulfilled, it has become a maxim in morals that a man is obliged to perform his promiſe.

3 Interpretation of a promiſe ſometimes difficult.

In many inſtances, the great difficulty concerning a promiſe is, how to explain it; for although the grounds of its obligation be thoſe expectations which it has raiſed, a queſtion will occur, Is the promiſer bound to anſwer fully all the expectations to which the different conſtructions of his words may have given birth? Should I, for inſtance, deſire a man to run with a letter to ſuch a place, and engage to ſatisfy him upon his return; and if on his return I gave him double of the uſual hire in like caſes; but if he be not ſatisfied with leſs than the triple of ſuch a ſum, am I obliged to grant his demands? This will lead us to conſider the rules by which a promiſe ſhould be interpreted.

4 Whether the meaning of the promiſer or promiſee ought to be taken.

If a promiſe were always to be deemed obligatory in the ſenſe in which the promiſee receives it, a man would not know what he had promiſed; the promiſee, from a difference of views, aſſociations, and intereſts, might conceive a ſenſe of which the promiſer had never dreamed; might ſuppoſe engagements which were never intended, which could not be foreſeen, and, although foreſeen, could not be performed. For theſe reaſons it is natural to think that the ſenſe of the promiſer ſhould rather direct the interpretation. He knows preciſely what it is he has undertaken, and is unqueſtionably the beſt judge of what meaning he affixed to his words. His explanation ſhould therefore be admitted, if information alone could give him a title to decide in the affair.

But ſomething more than mere information, or a knowledge of the cauſe, is expected from a judge, as integrity is equally eſſential to his character. Doubts may ariſe when the words will admit of various meanings, whether the promiſer will be ſo candid as impartially to own the preciſe meaning which he had actually annexed to his expreſſions: At any rate, if he wiſhes to deceive, he might purpoſely uſe an ambiguous phraſeology, and perform the promiſe in a ſenſe of his own without ſatisfying the reaſonable hopes of the promiſee.

When the daughter of Tarpeius bargained with Tatius to betray the citadel for what he and his Sabines wore on their left hands, meaning their rings and their golden bracelets, Tatius probably performed his promiſe in the way which he intended, when he cauſed her to be buried under their ſhields, which they carried alſo on their left hands. But who will ſay that here were not treachery and a diſhonourable abuſe of that confidence which had been repoſed in him?

It

Promise.

It must therefore be obvious, that the import of a promise, where its meaning is disputed, is not to be determined by the sense of the promiser nor by the expectations of the promisee; and if it was said that the obligation of a promise arose from those expectations which had been raised by it, the assertion now must be limited to those expectations which were intentionally raised by the promiser, or those which to his knowledge the promisee was induced to entertain in consequence of that declaration which had been made to him. Should there still be a doubt about what expectations were intentionally raised, and what should have been reasonably entertained, recourse must be had to the judgement of those who are allowed to be persons of candour, and who are acquainted with the characters of the men, and with those circumstances in which the promise was made.

5 In doubtful cases the interpretation of neither is to be trusted.

6 Cases where a promise is not binding.

The following are some of the cases in which a promise is not binding. As the obligation to perform the promise arises from those expectations which are intentionally raised by the promiser; it is plain that no promise can be binding before acceptance, before the promise has been communicated to the promisee, and before he has entertained hopes of its performance. The case is similar where a promise is released, that is, where the performance is dispensed with by the promisee, and where he entertains no expectations on account of any thing than the promiser has said to him. Should a third person entertain hopes on account of the promise, he is to cherish these hopes at his own hazard, having no encouragement from the promiser to do so: yet if this person has been warranted to hope by the promisee, the promisee has renounced his privilege of releasing the promise, and along with the promiser becomes bound for its performance.

7 When it is released by the promisee.

8 Where its performance is unlawful.

A promise is not binding where the performance is unlawful; and the performance is unlawful where it is contrary to former promises, or to any moral and religious precept, which from the beginning to the end of time is of perpetual and unalterable obligation. Thus no man is bound by his promise to give to me what he has already promised to another; and no man is bound by his promise to blaspheme God, to commit murder, or to criminate the innocent. Such promises are unlawfully made, and cannot be otherwise than unlawfully performed.

9 A case where doubts have arisen.

Some have even carried their scruples so far as to doubt, whether any promise unlawfully made, can be lawfully performed. Should a man, during the lifetime of his wife, happen to promise marriage to another, such a man (they say) by the Christian religion has already committed adultery in his heart; and should he afterwards become a widower, he is not bound, and he even ought not, to fulfil his engagements, as this would be putting his criminal intention into execution. This species of reasoning, we must confess, is to us unintelligible.—As the wife is dead, what now should prevent the man from marrying the object of his affections? Why, say the casuists, he already is under a promise to marry her, and his promise was made at a time when it should not have been made. It is true, the performance, considered by itself, is opposed by no law human or divine; but then it originated in what was wrong; and however much the Supreme Being and the bulk of the creation may be out of the secret, we have discovered by the ingenious logic of casuistry, that evil can never spring out of good, nor good out of evil; but that the means and the end, the motive and the action, are always of the same complexion in morals.

10 Erroneous promises.

When a promise is made, the particular circumstances in which it is to be deemed obligatory are sometimes mentioned. "I promise (for instance) to lend my friend 200 pounds within three days, provided a certain creditor which I name do not make a demand on me before that time. In other cases no circumstance is foreseen by the promiser to prevent the fulfilling of his engagement; and hence we have erroneous promises, which proceed on the supposition that things are true, possible, and lawful, which are not so. An erroneous promise, which proceeds on the false representation of the promisee, is not binding.

A London gentleman lately purchased an estate in the south of England at a public sale, believing the description which he saw in the newspapers, and which likewise was given by the auctioneer, to be true; but finding afterwards that the estate nowise corresponded to the description, the law freed him from his engagement, because the seller had evidently been guilty of a breach of promise in not satisfying those expectations which he had intentionally and even studiously excited in the buyers.

11 A promise not binding when the performance is impossible,

An erroneous promise, whose performance is impossible, is not binding. Before the conclusion of the late war a planter of Tobago promised to send to his friend in England 12 hogsheads of sugar from the next year's produce of his estate; but before that time Tobago fell into the hands of the French, and the West Indian found it impossible to answer the expectations of his friend in England.

12 nor when it is unlawful.

An erroneous promise, whose performance is unlawful, or, to speak more precisely, whose performance is contrary to a prior promise, or to any moral or religious obligation, is not binding. A father, believing the accounts from abroad of his son's death, soon after bequeathes his fortune to his nephew: but the son, the report of whose death had been false, returns home, and the father is released from the promise to his nephew, because it was contrary to a prior promise, which he had tacitly come under to his son. This prior promise was implied in the whole of the father's conduct, and was expressed in signs as emphatic and as unequivocal as those of language. It had all the effect too of the most solemn promise on the son, who, to his father's knowledge, was induced in consequence of this promise to entertain the most sanguine hopes of succeeding to his father, if he survived. The world likewise could bear testimony that these expectations were not rashly cherished. He was brought into existence by means of his father, who was thereby understood to love him affectionately; he was ushered into society as the representative of his family, and was therefore supposed to be the heir of its wealth. Religion itself supported his pretensions, pronouncing the father worse than an infidel who neglects to show that attention to his children which the world naturally expects from a parent.—That the father's promise was not released from the mere circumstance that the mistake was known to his nephew the promisee, will appear plain from the following circumstance. Suppose the father a landed proprietor, that the lease of one of his farms has expired, and that he has long been expecting to to let it at 200l.; ſuppoſe that this ſum is refuſed, and that he agrees with the preſent tenant to grant a new leaſe at 150l.—the obligation here to perform his promiſe is not diſſolved by an after offer of 200l., though the tenant knew that 200l. had been expected, and that only from deſpairing of that ſum his landlord had granted the new leaſe at 150l.: the promiſe is binding, becauſe the performance is every way lawful, contrary to no prior engagement, and oppoſed to no principle in morals. The law of the land, were the proprietor reluctant, would enforce the obligation, and exact obedience in the tone of authority; becauſe breaches of faith, were they permitted in ſuch caſes, would deſtroy all confidence, and annihilate the bonds of ſocial union:

> Men live and proſper but in mutual truſt;
> A confidence of one another's truth. *Oroonoko.*

13
Utility no criterion whereby to judge of the validity of promiſes

The great difficulty which many have to encounter in determining when erroneous promiſes ought or ought not to be kept, ariſes from their proceeding on a principle of whoſe conſequences they do not ſeem to be always aware. There is ſeldom, they perceive, a virtuous action that is not attended with ſome happy effects; and it will, perhaps, be generally allowed, that the comparative merit of ſimilar virtues may ſafely be eſtimated by their utility: But to make utility, as ſome do, the criterion of virtue, and pronounce an action vicious or virtuous merely on account of thoſe conſequences which they ſee may flow from it, is a dangerous maxim. Evil has often ſprung out of good, and good out of evil; and good and evil have frequently ſprung from the ſame action. In Mandeville's *Hive*,

14
This principle would give a ſanction to vice and falſehood.

> That root of evil Avarice,
> That damn'd ill-natur'd baneful vice,
> Was ſlave to Prodigality,
> That noble ſin; whilſt Luxury
> Employ'd a million of the poor,
> And odious Pride a million more.
> Envy itſelf and Vanity
> Were miniſters of Induſtry:
> That darling folly, Ficklenefs,
> In diet, furniture, and dreſs,
> That ſtrange ridiculous vice, was made
> The very wheel that turn'd the trade.

The deſcription here is not altogether falſe; and theſe indeed may be ſome of the conſequences that flow from avarice, luxury, pride, vanity, and envy: but theſe are not all.—To ſee at once all the conſequences that ſpring from an action, the good and the bad, the particular and general, the immediate and remote, would require ſometimes the foreſight of Omniſcience, and at all times a knowledge ſuperior to what is human. In the Fable of the Bees, the author's object was to ſhow that private vices are public benefits; and he therefore was naturally led by his argument to conſider only ſuch conſequences of vice as favoured his hypotheſis. He wanted candour. And that artifice which runs through his Fable happens to remind us, that while the remote and the general effects of an action may not be ſeen, the particular and immediate, which fall within our notice, are apt to be viewed through the medium of paſſion, intereſt, or opinion. For theſe reaſons, it appears ſurpriſing how any perſon ſhould ever imagine that the obligation to perform a promiſe ſhould depend entirely upon the ideas which the promiſer apprehended of its utility.

The beſt refutation of ſuch an opinion are the ſingular concluſions to which it leads.

15
The conſequences that flow from it ridiculous and abſurd.

A late writer on political juſtice, who appears to have embraced it, gets into reaſoning not very common. In a part of his ſyſtem he looks on morals as an article of trade: virtue and vice, in his Chapter of *Promiſes*, are but antiquated terms for profit and loſs; and right and wrong are uſed to expreſs what is beneficial and what is hurtful, in his apprehenſion, to himſelf and the community.—With reſpect to veracity, thoſe "rational and intelligent beings," by whom he wiſhes the affairs of the world to be carried on, may, while they act as rational and intelligent, break or perform their promiſes at pleaſure. He thinks it "eſſential to various circumſtances of human intercourſe, that we ſhould be known to beſtow a ſteady attention upon the quantities of convenience or inconvenience, of good or evil, that might ariſe to others from our conduct." After this attention, the diſappointment of the promiſee is not to be minded, though the expectations excited by theſe "rational and intelligent beings" may have "altered the nature of his ſituation, and engaged him in undertakings from which he would otherwiſe have abſtained." What the promiſer takes to be the general utility and the fitneſs of things is to be his guide. And a breach of promiſe will be attended with the following advantages: "The promiſee, and all other men, will be taught to depend more upon their own exertions, and leſs upon the aſſiſtance of others, which caprice may refuſe or juſtice withhold. He and all others will be taught to acquire ſuch merit, and to engage in ſuch purſuits, as ſhall oblige any honeſt man to come to their ſuccour if they ſhould ſtand in need of aſſiſtance." This breach of promiſe, with a view to the general utility, will, ſo far from being criminal, form a part of that reſolute execution of juſtice which would in a thouſand ways increaſe the independence, the energies, and the virtue of mankind *."

* Godwin's *Inquiry concerning Political Juſtice*, book iii. chap. 3.

16
A private individual has no right to intrude his ſchemes of utility on the public.

Such are the views which determined this author to conſider "the validity of promiſes" as "inconſiſtent with juſtice," and as "foreign to general good." From one, however, who relies with ſo much confidence on the promiſer, it would certainly be deſirable to know, whether the perſon, who violates his faith for the public utility, is always to be candid. Where breach of faith promotes his own intereſt, ought he alone to decide on the validity of his promiſe? or where promiſes are broken for the general good, is he to be guided by his own viſionary ſchemes of utility? Is he to act as truſtee for the public without any delegated power? and ſhall the community ſubmit to his deciſions without ſo much as putting the queſtion, Who hath made thee a ruler over us? When a writer thus deviates ſo far from the path of reaſon, it is natural to aſk, what was the *ignis fatuus* that miſled him? In the preſent caſe it is pretty obvious. Being ſomething of opinion with the celebrated Turgot †, that romances are the only books in which moral principles are treated in an impartial manner, this gentleman, in his Chapter of *Promiſes*, ſeems to have borrowed a part of his morality from

† See Note, book iii. chap. 6.

Promiſe.

from the doggerels of Butler; and having adopted, though from different motives, the political principles of Sir Hudibras's ſquire, that obedience to civil government is not due becauſe it is promiſed, he has come to exactly the ſame concluſion with reſpect to the obligation of keeping one's word. But Ralph has reaſoned with more ingenuity; and has ſhown not only that the public good, but the glory of the Lord, may be ſometimes promoted by a breach of faith.

* The ſaints are Godwin's rational and intelligent beings.

The ſaints, * whom oaths and vows oblige,
Know little of their privilege;
Farther, I mean, than carrying on
Some ſelf-advantage of their own:
For if the dev'l, to ſerve his turn,
Can tell truth, why the ſaints ſhould ſcorn,
When it ſerves theirs, to ſwear and lie,
I think there's little reaſon why:
Elſe h' has a greater pow'r than they,
Which 'twere impiety to ſay:
W' are not commanded to forbear,
Indefinitely, at all to ſwear;
But to ſwear idly, and in vain,
Without ſelf-intereſt and gain;
For breaking of an oath and lying
Is but a kind of ſelf-denying,
A ſaint-like virtue; and from hence
Some have broke oaths by Providence:
Some, to the glory of the Lord,
Perjur'd themſelves and broke their word:——
For ſaints may do the ſame thing by
The ſpirit, in ſincerity,
Which other men are tempted to,
And at the devil's inſtance do.

HUDIBRAS, *Canto* II.

Here are new views of utility; which, were they to be conſidered as of any weight, would increaſe the difficulty of determining when an erroneous promiſe ought to be kept.

But ſhould views of utility be laid aſide, and ſhould it be made an invariable rule that truth is on no account to be violated, that deceit is never to be practiſed, and

17 Views of utility an unſafe guide in morals.

that moral obligations are not to be diſſolved for the proſpect of any phyſical advantage; thoſe doubts which ariſe concerning the validity of erroneous promiſes will ſoon diſappear. Diſagreeable perhaps and ridiculous conſequences may ſometimes ariſe to a few individuals from an honeſt and conſcientious adherence to their promiſe; but will any aſſert that the general good, *that burden of the ſong*, will ever be endangered by too much veracity?

So numerous inconveniences ariſe daily from the regular operation of thoſe great phyſical laws, which are under the immediate direction of Providence, that thoſe philoſophers who have adopted the principle of utility, and are much ſurpriſed to ſee the univerſe ſo aukwardly planned for the eaſe and comfort of them and their ſpecies, have been under the neceſſity of imputing many events in nature to the malignity of ſome evil independent being; or of allowing that things have degenerated ſince they firſt came from the hands of the Creator, and that they muſt now be exceedingly altered from what they had been when He choſe to pronounce them all very good. Thus, abſurdity or impiety muſt always be the conſequence of judging of the vice and virtue of an action by its utility, and of eſtimating its utility by our limited views and erroneous conceptions.

Promiſe.

As for extorted promiſes, it is curious to obſerve how this queſtion ſhould always be ſtarted, whether or not they ought to be kept? and another queſtion ſhould ſeldom be thought of, whether or not they ought to be made? Fortitude was one of the cardinal virtues,

18 Extorted promiſes.

among the ancients; and is deemed of ſuch importance in the Chriſtian ſyſtem, that the fearful are claſſed with the unbelievers, and are thought unworthy of the favour of the Deity, as being incapable of ſupporting thoſe trials to which heaven expoſes the faithful as the trueſt teſt of Chriſtian virtue.—If a perſon ſhould want the

19 Whether binding or not.

neceſſary fortitude to be virtuous, it will be a poor excuſe for his baſeneſs, that he has added deceit to his cowardice: and ſurely it is not the buſineſs of morality, when it has found him guilty of one crime, to grant him a diſpenſation for committing two. The laws of juriſprudence, it will readily be allowed, cannot favour the claims of the promiſee; becauſe they ought never to lend their ſupport to oppreſſion and violence. But their acquittal, ſhould he violate his faith, will by no means vindicate the character of the promiſer. Their acquitting a woman from the charge of adultery, goes a ſhort way in reſtoring the fair reputation of her innocence.

Let juriſprudence decide as it will, the man of honour and the generous patriot can never be brought to reſpect the perſon who, ſtruck with a panic, could betray either himſelf or his friends. The magnanimous ſpirits who could die for the truth will view with contempt his pitiful deceit. Thoſe unfortunate men who may ſuffer from that very diſtruſt which the breach of his faith has begotten, will always deteſt him as a traitor and enemy; and heaven itſelf cannot be ſuppoſed to reward that ſoldier who deſerts her cauſe, and relinquiſhes the poſt which ſhe has aſſigned him, at the ſight of danger.

If we once begin to accommodate morality to the diſpoſitions and humours of mankind, it is hard to ſay where this ſpecies of complaiſance will end. The degrees of timidity are ſo various, and ſome tempers by nature ſo yielding, that repeated importunity or an earneſt requeſt will extort a promiſe.

20 The laws of morality are not to be accommodated to the humours and intereſts of mankind.

A young lady was frequently preſſed by her dying huſband to grant him a promiſe that ſhe would not marry after his death. For ſome time ſhe was able to reſiſt with becoming ſpirit his abſurd requeſt; but upon his declaring oftener than once that he could not otherwiſe die in peace, ſhe complied and promiſed. Too young, however, for this effort of continence, ſhe afterwards liſtened to the addreſſes of a ſecond lover, and found her heart inſenſibly engaged before ſhe adverted to the impropriety of a new attachment. But propoſals of marriage could ſcarcely fail to remind her of her promiſe and awaken her ſcruples. Theſe ſhe ſoon communicated to her lover, with her firm reſolution to remain a widow, if the contrary meaſure, which ſhe greatly preferred, and on which her earthly happineſs depended, were not approved by ſome ſpiritual counſellor.

Upon this declaration it was agreed to take the advice of their own miniſter, who was an eminent diſſenting clergyman

Promise. clergyman in the diocese of Oxford: but this gentleman, unwilling to decide in a matter of such importance, proposed to refer it to Dr Secker, who was then bishop of that see. This prelate too declined to give any judgment in the case; but, as was his way, mustered up a number of arguments on each side of the question, and committed them to a letter, which a learned gentleman of our acquaintance had some time ago an opportunity of seeing in manuscript.

If the sentiments to which the bishop was inclined could have been inferred from his statement of arguments, he seemed to think that the promise was binding. In our opinion, he ought to have given a positive decision. It was no matter whether the promise was extorted or not: the promise was made; and the question was now, whether or not was the performance lawful? That it was lawful appears evident. The lady was under a moral obligation to remain a widow; and no moral obligation, so far as we know, required her to marry.

To be fruitful and multiply, indeed, is declared in Scripture, and is found, to the woful experience of many, to be one of the general laws of our nature. But of all those laws intended by nature to regulate the conduct of inferior intelligences, the moral, which were meant to be checks and correctors of those abuses to which the physical are apt to be carried, are certainly the most sacred and obligatory. To procreate his species, a man is not then to be guilty of adultery, or of fornication, or to listen to the lewd calls of incontinency. St Paul's observation, that it is better to marry than burn, cannot be allowed in this instance to have much weight. He has not defined what degree of amorous inflammation constitutes burning, nor in what cases this burning would be a sufficient warrant for marrying. In the present instance he does not even consider marriage as a duty; he compares it with burning, and thinks it only the least of the two evils. Not that marriage is evil of itself; for he that marrieth doth well: but there are circumstances in which it would be inconvenient to marry, and in which he that marrieth not is said to do better. But if those inconveniences be reasons sufficient to deter from marrying, is that person to be held excusable who, in order to gratify an animal passion, somewhat refined, should violate an oath, and trample on a sacred moral obligation?

21 Moral laws superior to physical in point of obligation.

The young lady might indeed declare that her earthly happiness was at an end if she were not permitted to marry again: but what circumstance prevented her from marrying? It was not the opinion of her own pastor, or the bishop of Oxford: the truth is, it was certain scruples of her own, which being unable of herself to overcome, she had piously solicited the assistance of others. It is certainly a misfortune that a devotional and amorous turn should always be so closely connected in the females. Both, however, cannot always be indulged. Who will say, that the motive is rational which inclines one to cherish a passion which conscience disapproves? The virtue of continency might indeed have borne hard on this lady's constitution, and in her way to immortal happiness might have formed a gate so strait and narrow as it might be difficult for her to pass through: but after all, her case was not harder than that of nuns, who take the vows of perpetual chastity, and endure sufferings of a similar nature, and in some instances even perhaps greater than hers; yet doing it cheerfully, from the supposition that the Omniscient is well acquainted with the nature of the great sacrifice which they make, and that after death he will study to requite them, and bestow on them something like an equivalent, which in their opinion can scarcely be less than a happiness in heaven as ample as their wishes and as lasting as their souls.

Promise ‖ Prong-hoe.

Every promise, therefore, which is not released, nor fraudulently obtained by the promisee, is to be held binding if the performance be lawful and possible.

22 A promise of a similar nature with an oath.

The Christian cannot, and a man of honour will scarcely venture to reject this maxim, that a good man ought not to change though he swear to his hurt. Yet a simple promise and a promissory oath are not very different in point of obligation. Most people know, and where any moral duty is concerned, they ought particularly to reflect, that this world is governed by an Almighty Being, who knows all things, who lives always, and who is just to reward and to punish. The person who makes a promissory oath does it avowedly under an immediate sense of these truths; the person who makes a simple promise, though he certainly ought, yet may not reflect on these at the time. The former, when he violates his oath, exhibits, only to outward appearance, a greater contempt of the Divine power, knowledge, and justice, than he who violates a simple promise under an impression of the same truths. To Him who knows the secrets of the heart, the breach of the promise must appear as criminal as the breach of the oath. See Assumpsit and Oath.

PROMONTORY, in *Geography*, a high point of land or rock projecting into the sea; the extremity of which towards the sea is called a *cape* or *headland*. See Geography *Index*.

PROMPTER, in the drama, an officer posted behind the scenes, whose business it is to watch attentively the actors speaking on the stage, in order to suggest and put them forward when at a stand, to correct them when amiss, &c. in their parts.

PROMULGATED, or Promulged, something published or proclaimed, and generally applied to a law, to denote the publishing or proclaiming it to the people.

PRONAOS, in the ancient agriculture, a porch to a church, palace, or other spacious building. See the article Porch.

PRONATION, among anatomists. The radius of the arm has two kinds of motion, the one called *pronation*, the other *supination*. Pronation is that whereby the palm of the hand is turned downwards; and supination, the opposite motion thereto, is that whereby the back of the hand is turned downwards. The peculiar muscles whereby pronation is performed, are called *pronatores*, as those by which supination is performed are termed *supinatores*. See Anatomy, *Table of the Muscles*, and *Plates*.

PRONG-hoe, in husbandry, a term used to express an instrument used to hoe or break the ground near and among the roots of plants.

The ordinary contrivance of the hoe is very defective, it being only made for scraping on the surface; but the great use of hoeing being to break and open the ground, beside the killing of the weeds, which the ancients, and many among us, have thought the only use of the hoe, this

this dull and blunt inſtrument is by no means calculated for the purpoſes it is to ſerve. The prong-hoe conſiſts of two hooked points of ſix or ſeven inches long, and when ſtruck into the ground will ſtir and remove it the ſame depth as the plough does, and thus anſwer both the ends of cutting up the weeds and opening the land. It is uſeful even in the horſe-hoeing huſbandry, becauſe the hoe-plough can only come within three or four inches of the rows of the corn, turnips, and the like; whereas this inſtrument may be uſed afterwards, and with it the land may be raiſed and ſtirred even to the very ſtalk of the plant. See AGRICULTURE.

PRONOUN, PRONOMEN, in *Grammar*, a declinable part of ſpeech, which being put inſtead of a noun, points out ſome perſon or thing. See GRAMMAR.

PRONUNCIATION, in *Grammar*, the manner of articulating or ſounding the words of a language.

Pronunciation makes the moſt difficult part of written grammar; in regard that a book expreſſing itſelf to the eyes, in a matter that wholly concerns the ears, ſeems next akin to that of teaching the blind to diſtinguiſh colours: hence it is that there is no part ſo defective in grammar as that of pronunciation, as the writer has frequently no term whereby to give the reader an idea of the ſound he would expreſs; for want of a proper term, therefore, he ſubſtitutes a vicious and precarious one. To give a juſt idea of the pronunciation of a language, it ſeems neceſſary to fix as nearly as poſſible all the ſeveral ſounds employed in the pronunciation of that language. Cicero tells us, that the pronunciation underwent ſeveral changes among the Romans: and indeed it is more precarious in the living languages, being, as Du Bos tells us, ſubſervient to faſhion in theſe. The French language is clogged with a difficulty in pronunciation from which moſt others are free; and it conſiſts in this, that moſt of their words have two different pronunciations, the one in common proſe, the other in verſe.

As to the pronunciation of the Engliſh language, the ingenious Mr Martin, in his Spelling-Book of Arts and Sciences, lays down the following rules: 1. The final *(e)* lengthens the ſound of the foregoing vowel; as in *can, cane; rob, robe; tun, tune*, &c. 2. The final *(e)*, in words ending in *re*, is ſounded before the *r* like *u*; as *maſſacre, maſſa-cur; lucre, lu cur*, &c. 3. The Latin diphthongs *æ*, *œ*, are ſounded like *e*; as *Ætna, Etna, œconomy, economy*, &c.: but at the end of the words *oe* ſounds like *o*; as in *toe, foe*, &c. 4. Alſo the Engliſh improper diphthongs, *ea, eo, eu, ue*, ſound only the *e* and *u*; as *tea* or *te; feoffee* or *feffee; due* or *du; true* or *tru*, &c. though ſometimes *eo* and *ea* are pronounced like *ee*, as in *people, fear, near*, &c. 5. Sometimes the diphthong *(ie)* is pronounced like *e* in *ceiling*, like *ee* in *field*, and, at the end of words, always like *y*, as in *lie*, &c.; and *ei* is pronounced either like *e* or *ai*, as in *deceit, reign*, &c. 6. The triphthong *eau* is pronounced like *o*, in *beau* and *jet d'eau*; and *ieu* ſounds like *u* in *lieu, adieu*, &c. 7. The ſound of *c* is hard before the vowels *a, o, u*, as in *call, cold, cup*, &c.; alſo ſometimes before *h*, as in *chart, cold*, &c.; and before *l* and *r*, as in *clear, creep*, &c. It is otherwiſe generally ſoft, as in *city, cell, cyder, child*, &c. 8. In French words *ch* is ſounded like *ſh*, as in *chagreen, machine*; and ſometimes like *qu*, as in *choir*. 9. The ſound of *g* is hard before *a, o, u, l, r*, as in *gall, go, gum, glean, grope*; alſo before *ui*, as in *guilt, guild*, &c.; and before *h*, as in *ghoſt*; ſometimes before *i*, as in *gibbous, gibberiſh*. It is alſo generally hard before *e*, as in *get, geld*, &c.; but ſoft in many words derived from the Greek and Latin, as in *geometry, genealogy, genus*, &c. Two *gg* are always hard, as in *dagger*, &c. The ſound of *g*, when ſoft, is like that of *j*. 10. In any part of a word, *ph* ſounds like *f*, as in *philoſophy*, &c. 11. The ſound of *qu*, at the end of French words, is like *k*, as in *riſque*, &c. 12. The ſyllables *ti* and *ci*, if followed by a vowel, ſound like *ſi* or *ſhi*; as in *fiction, logician*, &c. 13. When *cc* occurs before *i*, the firſt is hard and the latter is ſoft; as in *flaccid*, &c. 14. The letter *p* is not pronounced at the beginning of ſyllables before *ſ* and *t*; as in *pſalm, ptarmics*, &c. As to other peculiarities regarding the pronunciation of ſingle letters, many of them have been taken notice of at the beginning of each, in the courſe of this work.

But it is not enough to know the juſt pronunciation of ſingle letters, but alſo of words: in order to which, the accenting of words ought to be well underſtood; ſince nothing is more harſh and diſagreeable to the ear, than to hear a perſon ſpeak or read with wrong accents. And indeed in Engliſh the ſame word is often both a noun and a verb, diſtinguiſhed only by the accent, which is on the firſt ſyllable of the noun, and on the laſt of the verb; as *fèrment* and *fermènt; rècord* and *recòrd*, &c. We are to obſerve alſo, that in order to a juſt expreſſion of words, ſome require only a ſingle accent on the ſyllable, as in *tòrment*, &c.; but in others it ſhould be marked double, as in *anì'mal*, becauſe it is pronounced as if the letter was wrote double, viz. *anni-mal*.

Mr Sheridan's Dictionary will be found extremely uſeful as a directory in acquiring the pronunciation of the Engliſh language; but care muſt be taken to avoid his provincial brogue, which has certainly miſled him in ſeveral inſtances. Mr Walker's Pronouncing Dictionary, lately publiſhed, will likewiſe deſerve the ſtudent's attention. It is a work of great labour and merit, and is highly uſeful. It has indeed ſome faults and inaccuracies, but it is notwithſtanding, in all probability, the beſt of the kind.

PRONUNCIATION is alſo uſed for the fifth and laſt part of rhetoric, which conſiſts in varying and regulating the voice agreeably to the matter and words, ſo as moſt effectually to perſuade and touch the hearers. See ORATORY, Part IV.

PROOF, in *Law* and *Logic*, is that degree of evidence which carries conviction to the mind. It differs from demonſtration, whioh is applicable only to thoſe truths of which the contrary is inconceivable. It differs likewiſe from probability, which produces for the moſt part nothing more than opinion, while proof produces belief. See PROBABILITY.

The *proof* of crimes was anciently effected among our anceſtors divers ways; viz. by duel or combat, fire, water, &c. See DUEL and ORDEAL.

PROOF of Artillery and Small Arms, is a trial whether they ſtand the quantity of powder allotted for that purpoſe. The rule of the board of ordnance is, that all guns, under 24-pounders, be loaded with powder as much as their ſhot weighs; that is, a braſs 24-pounder with 21 lb. a braſs 32-pounder with 26 lb. 12 oz. and a 42-pounder with 31 lb. 8. oz.; the iron 24-pounder with 18 lb. the 32-pounder with 21 lb. 8. oz. and the 42-pounder with 25 lb.

The

Proof.

The brafs light field-pieces are proved with powder that weighs half as much as their fhot, except the 24-pounder, which is loaded with 10 lb. only.

Government allows 11 bullets of lead in the pound for the proof of mufkets and 14.5, or 29 in two pounds, for fervice; 17 in the pound for the proof of carabines, and 20 for fervice; 28 in the pound for the proof of piftols, and 34 for fervice.

When guns of a new metal, or of lighter conftruction, are proved; then, befides the common proof, they are fired 200 or 300 times, as quick as they can be, loaded with the common charge given in actual fervice. Our light 6-pounders were fired 300 times in 3 hours 27 minutes, loaded with 1 lb. 4 oz. without receiving any damage.

PROOF of Powder, is in order to try its goodnefs and ftrength. See GUNPOWDER.

PROOF of Cannon, is made to afcertain their being well caft, their having no cavities in their metal, and, in a word, their being fit to refift the effort of their charge of powder. In making this proof, the piece is laid upon the ground, fupported only by a piece of wood in the middle, of about 5 or 6 inches thick, to raife the muzzle a little; and then the piece is fired againft a folid butt of earth.

Tools ufed in the PROOF of Cannon, are as follows:

Searcher, an iron focket with branches, from 4 to 8 in number, bending outwards a little, with fmall points at their ends: to this focket is fixed a wooden handle, from 8 to 12 feet long, and 1½ inch in diameter. This fearcher is introduced into the gun after each firing, and turned gently round to difcover the cavities within: if any are found, they are marked on the outfide with chalk; and then the

Searcher with one point is introduced: about which point a mixture of wax and tallow is put, to take the impreffion of the holes; and if any are found of one-fourth of an inch deep, or of any confiderable length, the gun is rejected as unferviceable to the government.

Reliever, is an iron ring fixed to a handle, by means of a focket, fo as to be at right angles; it ferves to difengage the firft fearcher, when any of its points are retained in a hole, and cannot otherwife be got out. When guns are rejected by the proof-mafters, they order them to be marked X thus, which the contractors generally alter *WP* thus; and after fuch alteration, difpofe of them to foreign powers for Woolwich proof.

The moft curious inftrument for finding the principal defects in pieces of artillery, was lately invented by Lieutenant-general Defaguliers, of the royal regiment of artillery. This inftrument, grounded on the trueft mechanical principles, is no fooner introduced into the hollow cylinder of the gun, than it difcovers its defects, and more particularly that of the piece not being truly bored; which is a very important one, and to which moft of the difafters happening to pieces of artillery are in a great meafure to be imputed; for, when a gun is not truly bored, the moft expert artillerift will not be able to make a good fhot.

PROOF of Mortars and Howitzers, is made to afcertain their being well caft, and of ftrength to refift the effort of their charge. For this purpofe the mortar or howitzer is placed upon the ground, with fome part of their trunnions or breech funk below the furface, and refting on wooden billets, at an elevation of about 70 degrees.

Proof. Propagation.

The mirror is generally the only inftrument to difcover the defects in mortars and howitzers. In order to ufe it, the fun muft fhine; the breech muft be placed towards the fun, and the glafs over-againft the mouth of the piece: it illuminates the bore and chamber fufficiently to difcover the flaws in it.

PROOF of Foreign Brafs-Artillery. 1ft, The Pruffians. Their battering-train and garrifon artillery are proved with a quantity of powder equal to ½ the weight of the fhot, and fired 75 rounds as faft as in real fervice; that is, 2 or 3 rounds in a minute. Their light field-train, from a 12-pounder upwards, are proved with a quantity of powder = 1-3d of the weight of the fhot, and fired 150 rounds, at 3 or 4 rounds in a minute. From a 12-pounder downwards, are proved with a quantity of powder = 1-5th of the fhot's weight, and fired 300 rounds, at 5 or 6 rounds each minute, properly fpunged and loaded. Their mortars are proved with the chambers full of powder, and the fhells loaded. Three rounds are fired as quick as poffible.

2d, The Dutch prove all their artillery by firing each piece 5 times; the two firft rounds with a quantity of powder = 2-3ds of the weight of the fhot; and the three laft rounds with a quantity of powder = ½ the weight of the fhot.

3d, The French the fame as the Dutch.

PROOF, in brandy and other fpirituous liquors, is a little white lather which appears on the top of the liquor when poured into a glafs. This lather, as it diminifhes, forms itfelf into a circle called by the French the *chapelet*, and by the Englifh the *bead* or *bubble*.

PROOFS of Prints, were anciently a few impreffions taken off in the courfe of an engraver's procefs. He proved a plate in different ftates, that he might afcertain how far his labours had been fuccefsful, and when they were complete. The excellence of fuch early impreffions, worked with care, and under the artift's eye, occafioning them to be greedily fought after, and liberally paid for, it has been cuftomary among our modern print-fellers to take off a number of them, amounting perhaps, to hundreds, from every plate of confiderable value; and yet their want of rarenefs has by no means abated their price. On retouching a plate, it has been alfo ufual, among the fame confcientious fraternity, to cover the infcription, which was immediately added after the firft proofs were obtained, with flips of paper, that a number of fecondary proofs might alfo be created.

Nichols's Life of Hogarth.

PROOF, in the fugar trade. See SUGAR.

PROOFS, in printing. See PRINTING.

PROPAGATION, the act of multiplying the kind. See GENERATION.

PROPAGATION of Plants. The moft natural and the moft univerfal way of propagating plants is by feeds. See PLANTS. But they may alfo be propagated by *fets*, *pieces*, or *cuttings*, taken from the parent plant. Willows are very eafily propagated by fets: fuch as rife to be confiderable timber trees being raifed from fets feven or eight feet long, fharpened at their larger ends, which are thruft into the ground by the fides of ditches, on the banks of rivers, or in any moift foil. The fallow trees are raifed from fets only three feet long. The plane tree, mint, &c. may be propagated in the fame way. In pro-

Propagation, Property.

viding the ſlips, ſprigs, or cuttings, however, care muſt be taken to cut off ſuch branches as have knots or joints two or three inches beneath them: ſmall top ſprigs of two or three years growth are the beſt for this operation. Plants are alſo propagated by parting their roots, each part of which, properly managed, ſends out freſh roots. Another mode of propagating plants is by layering or laying the tops of the branches in the ground.

The method of layering is this: Dig a ring-trench round the ſtool, of a depth ſuitable to the nature of the plant; and having pitched upon the ſhoots to be layered, bend them to the bottom of the trench (either with or without plaſhing, as may be found moſt convenient), and there *peg* them faſt; or, putting ſome mould upon them, *tread* them hard enough to prevent their ſpringing up again—fill in the mould—place the top of the layer in an upright poſture, treading the mould hard behind it; and cut it carefully off above the firſt, ſecond, or third eye. Plants are alſo propagated by their bulbs.

The number of vegetables that may be propagated from an individual is very remarkable, eſpecially in the moſt minute plants. The annual product of one ſeed even of the common mallow has been found to be no leſs than 200,000; but it has been proved, by a ſtrict examination into the more minute parts of the vegetable world, that the common wall moſs produces a much more numerous offspring. In one of the little heads of this plant there have been counted 13,824 ſeeds. Now allotting to a root of this plant eight branches, and to each branch ſix heads, which appears to be a very moderate computation, the produce of one ſeed is $6 \times 13824 = 82944$; and 8×82944 gives 663,552 ſeeds as the annual produce of one ſeed, and that ſo ſmall that 13824 of them are contained in a capſule, whoſe length is but one ninth of an inch, its diameter but one 23d of an inch, and its weight but the 13th part of a grain.

For the propagation or culture of particular plants, ſee AGRICULTURE.

PROPER, ſomething natural and eſſentially belonging to any thing.

PROPERTIUS, SEXTUS AURELIUS, a celebrated Latin poet, born at Mevania, a city of Umbria, now called *Bevagna*, in the duchy of Spoletto. He went to Rome after the death of his father, a Roman knight, who had been put to death by order of Auguſtus, for having followed Antony's party during the triumvirate. Propertius in a ſhort time acquired great reputation by his wit and abilities, and had a conſiderable ſhare in the eſteem of Mæcenas and Cornelius Gallus. He had alſo Ovid, Tibullus, Baſſus, and the other ingenious men of his time, for his friends. He died at Rome 19 B. C. He is printed with almoſt all the editions of Tibullus and Catullus: but the beſt edition of him is that which was given ſeparately by Janus Brouckhuſius at Amſterdam, 1702, in 4to, and again in 1714, 4to, *cum curis ſecundis ejuſdem.* We have four books of his Elegies or Amours with a lady called *Hoſtia*, or *Hoſtilia*, to whom he gave the name of *Cynthia*.

PROPERTY, in a general ſenſe, is a particular virtue or quality which nature has beſtowed on ſome things excluſive of all others: thus, colour is a property of light; extenſion, figure, diviſibility, and impenetrability, are properties of body.

PROPERTY, in *Law*, is deſcribed to be the higheſt right which a perſon has or can have to any thing.

1 Definition.

There is nothing which ſo generally ſtrikes the imagination, and engages the affections of mankind, as the right of property; or that ſole and deſpotic dominion which one man claims and exerciſes over certain external things of the world, in total excluſion of the right of any other individual in the univerſe. And yet there are very few that will give themſelves the trouble to conſider the original and foundation of this right. Pleaſed as we are with the poſſeſſion, we ſeem afraid to look back to the means by which it was acquired, as if fearful of ſome defect in our title; or at beſt we reſt ſatisfied with the deciſion of the laws in our favour, without examining the reaſon or authority upon which thoſe laws have been built. We think it enough that our title is derived by the grant of the former proprietor, by deſcent from our anceſtors, or by the laſt will and teſtament of the dying owner: not caring to reflect, that (accurately and ſtrictly ſpeaking) there is no foundation in nature or in natural law, why a ſet of words upon parchment ſhould convey the dominion of land; why the ſon ſhould have a right to exclude his fellow creatures from a determinate ſpot of ground, becauſe his father had done ſo before him; or why the occupier of a particular field or of a jewel, when lying on his death-bed and no longer able to maintain poſſeſſion, ſhould be entitled to tell the reſt of the world which of them ſhould enjoy it after him. Theſe inquiries, it muſt be owned, would be uſeleſs and even troubleſome in common life. It is well if the maſs of mankind will obey the laws when made, without ſcrutinizing too nicely into the reaſons of making them. But when law is to be conſidered not only as a matter of practice, but alſo as a rational ſcience, it cannot be improper or uſeleſs to examine more deeply the rudiments and grounds of theſe poſitive conſtitutions of ſociety.

2 The original foundation of the right to property not generally conſidered.

3 This right ariſes from a divine grant.

In the beginning of the world, we are informed by holy writ, that the all-bountiful Creator gave to man "dominion over all the earth; and over the fiſh of the "ſea, and over the fowl of the air, and over every li- "ving thing that moveth upon the earth." This is the only true and ſolid foundation of man's dominion over external things, whatever airy metaphyſical notions may have been ſtarted by fanciful writers upon this ſubject. The earth, therefore, and all things therein, are the general property of all mankind, excluſive of other beings, from the immediate gift of the Creator. And, while the earth continued thinly inhabited, it is reaſonable to ſuppoſe, that all was in common among them, and that every one took from the public ſtock to his own uſe ſuch things as his immediate neceſſities required.

4 The ſtate of property in the early ages of the world.

Theſe general notions of property were then ſufficient to anſwer all the purpoſes of human life; and might perhaps ſtill have anſwered them, had it been poſſible for mankind to have remained in a ſtate of primæval ſimplicity: as may be collected from the manners of many American nations, when firſt diſcovered by the Europeans; and from the ancient method of living among the firſt Europeans themſelves, if we may credit either the memorials of them preſerved in the golden age of the poets, or the uniform accounts given by hiſtorians of thoſe times wherein *erant omnia communia et indiviſa omnibus, veluti unum cunctis patrimonium eſſet.* Not that this communion of goods ſeems ever to have been applicable, even

Blackſt. Comment.

even in the earlieſt ages, to aught but the *ſubſtance* of the thing; nor could it be extended to the *uſe* of it. For, by the law of nature and reaſon, he who firſt began to uſe it, acquired therein a kind of tranſient property, that laſted ſo long as he was uſing it, and no longer: or, to ſpeak with greater preciſion, the *right* of poſſeſſion continued for the ſame time only that the *act* of poſſeſſion laſted. Thus the ground was in common, and no part of it was the permanent property of any man in particular; yet whoever was in the occupation of any determinate ſpot of it, for reſt, for ſhade, or the like, acquired for the time a ſort of ownerſhip, from which it would have been unjuſt, and contrary to the law of nature, to have driven him by force; but the inſtant that he quitted the uſe or occupation of it, another might ſeize it without injuſtice. Thus alſo a vine or other tree might be ſaid to be in common, as all were equally entitled to its produce; and yet any private individual might gain the ſole property of the fruit, which he had gathered for his own repaſt. A doctrine well illuſtrated by Cicero, who compares the world to a great theatre, which is common to the public, and yet the place which any man has taken is for the time his own.

5 Riſe of permanent property in various things.

But when mankind increaſed in number, craft, and ambition, it became neceſſary to entertain conceptions of more permanent dominion; and to appropriate to individuals, not the immediate *uſe* only, but the very *ſubſtance* of the thing to be uſed: otherwiſe innumerable tumults muſt have ariſen, and the good order of the world been continually broken and diſturbed, while a variety of perſons were ſtriving who ſhould get the firſt occupation of the ſame thing, or diſputing which of them had actually gained it. As human life alſo grew more and more refined, abundance of conveniencies were deviſed to render it more eaſy, commodious, and agreeable; as habitations for ſhelter and ſafety, and raiment for warmth and decency. But no man would be at the trouble to provide either, ſo long as he had only an uſufructuary property in them, which was to ceaſe the inſtant that he quitted poſſeſſion;—if, as ſoon as he walked out of his tent, or pulled off his garment, the next ſtranger who came by would have a right to inhabit the one and to wear the other. In caſe of habitations in particular, it was natural to obſerve, that even the brute creation, to whom every thing elſe was in common, maintained a permanent property in their dwellings, eſpecially for the protection of their young; that the birds of the air had neſts, and the beaſts of the field had caverns, the invaſion of which they eſteemed a very flagrant injuſtice, and would ſacrifice their lives to preſerve them. Hence a property was ſoon eſtabliſhed in every man's houſe and home-ſtall; which ſeem to have been originally mere temporary huts or moveable cabins, ſuited to the deſign of Providence for more ſpeedily peopling the earth, and ſuited to the wandering life of their owners, before any extenſive property in the ſoil or ground was eſtabliſhed. And there can be no doubt, but that moveables of every kind became ſooner appropriated than the permanent ſubſtantial ſoil: partly becauſe they were more ſuſceptible of a long occupancy, which might be continued for months together without any ſenſible interruption, and at length by uſage ripen into an eſtabliſhed right; but principally becauſe few of them could be fit for uſe, till improved and meliorated by the bodily labour of the occupant; which bodily labour, beſtowed upon any ſubject which before lay in common to all men, is univerſally allowed to give the faireſt and moſt reaſonable title to an excluſive property therein.

6 In food and other neceſſary articles.

The article of food was a more immediate call, and therefore a more early conſideration. Such as were not contented with the ſpontaneous product of the earth ſought for a more ſolid refreſhment in the fleſh of beaſts, which they obtained by hunting. But the frequent diſappointments incident to that method of proviſion induced them to gather together ſuch animals as were of a more tame and ſequacious nature; and to eſtabliſh a permanent property in their flocks and herds, in order to ſuſtain themſelves in a leſs precarious manner, partly by the milk of their dams, and partly by the fleſh of the young. The ſupport of theſe their cattle made the article of *water* alſo a very important point. And therefore the book of Geneſis (the moſt venerable monument of antiquity, conſidered merely with a view to hiſtory) will furniſh us with frequent inſtances of violent contentions concerning wells; the excluſive property of which appears to have been eſtabliſhed in the firſt digger or occupant, even in ſuch places where the ground and herbage remained yet in common. Thus we find Abraham, who was but a ſojourner, aſſerting his right to a well in the country of Abimelech, and exacting an oath for his ſecurity, "becauſe he had digged that well." And Iſaac, about 90 years afterwards, reclaimed this his father's property; and, after much contention with the Philiſtines, was ſuffered to enjoy it in peace.

7 Nature of patriarchal property.

All this while the ſoil and paſture of the earth remained ſtill in common as before, and open to every occupant: except perhaps in the neighbourhood of towns, where the neceſſity of a ſole and excluſive property in lands (for the ſake of agriculture) was earlier felt, and therefore more readily complied with. Otherwiſe, when the multitude of men and cattle had conſumed every convenience on one ſpot of ground, it was deemed a natural right to ſeize upon and occupy ſuch other lands as would more eaſily ſupply their neceſſities. This practice is ſtill retained among the wild and uncultivated nations that have never been formed into civil ſtates, like the Tartars and others in the eaſt; where the climate itſelf, and the boundleſs extent of their territory, conſpire to retain them ſtill in the ſame ſavage ſtate of vagrant liberty, which was univerſal in the earlieſt ages, and which Tacitus informs us continued among the Germans till the decline of the Roman empire. We have alſo a ſtriking example of the ſame kind in the hiſtory of Abraham and his nephew Lot. When their joint ſubſtance became ſo great, that paſture and other conveniencies grew ſcarce, the natural conſequence was, that a ſtrife aroſe between their ſervants; ſo that it was no longer practicable to dwell together. This contention Abraham endeavoured to compoſe: "Let there be no ſtrife, I pray thee, between thee and me. Is not the whole land before thee? Separate thyſelf, I pray thee, from me: If thou wilt take the left hand, then I will go to the right; or if thou depart to the right hand, then I will go to the left." This plainly implies an acknowledged right, in either, to occupy whatever ground he pleaſed, that was not pre-occupied by other tribes. "And Lot lifted up his eyes, and beheld all the plain of Jordan, that it was well watered every where, even as the garden of the Lord. Then Lot choſe him all the plain of Jordon, and journeyed eaſt; and Abraham dwelt in the land of Canaan."

Upon

Property.

Upon the same principle was founded the right of migration, or sending colonies to find out new habitations, when the mother-country was overcharged with inhabitants; which was practised as well by the Phœnicians and Greeks, as the Germans, Scythians, and other northern people. And, so long as it was confined to the stocking and cultivation of desert uninhabited countries, it kept strictly within the limits of the law of nature.

8 Necessity of property and of laws respecting it.

But as the world by degrees grew more populous, it daily became more difficult to find out new spots to inhabit, without encroaching upon former occupants; and by constantly occupying the same individual spot, the fruits of the earth were consumed, and its spontaneous produce destroyed, without any provision for a future supply or succession. It therefore became necessary to pursue some regular method of providing a constant subsistence; and this necessity produced, or at least promoted and encouraged, the art of agriculture. And the art of agriculture, by a regular connection and consequence, introduced and established the idea of a more permanent property in the soil than had hitherto been received and adopted. It was clear that the earth would not produce her fruits in sufficient quantities without the assistance of tillage; but who would be at the pains of tilling it, if another might watch an opportunity to seize upon and enjoy the product of his industry, art, and labour? Had not therefore a separate property in lands, as well as moveables, been vested in some individuals, the world must have continued a forest, and men have been mere animals of prey; which, according to some philosophers, is the genuine state of nature. Whereas now (so graciously has Providence interwoven our duty and our happiness together) the result of this very necessity has been the ennobling of the human species, by giving it opportunities of improving in *rational* faculties, as well as of exerting its *natural*. Necessity begat property: and in order to insure that property, recourse was had to civil society, which brought along with it a long train of inseparable concomitants; states, government, laws, punishments, and the public exercise of religious duties. Thus connected together, it was found that a part only of society was sufficient to provide, by their manual labour, for the necessary subsistence of all; and leisure was given to others to cultivate the human mind, to invent useful arts, and to lay the foundations of science.

9 Property acquired first by occupancy.

The only question remaining is, How this property became actually vested; or what it is that gave a man an exclusive right to retain in a permanent manner that specific land which before belonged generally to every body, but particularly to nobody? And as we before observed, that *occupancy* gave the right to the temporary *use* of the soil; so it is agreed upon all hands, that occupancy gave also the original right to the permanent property in the *substance* of the earth itself, which excludes every one else but the owner from the use of it. There is indeed some difference among the writers on natural law, concerning the reason why occupancy should convey this right, and invest one with this absolute property: Grotius and Puffendorf insisting, that this right of occupancy is founded upon a tacit and implied assent of all mankind, that the first occupant should become the owner; and Barbeyrac, Titius, Mr Locke, and others, holding that there is no such implied assent, neither is it necessary that there should be; for that the very act of occupancy, alone, being a degree of bodily labour, is from a principle of natural justice, without any consent or compact, sufficient of itself to gain a title. A dispute that savours too much of nice and scholastic refinement. However, both sides agree in this, that occupancy is the thing by which the title was in fact originally gained; every man seizing to his own continued use such spots of ground as he found most agreeable to his own convenience, provided he found them unoccupied by any one else.

10 By what means it is preserved or lost.

Property, both in lands and moveables, being thus originally acquired by the first taker, which taking amounts to a declaration, that he intends to appropriate the thing to his own use, it remains in him, by the principle of universal law, till such time as he does some other act which shows an intention to abandon it; for then it becomes naturally speaking, *publici juris* once more, and is liable to be again appropriated by the next occupant. So if one is possessed of a jewel, and casts it into the sea or a public highway, this is such an express dereliction, that a property will be vested in the first fortunate finder that shall seize it to his own use. But if he hides it privately in the earth, or other secret place, and it is discovered, the finder acquires no property therein; for the owner had not by this act declared any intention to abandon it, but rather the contrary: and if he loses or drops it by accident, it cannot be collected from thence that he designed to quit the possession; and therefore in such case the property still remains in the loser, who may claim it again of the finder. And this, we may remember, is the doctrine of the English law with relation to *TREASURE-Trove*.

But this method of one man's abandoning his property, and another seizing the vacant possession, however well-founded in theory, could not long subsist in fact. It was calculated merely for the rudiments of civil society, and necessarily ceased among the complicated interests and artificial refinements of polite and established governments. In these it was found, that what became inconvenient or useless to one man, was highly convenient and useful to another; who was ready to give in exchange for it some equivalent that was equally desirable to the former proprietor. This mutual convenience introduced commercial traffic, and the reciprocal transfer of property by sale, grant, or conveyance: which may be considered either as a continuance of the original possession which the first occupant had; or as an abandoning of the thing by the present owner, and an immediate successive occupancy of the same by the new proprietor. The voluntary dereliction of the owner, and delivering the possession to another individual, amount to a transfer of the property; the proprietor declaring his intention no longer to occupy the thing himself, but that his own right of occupancy shall be vested in the new acquirer. Or, taken in the other light, if I agree to part with an acre of my land to Titius, the deed of conveyance is an evidence of my intending to abandon the property; and Titius, being the only or first man acquainted with such my intention, immediately steps in and seizes the vacant possession: thus the consent expressed by the conveyance gives Titius a good right against me; and possession or occupancy confirms that right against all the world besides.

11 How it goes on the death of the occupant.

The most universal and effectual way of abandoning property is by the death of the occupant: when, both the actual possession and intention of keeping posses-sion

ſion ceaſing, the property, which is founded upon ſuch poſſeſſion and intention, ought alſo to ceaſe of courſe. For, naturally ſpeaking, the inſtant a man ceaſes to be, he ceaſes to have any dominion: elſe, if he had a right to diſpoſe of his acquiſitions one moment beyond his life, he would alſo have a right to direct their diſpoſal for a million of ages after him; which would be highly abſurd and inconvenient (A). All property muſt therefore ceaſe upon death, conſidering men as abſolute individuals, and unconnected with civil ſociety: for then, by the principles before eſtabliſhed, the next immediate occupant would acquire a right in all that the deceaſed poſſeſſed. But as, under civilized governments, which are calculated for the peace of mankind, ſuch a conſtitution would be productive of endleſs diſturbances, the univerſal law of almoſt every nation (which is a kind of ſecondary law of nature) has either given the dying perſon a power of continuing his property, by diſpoſing of his poſſeſſions by will; or, in caſe he neglects to diſpoſe of it, or is not permitted to make any diſpoſition at all, the municipal law of the country then ſteps in, and declares who ſhall be the ſucceſſor, repreſentative, or heir of the deceaſed; that is, who alone ſhall have a right to enter upon this vacant poſſeſſion, in order to avoid that confuſion which its becoming again common would occaſion. And farther, in caſe no teſtament be permitted by the law, or none be made, and no heir can be found ſo qualified as the law requires, ſtill, to prevent the robuſt title of *occupancy* from again taking place, the doctrine of eſcheats is adopted in almoſt every country; whereby the ſovereign of the ſtate, and thoſe who claim under his authority, are the ultimate heirs, and ſucceed to thoſe inheritances to which no other title can be formed.

12 Of the right of inheritance.

The right of inheritance, or deſcent to the children and relations of the deceaſed, ſeems to have been allowed much earlier than the right of deviſing by teſtament. We are apt to conceive at the firſt view that it has nature on its ſide; yet we often miſtake for nature what we find eſtabliſhed by long and inveterate cuſtom. It is certainly a wiſe and effectual, but clearly a political, eſtabliſhment; ſince the permanent right of property, veſted in the anceſtor himſelf, was no *natural*, but merely a *civil*, right. It is true, that the tranſmiſſion of one's poſſeſſions to poſterity has an evident tendency to make a man a good citizen and a uſeful member of ſociety: it ſets the paſſions on the ſide of duty, and prompts a man to deſerve well of the public, when he is ſure that the reward of his ſervices will not die with himſelf, but be tranſmitted to thoſe with whom he is connected by the deareſt and moſt tender affections. Yet, reaſonable as this foundation of the right of inheritance may ſeem, it is probable that its immediate original aroſe not from ſpeculations altogether ſo delicate and refined, and, if not from fortuitous circumſtances, at leaſt from a plainer and more ſimple principle. A man's children or neareſt relations are uſually about him on his death-bed, and are the earlieſt witneſſes of his deceaſe. They became therefore generally the next immediate occupants, till at length in proceſs of time this frequent uſage ripened into general law. And therefore alſo in the earlieſt ages, on failure of children, a man's ſervants born under his roof were allowed to be his heirs; being immediately on the ſpot when he died. For we find the old patriarch Abraham expreſsly declaring, that "ſince God had given him no ſeed, his ſteward Eliezer, one born in his houſe, was his heir."

13 Laſt wills or teſtaments

While property continued only for life, teſtaments were uſeleſs and unknown; and when it became inheritable, the inheritance was long indefeaſible, and the children or heirs at law were incapable of excluſion by will. Till at length it was found, that ſo ſtrict a rule of inheritance made heirs diſobedient and headſtrong, defrauded creditors of their juſt debts, and prevented many provident fathers from dividing or charging their eſtates as the exigence of their families required. This introduced pretty generally the right of diſpoſing of one's property, or a part of it, by *teſtament;* that is, by written or oral inſtructions properly *witneſſed* and authenticated, according to the *pleaſure* of the deceaſed; which we therefore emphatically ſtyle his *will.* This was eſtabliſhed in ſome countries much later than in others. In England, till modern times, a man could only diſpoſe of one-third of his moveables from his wife and children; and in general, no will was permitted of lands till the reign of Henry VIII. and then only of a certain portion; for it was not till after the Reſtoration that the power of deviſing real property became ſo univerſal as at preſent.

14 are creatures of the civil or municipal laws.

Wills, therefore, and teſtaments, rights of inheritance, and ſucceſſions, are all of them creatures of the civil or municipal laws, and accordingly are in all reſpects regulated by them; every diſtinct country having different ceremonies and requiſites to make a teſtament completely valid; neither does any thing vary more than the right of inheritance under different national eſtabliſhments. In England particularly, this diverſity is carried to ſuch a length, as if it had been meant to point out the power of the laws in regulating the ſucceſſion to property, and how futile every claim muſt be that has not its foundation in the poſitive rules of the ſtate. In perſonal eſtates, the father may ſucceed to his children; in landed property, he never can be their immediate heir by any the remoteſt poſſibility: in general, only the eldeſt ſon, in ſome places only the youngeſt, in others all the ſons together, have a right to ſucceed to the inheritance: In real eſtates, males are preferred to females, and the eldeſt male will uſually exclude the reſt; in the diviſion of perſonal eſtates, the females of equal degree are admitted together with the males, and no right of primogeniture is allowed.

Blackſt. Comment.

15 Scruples reſpecting heritable property removed.

This one conſideration may help to remove the ſcruples of many well-meaning perſons, who ſet up a miſtaken conſcience in oppoſition to the rules of law. If a man diſinherits his ſon, by a will duly executed, and leaves his eſtate to a ſtranger, there are many who conſider this proceeding as contrary to natural juſtice; while others ſo ſcrupulouſly adhere to the ſuppoſed intention of the dead, that if a will of lands be atteſted by only *two* witneſſes inſtead of *three*, which the law requires,

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(A) This right, inconvenient as it certainly is, the law of Scotland gives to every man over his *real* eſtate, by authoriſing him to entail it on his heirs for ever. See LAW, clxxx. 9, 10, 11. and TAILZIE.

requires, they are apt to imagine that the heir is bound in conſcience to relinquiſh his title to the deviſee. But both of them certainly proceed upon very erroneous principles: as if, on the one hand, the ſon had by nature a right to ſucceed to his father's lands; or as if, on the other hand, the owner was by nature entitled to direct the ſucceſſion of his property after his own deceaſe. Whereas the law of nature ſuggeſts, that on the death of the poſſeſſor, the eſtate ſhould again become common, and be open to the next occupant, unleſs otherwiſe ordered, for the ſake of civil peace, by the poſitive law of ſociety. The poſitive law of ſociety, which is with us the municipal laws of England and Scotland, directs it to veſt in ſuch perſon as the laſt proprietor ſhall by will, attended with certain requiſites, appoint; and, in defect of ſuch appointment, to go to ſome particular perſon, who, from the reſult of certain local conſtitutions, appears to be the heir at law. Hence it follows, that, where the appointment is regularly made, there cannot be a ſhadow of right in any one but the perſon appointed: and, where the neceſſary requiſites are omitted, the right of the heir is equally ſtrong, and built upon as ſolid a foundation, as the right of the deviſee would have been, ſuppoſing ſuch requiſites were obſerved.

16 Of things that are ſtill in common.

But, after all, there are ſome few things, which, notwithſtanding the general introduction and continuance of property, muſt ſtill unavoidably remain in common; being ſuch wherein nothing but an uſufructuary property is capable of being had: and therefore they ſtill belong to the firſt occupant, during the time he holds poſſeſſion of them, and no longer. Such (among others) are the elements of light, air, and water; which a man may occupy by means of his windows, his gardens, his mills, and other conveniences: ſuch alſo are the generality of thoſe animals which are ſaid to be *feræ naturæ*, or of a wild and untameable diſpoſition; which any man may ſeize upon and keep for his own uſe or pleaſure. All theſe things, ſo long as they remain in poſſeſſion, every man has a right to enjoy without diſturbance; but if once they eſcape from his cuſtody, or he voluntarily abandons the uſe of them, they return to the common ſtock, and any other man has an equal right to ſeize and enjoy them afterwards.

17 Of ſimilar things which have been appropriated.

Again, there are other things in which a permanent property may ſubſiſt, not only as to the temporary uſe, but alſo the ſolid ſubſtance; and which yet would be frequently found without a proprietor, had not the wiſdom of the law provided a remedy to obviate this inconvenience. Such are foreſts and other waſte grounds, which were omitted to be appropriated in the general diſtribution of lands: ſuch alſo are wrecks, eſtrays, and that ſpecies of wild animals, which the arbitrary conſtitutions of poſitive law have diſtinguiſhed from the reſt by the well-known appellation of *game*. With regard to theſe and ſome others, as diſturbances and quarrels would frequently ariſe among individuals contending about the acquiſition of this ſpecies of property by firſt occupancy, the law has therefore wiſely cut up the root of diſſenſion, by veſting the things themſelves in the ſovereign of the ſtate; or elſe in his repreſentatives appointed and authoriſed by him, being uſually the lords of manors. And thus our legiſlature has univerſally promoted the grand ends of civil ſociety, the peace and ſecurity of individuals, by ſteadily purſuing that wiſe and orderly maxim, of aſſigning to every thing capable of ownerſhip a legal and determinate owner.

18 The reaſoning of thoſe who contend for an equalization of property.

In this age of paradox and innovation, much has been ſaid of *liberty* and *equality*; and ſome few have contended for an equalization of property. One of the wildeſt declaimers on this ſubject, who is for aboliſhing property altogether, has (inadvertently we ſuppoſe) given a complete confutation, not only of his own arguments, but alſo of the arguments of all who have written, or, we think, can write, on the ſame ſide of the queſtion. After labouring to prove that it is groſs injuſtice in any man to retain more than is abſolutely neceſſary to ſupply him with food, clothes, and ſhelter, this zealous reformer ſtates an objection to his theory, ariſing from the well-known allurements of ſloth, which, if the accumulation of property were not permitted, would baniſh induſtry from the whole world. The objection he urges fairly, and anſwers it thus: "It may be obſerved, that the equality for which we are pleading is an equality that would ſucceed to a ſtate of great intellectual improvement. So bold a revolution cannot take place in human affairs, till the general mind has been highly cultivated. The preſent age of mankind is greatly enlightened; but it is to be feared is not yet enlightened enough. Haſty and undigeſted tumults may take place, under the idea of an equalization of property; but it is only a calm and clear conviction of juſtice, of juſtice mutually to be rendered and received, of happineſs to be produced by the *deſertion of our moſt rooted habits*, that can introduce an invariable ſyſtem of this ſort. Attempts without this preparation will be productive only of confuſion. Their effect will be momentary, and a new and more barbarous inequality will ſucceed. Each man with unaltered appetite will watch his opportunity to gratify his love of power, or his love of diſtinction, by uſurping on his inattentive neighbours."

19 The effect of ignorance of human nature.

Theſe are juſt obſervations, and ſuch as we have often made to ourſelves on the various propoſed reformations of government. The illumination which the author requires before he would introduce his abolition of property, would conſtitute men more than angels; for to be under the influence of no paſſion or appetite, and to be guided in every action by unmixed benevolence and pure intellect, is a degree of perfection which we can attribute to no being inferior to God. But it is the object of the greater part of this writer's book to prove that all men muſt arrive at ſuch perfection before his ideal republic can contribute to their happineſs; and therefore every one who is conſcious of being at any time ſwayed by paſſion, and who feels that he is more attached to his wife or children than to ſtrangers, will look without envy to the preſent inequalities of property and power, if he be an intelligent diſciple of Mr Godwin.

Literary PROPERTY. See *COPY-Right*.

1 Definition.

PROPHECY is a word derived from προφητεια, and in its original import ſignifies the prediction of future events.

2 Prophecy proves a ſupernatural communion with the Deity.

As God alone can perceive with certainty the future actions of free agents, and the remote conſequences of thoſe laws of nature which he himſelf eſtabliſhed, prophecy, when clearly fulfilled, affords the moſt convincing evidence of an intimate and ſupernatural communion between

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between God and the person who uttered the prediction. Together with the power of working miracles, it is indeed the only evidence which can be given of such a communion. Hence among the professors of every religious system, except that which is called the religion of nature, there have been numberless pretenders to the gift of prophecy. The Pagan nations of antiquity had their oracles, augurs, and soothsayers. Modern idolaters have their necromancers and diviners; and the Jews, Christians, and Mahometans, have their seers and prophets.

3 The professors of all religions have pretended to it.

The ill-founded pretensions of paganism, ancient and modern, have been exposed under various articles of this work. (See DIVINATION, MAGIC, NECROMANCY, and MYTHOLOGY). And the claims of the Arabian impostor are examined under the articles ALCORAN and MAHOMETANISM; so that at present we have only to consider the use, intent, and truth, of the Jewish and Christian prophecies.

4 The word in Scripture has various meanings.

Previous to our entering on this investigation, it may be proper to observe, that in the Scriptures of the Old and New Testaments, the signification of the word prophecy is not always confined to the foretelling of future events. In several instances it is of the same import with preaching, and denotes the faculty of illustrating and applying to present practical purposes the doctrines of prior revelation. Thus in Nehemiah it is said, "Thou hast appointed prophets to preach *," and whoever speaketh unto men to edification, and exhortation, and comfort, is by St Paul called a *prophet* †. Hence it was that there were schools of prophets in Israel, where young men were instructed in the truths of religion, and fitted to exhort and comfort the people.

* Ch. vi. ver. 7.
† 1 Cor. ch. xiv. ver. 3.

In this article, however, it is chiefly of importance to confine ourselves to that kind of prophecy which, in declaring truths either past, present, or future, required the immediate inspiration of God.

5 Science and religion gradually acquired.

Every one who looks into the history of the world must observe, that the minds of men have from the beginning been gradually opened by a train of events still improving upon, and adding light to each other; as that of each individual is, by proceeding from the first elements and seeds of science, to more enlarged views, and a still higher growth. Mankind neither are nor ever have been capable of entering into the depths of knowledge at once; of receiving a whole system of natural or moral truths together; but must be let into them by degrees, and have them communicated by little and little, as they are able to bear it. That this is the case with respect to human science, is a fact which cannot be questioned; and there is as little room to question it with respect to the progress of religious knowledge among men, either taken collectively or in each individual. Why the case is thus in both, why all are not adult at once in body and mind, is a question which the religion of nature is equally called upon with revelation to answer. The fact may not be easily accounted for, but the reality of it is incontrovertible.

6 The revelations of the Old Testament gradual.

Accordingly, the great object of the several revelations recorded in the Old Testament was evidently to keep alive a sense of religion in the minds of men, and to train them by degrees for the reception of those simple but sublime truths by which they were to be saved. The notions which the early descendants of Adam entertained of the Supreme Being, and of the relation in which they stood to him, were probably very gross; and we see them gradually refined by a series of revelations or prophecies, each in succession more explicit than that by which it was preceded, till the advent of Him who was the way, the truth, and the life, and who brought to light life and immortality.

7 Prophecy always accompanied by miracles,

When a revelation was made of any important truth, the grounds of which the mind of man has not faculties to comprehend, that revelation, though undoubtedly a prophecy, must have been so far from confirming the truth of revealed religion in general, that it could not gain credit itself, but by some extrinsic evidence that it came indeed from God. Hence we find Moses, after it was revealed to him from the burning bush that he should deliver his countrymen from Egyptian bondage, replying, "Behold, they will not believe me, nor hearken to my voice; for they will say, the Lord hath not appeared unto thee." This revelation certainly constituted him a prophet to Israel; and there cannot be a doubt but that he perfectly knew the divine source from which he received it: but he very naturally and reasonably concluded, that the children of Israel would not believe that the Lord had appeared to him, unless he could give them some other proof of this preternatural appearance than his own simple affirmation of its reality. This proof he was immediately enabled to give, by having conferred upon him the power of working miracles in confirmation of his prophecy. Again, when Gideon was called to the deliverance of Israel, the angel of the Lord came and said unto him, "The Lord is with thee, thou mighty man of valour: go in this thy might, and thou shalt save Israel from the hand of the Midianites. Have not I sent thee?" Here was a prophecy delivered by the angel of the Lord to encourage Gideon's undertaking: but he, being probably afraid of some illusion of sense or imagination, demanded a sign that he was really an angel who talked with him. A sign is accordingly given him, a miraculous sign, with which he is satisfied, and undertakes the work appointed him.

8 and of itself can be no proof of a revelation.

From these and many similar transactions recorded in the Old Testament, it appears that prophecy was never intended as evidence of an original revelation. It is indeed, by its very nature, totally unfit for such a purpose; because it is impossible, without some extrinsic proof of its divine origin, to know whether any prophecy be true or false, till the era arrive at which it ought to be fulfilled. When it is fulfilled, it affords complete evidence that he who uttered it spake by the spirit of God, and that the doctrines which he taught of a religious nature, were all either dictated by the same spirit, or at least are true, and calculated to direct mankind in the way of their duty.

9 It was intended to preserve a sense of religion among men.

The prophecies vouchsafed to the patriarchs in the most early periods of the world, were all intended to keep alive in their minds a sense of religion, and to direct their views to the future completion of that first and greatest prophecy which was made to Adam immediately on his fall: but in order to secure credit to those prophecies themselves, they were always accompanied by some miraculous sign that they were indeed given by the God of truth, and not the delusions of fanaticism or hypocrisy. Prophecy, in the proper sense of the word, commenced with the fall; and the first instance of it is implied in the sentence denounced upon the

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the original deceiver of mankind; "I will put enmity between thee and the woman, and between thy feed and her feed: It fhall bruife thy head, and thou fhalt bruife his heel."

10 Probable effects of the firft prophecy on our firft parents.

This prophecy, though one of the moft important that ever was delivered, when confidered by itfelf, is exceedingly obfcure. That Adam fhould have underftood it, as fome of his degenerate fons have pretended to do, in a literal fenfe, is abfolutely impoffible. He knew well that it was the great God of heaven and earth who was fpeaking, and that fuch a Being was incapable of trifling with the wretchednefs of his fallen creature. The fentence denounced upon himfelf and his wife was awful and fevere. The woman was doomed to forrow in conception; the man to forrow and travel all the days of his life. The ground was curfed for his fake; and the end of the judgement was, "Duft thou art, and to duft thou fhalt return." Had our firft parents been thus left, they muft have looked upon themfelves as rejected by their Maker, delivered up to trouble and forrow in the world, and as having no hope in any other. With fuch impreffions on their minds they could have retained no fenfe of religion; for religion, when unaccompanied by hope, is a ftate of frenzy and diftraction: yet it is certain that they could have no hope from any thing exprefsly recorded by Mofes, except what they might draw from this fentence paffed on their deceiver. Let us then endeavour to afcertain what confolation it could afford them.

At that awful juncture, they muft have been fenfible that their fall was the victory of the ferpent, whom by experience they had found to be an enemy to God and to man. It could not therefore but be fome comfort to them to hear this enemy firft condemned, and to fee that, however he had prevailed againft them, he had gained no victory over their Maker. By his condemnation they were fecured from thinking that there was any malignant being equal to the Creator in power and dominion; an opinion which, through the prevalency of evil, gained ground in after times, and was deftructive of all true religion. The belief of God's fupreme dominion being thus preferved, it was ftill neceffary to give them fuch hopes as might induce them to love as well as to fear him; and thefe they could not but conceive when they heard from the mouth of their Creator and Judge, that the ferpent's victory was not complete even over themfelves; that they and their pofterity fhould be enabled to conteft his empire; and that though they were to fuffer much in the ftruggle, they fhould yet finally prevail, bruife the ferpent's head, and deliver themfelves from his power and dominion.

This prophecy therefore was to our firft parents a light fhining in a dark place. All that they could certainly conclude from it was, that their cafe was not defperate; that fome remedy, fome deliverance from the evil they were under, would in time appear; but *when* or *where*, or by *what means* they were to be delivered, they could not poffibly underftand, unlefs the matter was further revealed to them, as probably it was at the inftitution of facrifice (See SACRIFICE). Obfcure, however, as this promife or prophecy was, it ferved after the fall as a foundation for religion, and truft and confidence towards God in hopes of deliverance in time from the evils of difobedience: and this appears to have been the fole purpofe for which it was given, and not, as fome well-meaning though weak advocates for Chriftianity have imagined, as a prediction pointing *directly* to the crofs of Chrift.

As this prophecy was the firft, fo is it the only confiderable one in which we have any concern from the creation to the days of Noah. It was proportioned to the then wants and neceffities of the world, and was the grand charter of God's mercy after the fall. Nature had no certain help for finners; her rights were loft with her innocence. It was therefore neceffary either to deftroy the offenders, or to raife them to a capacity of falvation, by given them fuch hopes as might enable them to exercife a reafonable religion. So far the light of this prophecy extended. By what *means* God intended to work their falvation, he did not exprefsly declare: and who has a right to complain that he did not, or to prefcribe to him rules in difpenfing his mercy to the children of men?

Upon the hopes of mercy which this prophecy gives in very general terms, mankind refted till the birth of Noah. At that period a new prophecy was delivered by Lamech, who foretels that his fon fhould comfort them concerning the work and toil of their hands, "becaufe of the *earth which the Lord had curfed*." We are to remember that the curfe pronounced upon the earth was part of the fentence paffed upon our firft parents; and when that part was remitted, if it ever was remitted, mankind would acquire new and more lively hopes that in God's good time they fhould be freed from the whole. But it has been fhown by Bifhop Sherlock*, that this declaration of Lamech's was a prediction, that during the life of his fon the curfe fhould be taken off from the earth: and the fame prelate has proved with great perfpicuity, and in the moft fatisfactory manner, that this happy revolution actually took place after the flood. The limits prefcribed to an article of this kind will not permit us even to abridge his arguments. We fhall only obferve, that the truth of his conclufion is manifeft from the very words of fcripture; for when God informs Noah of his defign to deftroy the world, he adds, "But with thee will I eftablifh my covenant:" and as foon as the deluge was over, he declared that he "would not again curfe the ground any more for man's fake; but that while the earth fhould remain, feed-time and harveft, and cold and heat, and fummer and winter, and day and night, fhould not ceafe." From this laft declaration it is apparent that a curfe *had* been on the earth, and that feed-time and harveft had often failed; that the curfe was now taken off; and that in confequence of this covenant, as it is called, with Noah and his feed and with every living creature, mankind fhould not henceforth be fubjected to toil fo fevere and fo generally fruitlefs. 11 The curfe removed from the ground.

* *Ufe and Intent of Prophecy.*

It may feem furprifing perhaps to fome, that after fo great a revolution in the world as the deluge made, God fhould fay nothing to the remnant of mankind of the punifhments and rewards of another life, but fhould make a new covenant with them relating merely to fruitful feafons and the bleffings of the earth. But in the fcriptures we fee plainly a gradual working of providence towards the redemption of the world from the curfe of the fall; that the temporal bleffings were firft reftored as an earneft and pledge of better things to follow; and that the covenant given to Noah had, ftrictly fpeaking, nothing to do with the hopes of futurity, 12 A future life not then explicitly revealed.

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Upon this assurance mankind rested for some generations, and practised, as we have every reason to believe, a rational worship to the one God of the universe. At last, however, idolatry was by some means or other introduced (see POLYTHEISM), and spread so universally through the world, that true religion would in all probability have entirely failed, had not God visibly interposed to preserve such a sense of it as was necessary for the accomplishment of his great design to restore mankind. This he did by calling Abraham from amidst his idolatrous kindred, and renewing to him the word of prophecy: "Get thee out of thy country (said he), and from thy kindred, and from thy father's house, unto a land that I will shew thee. And I will make of thee a great nation, and I will bless thee and make thy name great; and thou shalt be a blessing. And I will bless them that bless thee, and curse him that curseth thee; and in thee shall all the families of the earth be blessed." These magnificent promises are several times repeated to the father of the faithful with additional circumstances of great importance, such as, "that he should be multiplied exceedingly; that he should be a father of many nations; that kings should come out of him;" and above all, that God would establish an *everlasting covenant* with him and his feed, to give him and them all the land of Canaan for an *everlasting possession*, and to be *their God*."

13 Promise to Abraham.

Upon such of these promises as relate to temporal blessings we need not dwell. They are much of the same nature with those which had been given before to Lamech, Noah, Shem, and Japheth; and all the world knows how amply and literally they have been fulfilled. There was however so little probability in nature of their accomplishment at the time when they were made, that we find the patriarch asking "Whereby he should *know* † that he should inherit such an extent of country?" And as the promises that he should inherit it were meant to be a foundation for religion and confidence in God, a miraculous sign was given him that they came indeed from the spirit of truth. This removed from his mind every doubt, and made him give the fullest credit, not only to them, but also to that other promise, "that in his seed should all the nations of the earth be blessed."

† Genesis xv. 8. &c.

What distinct notion he had of this blessing, or in what manner he hoped it should be effected, we cannot pretend to say. "But that he understood it to be a promise of restoring mankind, and delivering them from the remaining curse of the fall, there can be no doubt. He knew that death had entered by sin; he knew that God had promised victory and redemption to the seed of the woman. Upon the hopes of this restoration the religion of his ancestors was founded; and when God, from whom this blessing on all men was expected, did expresly promise a blessing on all men, and in this promise founded his everlasting covenant—what could Abraham else expect but the completion in his seed of that ancient promise and prophecy concerning the victory to be obtained by the woman's seed? The curse of the ground was expiated in the flood, and the earth restored with a blessing, which was the foundation of the temporal covenant with Noah; a large share of which God expresly grants to Abraham and his posterity particularly, together with a promise to bring, by their means, a new and further blessing upon the whole race of men. If we lay these things to heart, we cannot suppose that less could be expected from the new promise or prophecy given to Abraham than a deliverance from that part of the curse still remaining on men: *Dust thou art, and to dust thou shalt return.* In virtue of this covenant Abraham and his posterity had reason to expect that the time would come when man should be called from his dust again. For this expectation they had his assurance who gave the covenant, that he would be their God for ever. Well might our Saviour then tell the sons of Abraham, that even Moses at the bush showed the resurrection of the dead, when he called the Lord the God of Abraham, and the God of Isaac, and the God of Jacob *."

* Sherlock's *Use and Intent of Prophecy.*

These promises made to Abraham were renewed to Isaac and Jacob; to the last of whom it was revealed, not only that all the nations of the earth should be blessed in his seed, but that the blessing should spring from his son Judah. It is, however, by no means evident that any one of those patriarchs knew precisely by what *means* (A) the curse of the fall was to be entirely removed, and all men called from their dust again. It was enough that they were convinced of the fact in general terms, since such conviction was a sufficient foundation of a rational religion; and the descendants of Abraham had no other foundation upon which to rest their

14 To Isaac and Jacob.

(A) This they certainly could not know from the promises expressed in the very general terms in which they are recorded in the book of Genesis. It is, however, not improbable that those promises, as they immediately received them, were conceived in terms more precise and particular; and, at all events, Dr Warburton has proved to the full conviction of every man who is not a determined unbeliever, that Abraham was commanded to sacrifice his son Isaac, not only as a trial of his obedience, but also that God might give him what he earnestly desired, a scenical representation of the means by which mankind were to be redeemed from death. The learned writer thinks, and his reasoning compels us to think with him, that to this transaction our Saviour alludes when he says, "Your father Abraham rejoiced to see my *day*, and he saw it and was glad."

their hopes, and pay a cheerful worſhip to the God of their fathers, till the giving of the law to Moſes. Then indeed they were incorporated into a ſociety with municipal laws of their own, and placed under a theocratic government; the temporal promiſes made to their fathers were amply fulfilled; religion was maintained among them by rewards and puniſhments equally diſtributed in this world (ſee THEOLOGY): and a ſeries of prophets ſucceeding one another pointed out with greater and greater clearneſs, as the fulneſs of time approached, the perſon who was to redeem mankind from the power of death; by what means he was to work that great redemption, and at what preciſe period he was to make his appearance in the world. By theſe ſupernatural interpoſitions of divine providence, the principles of pure theiſm and the practice of true religion were preſerved among the children of Iſrael, when all other nations were ſunk in the groſſeſt idolatry, and wallowed in the moſt abominable vices; when the far-famed Egyptians, Greeks, and Romans, fell down with adoration to ſtocks and ſtones and the vileſt reptiles; and when they had no well-grounded hope of another life, and were in fact without God in the world.

15 The law of Moſes and the ſucceeding prophets.

16 Were all intended to keep alive a ſenſe of religion.

From this ſhort deduction, we think ourſelves intitled to conclude, that the *primary* uſe and intent of prophecy, under the various diſpenſations of the Old Teſtament, was not, as is too often ſuppoſed, to eſtabliſh the divine miſſion of Jeſus Chriſt, but to keep alive in the minds of thoſe to whom it was given, a ſenſe of religion, and a hope of future deliverance from the curſe of the fall. It was, in the expreſſive language of St Peter, "a light that ſhone in a dark place, unto which men did well to take heed until the day dawned and the day-ſtar aroſe in their hearts." But though this was certainly the original intent of prophecy (for Chriſt, had he never been foretold, would have proved himſelf to be the ſon of God with power by his aſtoniſhing miracles, and his reſurrection from the dead), yet it cannot be denied, that a long ſeries of prophecies, given in different and far diſtant ages, and having all their completion in the life, death, and reſurrection, of Jeſus, concur very forcibly with the evidence of miracles to prove that he was the ſeed of the woman ordained to bruiſe the head of the ſerpent, and reſtore man to his forfeited inheritance. To the Jews the force of this evidence muſt have been equal, if not ſuperior, to that of miracles themſelves; and therefore we find the Apoſtles and firſt preachers of the goſpel, in their addreſſes to them, conſtantly appealing to the law and the prophets, whilſt they urged upon the Gentiles the evidence of miracles.

17 The prophecies to be conſidered in connection.

In order to form a right judgement of the argument for the truth of Chriſtianity drawn from the ſure word of prophecy, we muſt not conſider the prophecies given in the Old Teſtament as ſo many *predictions* only independent of each other; for if we do, we ſhall totally loſe ſight of the purpoſe for which they were originally given, and ſhall never be able to ſatiſfy ourſelves when confronted by the objections of unbelievers. It is eaſy for men of leiſure and tolerable parts to find difficulties in particular predictions, and in the application of them made by writers, who lived many hundred years ago, and who had many ancient books and records of the Jewiſh church, from which they drew many paſſages, and perhaps ſome prophecies; which books and records we have not to enable us to underſtand, and to juſtify their applications. But it is not ſo eaſy a matter to ſhow, or to perſuade the world to believe, that a chain of prophecies reaching through ſeveral thouſand years, delivered at different times, yet manifeſtly ſubſervient to one and the ſame adminiſtration of providence from beginning to end, is the effect of art and contrivance and religious fraud. In examining the ſeveral prophecies recorded in the Old Teſtament, we are not to ſuppoſe that each of them *expreſsly* pointed out and *clearly* characterized Jeſus Chriſt. Had they done ſo, inſtead of being a ſupport to religion in general, the purpoſe for which they were originally intended, they would have had a very different effect, by making thoſe to whom they were given repine at being placed under diſpenſations ſo very inferior to that of the goſpel. We are therefore to inquire only whether all the notices, which, in general and often metaphorical terms, God gave to the fathers of his intended ſalvation, are perfectly anſwered by the coming of Chriſt; and we ſhall find that nothing has been promiſed with reſpect to that ſubject which has not been performed in the ampleſt manner. If we examine the prophecies in this manner, we ſhall find that there is not one of them, which the Apoſtles have applied to the Meſſiah, that is not applicable in a rational and important ſenſe to ſomething in the birth, life, preaching, death, reſurrection, and aſcenſion of Jeſus of Nazareth; that as applied to him they are all conſiſtent with each other; and that though ſome few of them may be applied without abſurdity to perſons and events under the Jewiſh diſpenſation, Chriſt is the only perſon that ever exiſted in whom they all meet as in a centre. In the limits preſcribed us, it is impoſſible that we ſhould enter upon a particular proof of this poſition. It has been proved by numberleſs writers, and, with reſpect to the moſt important prophecies, by none with greater ſucceſs than Biſhop Sherlock in his Uſe and Intent of Prophecy in the ſeveral ages of the World; a work which we recommend to our readers as one of the moſt valuable on the ſubject in our own or any other language.

18 Objection from the obſcurity of propheсy.

But admitting that it would have been improper, for the reaſons already hinted at, to have given a clear and preciſe deſcription of Chriſt, and the Chriſtian diſpenſation, to men who were ordained to live under diſpenſations leſs perfect, how, it may be aſked, comes it to paſs that many of the prophecies applied by the writers of the goſpel to our Saviour and his actions are ſtill dark and obſcure, and ſo far from belonging evidently to him and to him only, that it requires much learning and ſagacity to ſhow even now the connection between ſome prophecies and the events?

19 Anſwered.

In anſwer to theſe queſtions, the learned prelate juſt referred to obſerves, "That the obſcurity of prophecy does not ariſe from hence, that it is a relation or deſcription of ſomething *future*; for it is as eaſy to ſpeak of things future plainly, and intelligibly, as it is of things paſt or preſent. It is not, therefore, of the nature of prophecy to be obſcure; for it may eaſily be made, when he who gives it thinks fit, as plain as hiſtory. On the other ſide, a figurative and dark deſcription of a future event will be figurative and dark ſtill when the event happens; and conſequently will have all the obſcurity of a figurative and dark deſcription as well after as before the event. The prophet Iſaiah deſcribes the peace

peace of Chriſt's kingdom in the following manner: 'The wolf ſhall dwell with the lamb, and the leopard ſhall lie down with the kid, and the calf and the young lion, and the fatling, together, and a little child ſhall lead them.' Nobody, ſome modern Jews excepted, ever underſtood this literally; nor can it now be *literally* applied to the ſtate of the goſpel. It was and is capable of different interpretations: it may mean temporal peace, or that internal and ſpiritual peace—that tranquillity of mind, which ſets a man at peace with God, himſelf, and the world. But whatever the true meaning is, this prophecy does no more obtrude one determinate ſenſe upon the mind ſince the coming of Chriſt than it did before. But then we ſay, the ſtate of the goſpel was very properly prefigured in this deſcription, and is as properly prefigured in a hundred more of the like kind; and ſince they all agree in a fair application to the ſtate of the goſpel, we ſtrongly conclude, that this ſtate was the thing foretold under ſuch expreſſions. So that the argument from prophecy for the truth of Chriſtianity does not reſt on this, that the event has neceſſarily limited and aſcertained the particular ſenſe and meaning of every prophecy; but in this, that every prophecy has in a proper ſenſe been completed by the coming of Chriſt. It is abſurd, therefore, to expect clear and evident conviction from every ſingle prophecy applied to Chriſt; the evidence muſt ariſe from a view and compariſon of all together." It is doubtleſs a great miſtake to ſuppoſe that prophecy was intended ſolely or chiefly for their ſakes in whoſe time the events predicted are to happen. What great occaſion is there to lay in ſo long beforehand the evidence of prophecy to convince men of things that are to happen in their own times; the truth of which they may, if they pleaſe, learn from their own ſenſes? Yet ſome people are apt to talk as if they thought the truth of the events predicted depended very much on the evidence of prophecy: they ſpeak, for inſtance, as if they imagined the certainty and reality of our Saviour's reſurrection were much concerned in the clearneſs of the prophecies relating to that great and wonderful event, and ſeem to think that they are confuting the truth of his reſurrection when they are pointing out the abſurdity of the prophecies relating to it. But can any thing be more abſurd? For what ground or pretence is there to inquire whether the prophecies foretelling that the Meſſiah ſhould die and riſe again do truly belong to Chriſt, unleſs we are firſt ſatisfied that Chriſt died and roſe again?

The part which unbelievers ought to take in this queſtion, if they would make any uſe of prophecy, ſhould be, to ſhow from the prophets that Chriſt was neceſſarily to riſe from the dead; and then to prove that in fact Jeſus never did riſe. Here would be a plain conſequence. But if they like not this method, they ought to let the prophecies alone; for if Chriſt did not riſe, there is no harm done though the prophets have not foretold it. And if they allow the reſurrection of Chriſt, what do they gain by diſcrediting the prophets? The event will be what it is, let the prophecies be what they will.

Theſe conſiderations ſhow how far the goſpel is *neceſſarily* concerned in prophetical evidence, and how clear the prophecies ſhould be. Chriſt claims to be the perſon foretold in the law and the prophets; and as truth muſt ever be conſiſtent with itſelf, this claim muſt be true as well as all others. This is the part then to be tried on the evidence of prophecy: Is Chriſt that perſon deſcribed and foretold under the Old Teſtament or not? Whether all the prophecies relating to him be plain or not plain, it matters little; the ſingle queſtion is, Are there enough plain to ſhow us that Chriſt is the perſon foretold under the Old Teſtament? If there be, we are at an end of our inquiry, and want no farther help from prophecy; eſpecially ſince we have ſeen the day dawn and enjoyed the marvellous light of the goſpel of God.

20
Objections from the clearneſs of ſome prophecies,

But ſo unreaſonable are unbelievers, that whilſt ſome of them object to the obſcurity of the prophecies, others have rejected them altogether on account of their clearneſs, pretending that they are hiſtories and not predictions. The prophecies againſt which this objection has been chiefly urged are thoſe of Daniel, which were firſt called in queſtion by the famous Porphyry. He affirmed that they were not compoſed by Daniel, whoſe name they bear, but by ſome author who lived in Judea about the time of Antiochus Epiphanes; becauſe all to that time contained true hiſtory, but that all the facts beyond that were manifeſtly falſe.

21
anſwered,

This method of oppoſing the prophecies, as a father of the church rightly obſerves, is the ſtrongeſt teſtimony of their truth: for they are ſo exactly fulfilled, that to infidels the prophet ſeemed not to have foretold things future, but to have related things paſt. To an infidel of this age, if he has the ſame ability and knowledge of hiſtory that Porphyry had, all the ſubſequent prophecies of Daniel, except thoſe which are ſtill fulfilling, would appear to be hiſtory and not prophecy; for it entirely overthrows the notion of their being written in the days of *Antiochus Epiphanes*, or of the *Maccabees*, and eſtabliſhes the credit of Daniel as a prophet beyond contradiction, that there are ſeveral of thoſe prophecies which have been fulfilled ſince that period as well as before; nay, that there are prophecies of Daniel which are fulfilling at this very time in the world.

22
from what has happened ſince the objection was firſt ſtarted,

Our limits will not permit us to enter into the objections which have been made to this prophet by the author of The Literal Scheme of Prophecy conſidered; nor is there occaſion that we ſhould enter into them. They have been all examined and completely anſwered by Biſhop Chandler in his Vindication of his Defence of Chriſtianity, by Mr Samuel Chandler in his Vindication of the Antiquity and Authority of Daniel's Prophecies, and by Biſhop Newton in his excellent Diſſertations on the Prophecies. To theſe authors we refer the reader; and ſhall conclude the preſent article with a view of ſome prophecies given in very remote ages, which are in this age receiving their accompliſhment.

23
and from facts of the preſent age.

Of theſe the firſt is that of Noah concerning the ſervitude of the poſterity of Canaan. In the greater part of original manuſcripts, and in our verſion of the holy ſcriptures, this prophecy is thus expreſſed: "Curſed be Canaan; a ſervant of ſervants ſhall he be unto his brethren:" but in the Arabic verſion, and in ſome copies of the Septuagint, it is, "Curſed be *Ham* the father of Canaan; a ſervant of ſervants ſhall he be to his brethren." Whether the curſe was really pronounced upon Ham, which we think moſt probable, or only upon his ſon Canaan, we ſhall find the prediction remarkably

ably fulfilled, not barely ages after the book of Genefis was very generally known, but alfo at this very day. It is needlefs to inform any man who has but looked into the Old Teftament, that when the ancient patriarchs pronounced either a curfe or a bleffing upon any of their fons, they meant to declare the future fortunes, not of that fon individually, but of his defcendants as a tribe or a nation. Let us keep this in mind, and proceed to compare with Noah's prophecy *firft* the fortunes of the defcendants of Canaan, the fourth fon of Ham, and then the fortunes of the pofterity of Ham by his other fons.

With the fate of the Canaanites every reader is acquainted. They were conquered by Jofhua feveral centuries after the delivery of this prophecy; and fuch of them as were not exterminated were by him and Solomon reduced to a ftate of the loweft fervitude to the Ifraelites, the pofterity of Shem the brother of Ham. The Greeks and Romans, too, who were the defcendants of Japheth, not only fubdued Syria and Paleftine, but alfo purfued and conquered fuch of the Canaanites as were anywhere remaining, as for inftance the Tyrians and Carthaginians, of whom the former were ruined by Alexander and the Grecians, and the latter by Scipio and the Romans. Nor did the effects of the curfe ftop there. The miferable remainder of that devoted people have been ever fince flaves to a foreign yoke; firft to the Saracens who are defcended from Shem, and afterwards to the Turks who are defcended from Japheth; and under the Turkifh dominion they groan at this day.

If we take the prophecy as it ftands in the Arabic verfion, its accomplifhment is ftill more remarkable. The whole continent of Africa was peopled principally by the pofterity of Ham. And for how many ages have the better parts of that country lain under the dominion firft of the Romans, then of the Saracens, and now of the Turks? In what wickednefs, ignorance, barbarity, flavery, and mifery, live moft of its inhabitants? and of the poor negroes how many thoufands are every year fold and bought like beafts in the market, and conveyed from one quarter of the world to do the work of beafts in another; to the full accomplifhment indeed of the prophecy, but to the lafting difgrace of thofe who are from the love of gain the inftruments of fulfilling it. Nothing can be more complete than the execution of the fentence as well upon Ham as upon Canaan; and the hardieft infidel will not dare to fay that it was pronounced after the event.

The next prophecy which we fhall notice is that of Abraham concerning the multitude of his defcendants; which every one knows is ftill fulfilled in the Jews even in their difperfed ftate, and therefore cannot have been given after the event of which it fpeaks.

Of the fame kind are the feveral prophecies concerning Ifhmael; of which fome have been fulfilled, and others are at prefent fulfilling in the moft aftonifhing manner. Of this fon of Abraham it was foretold, that "he fhould be a wild man; that his hand fhould be againft every man, and every man's hand againft him; that he fhould dwell in the prefence of all his brethren; that he fhould be multiplied exceedingly, beget twelve princes, and become a great nation." The facred hiftorian who records thefe prophecies adds, that "God was with the lad, and he grew, and dwelt in the wildernefs, and became an archer."

To fhow how fully and literally all thefe prophecies have been accomplifhed, would require more room than we have to beftow; and to the reader of hiftory the labour would be fuperfluous. We fhall therefore only requeft the unbeliever to attend to the hiftory of the Arabs, the undoubted defcendants of Ifhmael; and to fay how it comes to pafs, that though they have been robbers by land and pirates by fea for time immemorial, though their hands have been againft every man, and every man's hand againft them, they always have dwelt, and at this day dwell, in the prefence of their brethren, a free and independent people. It cannot be pretended that no attempt has ever been made to conquer them; for the greateft conquerors in the world have all in their turns attempted it: but though fome of them made great progrefs, not one was ever crowned with fuccefs. It cannot be pretended that the inacceffiblenefs of their country has been their protection; for their country has been often penetrated, though it never was entirely fubdued. When in all human probability they have been on the brink of ruin, they were fignally and providentially delivered. Alexander was preparing an expedition againft them, when he was cut off in the flower of his age. Pompey was in the career of his conquefts when urgent affairs called him elfewhere. Ælius Gallus had penetrated far into their country, when a fatal difeafe deftroyed great numbers of his men, and obliged him to return. Trajan befieged their capital city, but was defeated by thunder and lightning and whirlwinds. Severus befieged the fame city twice, and was twice repelled from before it. The Turks, though they were able to wreft from them their foreign conquefts, have been fo little able to fubdue the Arabs themfelves, or even to reftrain their depredations, that they are obliged to pay them a fort of annual tribute for the fafe paffage of the pilgrims who go to Mecca to pay their devotions. On thefe facts we fhall not exclaim. He who is not ftruck upon comparing the fimple hiftory of this fingular people with the prophecies fo long ago delivered of them and their great anceftor, whofe love of liberty is compared to that of the wild afs, would rife wholly unmoved from our exclamations.

24 The difperfion of the Jews plainly foretold,

A fourth prophecy of this kind, which cannot be alleged to have been uttered after the event, is the denunciation of Mofes againft the children of Ifrael in cafe of their difobedience; which is fo literally fulfilled, that even at this moment it appears rather a hiftory of the prefent ftate of the Jews, than a remote prediction of their apoftafy and punifhment. "And the Lord fhall fcatter thee among all people from the one end of the earth even unto the other. And among thefe nations fhalt thou find no eafe, neither fhall the fole of thy foot have reft; but the Lord fhall give thee there a trembling heart and failing of eyes, and forrow of mind. And thy life fhall hang in doubt before thee; and thou fhalt fear day and night, and fhalt have none affurance of thy life," (Deut. xxviii. 64, 65, 66.). "And thou fhalt become an aftonifhment, a proverb, and a bye-word, among all nations, whither the Lord fhall lead you." (Deut. xxviii. 37.).

Similar to this denunciation, but attended with fome circumftances ftill more wonderful, is the following prediction of the prophet Hofea: "The children of Ifrael fhall abide many days without a king, and without a prince, and without a facrifice, and without an image,

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and without an ephod, and without teraphim. Afterwards ſhall the children of Iſrael return, and ſeek the Lord their God, and David their king; and ſhall fear the Lord and his goodneſs in the latter days (B)." In this paſſage we find the ſtate of the Jews for the laſt 1700 years clearly and diſtinctly deſcribed with all its circumſtances. From the time that they rejected their Meſſiah all things began to work towards the deſtruction of their politics both civil and religious; and within a few years from his death, their city, temple, and government, were utterly ruined; and they themſelves not carried into a gentle captivity, to enjoy their laws, and live under governors of their own, as they did in Babylon, but they were ſold like beaſts in a market, and became ſlaves in the ſtricteſt ſenſe; and from that day to this have had neither prince nor chief among them. Nor will any one of them ever be able, after all their pretences, to prove his deſcent from Aaron, or to ſay with certainty whether he is of the tribe of Judah or of the tribe of Levi, till he ſhall diſcover that unknown country where never mankind dwelt, and where the apocryphal Eſdras has placed their brethren of the ten tribes. This being the caſe, it is impoſſible they can have either an altar, or a ſacrifice, or a prieſthood, according to the inſtitution of Moſes, but are evidently an outcaſt people living under laws which cannot be fulfilled.

25 and the cauſe of it.

The cauſe of this deplorable condition is likewiſe aſſigned with the ſame perſpicuity: They are ſcattered over the face of the earth, becauſe they do not acknowledge Chriſt for the Meſſiah; becauſe they do not ſubmit to their own king, the true David. In the prophetic writings the name of David is frequently given to the Meſſiah, who was to deſcend from that prince. Thus Ezekiel, ſpeaking of the kingdom of Chriſt, ſays, "I will ſet up one Shepherd over them, and he ſhall feed them, even my ſervant David; he ſhall feed them, and he ſhall be their ſhepherd." And Jeremiah ſays, "They ſhall ſerve the Lord their God, and David their king, whom I will raiſe up unto them."

That in theſe places, as well as in the paſſage under conſideration, the Meſſiah is meant, is undeniable; for David the ſon of Jeſſe was dead long before any of the three prophets was born; and by none of them it is ſaid, "afterwards David their king ſhall come again;" but "afterwards the children of Iſrael *ſhall* return to David their king," they ſhall recover from their blind infatuation, and ſeek him whom they have not yet known. By their not receiving Jeſus for their Chriſt, they have forfeited all claim to the divine favour, and are, of conſequence, "without a king, and without a chief, and without a ſacrifice, and without an altar, and without a prieſthood."

26 Their return alſo foretold.

The time, however, will come, when they ſhall return and ſeek "the Lord their God and David their king;" when they ſhall tremble before him whom their fathers crucified, and honour the ſon even as they honour the father. That this part of the prophecy will in time be as completely fulfilled as the other has been, may be confidently expected from the wonderful preſervation of the Jews for ſo many ages. Scattered as they are over the whole earth, and hated as they are by all nations, it might naturally be thought, that in proceſs of time they would have coaleſced with their conquerors, and have been ultimately abſorbed and annihilated by their union, ſo that no trace of them ſhould now have remained; yet the fact is, that, diſperſed as they have ever ſince been over the whole face of the globe, they have never, in a ſingle inſtance, in any country, loſt their religious or natural diſtinctions; and they are now generally ſuppoſed to be as numerous as they were under the reigns of David and Solomon. This is contrary to all hiſtory, and all experience of the courſe of human affairs in ſimilar caſes; it has been boldly and juſtly ſtyled a ſtanding miracle. Within 1000 or 1200 years back, a great variety of extraordinary and important revolutions have taken place among the nations of Europe. In the ſouthern part of this iſland the Britons were conquered by the Saxons, the Saxons by the Danes, and the Danes and Saxons by the Normans; but in a few centuries theſe oppoſite and hoſtile nations were conſolidated into one indiſtinguiſhable maſs. Italy, about the ſame time that Britain was ſubdued by the Saxons, was conquered by the Goths and Vandals: and it is not eaſy to conceive a more ſtriking contraſt than that which ſubſiſted between the poliſhed inhabitants of that delightful country and their ſavage invaders; and yet how ſoon did all diſtinction ceaſe between them! In France, the Roman colonies gradually aſſimilated with the ancient Gauls; and in Spain, though the Moors continued for ſeveral ages, and till their final expulſion, a diſtinct people, yet after they were once reduced to a ſtate of ſubjection, their numbers very ſenſibly diminiſhed; and ſuch of them as were ſuffered to remain after their laſt overthrow have been long ſince ſo blended with the Spaniards that they cannot now be diſtinguiſhed. But with regard to the Jews, the wonder is, that though they do not in any country where they are ſettled bear any proportion to the natural inhabitants, though they are univerſally reduced to a ſtate of the loweſt ſubjection, and even expoſed to hatred, contempt, and perſecution; yet in no inſtance does there ſeem to be the leaſt appearance or probability of their numbers being diminiſhed, in no inſtance do they diſcover any decay of attachment to their religious principles. Whence then comes it that this people alone, who, having no form of government or a republic anywhere ſubſiſting, are without the means by which other people are kept united and diſtinct, ſhould ſtill be preſerved amongſt ſo many different nations? How comes it, when they have been thus ſcattered into ſo many diſtant corners, like duſt which cannot be perceived, that they ſhould ſtill ſo long ſurvive the diſſolution of their own ſtate, as well as that of ſo many others? To theſe queſtions the anſwer is obvious: They are

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(B) Such is our tranſlation of this remarkable prophecy; but the Greek verſion of the Seventy has it, perhaps more properly, thus: "The children of Iſrael ſhall abide many days without a king, and without a chief, and without a ſacrifice, and without an altar, and without a prieſthood, and without a prophecies. Afterwards,' &c.

are preferved, that, as a nation, "they may return and feek the Lord their God and David their king, and fear the Lord and his goodnefs in the latter days."

27 Of prophecies refpecting the Chriftian church.

We might here fubjoin many prophecies both from the Old and the New Teftament, and efpecially from the writings of St Paul and St John, which fo clearly defcribe the various fortunes of the Chriftian church, her progrefs to that ftate of general corruption under which fhe was funk three centuries ago, and her gradual reftoration to her primitive purity, that they cannot be fuppofed to proceed from the cunning craftinefs of men, or to have been written after the events of which they fpeak. To do juftice to thefe, however, would require a volume, and many excellent volumes have been written upon them. The reader who wifhes for fatisfaction on fo interefting a fubject will do well to confult the writings of Mr Mede and Sir Ifaac Newton, together with Bifhop Newton's Differtations, and the Sermons of Hurd, Halifax, and Bagot, preached at Warburton's lecture. We fhall only obferve, that one of the ableft reafoners that Great Britain ever produced, after having paid the clofeft attention to the predictions of the New Teftament, hath been bold enough to put the truth of revealed religion itfelf upon the reality of that prophetic fpirit which foretold the defolation of Chrift's church and kingdom by antichrift. "If (fays he), IN THE DAYS OF ST PAUL AND ST JOHN, there was any footftep of fuch a fort of power as this in the world; or if there HAD BEEN any fuch power in the world; or if there WAS THEN any appearance or probability that could make it enter into the heart of man to imagine that there EVER COULD BE any fuch kind of power in the world, much lefs in the *temple* or *church of God;* and if there be not NOW fuch a power actually and confpicuoufly exercifed in the world; and if any picture of this power. DRAWN AFTER THE EVENT, can now defcribe it more plainly and exactly than it was originally defcribed in the words of the prophecy—then may it, with fome degree of plaufibility, be fuggefted, that the prophecies are nothing more than enthufiaftic imaginations."

Upon the whole, we conclude with Bifhop Sherlock, that the various prophecies recorded in the Holy Scriptures were given, not to enable man to forefee with clearnefs future events, but to fupport the feveral difpenfations of religion under which they were refpectively promulgated. The principal prophecies recorded in the Old Teftament led mankind to hope for a complete deliverance from the curfe of the fall; and therefore tended to fill their minds with gratitude, and to enforce a cheerful obedience to that God who in the midft of judgement remembereth mercy. The prophecies, whether in the Old or New Teftament, that pourtray the prefent ftate of the Jews, and the various fortunes of the Chriftian church, as they are daily fulfilling in the prefence of all men, are the ftrongeft poffible proof of the divinity of our holy religion, and fupply to us in the latter days the place of miracles, by which it was at firft eftablifhed.

PROPHET, in general, a perfon who foretels future events; but is particularly applied to fuch infpired perfons among the Jews as were commiffioned by God to declare his will and purpofes to that people. Among the canonical books of the Old Teftament we have the writings of 16 prophets, four of whom are denominated

the *greater prophets*, viz. Ifaiah, Jeremiah, Ezekiel, and Daniel; fo called from the length and extent of their writings, which exceed thofe of the others, viz. Hofea, Joel, Amos, Obadiah, Jonah, Micah, Nahum, Habakkuk, Haggai, Zechariah, and Malachi, who are called the *leffer prophets*, from the fhortnefs of their writings. The Jews do not place Daniel among the prophets, becaufe, they fay, he lived the life of a courtier rather than that of a prophet. An account of the feveral writings of the prophets may be feen each under its particular head. See the article ISAIAH, &c.

Sons of the PROPHETS, in fcripture hiftory, an appellation given to young men who were educated in the fchools or colleges under a proper mafter, who was commonly, if not always, an infpired prophet, in the knowledge of religion and in facred mufic, and thus were qualified to be public preachers; which feems to have been part of the bufinefs of the prophets on the Sabbath days and feftivals. It is probable that God generally chofe the prophets, whom he infpired, out of thefe fchools. See PROPHECY.

PROPITIATION, in *Theology*, a facrifice offered to God to affuage his wrath and render him propitious. Among the Jews there were both ordinary and public facrifices, as holocaufts, &c. offered by way of thankfgiving; and extraordinary ones, offered by particular perfons guilty of any crime, by way of propitiation. The Romifh church believe the mafs to be a facrifice of propitiation for the living and the dead. The reformed churches allow of no propitiation but that one offered by Jefus Chrift on the crofs. See SACRIFICE.

PROPITIATORY, any thing rendering God propitious; as we fay *propitiatory* facrifices, in contradiftinction to facrifices which were *euchariftical*. Among the Jews the propitiatory was the cover or lid of the ark of the covenant; which was lined both within and withoutfide with plates of gold, infomuch that there was no wood to be feen. This propitiatory was a type or figure of Chrift, whom St Paul calls the propitiatory ordained from all ages. See *ARK of the Covenant*.

PROPOLIS, the name of a certain fubftance more tenacious than wax, with which the bees ftop up all the holes or cracks in the fide of their hives. See BEE, N° 13.

PROPONTIS, or SEA OF MARMORA, a part of the Mediterranean, dividing Europe from Afia; it has the Hellefpont or canal of the Dardanelles to the fouthweft, whereby it communicates with the Archipelago, and the ancient Bofphorus of Thrace, or ftrait of Conftantinople to the north-eaft, communicating with the Black or Euxine fea. It has two caftles: that on the Afia fide is on a cape, where formerly ftood a temple of Jupiter. The caftle of Europe is on an oppofite cape, and had anciently a temple of Serapis. It is 120 miles long, and in fome places upwards of 40 miles broad.

PROPORTION, the identity or fimilitude of two ratios. Hence quantities that have the fame ratio between them are faid to be proportional; *e. gr.* if A be to B as C to D, or 8 be to 4 as 30 to 15; A, B, C, D, and 8, 4, 30, and 15, are faid to be in proportion, or are fimply called proportionals. Proportion is frequently confounded with ratio; yet have the two in reality very different ideas, which ought by all means to be diftinguifhed. Ratio is properly the relation or habitude

tude of two things, which determines the quantity of one from the quantity of another, without the intervention of any third: thus we say the ratio of 5 and 10 is 2, the ratio of 12 and 24 is 2. Proportion is the sameness or likeness of two such relations; thus the relations between 5 and 10 and 12 and 24 being the same, or equal, the four terms are said to be in proportion. Hence ratio exists between two numbers, but proportion requires at least three. Proportion, in fine, is the habitude or relation of two ratios when compared together; as ratio is of two quantities. See ALGEBRA, ARITHMETIC and GEOMETRY.

Arithmetical and Geometrical PROPORTION. See PROGRESSION.

Inordinate PROPORTION, is where the order of the terms compared is disturbed or irregular. As, for example, in two ranks of numbers, three in each rank,
viz. in one rank, - - 2, 3, 9,
and in the other, - - 8, 24, 36,
which are proportional, the former to the latter, but in a different order, viz. - 2 : 3 :: 24 : 36,
and - - - - - 3 : 9 :: 8 : 24,
then; casting out the mean terms in each rank it is concluded that - - 2 : 9 :: 8 : 36,
that is, the first is to the third in the first rank, as the first is to the third in the second rank.

Harmonical or Musical PROPORTION, is a kind of numeral proportion formed thus: of three numbers, if the first be to the third as the difference of the first and second to the difference of the second and third; the three numbers are in harmonical proportion.

Thus 2, 3, 6, are harmonical, because 2 : 6 :: 1 : 3. So also four numbers are harmonical, when the first is to the fourth as the difference of the first and second to the difference of the third and fourth.

Thus 24, 16, 12, 9, are harmonical, because 24 : 9 :: 8 : 3. By continuing the proportional terms in the first case, there arises an harmonical progression or series.

1. If three or four numbers in harmonical proportion be multiplied or divided by the same number; the products or quotients will also be in harmonical proportion: thus, if 6, 8, 12, which are harmonical, be divided by 2, the quotients 3, 4, 6, are also harmonical; and reciprocally the products by 2, viz. 6, 8, 12.

2. To find an harmonical mean between two numbers given; divide double the product of the two numbers by their sum, the quotient is the mean required; thus suppose 3 and 6 the extremes, the product of these is 18, which doubled gives 36; this divided by 9 (the sum of 3 and 6) gives the quotient 4. Whence 3, 4, 6, are harmonical.

3. To find a third harmonical proportion to two numbers given.

Call one of them the first term, and the other the second; multiply them together, and divide the product by the number remaining after the second is subtracted from double the first; the quotient is a third harmonical proportional: thus, suppose the given terms 3, 4, their product 12 divided by 2 (the remainder after 4 is taken from 6, the double of the first), the quotient is 6, the harmonical third sought.

4. To find a fourth harmonical proportion to three terms given; multiply the first into the third, and divide the product by the number remaining after the middle or second is subtracted from double the first; the quotient is a third harmonical proportion; thus supposing the numbers 9, 12, 16, a fourth will be found by the rule to be 24.

5. If there be four numbers disposed in order, whereof one extreme and the two middle terms are in arithmetical proportion; and the same middle terms with the other extreme are in harmonical proportion; the four are in geometrical proportion; as here 2 : 3 :: 4 : 6, which are geometrical; whereof 2, 3, 4, are arithmetical, and 3, 4, 6, are harmonical.

6. If betwixt any two numbers you put an arithmetical mean, and also an harmonical one, the four will be in geometrical proportion: thus betwixt 2 and 6 an arithmetical mean is 4, and a harmonical one 3; and the four 2 : 3 :: 4 : 6, are geometrical.

We have this notable difference between the three kinds of proportion, arithmetical, harmonical, and geometrical; that from any given number we can raise a continued arithmetical series increasing *in infinitum*, but not decreasing: the harmonical is decreasable *in infinitum*, but not increasable; the geometrical is both.

PROPORTION, or *Rule of Three.* See ARITHMETIC.

Reciprocal PROPORTION. See RECIPROCAL.

PROPORTION is also used for the relation between unequal things of the same kind, whereby their several parts correspond to each other with an equal augmentation or diminution.

Thus, in reducing a figure into little, or in enlarging it, care is taken to observe an equal diminution or enlargement, through all its parts: so that if one line, *e. gr.* be contracted by one-third of its length, all the rest shall be contracted in the same proportion.

PROPORTION, in *Architecture*, denotes the just magnitude of the members of each part of a building, and the relation of the several parts to the whole; *e. gr.* of the dimensions of a column, &c. with regard to the ordonnance of the whole building.

One of the greatest differences among architects, M. Perrault observes, is in the proportion of the heights of entablatures with respect to the thickness of the columns, to which they are always to be accommodated.

In effect, there is scarcely any work, either of the ancients or moderns, wherein this proportion is not different; some entablatures are even near twice as high as others:—yet it is certain this proportion ought of all others to be most regulated; none being of greater importance, as there is none in which a defect is sooner seen, nor any in which it is more shocking.

Compass of PROPORTION, a name by which the French, and after them some English, authors call the SECTOR.

PROPORTIONAL, relating to proportion. Thus we say, proportional compasses, parts, scales, spirals, &c.

PROPORTIONALS, in *Geometry*, are quantities, either linear or numeral, which bear the same ratio or relation to each other.

PROPOSITION, in *Logic*, part of an argument wherein some quality, either negative or positive, is attributed to a subject.

PROPOSITION, in *Mathematics*, is either some truth advanced and shown to be such by demonstration, or some operation proposed and its solution shown. If the propofition be deduced from feveral theoretical definitions compared together, it is called a *theorem;* if from a praxis, or feries of operations, it is called a *problem.* See the articles THEOREM and PROBLEM.

PROPOSITION, in *Oratory*. See ORATORY, N° 28. 124.

PROPOSITION, in *Poetry*, the firft part of a poem, wherein the author propofes briefly, and in general, what he is to fay in the body of his work. It fhould comprehend only the matter of the poem, that is, the action and perfons that act. Horace prefcribes modefty and fimplicity in the propofition, and would not have the poet promife too much, nor raife in the reader too great ideas of what he is going to relate.

PROPREFECT, among the Romans, the prefect's lieutenant, or an officer whom the prefect of the pretorium commiffioned to do part of his duty in his place.

PROPRETOR, a Roman magiftrate, who, having difcharged the office of pretor at home, was fent into a province to command there with his former pretorial authority. It was alfo an appellation given to thofe who, without having been pretors at Rome, were fent extraordinarily into the provinces to adminifter juftice with the authority of pretors.

PROPRIETOR, or PROPRIETARY, is he who poffeffes any thing as his own in the utmoft degree. Such monks were called *proprietary* as had referved goods and effects to themfelves, notwithftanding their formal renunciation of all at the time of their profeffion. They are frequently mentioned in the *Monaft. Anglic.* &c. and were to be very feverely dealt with; to be excommunicated, deprived of burial, &c. *Monachi proprietarii excommunicentur ab abbatibus: et, fi in morte proprietarius inventus fuerit, ecclefiaftica careat fepultura*, &c. Addit. ad Matt. Par.

PRO RATA, in commerce, a term fometimes ufed by merchants for *in proportion;* as, each perfon muft reap the profit or fuftain the lofs, *pro rata* to his intereft, that is, in proportion to his ftock.

PROROGATION, the act of prolonging, adjourning, or putting off, to another time. The difference bebetween a prorogation and an adjournment of parliament is, that by prorogation the feffion is ended, and fuch bills as paffed in either houfe, or both houfes, and had not the royal affent, muft at the next affembly begin again.

PROSCRIPTION, a publication made in the name of the chief or leader of a party, whereby he promifes a reward to any one who fhall bring him the head of one of his enemies.

Sylla and Marius by turns profcribed each others adherents.—Under the triumvirate great part of the beft and braveft of the Romans fell by profcription.

The term took its rife from the practice of writing down a lift of the perfons names, and pofting it in public; from *pro* and *fcribo* "I write."

PROSE, the natural language of mankind, loofe and unconfined by poetical meafures, rhymes, &c. In which fenfe it ftands oppofed to verfe.

There is, however, a fpecies of profe which is meafured, fuch as that in which epitaphs and other infcriptions are generally written; and indeed every man who has formed for himfelf a ftyle writes in uniform periods regularly recurring. It has been much difputed whether a poem can be written in profe. We enter not into that difpute, as we have faid enough on the fubject elfewhere. See NOVEL.

The word *profe* comes from the Latin *profa*, which fome will have derived from the Hebrew *poras*, which fignifies *expendit:* others deduce it from the Latin *prorfa*, of *prorfus*, "going forwards:" by way of oppofition to *verfa*, or "turning backwards," as is neceffary in writing.

PROSECUTION, in the criminal law. The next ftep towards the punifhment of offenders after COMMITMENT, is their profecution, or the manner of their formal accufation. And this, in the Englifh law, is either upon a previous finding of the fact by an inqueft or grand jury; or without fuch previous finding.

The former way is either by PRESENTMENT or INDICTMENT. See thefe articles.

The remaining methods of profecution are without any previous finding by a jury, to fix the authoritative ftamp of verifimilitude upon the accufation. One of thefe, by the common law, was when a thief was taken *with the mainour*, that is, with the thing ftolen upon him, *in manu*. For he might, when fo detected, *flagrante delicto*, be brought into court, arraigned, and tried, without indictment: as by the Danifh law he might be taken and hanged upon the fpot without accufation or trial. But this proceeding was taken away by feveral ftatutes in the reign of Edward III. though in Scotland a fimilar procefs remains to this day. So that the only fpecies of proceeding at the fuit of the king, without a previous indictment or prefentment by a grand jury, now feems to be that of INFORMATION; which fee.

Thefe are all the methods of profecution at the fuit of the king. There yet remains another, which is merely at the fuit of the fubject, and is called an APPEAL. See that article.

But of all the methods of profecution, that by indictment is the moft general. See INDICTMENT.

PROSECUTOR, in law, he that purfues a caufe in another's name.

PROSELYTE, a new convert to fome religion or religious fect.

PROSERPINACA, a genus of plants belonging to the triandria clafs, and in the natural method ranking under the 15th order, *Inundatæ*. See BOTANY *Index*.

PROSERPINE, in fabulous hiftory, the daughter of Jupiter and Ceres, was carried off by Pluto as fhe was gathering flowers with her companions. Ceres, difconfolate for the lofs of her daughter, after having long fought her, heard where fhe was, and intreated Jupiter to let her return from hell. This requeft Jupiter granted, on condition fhe had tafted nothing in Pluto's dominions. Ceres therefore went to fetch her; but when her daughter was preparing to return, Afcalaphus gave information that he had feen Proferpine eat fome grains of a pomegranate fhe had gathered in Pluto's garden; on which fhe was fentenced to continue in Tartarus in quality of Pluto's fpoufe, and the queen of thofe gloomy regions: but to mitigate the grief of Ceres for her difappointment, Jupiter granted that her daughter fhould only fpend fix months together in hell with her hufband, and the other fix on earth with her mother.

Some mythologifts imagine that the latter part of the fable

fable alludes to the corn, which must remain all the winter hid in the earth, in order to sprout forth in the spring, and produce the harvest.

PROSEUCHE, in antiquity, properly signifies *prayer;* but it is taken for the places of prayer of the Jews, and was pretty near the same as their synagogues. But the synagogues were originally in the cities, and were covered places: whereas, for the most part, the proseuches were out of the cities, and on the banks of rivers; having no covering, except perhaps the shade of some trees or covered galleries. The word is Greek, *προσευχη, prayer.*

PROSLAMBANOMENE, the name of a musical note in the Greek system.

As the two tetrachords of the Greeks were conjunctive, or, in other words, as the highest note of the first served likewise for the lowest note of the second, it is plain that a complete octave could not be formed. To remedy this deficiency, therefore, one note beneath the lowest tetrachord was added, as an octave to the highest of the last tetrachord. Thus, if we suppose the first to have begun on B, the last must have ended upon A, to which one note subjoined immediately beneath the lowest B in the diatonic order must have formed an octave. This note was called *proslambanomene.* But it appears from authors who have scrutinized antiquity with some diligence, and perhaps with as much success as the data upon which they proceeded could produce, that the names of the notes in the Greek system, which originally signified their natural station in the scale of ascending or descending sounds, were afterwards applied to their positions in the lyre. *Higher* or *lower*, then, according to this application, did not signify their degrees of acuteness or gravity, but their higher or lower situation upon this instrument.

Burney's History of Music. Differt. § 1.

PROSODY, that part of grammar which treats of the quantities and accents of syllables, and the manner of making verses.

The English prosody turns chiefly on two things, numbers and rhyme. See POETRY, n° 66—76. and Part III.

PROSOPIS, in *Botany*, a genus of the monogynia order, belonging to the decandria class of plants. The calyx is hemispherical and quadridentate; the stigma is simple; the legumen inflated and monospermous. See BOTANY *Index.*

PROSOPOPŒIA, a figure in oratory, whereby we raise qualities of things inanimate into persons. See ORATORY.

PROSTATÆ, in *Anatomy*, a gland, generally supposed to be two separate bodies, though in reality but one, situated just before the neck of the bladder, and surrounding the beginning of the urethra. See ANATOMY *Index.*

PROSTYLE, in *Architecture*, a range of columns in the front of a temple.

PROTAGORAS, a famous Greek philosopher, was born at Abdera. In his youth, his poverty obliged him to submit to the servile office of frequently carrying logs of wood from the neighbouring fields to Abdera. It happened that as he was one day going on briskly towards the city under one of these loads, he was met by Democritus, who was particularly struck with the neatness and regularity of the bundle. Desiring him to stop and rest himself, Democritus examined more closely the structure of the load, and found that it was put together with mathematical exactness; upon which he asked the youth whether he himself had made it up. Protagoras assured him that he had; and immediately taking it to pieces, with great ease replaced every log in the same exact order as before. Democritus expressed much admiration of his ingenuity; and said to him, "Young man, follow me, and your talents shall be employed upon greater and better things." The youth consented, and Democritus took him home, maintained him at his own expence, and taught him philosophy, which qualified him for the office of legislator of the Thurians. He was more subtle than solid in his reasonings; however he taught at Athens with great reputation, but was at length banished from thence for the impiety of his doctrines. He then travelled, and visited the islands in the Mediterranean, where it is said that he was the first philosopher who taught for money. He died in a voyage to Sicily, in a very advanced age. He commonly reasoned by dilemmas, and left the mind in suspense with respect to all the questions he proposed. His moral principles were adopted by Hobbes. (See MORAL PHILOSOPHY). Plato wrote a dialogue against him. He flourished 400 years B. C.

Enfield's History of Philosophy, vol. i.

PROTASIS, in the ancient drama, the first part of a comic or tragic piece, wherein the several persons are shown, their characters intimated, and the subject of the piece proposed and entered upon.

It might reach as far as our two first acts; and where it ended the epitasis commenced. See the article EPITASIS.

PROTEA, the SILVER-TREE, a genus of plants, belonging to the tetrandria class; and in the natural method ranking under the 47th order, *Stellatæ.* See BOTANY *Index.*

PROTECTOR, a person who undertakes to shelter and defend the weak, helpless, and distressed.

Every Catholic nation, and every religious order, has a protector residing at the court of Rome, who is a cardinal, and is called the *cardinal protector.*

Protector is also sometimes used for a regent of a kingdom, made choice of to govern it during the minority of a prince.

Cromwell assumed the title and quality of *lord protector of the commonwealth of England.*

PROTESILAI TURRIS, the sepulchre of Protesilaus, with a temple, at which Alexander sacrificed, (Arian); situated at the south extremity of the Hellespont, near the Chersonesus Thracia. Protesilaus was the first Greek who landed on the coast of Troy, and the first Greek slain by the Trojans, (Homer, Ovid). His wife Laodamia, to assuage her grief, begged the gods for a sight of his shade; and obtaining her request, she expired in his embraces, (Hyginus.) Protesilaus was also called *Phylacides*, from Phylace, a town of Thessaly.

PROTEST, in *Law*, is a call of witness, or an open affirmation that a person does, either not at all, or but conditionally, yield his consent to any act, or to the proceeding of any judge in a court in which his jurisdiction is doubtful, or to answer upon his oath farther than he is bound by law.

Any of the lords in parliament have a right to protest their dissent to any bill passed by a majority: which protest is entered in form. This is said to be a very

Protest || Protogenes.

ancient privilege. The commons have no right to protest. See PARLIAMENT.

PROTEST, in *Commerce*, a summons written by a notary-public to a merchant, banker, or the like, to accept or discharge a bill of exchange drawn on him, after his having refused either to accept or pay it. See *BILL of Exchange*.

PROTESTANT, a name first given in Germany to those who adhered to the doctrine of Luther; because in 1529 they protested against a decree of the emperor Charles V. and the diet of Spires; declaring that they appealed to a general council. The same name has also been given to those of the sentiments of Calvin; and is now become a common denomination for all those of the reformed churches.

PROTEUS, in *Heathen Mythology*. See EGYPT, n° 6.

PROTHONOTARY, a term which properly signifies *first notary*, and which was anciently the title of the principal notaries of the emperors of Constantinople.

Prothonotary, with us, is used for an officer in the court of king's bench and common pleas; the former of which courts has one, and the latter three. The prothonotary of the king's bench records all civil actions sued in that court, as the clerk of the crown-office does all criminal causes. The prothonotaries of the common pleas enter and enrol all declarations, pleadings, assizes, judgements, and actions: they also make out all judicial writs, except writs of *habeas corpus*, and *distringas jurator*, for which there is a particular office, called the *habeas corpora office*; they likewise enter recognizances acknowledged, and all common recoveries; make exemplifications of records, &c.

In the court of Rome there is a college of 12 prelates, called *apostolical prothonotaries*, empowered to receive the last wills of cardinals, to make all informations and proceedings necessary for the canonization of saints; and all such acts as are of great consequence to the Papacy: for which purpose they have the right of admission into all consistories, whether public or half public. They also attend on the pope whenever he performs any extraordinary ceremony out of Rome.

PROTO, a Greek term, frequently used in composition of priority: thus proto-collum, in the ancient jurisprudence, signifies the first leaf of a book; protomartyr, the first martyr; proto-plast, the first man formed, &c.

PROTOGENES, a celebrated ancient painter, was born at Caunas, a city of Caria, subject to the Rhodians, and flourished 300 years before the birth of our Saviour. He was first obliged to paint ships for his livelihood; but afterwards acquired the highest reputation for history-painting; though Apelles blamed him for finishing his pieces too highly, and not knowing when to have done. The finest of his pictures was that of Jalisus, which is mentioned by several ancient authors, though none of them gave any description of it. He worked seven years on this picture; during which time he lived entirely upon lupines and water, being of opinion that this light and simple nourishment left him greater freedom of fancy. Apelles, on seeing this picture, was struck with such admiration, that he was unable to speak, or to find words sufficient to express his idea of its beauty. It was this picture that saved the city of Rhodes when besieged by Demetrius king of Macedon; for being able to attack it only on that side where Protogenes worked, which he intended to burn, he chose rather to abandon his design than to destroy so fine a piece. Pliny says, that Apelles asking him what price he had for his pictures, and Protogenes naming an inconsiderable sum, Apelles concerned at the injustice done to the beauty of his productions, gave him 50 talents, about 10,000l. for one picture only, declaring publicly that he would sell it for his own. This generosity made the Rhodians sensible of the merit of Protogenes; and they were so eager to purchase the picture Apelles had bought, that they paid him a much greater price for it than he had given.

Protogenes || Protractor.

PROTOTYPE, is the original or model after which a thing was formed; but chiefly used for the patterns of things to be engraved, cast, &c.

PROTRACTOR, an instrument for laying down and measuring angles upon paper with accuracy and dispatch; and by which the use of the line of chords is superseded. This instrument is variously formed, as semicircular, rectangular, or circular; and constructed of different materials, as brass, ivory, &c. It is necessary in laying down those surveys or other plans where angles are concerned.

The rectangular protractor is constructed in form of a right-angled parallelogram, which, when applied to a case of mathematical instruments, is substituted in place of the semicircular protractor and scale of equal parts. Fig. 1. is a representation of it: the manner of using it is exactly similar to that of the semicircular one. Plate CCCCXLVIII Fig. 1.

The circular protractor, as its name implies, is a complete circle, and is superior by far to either of the former, both in point of accuracy and dispatch, especially when several angles are to be formed at the same point. The limb of this instrument is divided into 360 degrees, and each degree in some protractors is halved: it has a subdividing scale or vernier, by which an angle may be laid down or measured to a single minute. In the centre of the protractor is a fine mark, which, when an angle is to be protracted or measured, is to be laid upon the angular point, and 0, or zero on the limb, upon the given line forming one side of the angle.

Fig. 2. represents a circular protractor whose limb is divided as above described, and the dividing scale on the index, which moves round the limb of the protractor on a conical centre, gives every minute of a degree. That part of the index beyond the limb has a steel point fixed at the end, in a direct line with the centre of the protractor, and whose use is to prick off the proposed angles. Fig. 2.

Fig. 3. is another circular protractor, a little differently constructed from the former. The central point is formed by the intersection of two lines crossing each other at right angles, which are cut on a piece of glass. The limb is divided into degrees and half degrees, having an index with a vernier graduated to count to a single minute, and is furnished with a tooth and pinion, by means of which the index is moved round by turning a small nut. It has two pointers, one at each end of the index, furnished with springs for keeping them suspended while they are bringing to any angle; and being Fig. 3.

Fig. 1.

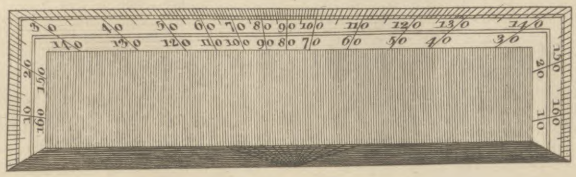


Fig. 2.

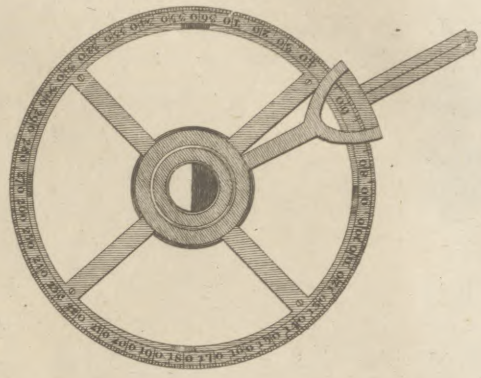


Fig. 3.

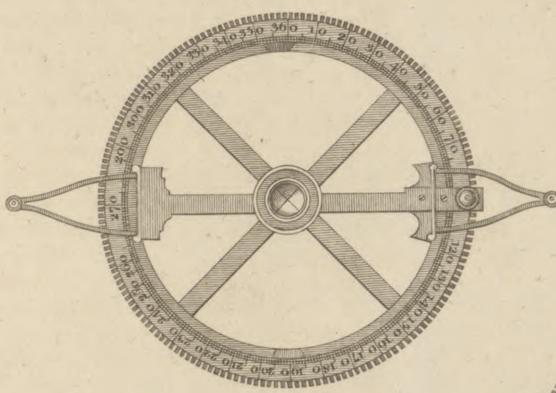
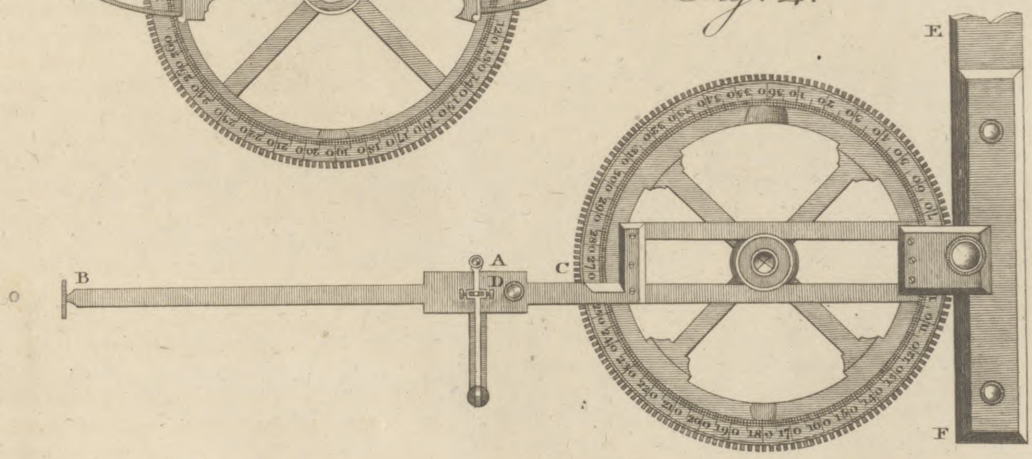


Fig. 4.



REDUCTION.

Fig. 1.

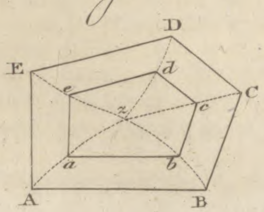


Fig. 2.

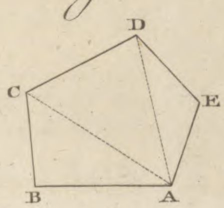


Fig. 3.

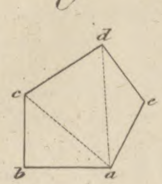
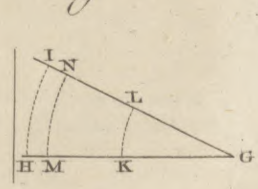


Fig. 4.



A. Bell Prin. Wal. Sculptor fecit.

Protractor || Proverb.

being brought, applying a finger to the top of the pointer, and preffing it down, pricks off the angle. There is this advantage in having two pointers, that all the bearings round a circuit may be laid or pricked off, although the index traverfes but one half of the protractor.

Fig. 4. Another circular protractor, different from either of the former, is reprefented at fig. 4. The centre is alfo formed by the interfection of two lines at right angles to each other, which are cut on glafs, that all parallax may thereby be avoided. The index is moved round by a tooth and pinion. The limb is divided into degrees and half degrees, and fubdivided to every minute by the vernier. The pointer may be fet at any convenient diftance from the centre, as the focket which carries it moves upon the bar BC, and is fixed thereto by the nut D, at right angles to the bar BC, and moveable with it. There is another bar EF: On this bar different fcales of equal parts are placed; fo that by moving a fquare againft the inner edge thereof, angles may be transferred to any diftance within the limits, from the centre containing the fame number of degrees marked out by the index.

It would indeed be fuperfluous to defcribe any more of thefe circular protractors, efpecially as the little alterations in them depend very much upon the fancy of the artift. Suffice it however to fay, that we have feen others ftill differently conftructed, one of which we fhall briefly defcribe. The divifions upon the limb of this inftrument are fimilar to thofe already defcribed; but the index is a ftraight bar continued to fome confiderable diftance each way beyond the limb of the inftrument, and has a vernier to fhow minutes as ufual; a mark upon one of the edges of the index always coincides with the centre of the inftrument. Inftead, therefore, of pricking down the angle as in the former, part of the line containing the angle may be drawn, which, although perhaps not fo accurate as a point, is more confpicuous, and the line is eafily completed upon removal of the protractor. The common dimenfions of the circular part of thefe inftruments is from fix to ten inches diameter; and they are made of brafs.

PROTUBERANCE, in *Anatomy*, is any eminence, whether natural or preternatural, that projects or advances out beyond the reft.

PROVEDITOR, an officer in feveral parts of Italy, particularly at Venice, who has the direction of matters relating to policy.

PROVENCE, a province or government of France bounded by Dauphiné on the north, by Piedmont on the eaft, by the Mediterranean on the fouth, and by the river Rhone, which feparates it from Languedoc, on the weft: it is about 100 miles long, and near as many broad.

PROVEND, or PROVENDER, originally fignified a kind of veffel containing the meafure of corn daily given to a horfe, or other beaft of labour, for his fubfiftence; but is now generally ufed to fignify the food for cattle; whatever it is.

PROVERB, according to Camden, is a concife, witty, and wife fpeech, grounded upon experience, and for the moft part containing fome ufeful inftruction.

Book of PROVERBS, a canonical book of the Old Teftament, containing a part of the proverbs of Solomon the fon of David king of Ifrael. The firft 24 chapters are acknowledged to be the genuine work of that prince; the next five chapters are a collection of feveral of his proverbs made by order of King Hezekiah; and the two laft feem to have been added, though belonging to different and unknown authors, Agur the fon of Jakeh, and King Lemuel.

Proverb, Providence.

In this excellent book are contained rules for the conduct of all conditions of life; for kings, courtiers, mafters, fervants, fathers, mothers, children, &c.

PROVIDENCE, the fuperintendence and care which God exercifes over creation. 1 Definition.

2 Belief of a providence univerfal.

That there exifts a divine providence which attends to the affairs of this world, and directs their courfe, has been a received opinion among the human race in every country and in every period of hiftory. Every altar that is erected, every prayer and every facrifice that is offered up, affords a proof of this belief. So fully have men been convinced of the fincerity of each other's faith upon this fubject, that in one form, that of an appeal to the Divine Ruler of the world, by the folemnity of an oath, they have introduced it both into the moft ordinary and the moft important bufinefs of life.

3 Exiftence of providence may be proved on fcientific principles.

This univerfal conviction of men of all degrees of knowledge, from the moft profound philofopher to the rudeft barbarian, is probably to be traced to fome primæval tradition, never totally effaced from any nation under heaven. The truth itfelf, however, is fufceptible of the moft complete proof from principles of fcience. If the world had a beginning, it may obvioufly have an end, and can be continued in exiftence only by the conftant energy of that power by which it was at firft created. He therefore who acknowledges a creation and denies a providence, involves himfelf in this palpable contradiction—"that a fyftem, which of itfelf had not an original and momentary exiftence, may yet of itfelf have a perpetual exiftence; or that a being which cannot of itfelf exift for a fecond of time, may yet, of itfelf, exift for thoufands of years!" Or fhould we be fo complaifant, as for a moment to fuppofe, with certain theifts, ancient and modern, that the *matter* of the univerfe is felf-exiftent and eternal, and that the power of God was exerted, not in creating fubftances, but in reducing the original matter from a ftate of chaos into that beautiful order in which we fee it arranged; the conftant energy of providence muft ftill be admitted as neceffary to preferve the forms and to continue the motions which were originally impreffed upon the chaotic mafs. From late experiments it appears extremely doubtful whether any two atoms of the moft folid body be in actual contact; and that they are not *all* in contact is certain. (See METAPHYSICS, N° 176. and OPTICS, N° 45, p. 185. Yet it requires a very confiderable degree of force to carry to a greater diftance from one another the parts of a ftone or of a bar of iron. By what power then are thefe parts kept contiguous? It cannot be by their own; becaufe nothing can act where it is not prefent, and becaufe our beft philofophy has long taught us that the atoms of matter are effentially inactive. Again, it requires a very great degree of force to bring two bodies, however fmall, into *apparent* contact (fee OPTICS, *ubi fupra*); and therefore it follows that they muft be kept afunder by fome foreign power. Every attempt to folve thefe phenomena by the intervention

vention of a subtle fluid is vain; for the question recurs, what keeps the parts of the fluid itself contiguous, and yet separated from each other?

The cohesion therefore of the parts of matter, and that which is called their repulsive power, demonstrate, through the whole system, the immediate energy of something which is not matter, and by which every body small and great is preserved in its proper form. It has been elsewhere shown [see METAPHYSICS, Part II. chap. 5. and MOTION, N° 19, 20.), that the various motions which are regularly carried on through the universe, by which animals and vegetables grow and decay, and by which we have day and night, summer and winter, cannot be accounted for by any laws of mere mechanism, but necessarily imply the constant agency of something which is itself distinct from matter. But the forms of bodies are preserved, and their natural motions carried on, for purposes obviously planned by Wisdom. The power therefore which effects these things must be combined with intelligence: but power and intelligence preserving the order of the universe constitute all that is meant by a general providence; which is therefore as certainly administered as the sun daily rises and sets, or as bodies are kept solid by what is termed cohesion and repulsion.

4 Reasoning of the Bramins of Hindostan.

Abstracted and metaphysical as this reasoning may appear, it is by no means peculiar to the philosophers of Europe. Its force has been felt from time immemorial by the Bramins of Hindostan, who, as Sir William Jones informs us *, "being unable to form a distinct idea of brute matter independent of mind, or to conceive that the work of supreme goodness was left a moment to itself, imagine that the Deity is ever present to his work, not in substance but in spirit and in energy." On this rational and sublime conception they have indeed built numberless absurd superstitions; but their holding the opinion itself, shows that they believe in the reality of providence upon philosophical principles: and what truth is there on which the mind of man has not ingrafted marks of its own weakness?

* *Asiatic Researches*, vol. i.

Few nations, however, except the ancient Greeks, have had philosophers equally subtile with the Bramins of India; and therefore though all mankind have in general agreed in the belief of a superintending Providence, they have in different ages and countries admitted that truth upon different kinds of evidence, and formed very different notions concerning the mode in which the Divine superintendence is exerted.

5 Idea of providence in rude ages.

While societies are still in a rude and unpolished state, while individuals possess little security and little leisure for the exertion of their rational powers, every important or singular appearance in nature becomes an object of wonder or of terror. In this state of ignorance, men see not the universe as it is, a great collection of connected parts, all contributing to form one grand and beautiful system. Every appearance seems to stand alone; they know that it must have a cause, but what that cause is they are ignorant. The phenomena exhibited by nature are so complicated and so various, that it never occurs to them that it is possible for one Being to govern the whole. Hence arose the different systems of polytheism that have appeared in the world. Nature was divided into different regions, and a particular invisible power was assigned to each department: one conducted the flaming chariot of the sun, another wielded the terrible thunderbolt, and others were employed in diffusing plenty, and introducing the useful arts among men. Thus, although the various systems of polytheism in general acknowledged one Supreme Ruler, the father of gods and men, yet they at the same time peopled not only the regions above, the air and the heavens, but they also filled the ocean and the land, every grove, and every mountain, with active but invisible natures. Having arisen from the same causes, these systems of polytheism, which are so many hypotheses concerning Divine providence, are all extremely similar; and we have a very favourable specimen of them in the elegant mythology of Greece and Rome, which gave to every region of nature a guardian genius, and taught men in the deep recesses of the forest, or in the windings of the majestic flood, to expect the presence of protecting and friendly powers. See POLYTHEISM.

Notwithstanding this universal reception, in some form or other, of the doctrine of a divine providence, it has in every age met with some opponents. The most ancient of these were Democritus and Leucippus. They denied the existence of a Deity—asserted that all things were mechanically necessary, and that thought and sense were only modifications of matter. This is atheism in the strictest sense, and the only form of it that has ever been consistently supported. Epicurus followed upon the same principles; but he rendered the system altogether absurd, by confessing the freedom of the human will. To avoid the imputation of atheism, he asserted the existence of God; but declared that he resided above the heavens, and interfered not in human affairs. One of his maxims was, that "the blessed and immortal Being neither hath any employment himself, nor troubles himself with others." Maximus Tyrius * justly observes, that this is rather a description of a Sardanapalus than of a Deity. And some of the moralists † of antiquity remarked, that they knew many men among themselves possessed of active and generous minds, whose characters they valued more highly than that of Epicurus's god. Some of the ancients also appear to have entertained the following strange notion: They acknowledged the existence of a Supreme and of many inferior deities; but at the same time, they supposed that there is a certain fate which rules over all, and is superior to the gods themselves. See *NECESSITY* in Mythology.

6 The doctrine has had opponents in almost every age.

* *Max. Tyr. Dissert.* 29.

† *Cicero de finibus*, lib. i. and *De Natura Deorum*, lib. ii.

The providence exerted by the Author of nature over his works is usually divided into two branches: a *general*, referring to the management of the universe at large; and a *particular* providence, chiefly regarding particular men.

7 General providence.

Upon the first of these, in *The Religion of Nature delineated*, the question is stated somewhat in the following manner: The world may be said to be governed, or at least cannot be said to fluctuate fortuitously, if there are laws or rules by which natural causes act; if the several phenomena in it succeed regularly, and in general the constitution of things is preserved; if there are rules observed in the production of herbs, trees, and the like; if the several kinds of animals are furnished with faculties proper to determine their actions in the different stations which they hold in the general economy of the world; and lastly, if rational beings are taken care of in such a manner as will at last agree best with reason. By the providence of God we ought to understand

Providence. understand his governing the world by *such* laws as these now mentioned: so that if there are such, there must be a Divine providence.

8 as it respects inanimate objects,

With regard to *inanimate objects*, the case agrees precisely with the above supposition. The whole of that universe which we see around us is one magnificent and well regulated machine. The world that we inhabit is a large globe, which, conducted by an invisible power, flies with a rapidity of which we have no conception, through an extent of space which sets at defiance every power of fancy to embody it into any distinct image. A large flaming orb stands immoveable in the heavens; around which this, and other worlds of different magnitudes, perform their perpetual revolutions. Hence arise the expected returns of day and night, and the regular diversity of seasons. Upon these great operations a thousand other circumstances depend. Hence, for example, the vapours ascend from the ocean, meet above in clouds, and after being condensed, descend in showers to cover the earth with fertility and beauty. And these appearances are permanent and regular. During every age since men have been placed upon the earth, this astonishing machine continued steadily to perform its complicated operations. Nothing is left to chance. The smallest bodies are not less regular than the largest, and observe continually the same rules of attraction, repulsion, &c. The apparent variations of nature proceed only from different circumstances and combinations of things, acting all the while under their ancient laws. We ourselves can calculate the effects of the laws of gravitation and of motion. We can render them subservient to our own purposes, with entire certainty of success if we only adhere to the rules established by nature, that is to say, by providence.

9 vegetables.

Vegetables also live and flourish according to prescribed methods. Each sort is produced from its proper seed; has the same texture of fibres, is at all times nourished by the *same* kind of juices, digested and prepared by the *same* vessels. Trees and shrubs receive annually their peculiar liveries, and bear their proper fruits: so regular are they in this last respect, that every species may be said to have its profession or trade appointed to it, by which it furnishes a certain portion of manufacture, or of food, to supply the wants of animals: being created for the purpose of consumption, all vegetables produce great quantities of seed to supply the necessary waste. Here too, then, there is evidently a *regulation* by which the several orders are preserved, and the ends of them answered according to their first establishment.

10 animals,

With regard to *animals*, they too, in structure of their form, are subject to laws similar to those which govern the vegetable world. In the sentient part of their constitution they are no less subject to rule. The lion is always fierce, the fox is crafty, and the hare is timid. Every species retains from age to age its appointed place and character in the great family of nature. The various tribes are made and placed in such a manner as to find proper means of support and defence. Beasts, birds, fishes, and insects, are all possessed of organs and faculties adapted to their respective circumstances, and opportunities of finding their proper food and prey.

11 and man.

Man is subject to the ordinary laws which other material and animal substances obey; but he is left more at large in the determination of his actions. Yet even here things do not fluctuate at random. Individuals do indeed rise and perish according to fixed rules, and nations themselves have only a temporary endurance. But the species advances with a steady progress to intellectual improvement. This progress is often interrupted; but it appears not to be less sure at the long-run than even the mechanical laws which govern the material part of our constitution. Amidst the convulsion of states and the ruin of empires, the useful arts, when once invented, are never lost. These, in better times, render subsistence easy, and give leisure for reflection and study to a greater number of individuals. Tyre and Sidon have passed away, Athens itself has become the prey of barbarians, and the prosperity of ancient Egypt is departed, perhaps for ever; but the ship, the plow, and the loom, remain, and have been perpetually improving. Thus every new convulsion of society does less mischief than the last; and it is hoped that by the assistance of printing the most polished arts and the most refined speculations have now become immortal.

The world is not then left in a state of confusion: it is reduced into order, and methodised for ages to come; the several species of beings having their offices and provinces assigned them. Plants, animals, men, and nations, are in a state of continual change; but successors are appointed to relieve them, and to carry on the *scheme of Providence*.

12 Difficulty of accounting for particular providence.

But the great difficulty is, how to account for that providence which is called *particular*: For rational beings, and free agents, are capable of doing and deserving well or ill; and the safety or danger, that happiness or unhappiness of a man here, must depend upon many things that seem scarcely *capable* of being determined by Providence. Besides *himself* and his own conduct, he depends upon the conduct of *other men*; whose actions, as we naturally suppose, cannot, consistently with their free will, be controuled for the advantage of another individual. The actions of numbers of men proceeding upon their private freedom, with different degrees of ability, as they cross and impede, or directly oppose each other, must produce very different effects upon men of different characters, and thus in a strange manner embarrass and entangle the general plan. And as to the *course of nature*, it may justly be asked, is the force of gravitation to be suspended till a good man pass by an infirm building? (See PRAYER). Add to this, that some circumstances appear absolutely irreconcileable. The wind which carries one into port drives another back to sea; and the rains that are just sufficient upon the hills may drown the inhabitants of the valleys. In short, may we expect *miracles?* or can there be a particular Providence that foresees and prepares for the several cases of individuals, without force frequently committed upon the laws of nature and the freedom of intelligent agents?

13 No good argument against its existence.

In whatever way it is brought about, there is little doubt that something of this kind *must* take place. For as the Deity *does* direct, as already mentioned, the great and general progress of things in this world, he must also manage those of less importance. Nations are composed of individuals. The progress of individuals is the progress of the nation, and the greatest events usually depend upon the history and the most trifling actions

actions of private perſons. The difficulty is to conceive how the ſuperintendence and management of all this can be brought about. But as the ways and the thoughts of the Omnipotent Spirit, whoſe influence pervades, and rules, and animates nature, reſemble not the limited operations of men, we can only form conjectures concerning the means by which his government is conducted.

14 The Deity may eaſily foreſee the actions of men;

1. In the firſt place, then, it is not impoſſible that the Deity ſhould foreſee the future actions of intelligent beings. Many of theſe actions depend upon the mechaniſm of the material world, which was formed by himſelf, and muſt be entirely known to him. Many men among ourſelves poſſeſs much ſagacity in diſcerning the future actions of others, from attending to their known characters, and the circumſtances in which they are placed. If ſuperior natures do exiſt, and minds more perfect than the human, they muſt poſſeſs this penetration in a more eminent degree in proportion to the excellence of their intellectual powers. But if this diſcernment be in God proportionable to his nature, as in lower beings it is proportionable to theirs, it then becomes altogether unlimited, and the future actions of free agents are at once unlocked and expoſed to his view. Add to this, that the Author of nature is well acquainted with the creatures that he has made; he knows the mechaniſm of our bodies, the nature and extent of our underſtandings, and all the circumſtances by which we are ſurrounded. With all theſe advantages, it is making no great ſtretch to ſuppoſe him capable of diſcerning the line of conduct which we will purſue; and this even ſetting aſide the infinity of his nature, to which a thouſand years are as one day, and ſuppoſing him to reaſon from probabilities in the imperfect manner that we do.

15 and may thence fit them for their ſituations in life.

2. There is no impoſſibility at leaſt, that men, whoſe characters and actions are thus foreknown, may be introduced into the world in ſuch times and places as that their acts and behaviour may not only coincide with the general plan of things, but may alſo anſwer many private caſes. The celeſtial bodies are ſo placed that their jarring attractions make out a ſplendid ſyſtem. Why then may there not be in the Divine mind ſomething like a projection of the future hiſtory of mankind, as well as of the motions of the heavenly bodies? And why ſhould it not be thought poſſible for men, as well as for them, by ſome ſecret law, or rather by the management of an unſeen power, to be brought into their places in ſuch a manner as that, by the free uſe of their faculties, the conjunctions and oppoſitions of their intereſts and inclinations, the natural influence of their different degrees of talents, power, and wealth, they may conſpire to make out the great ſcheme of human affairs? There is no abſurdity in this ſuppoſition: it is not beyond the power of an almighty and perfect Being; and it is worthy of him. Let us take from the Jewiſh hiſtory, as moſt generally known, an example of what may be ſuppoſed to happen daily. It was the intention of providence to place David the ſon of Jeſſe upon the throne of the Hebrews. The country is invaded by a foreign enemy: the hoſtile armies meet, and lie encamped upon oppoſite mountains. A man comes forth from the army of the invaders, as was extremely common in thoſe times, and defies the Hebrew hoſt to ſend forth a champion to meet him in ſingle combat. Terrified by the gigantic bulk and mighty force of Goliah, no man would riſk the unequal conflict. David, who was too young to carry arms, had been ſent to the camp with proviſions for his brothers, and heard the challenge. In defence of his flock he had killed ſome beaſts of prey in the wilderneſs, and he was an excellent markſman with the ſling. He thought it might probably be as eaſy to kill a man as a wild beaſt; at all events, he knew that a ſtone well directed would prove no leſs fatal to a giant than to a dwarf: he therefore reſolved to try his ſkill; and he tried it with ſucceſs. Here no man's free will was interrupted, and no miracle was accompliſhed: Yet by this *train* of circumſtances thus *brought* together, a foundation was laid for the future fortunes of the ſon of Jeſſe, for the greatneſs of his country, and for accompliſhing the purpoſes of Providence. According to Seneca, "Hoc dico, fulmina non mitti à Jove, ſed ſic omnia diſpoſita, ut ea etiam quæ ab illo non fiunt, tamen ſine ratione non fiunt; quæ illius eſt.—Nam etſi Jupiter illa nunc non facit, fecit ut fierent."—*I ſay, that the lightning comes not directly from the hand of Jove, but things are properly diſpoſed for the indirect execution of his will; for he acts not immediately, but by the intervention of means.*

16 The poſſibility of this exemplified.

17 Secret influences on the mind are far from impoſſible.

3. Laſtly, it is *not impoſſible* that many things may be accompliſhed by ſecret influence, upon the human mind, either by the Deity himſelf, or by the intervention of agents poſſeſſed of powers ſuperior to thoſe which belong to us. "For inſtance, if the caſe ſhould require that a particular man be delivered from ſome threatening *ruin*, or from ſome *misfortune*, which would certainly befal him if he ſhould go ſuch a way at ſuch a time, as he intended: upon this occaſion ſome *new* reaſons may be preſented to his mind why he ſhould not go *at all*, or not *then*, or not *by that road;* or he may forget to go. Or, if he is to be delivered from ſome dangerous *enemy*, either ſome new turn given to his thoughts may divert him from going where the *enemy* will be, or the enemy may be after the ſame manner diverted from coming where *he* ſhall be, or his reſentment may be *qualified;* or ſome proper method of *defence* may be ſuggeſted to the perſon in danger. After the ſame manner advantages and ſucceſſes may be conferred on the deſerving; as, on the other ſide, men, by way of puniſhment for their crimes, may incur miſchiefs and calamities. Theſe things, and ſuch as theſe (ſays Mr Wollaſton *), *may be*. For ſince the motions and actions of men, which depend upon their wills, do alſo depend upon their judgments, as theſe again do upon the *preſent appearances* of things in their minds; if a new proſpect of things can be any way produced, the lights by which they are ſeen *altered*, new forces and directions impreſſed upon the ſpirits, paſſions *exalted* or *abated*, the power of judging *enlivened* or *debilitated*, or the attention taken off without any ſuſpenſion or alteration of the ſtanding laws of nature,—then, without that, *new* volitions, deſigns, meaſures, or a ceſſation of thinking, may alſo be produced; and thus many things prevented that otherwiſe would *be*, and many brought about that would *not*. That there may poſſibly be ſuch inſpirations of new thoughts and counſels (continues our author), may perhaps appear farther from this, that we frequently find thoughts ariſing in our heads, into which we are led by no diſcourſe, nothing we read, no clue of reaſoning, but they ſurpriſe and come upon us from we know

* *Religion of Nature delineated*, ſect. 5.

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not what quarter. If they proceeded from the mobility of ſpirits ſtraggling out of order, and fortuitous affections of the brain, or were they of the nature of *dreams*, why are they not as wild, incoherent, and extravagant as they are?" Is it not much more reaſonable to imagine that they come by the order and direction of an all-ſeeing and all-gracious God, who continually watches over us, and diſpoſes every thing in and about us for the good of ourſelves or others? not to ſpeak of the agreeableneſs of this notion to the opinions of the beſt and wiſeſt men in all ages (A). "If this, then, be the caſe, as it ſeems to be, that men's minds are ſuſceptible of ſuch *inſinuations* and *impreſſions*, as frequently, by ways unknown, do affect them, and give them an inclination towards this or that; how many things (aſks our author) may be brought to paſs by theſe means without *fixing* and *refixing* the laws of nature, any more than they are unfixed when one man alters the opinion of another by throwing in his way a book proper for that purpoſe?"

18 And may be effected by beings ſuperior to us, or by the Deity.

All this may be effected either by the immediate interpoſition of God himſelf, or by that of beings *inviſible*, and in nature ſuperior to us, who act as the miniſters of his providence. That there are ſuch beings we can hardly doubt, as it is in the higheſt degree improbable that ſuch imperfect beings as men are at the top of the ſcale of created exiſtence. And ſince we ourſelves, by the uſe of our limited powers, do often alter the courſe of things within our ſphere from what they would be if left to the ordinary laws of motion and gravitation, without being ſaid to alter thoſe laws; why may not ſuperior beings do the ſame as inſtruments of divine providence? This idea of the intervention of ſuperior natures is beautifully illuſtrated by Thomſon in the following paſſage:

> Theſe are the haunts of meditation, theſe
> The ſcenes where ancient bards th' inſpiring breath,
> Ecſtatic, felt; and from this world retir'd,
> Convers'd with angels and immortal forms,
> On gracious errands bent: to ſave the fall
> Of virtue ſtruggling on the brink of vice;
> In waking whiſpers, and repeated dreams,
> To hint pure thought, and warn the favour'd ſoul
> For future trials fated to prepare.

We agree, however, with Mr Wollaſton, in thinking the power of theſe beings not ſo large as to alter or ſuſpend the general laws of nature (ſee MIRACLE); for the world is not like a bungling piece of clock-work, which requires to be often ſet backwards or forwards. We are likewiſe perfectly ſatisfied, that they cannot change their condition, to ape us or inferior beings; and conſequently we are not apt haſtily to credit ſtories of *portents*, &c. ſuch as cannot be true, unleſs the nature of things and their manner of exiſtence were occaſionally reverſed. Yet as men may be ſo placed as to become, even by the free exerciſe of their own powers, *inſtruments* of God's particular providence to other men; ſo may we well ſuppoſe that theſe higher beings may be ſo *diſtributed* through the univerſe, and ſubject to ſuch an economy, unknown to us, as may render *them alſo* inſtruments of the ſame providence; and that they may, in proportion to their greater abilities, be capable, *conſiſtently with the laws of nature*, of influencing human affairs in proper places.

19 Objections to the doctrine of Providence

We ſhall next proceed to ſtate ſome of the chief objections which in ancient or modern times have been brought againſt the opinion, that the world is governed by a Divine providence.

20 from the imperfections of nature,

1. The firſt of theſe is this, that the ſyſtem of nature contains many imperfections which it ought not to do if it be the work of a perfectly wiſe and good Being. To avoid the force of this objection, ſome modern writers have deſerted the ground of ſupreme and abſolute goodneſs, which the ancient theiſts always occupied, and have aſſerted that the divine perfection conſiſts in unlimited power and uncontrouled ſupremacy of will; that conſequently the Deity does not always that which is beſt, but merely what he himſelf pleaſes; and that for no other reaſon but becauſe he *wills* to do ſo. But this is no better than atheiſm itſelf. For it is of no importance to us whether the univerſe is governed by blind fate or chance, that is to ſay, by nothing at all; or whether it is governed by an arbitrary ſovereign will that is directed by chance, or at leaſt by no principle of beneficence.

21 anſwered.

The true anſwer to this objection is, that no created ſyſtem can have every perfection, becauſe it muſt neceſſarily be deſtitute of ſelf-exiſtence and independence; and therefore if beings deſtitute of ſome perfections be better than nothing, it was worthy of infinite power and perfect goodneſs to create ſuch beings. In our preſent ſtate, we mortals ſtand upon too low ground to take a commanding view of the whole frame of things. We can only reaſon concerning what is unknown from the little that is within our reach. In that little, we can ſee that wiſdom and goodneſs reign; that nature always aims to produce perfection; that many ſalutary effects reſult even from the thunder and the ſtorm: and we doubt not that a view of the whole ſtructure of the univerſe would afford an additional triumph to the goodneſs and ſkill of its great Architect.

We ſee a regular aſcent in the ſcale of beings from mere lifeleſs matter up to man; and the probability is, that the ſcale continues to aſcend as far above man in perfection as created beings can poſſibly be raiſed.—The ſole purpoſe of God in creating the world muſt have been to produce happineſs: but this would be moſt effectually done by creating, in the firſt place, as many of the moſt perfect claſs of beings as the ſyſtem could contain; and afterwards other claſſes leſs and leſs perfect, till the whole univerſe ſhould be completely full. We do not poſitively aſſert ſuch a ſcheme of creation,

(A) That ſuch was the general belief of the Greeks in the days of Homer, is plain from that poet's conſtantly introducing his deities into the narrative of his poems, and telling us that Minerva, or ſome other god, altered the minds of his heroes. "By this," ſays Plutarch, "the poet does not mean to make God *deſtroy* the will of man, but only move him to will: nor does he miraculouſly produce the appetites themſelves in men, but only cauſes ſuch imaginations as are capable of exciting them."

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Where all muſt full, or not coherent be;
And all that riſes, riſe in due degree,

was actually in the divine Architect's intention; but that it is poſſible, is ſufficiently obvious. No man will pretend to ſay, that this earth could afford a comfortable ſubſiſtence to a greater number of the human race, were all the inferior animals annihilated, than it could at preſent, ſwarming as every element is with life.—Suppoſe then, that as many men had been placed at firſt upon the earth as it could poſſibly ſupport, and that matters had been ſo conſtituted, as that the number ſhould never have been either increaſed or diminiſhed; we beg leave to aſk, whether, ſince there would have been evidently room for inferior animals, it would have been moſt worthy of infinite goodneſs to leave the whole globe to men, or to introduce into it different orders of leſs perfect beings, which, while they could not incommode this principal inhabitant, would each find pleaſure in its own exiſtence? To this queſtion different anſwers cannot ſurely be given. Let the reader then extend his view, and conſider the univerſe, which, however vaſt, cannot be poſitively infinite, as one ſyſtem as much united as the ſeveral parts of this globe; let him ſuppoſe that there were at firſt created as many of the higheſt order of beings as it could have contained had creation there ſtopt; let him remember that happineſs in many different degrees is valuable;—and he will not ſurely think it any imputation on the goodneſs of God that there are in the univerſe many beings far from perfection. The moſt imperfect of theſe are by themſelves better than nothing; and they all contribute to make up a ſyſtem which, conſidered as a whole, we have every reaſon to believe to be as perfect as any thing not ſelf-exiſtent can poſſibly be.

22 Objection from the introduction of evil,

2. If the world is conducted by a benevolent providence, how came evil to be introduced into it? This queſtion has perplexed mankind in all ages. The ancient Perſians reſolved it, by aſſerting the exiſtence of two gods, Oromaſdes the author of good, and Arimanius the author of evil. From them the Chriſtian heretics called *Manichees* borrowed their doctrine of two oppoſite co-eternal principles. Both the Platoniſts and Stoics aſcribed the origin of evil to the perverſeneſs or imperfection of matter, which they thought the Deity could not alter: and Pythagoras imagined a ſtate of pre-exiſtence, in which the ſouls of men had committed offences, for which they are here ſuffering the puniſhment. But theſe hypotheſes are, ſome of them impious, and all unſatisfactory.

23 anſwered.

Taking the expreſſion in its moſt extenſive ſenſe, the evils to which the human race are expoſed may be reduced to *pain*, *uneaſineſs*, *diſappointment of appetites*, and *death*; of which not one could have been wholly prevented without occaſioning greater evils, inconſiſtent with the perfect goodneſs of the Creator. As long as we have ſolid bodies capable of motion, ſupported by food, ſubject to the influence of the atmoſphere, and diviſible, they muſt neceſſarily be liable to diſſolution or death: But if a man could ſuffer death, or have his limbs broken, without feeling pain, the human race had been long ago extinct. A fever is a ſtate of the body in which the fluids are in great diſorder. Felt we no uneaſineſs from that diſorder, we ſhould have no inducement to pay the proper attention to our ſtate, and ſhould certainly die unawares, without ſuſpecting ourſelves to be in danger; whereas, under the preſent adminiſtration of divine providence, the pain and ſickneſs of the diſeaſe compel us to have recourſe to the remedies proper for reſtoring us to ſoundneſs and to health. Of the uneaſineſſes to which we are liable, and which are not the effect of immediate pain, the greateſt has been ſometimes ſaid to ariſe from the apprehenſion of death, which conſtantly ſtares us in the face, and frequently embitters all our pleaſures even in the hour of perfect health.—But this dread of death is implanted in our breaſts for the very beſt of purpoſes. Had we no horror at the apprehenſion of death, we ſhould be apt, whenever any misfortune beſel us, to quit this world raſhly, and ruſh unprepared into the preſence of our Judge: but the horror which attends our reflections on our own diſſolution, ariſing not from any apprehenſions of the pain of dying, but from our anxiety concerning our future ſtate of exiſtence, tends ſtrongly to make us act, while we are here, in ſuch a manner as to enſure our happineſs hereafter. Add to this, that the fear of death is the greateſt ſupport of human laws. We every day ſee perſons breaking through all the regulations of ſociety and good life, notwithſtanding they know death to be the certain conſequence, and feel all the horrors of it that are natural to man: and therefore were death diveſted of theſe horrors, how inſignificant would capital puniſhments be as guardians of the law, and how inſecure would individuals be in civil ſociety?

With regard to the unavoidable misfortunes and anxieties of our preſent ſtate, ſo far from being truly hurtful in themſelves, they are proofs of divine beneficence. When we ſee men diſpleaſed with their ſituation, when we hear them complain of the difficulties, the miſeries, and the cares of life, of the hardſhips which they have undergone, and the labours which ſtill lie before them; inſtead of accounting them unfortunate, we ought to regard them as active beings, placed in the only ſituation that is fit for the improvement of their nature. That diſcontent, theſe reſtleſs wiſhes to improve their condition, are ſo many ſure indications that their faculties will not languiſh. They who are in the leaſt degree accuſtomed to obſerve the human character, know well the influence which pleaſure and repoſe have in enfeebling every manly principle, and how capable they are of attaching us even to a ſordid and diſhonourable exiſtence.

Happy indeed it is for the human race, that the number of thoſe men is ſmall whom providence has placed in ſituations in which perſonal activity is unneceſſary. By far the greater number are compelled to exert themſelves, to mix and to contend with their equals, in the race of fortune and of honour. It is thus that our powers are called forth, and that our nature reaches its higheſt perfection. It is even perhaps a general truth, that they who have ſtruggled with the greateſt variety of hardſhips, as they always acquire the higheſt energy of character, ſo if they have retained their integrity, and have not ſunk entirely in the conteſt, ſeldom fail to ſpend their remaining days reſpectable and happy, ſuperior to paſſion, and ſecured from folly by the poſſeſſion of a wiſdom dearly earned.

But the benefits of phyſical evils have been ſet in a ſtill ſtronger light by a great maſter of moral wiſdom, who was himſelf ſubject to many of thoſe evils. That 24 Phyſical evil the cauſe of moral good.

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man is a moral agent, sent into this world to acquire habits of virtue and piety to fit him for a better state, is a truth to which no consistent theist will for a moment refuse his assent. But almost all the moral good which is left among us, is the apparent effect of physical evil.

Johnson's Idler, n° 89.

" Goodness is divided by divines into soberness, righteousness, and godliness. Let it be examined how each of these duties would be practised if there were no physical evil to enforce it.

" Sobriety or temperance is nothing but the forbearance of pleasure ; and if pleasure was not followed by pain, who would forbear it ? We see every hour those in whom the desire of present indulgence overpowers all sense of past, and all foresight of future misery. In a remission of the gout, the drunkard returns to his wine, and the glutton to his feast ; and if neither disease nor poverty were felt or dreaded, every one would sink down in idle sensuality, without any care of others, or of himself. To eat and drink, and lie down to sleep, would be the whole business of mankind.

" Righteousness, or the system of social duty, may be subdivided into justice and charity. Of justice, one of the heathen sages has shown, with great acuteness, that it was impressed upon mankind only by the inconveniences which injustice had produced. ' In the first ages (says he) men acted without any rule but the impulse of desire ; they practised injustice upon others, and suffered it from others in their turn ; but in time it was discovered, that the pain of suffering wrong was greater than the pleasure of doing it ; and mankind, by a general compact, submitted to the restraint of laws, and resigned the pleasure to escape the pain.'

" Of charity, it is superfluous to observe, that it could have no place if there were no want ; for of a virtue which could not be practised, the omission could not be culpable. Evil is not only the occasional but the efficient cause of charity ; we are incited to the relief of misery by the consciousness that we have the same nature with the sufferer ; that we are in danger of the same distresses, and may some time implore the same assistance.

" Godliness or piety is elevation of the mind towards the Supreme Being, and extension of the thoughts of another life. The other life is future, and the Supreme Being is invisible. None would have recourse to an invisible power, but that all other subjects had eluded their hopes. None would fix their attention upon the future, but that they are discontented with the present. If the senses were feasted with perpetual pleasure, they would always keep the mind in subjection. Reason has no authority over us but by its power to warn us against evil.

" In childhood, while our minds are yet unoccupied, religion is impressed upon them ; and the first years of almost all who have been well educated are passed in a regular discharge of the duties of piety : But as we advance forward into the crowds of life, innumerable delights solicit our inclinations, and innumerable cares distract our attention. The time of youth is passed in noisy frolics ; manhood is led on from hope to hope, and from project to project ; the dissoluteness of pleasure, the inebriation of success, the ardour of expectation, and the vehemence of competition, chain down the mind alike to the present scene : nor is it remembered how soon this mist of trifles must be scattered, and the bubbles that float upon the rivulet of life be lost for ever in the gulf of eternity. To this consideration scarce any man is awakened but by some pressing and resistless evil ; the death of those from whom he derived his pleasures, or to whom he destined his possessions, some disease which shows him the vanity of all external acquisitions, or the gloom of age which intercepts his prospects of long enjoyment, forces him to fix his hopes upon another state ; and when he has contended with the tempests of life till his strength fails him, he flies at last to the shelter of religion.

" That misery does not make all virtuous, experience too certainly informs us ; but it is no less certain, that of what virtue there is, misery produces far the greater part. Physical evil may be therefore endured with patience, since it is the cause of moral good ; and patience itself is one virtue by which we are prepared for that state in which evil shall be no more."

25 Objections from the permission of moral guilt,

The calamities and the hardships of our present state, then, are so far from being real evils, of which providence ought to be accused, that in every point of view in which we can consider them, they afford the surest proofs of the wisdom of its administration, and of its goodness to man.

The most serious difficulty lies in accounting for the permission of moral evil or guilt, in a system governed by infinite benevolence and wisdom. Those who in a consistent manner hold the doctrine of the absolute necessity of human actions in its full extent, and acknowledge all its consequences, find it easy to elude this difficulty. They very fairly deny the existence of any such thing as moral evil in the abstract ; and assert, that what we call a *crime*, is nothing more than an action which we always regard with a painful sensation : that these apparent evils endure only for a time ; and that all will at last terminate in the perfection and happiness of every intelligent being.

26 answered.

Upon the system of liberty, the shortest answer seems to be this : that some things are absolutely impossible, not from any weakness in the Deity, but because they infer absurdity or contradiction. Thus it is impossible for twice two to be any thing else than four ; and thus it is impossible for Omnipotence itself to confer self-approbation upon an intelligent being who has never deserved it ; that is to say, it is impossible for a man of sense to be pleased with himself for having done a certain action, while he himself is conscious that he never did that action. But self-approbation constitutes the highest, the most unmingled, and permanent felicity, of which our nature is capable. It is not in the power of Omnipotence itself, then, to bestow the highest and most permanent felicity of our nature ; it must be *earned* and deserved before it can be obtained. In the same manner good desert, virtue or merit, cannot be *conferred;* they must be *acquired.* To enable us to acquire these, we must be exposed to difficulties, and must suffer in a certain degree. If these difficulties had no influence upon our conduct and feelings, if they exposed us to no real danger, no fabric of merit and of self-approbation could be reared upon them. All that the Supreme Being could do for us, was to confer such an original constitution and character as would enable us to do well if we should exert our utmost powers. The

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univerſe is not ruled by favour, but by juſtice. Complete felicity muſt be purchaſed. Guilt is an abuſe of our freedom, a doing ill where we could have done well, and is entirely the work of man. Heaven could not avoid permitting its exiſtence, and expoſing us to danger; for temptation is neceſſary to virtue, and virtue is the perfection of our nature, our glory, and our happineſs.

27 By Simplicius.

The permiſſion of moral evil has been ſo ably accounted for by Simplicius, a Pagan writer, and therefore not biaſſed by any partiality to the Jewiſh or Chriſtian Scriptures, that we cannot deny ourſelves the pleaſure of laying his reaſoning before our readers. He aſks *, "Whether God may be called the author of ſin, becauſe he permits the ſoul to uſe her liberty? and anſwers the queſtion thus:

* *Simplic. Com in Epict.* p. 186, 187. *ed. Salmaſ.*

"He who ſays that God ſhould not permit the exerciſe of its freedom to the ſoul, muſt affirm one of theſe two things; either that the ſoul, though by nature capable of indifferently chooſing *good* or *evil*, ſhould yet be conſtantly prevented from chooſing evil; or elſe that it ſhould have been made of ſuch a nature as to have no *power* of chooſing *evil*.

"The former aſſertion (continues he) is irrational and abſurd; for what kind of liberty would that be in which there ſhould be no freedom of choice? and what choice could there be, if the mind were conſtantly reſtrained to one ſide of every alternative? With reſpect to the ſecond aſſertion, it is to be obſerved (ſays he), that no evil is in itſelf deſirable, or can be choſen *as evil*. But if this power of determining itſelf either way in any given caſe muſt be taken from the ſoul, it muſt either be as ſomething not good, or as ſome great evil. But whoever ſaith ſo, does not conſider how many things there are which, though accounted good and deſirable, are yet never put in competition with this freedom of will: for without it we ſhould be on a level with the brutes; and there is no perſon who would rather be a brute than a man. If God then ſhows his goodneſs in giving to inferior beings ſuch perfections as are far below this, is it incongruous to the divine nature and goodneſs to give man a ſelf-determining power over his actions, and to permit him the free exerciſe of that power? Had God, to prevent man's ſin, taken away the liberty of his will, he would likewiſe have deſtroyed the foundation of all virtue, and the very nature of man; for there could be no virtue were there not a poſſibility of vice; and man's nature, had it continued rational, would have been divine, becauſe impeccable. Therefore (continues he), though we attribute to God, as its author, this ſelf-determining power, which is ſo neceſſary in the order of the univerſe; we have no reaſon to attribute to him that evil which comes by the abuſe of liberty: For God doth not cauſe that averſion from good which is in the ſoul when it ſins; he only gave to the ſoul ſuch a power as might turn itſelf to evil, out of which he produces much good, which, without ſuch a power, could not have been produced by Omnipotence itſelf." So conſonant to the doctrine of our ſcriptures is the reaſoning of this opponent of the writings of Moſes! *Fas eſt et ab hoſte doceri.*

28 Objection from the apparent confuſion of human affairs,

The laſt objection to the belief of a divine providence ariſes from the apparent confuſion of human affairs, that all things happen alike to all, that bad men are proſperous, and that a total want of juſtice appears to attend the divine adminiſtrations. Even the beſt men have at times been ſhaken by this conſideration.—But there are many reaſons for rendering this world a mixed ſcene: it would become unfit for a ſtate of trial and of education to virtue were it otherwiſe.

It has been ſhown already, that phyſical evil is the parent of moral good; and therefore it would be abſurd to expect that the virtuous ſhould be entirely exempted from that evil. For the occaſional proſperity of the wicked, many reaſons have been aſſigned even by thoſe who, in their diſquiſitions, were not guided by that revelation which has brought to light life and immortality. "God (ſays Plutarch) ſpares the wicked, that he may ſet to mankind an example of forebearance, and teach them not to revenge their injuries too haſtily on each other. He ſpares ſome wicked men from early puniſhment, in order to make them inſtruments of his juſtice in puniſhing others. And he ſpares all for a time, that they may have leiſure for repentance; for men (ſays the ſame excellent moraliſt) look at nothing further, in the puniſhments which they inflict, than to ſatisfy their revenge and malice, and therefore they purſue thoſe who have offended them with the utmoſt rage and eagerneſs; whereas God, aiming at the cure of thoſe who are not utterly incurable, gives them μεταβαλλεσθαι χρονον, "time to be converted."

Providence. 29 anſwered, 30 by Plutarch.

But this objection receives the beſt ſolution from the doctrine of the immortality of the human ſoul.

31 The immortality of the ſoul the beſt anſwer to this objection.

——————And ſee!
'Tis come, the glorious morn! the ſecond birth
Of heav'n and earth! awakening nature hears
The *new creating word*, and ſtarts to life,
In every height'ned form, from pain and death
For ever free. *The great eternal ſcheme*,
Involving all, and in a *perfect whole*
Uniting, as the proſpect wider ſpreads,
To reaſon's eye refin'd clears up apace.
Ye vainly wiſe! Ye blind preſumptuous! now,
Confounded in the duſt, adore that Pow'r
And Wiſdom oft arraign'd; ſee now the cauſe,
Why unaſſuming worth in ſecret liv'd
And died neglected: why the good man's ſhare
In life was gall and bitterneſs of ſoul:
Why the lone widow and her orphans pin'd
In ſtarving ſolitude; while luxury,
In palaces, lay ſtraining her low thought,
To form unreal wants: why heav'n-born truth,
And moderation fair, wore the red marks
Of ſuperſtition's ſcourge; why licenc'd pain,
That cruel ſpoiler, that emboſom'd foe,
Imbitter'd all our bliſs. Ye good diſtreſt!
Ye noble few! who here unbending ſtand
Beneath life's preſſure, yet bear up a while,
And what your bounded view, which only ſaw
A little part, deem'd evil, is no more:
The ſtorms of wintry time will quickly paſs,
And one unbounded ſpring encircle all.

THOMSON'S *Winter.*

PROVIDENCE-Plantation, a colony of New-England, which, with Rhode-iſland, formerly conſtituted a charter government. Its chief town is Newport.

PROVIDENCE, one of the leaſt of the Bahama iſlands in the American ocean, but the beſt of thoſe planted and fortified by the Engliſh. It is ſeated on the eaſt

ſide

side of the gulf of Florida. W. Long. 77. 35. N. Lat. 25. 0.

PROVINCE, in Roman antiquity, a country of considerable extent, which, upon being entirely reduced under the Roman dominion, was new-modelled according to the pleasure of the conquerors, and subjected to the command of annual governors, sent from Rome; being commonly obliged to pay such taxes and contributions as the senate thought fit to demand.

Of these countries, that part of France next the Alps was one, and still retains the name *Provence*.

Nicod derives the word *à procul vivendo*, "living afar off;" but it is better deduced from *pro* and *vinco* "I overcome."

PROVINCE, in *Geography*, a division of a kingdom or state, comprising several cities, towns, &c. all under the same government, and usually distinguished by the extent either of the civil or ecclesiastical jurisdiction.

The church distinguishes its provinces by archbishoprics; in which sense, England is divided into two provinces, Canterbury and York.

The United Provinces are seven provinces of the Netherlands, who, revolting from the Spanish dominion, made a perpetual alliance, offensive and defensive, at Utrecht, anno 1579. See *UNITED Provinces*.

PROVINCIAL, something relating to a province. It also denotes, in Romish countries, a person who has the direction of the several convents of a province.

PROVISIONS, in a military sense, implies all manner of eatables, food or provender, used in an army, both for man and beast.

PROVOST of a city or town, is the chief municipal magistrate in several trading cities, particularly Edinburgh, Paris, &c. being much the same with mayor in other places. He presides in city-courts, and together with the bailies, who are his deputies, determines in all differences that arise among citizens.

The provost of Edinburgh is called *lord*, and the same title is claimed by the provost of Glasgow. The former calls yearly conventions of the royal boroughs to Edinburgh by his missives, and is, *ex officio*, president to the convention when met.

PROVOST, *or Prevot-Royal*, a sort of inferior judge formerly established throughout Frace, to take cognizance of all civil, personal, real, and mixed causes, among the people only.

Grand PROVOST of France, or *of the Household*, had jurisdiction in the king's house, and over the officers therein; looked to the policy thereof, the regulation of provisions, &c.

Grand PROVOST of the Constable, a judge who manages processes against the soldiers in the army who have committed any crime.

He has four lieutenants distributed throughout the army, called *provosts of the army*, and particularly provosts in the several regiments.

PROVOST Marshal of an Army, is an officer appointed to seize and secure deserters, and all other criminals. He is to hinder soldiers from pillaging, to indict offenders, and see the sentence passed on them executed. He also regulates the weights and measures, and the price of provisions, &c. in the army. For the discharge of his office, he has a lieutenant, a clerk, and a troop of marshal-men on horseback, as also an executioner.

There is also a provost-marshal in the navy, who has charge over prisoners, &c.

The French also had a provost-general of the marines, whose duty it was to prosecute the marines when guilty of any crime, and to make report thereof to the council of war; besides a marine provost in every vessel, who was a kind of gaoler, and took the prisoners into his care, and kept the vessel clean.

PROVOSTS of the Marshals, were a kind of lieutenants of the marshals of France; of these there were 180 seats in France; their chief jurisdiction regarded highwaymen, foot-pads, house-breakers, &c.

PROVOST of the Mint, a particular judge instituted for the apprehending and prosecuting of false coiners.

PROVOST, or *Prevot*, in the king's stables; his office is to attend at court, and hold the king's stirrup when he mounts his horse. There are four provosts of this kind, each of whom attends in his turn, monthly.

PROW, denotes the head or fore-part of a ship, particularly in a galley; being that which is opposite to the poop or stern.

PROXIMITY, denotes the relation of nearness, either in respect of place, blood, or alliance.

PRUDENCE, in ethics, may be defined an ability of judging what is best, in the choice both of ends and means. According to the definition of the Roman moralist, *De Officiis*, lib. i. cap. 43. prudence is the knowledge of what is to be desired or avoided. Accordingly, he makes *prudentia* (*De Legibus*, lib. i.) to be a contraction of *providentia*, or foresight. Plato (*De Legibus*, lib. iii.) calls this the leading virtue; and Juvenal, Sat. x. observes,

Nullum numen abest si sit prudentia.

The idea of prudence includes ευϐȣλια, or due consultation; that is, concerning such things as demand consultation in a right manner, and for a competent time, that the resolution taken up may be neither too precipitate nor too slow; and συνησις, or a faculty of discerning proper means when they occur; and to the perfection of prudence, these three things are farther required, viz. δεινοτης, or a natural sagacity; αγχινοια, presence of mind, or a ready turn of thought; and εμπειρια, or experience. The extremities of prudence are craft or cunning on the one hand, which is the pursuit of an ill end by direct and proper though not honest means; and folly on the other, which is either a mistake, both as to the end and means, or prosecuting a good end by foreign and improper means. Grove's *Moral Philosophy*, vol. ii. chap. ii.

PRUDENTIUS, or AURELIUS PRUDENTIUS CLEMENS, a famous Christian poet, under the reign of Theodosius the Great, who was born in Spain in the year 348. He first followed the profession of an advocate, was afterwards a judge, then a soldier, and at length had an honourable employment at court. We have a great number of his poems, which, from the choice of his subjects, may be termed *Christian poems*; but the style is barbarous, and very different from the purity of the Augustan age. The most esteemed editions of Prudentius's works are that of Amsterdam, in 1667, with Heinsius's Notes, and that of Paris in 1687, *in usum Delphini*.

PRUNELLA, a genus of plants belonging to the didynamia class; and in the natural method ranking under

under the 12th order, *holoraceæ*. See BOTANY *Index*.

PRUNES, are plums dried in the funfhine, or in an oven.

PRUNING, in *Gardening* and *Agriculture*, is the lopping off the fuperfluous branches of trees, in order to make them bear better fruit, grow higher, or appear more regular.

Pruning, though an operation of very general ufe, is neverthelefs rightly underftood by few; nor is it to be learned by rote, but requires a ftrict obfervation of the different manners of growth of the feveral forts of fruit-trees; the proper method of doing which cannot be known without carefully obferving how each kind is naturally difpofed to produce its fruit: for fome do this on the fame year's wood, as vines; others, for the moft part, upon the former year's wood, as peaches, nectarines, &c.; and others upon fpurs which are produced upon wood of three, four, &c. to fifteen or twenty years old, as pears, plums, cherries, &c. Therefore, in order to the right management of fruit-trees, provifion fhould always be made to have a fufficient quantity of bearing wood in every part of the trees; and at the fame time there fhould not be a fuperfluity of ufelefs branches, which would exhauft the ftrength of the trees, and caufe them to decay in a few years.

The reafons for pruning of fruit-trees, are, 1. To preferve them longer in a vigorous bearing-ftate; 2. To render them more beautiful; and, 3. To caufe the fruit to be larger and better tafted.

The general inftructions for pruning are as follow. The greateft care ought to be taken of fruit-trees in the fpring, when they are in vigorous growth; which is the only proper feafon for procuring a quantity of good wood in the different parts of the tree, and for difplacing all ufelefs branches as foon as they are produced, in order that the vigour of the tree may be entirely diftributed to fuch branches only as are defigned to remain. For this reafon trees ought not to be neglected in April and May, when their fhoots are produced: however, thofe branches which are intended for bearing the fucceeding year fhould not be fhortened during the time of their growth, becaufe this would caufe them to produce two lateral fhoots, from the eyes below the place where they were ftopped, which would draw much of the ftrength from the buds of the firft fhoot: and if the two lateral fhoots are not entirely cut away at the winter-pruning, they will prove injurious to the tree. This is to be chiefly underftood of ftone-fruit and grapes; but pears and apples, being much harder, fuffer not fo much, though it is a great difadvantage to thofe alfo to be thus managed. It muft likewife be remarked, that peaches, nectarines, apricots, cherries, and plums, are always in the greateft vigour when they are leaft maimed by the knife; for where large branches are taken off, they are fubject to gum and decay. It is therefore the moft prudent method to rub off all ufelefs buds when they are firft produced, and to pinch others, where new fhoots are wanted to fupply the vacancies of the wall; by which management they may be fo ordered as to want but little of the knife in winter-pruning. The management of pears and apples is much the fame with thefe trees in fummer; but in winter they muft be very differently pruned: for as peaches and nectarines, for the moft part, produce their fruit upon the former year's wood, and muft therefore have their branches fhortened according to their ftrength, in order to produce new fhoots for the fucceeding year; fo, on the contrary, pears, apples, plums, and cherries, producing their fruit upon fpurs, which come out of the wood of five, fix, and feven years old, fhould not be fhortened, becaufe thereby thofe buds which were naturally difpofed to form thefe fpurs, would produce wood-branches; by which means the trees would be filled with wood, but would never produce much fruit. The branches of ftandard-trees fhould never be fhortened unlefs where they are very luxuriant, and, by growing irregularly on one fide of the trees, attract the greateft part of the fap, by which means the other parts are either unfurnifhed with branches, or are rendered very weak; in which cafe the branch fhould be fhortened down as low as is neceffary, in order to obtain more branches to fill up the hollow of the tree: but this is only to be underftood of pears and apples, which will produce fhoots from wood of three, four, or more years old; whereas moft forts of ftone-fruit will gum and decay after fuch amputations: whenever this happens to ftone-fruit, it fhould be remedied by ftopping or pinching thofe fhoots in the fpring, before they have obtained too much vigour, which will caufe them to pufh out fide-branches; but this muft be done with caution. You muft alfo cut out all dead or decaying branches, which caufe their heads to look ragged, and alfo attract noxious particles from the air: in doing of this, you fhould cut them clofe down to the place where they were produced, otherwife that part of the branch which is left will alfo decay, and prove equally hurtful to the reft of the tree; for it feldom happens, when a branch begins to decay, that it does not die quite down to the place where it was produced, and if permitted to remain long uncut, often infects fome of the other parts of the tree. If the branches cut off are large, it will be very proper, after having fmoothed the cut part exactly even with a knife, chiffel, or hatchet, to put on a plafter of grafting clay, which will prevent the wet from foaking into the tree at the wounded part. All fuch branches as run acrofs each other, and occafion a confufion in the head of the tree, fhould be cut off; and as there are frequently young vigorous fhoots on old trees, which rife from the old branches near the trunk, and grow upright into the head, thefe fhould be carefully cut out every year, left, by being permitted to grow, they fill the tree too full of wood.

As to the pruning of foreft-trees, if they be large, it is beft not to prune them at all; yet, if there be an abfolute neceffity, avoid taking off large boughs as much as poffible. And, 1. If the bough be fmall, cut it fmooth, clofe and floping. 2. If the branch be large, and the tree old, cut it off at three or four feet from the ftem. 3. If the tree grow crooked, cut it off at the crook, floping upward, and nurfe up one of the moft promifing fhoots for a new ftem. 4. If the tree grow top-heavy, its head muft be lightened, and that by thinning the boughs that grow out of the main branches. But if you would have them fpring, rub off the buds, and fhroud up the fide-fhoots. 5. If the fide-bough ftill break out, and the top be able to fuftain itfelf, give the boughs that put forth in fpring a pruning after Midfummer, cutting them clofe.

It has been obſerved, that trees are ſubject to gum and decay, in conſequence of pruning; to prevent theſe injurious effects, a remedy has been propoſed by Mr Bucknall, which on trial, it is ſaid, has been ſucceſsful. By this method the branches to be removed are to be cut cloſe to the place of ſeparation from the trunk, ſmoothed well with a knife, and the wound is to be ſmeared over with medicated tar, laid on with a painter's bruſh. The following is the compoſition of this medicated tar. One quarter of an ounce of corroſive ſublimate reduced to fine powder, by beating it with a wooden hammer, is introduced into a three pint earthen pipkin, with about a glaſsful of gin or other ſpirit. The mixture is to be well ſtirred till the ſublimate is diſſolved. The pipkin is then gradually filled with vegetable or common tar, and conſtantly ſtirred, till the mixture be blended together as intimately as poſſible; and this quantity will at any time be ſufficient for 200 trees. To prevent danger, let the corroſive ſublimate be mixed with the tar as quickly as poſſible after it is purchaſed; for being of a very poiſonous nature to all animals, it ſhould not be ſuffered to lie about a houſe, for fear of miſchief to ſome part of the family.

By applying this compoſition, Mr Bucknall can, without the leaſt danger, uſe the pruning hook on all ſorts of trees, much more freely than by the uſe of any article hitherto recommended. The following remarks by the author on pruning in general, ſeem worthy of notice, and we give them in his own words. "I give no attention (ſays he) to fruit branches, and wood branches; but beg, once for all, that no branch ſhall ever be ſhortened, unleſs for the figure of the tree, and then conſtantly taken off cloſe to the ſeparation, by which means the wound ſoon heals. The more the range of the branches ſhoots circularly, a little inclining upwards, the more equally will the ſap be diſtributed, and the better will the tree bear; for, from that circumſtance, the ſap is more evenly impelled to every part. Do not let the ranges of branches be too near each other; for, remember all the fruit and the leaves ſhould have their full ſhare of the ſun; and where it ſuits, let the middle of the tree be free from wood, ſo that no branch ſhall ever croſs another, but all the extreme ends point upwards.

PRUNUS, a genus of plants belonging to the icoſandria claſs; and in the natural method ranking under the 36th ordea, *Pomaceæ*. See BOTANY *Index*.

PRUSA, in *Ancient Geography*, a town ſituated at Mount Olympus in Myſia, built by Pruſias, who waged war with Crœſus, (Strabo); with Cyrus, (Stephanus); both cotemporary princes. Now called *Burſa* or *Pruſa*, capital of Bithynia, in Aſia Minor. E. Long. 29. 5. N. Lat. 39. 22.

PRUSIAS, the name of ſeveral kings of Bithynia.

PRUSIAS, a town of Bithynia, anciently called *Cios*, from a cognominal river, and giving name to the Sinus Cianus of the Propontis; rebuilt by Pruſias the ſon of Zela, after having been deſtroyed by Philip the ſon of Demetrius: it ſtood on the Sinus Cianus, at the foot of Mount Arganthonius. This is the Pruſias who harboured Hannibal after the defeat of Antiochus.—Of this place was Aſclepiades, ſurnamed *Pruſicus*, the famous phyſician.

PRUSSIA, a modern, but deſervedly celebrated kingdom of Europe, whoſe monarch, along with Pruſſia Proper, poſſeſſes alſo the electorate of Brandenburg, and ſome other territories of conſiderable extent. The diſtrict properly called *Pruſſia* is of great extent, and divided into the Ducal and Regal Pruſſia, the latter belonging to the republic of Poland till the late partition of the Poliſh territories. Both together are of great extent; being bounded on the north by the Baltic, on the ſouth by Poland and the duchy of Mazovia, on the weſt by Pomerania, and on the eaſt by Lithuania and Samogitia. The name is by ſome thought to be derived from the *Boruſſi*, a tribe of the Sarmatians, who, migrating from the foot of the Riphæan mounntains, were tempted by the beauty and fertility of the country to ſettle there. Others think that the name of this country is properly *Poruſſia; Po* in the language of the natives ſignifying *near*, and *Poruſſia* ſignifying *near Ruſſia*. To the latter etymology we find the king of Pruſſia himſelf aſſenting in the treatiſe intitled *Memoirs of the Houſe of Brandenburg*. However, it muſt be owned, that theſe or any other etymologies of the word are very uncertain, and we find nothing like it mentioned by hiſtorians before the tenth century.

Plate CCCCXLIV.

1 Etymology of the name.

2 Exrreme barbarity of the ancient inhabitants.

The ancient ſtate of Pruſſia is almoſt entirely unknown. However, the people are ſaid to have been very ſavage and barbarous; living upon raw fleſh, and drinking the blood of horſes at their feaſts, according to Stella, even to intoxication (A). Nay, ſo extremely ſavage were this people, that they were even unacquainted with the method of conſtructing huts, and took up their dwelling in caves and cavities of rocks and trees, where they protected themſelves and children from the inclemencies of the weather. Among ſuch a people it is vain to expect that any tranſactions would be recorded, or indeed that any thing worthy of being recorded would be tranſacted. We ſhall therefore begin our hiſtory of Pruſſia with the time when the Teutonic knights firſt got footing in the country. (See TEUTONIC *Knights*).

3 Teutonic knights firſt get footing in the country.

On the expulſion of the Chriſtians from the Holy Land by Saladin, a ſettlement was given to the Teutonic knights in Pruſſia by Conrade duke of Mazovia, the competitor of Boleſlaus V. for the crown of Poland. Their firſt reſidence in this country was Culm; to which territory they were confined by the conditions of the donation, excepting what they could conquer from their pagan neighbours, all which the emperor granted to them in perpetuity.

Encouraged by this grant, the knights conquered the greateſt

(A) This author does not mention any particular method by which they communicated an inebriating quality to the blood of animals. Poſſibly, however, the vital fluid may have a property of this kind, though unknown in our days where ſuch barbarous cuſtoms are diſuſed. Drunkenneſs from drinking blood is frequently mentioned in Scripture, but whether literally or metaphorically muſt be decided by the learned.

greateft part of the country which now goes by the name of *Pruffia;* and, not content with this, became very troublefome to Poland, infomuch that the monarchs of that kingdom were fometimes obliged to carry on dangerous and bloody wars with them; for an account of which we refer to the article POLAND, n° 61. 67, &c.

The Teutonic order continued in Pruffia till the year 1531. Their laft grand-mafter was Albert marquis of Brandenburg, and nephew to Sigifmund I. king of Poland. He was preferred to this dignity in hopes that his affinity to Sigifmund might procure a reftitution of fome of the places which had been taken from the order during the former unfuccefsful wars with Poland; but in this the fraternity were difappointed. Albert, however, was fo far from endeavouring to obtain any favour from his uncle by fair means, that he refufed to do homage to him, and immediately began to make preparations for throwing off his dependence altogether, and recovering the whole of Pruffia and Pomerania by force of arms. In this he was fo far from fucceeding, that, being foiled in every attempt, he was forced to refign the dignity of grand-mafter; in recompenfe for which, his uncle beftowed on him that part of Pruffia

4 Expelled.

now called *Ducal*, in quality of a fecular duke. It was now the intereft of the houfe of Brandenburg to affift in the expulfion of the fraternity; and accordingly, being at laft driven out of Pruffia and Pomerania, they transferred their chapter to Mariendal in Franconia; but in that and other provinces of the empire where they fettled, little more than the name of the order, once fo famous, now remains.

5 Hiftory of Brandenburg.

The other moft confiderable part of his Pruffian majefty's dominions is the electorate of Brandenburg. Like other parts of Germany, it was anciently poffeffed by barbarians, of whom no hiftory can be given. Thefe were fubdued by Charlemagne, as is related under the article FRANCE *; but being on every occafion ready to revolt, in 927 Henry the Fowler eftablifhed margraves, or governors of the frontiers, to keep the barbarians in awe. The firft margrave of Brandenburg was Sigefroy, brother-in-law to the above-mentioned emperor; under whofe adminiftration the bifhoprics of Brandenburg and Havelberg were eftablifhed by Otho I. From this Sigefroy, to the fucceffion of the houfe of Hohenzollern, from whom the prefent elector is defcended, there are reckoned eight different families, who have been margraves of Brandenburg; namely, the family of the Saxons, of Walbeck, Staden, Plenck, Anhalt, Bavaria, Luxemburg, and Mifnia. The margraves of the four firft races had continual wars with the Vandals and other barbarous people; nor could their ravages be ftopped till the reign of Albert furnamed *the Bear*, the firft prince of the houfe of Anhalt. He was made margrave by the emperor Conrad III. and afterwards raifed to the dignity of elector by Frederic Barbaroffa, about the year 1100. Some years afterwards the king of the Vandals dying without iffue, left the Middle Marche by his laft will to the elector, who was befides poffeffed of the Old Marche, Upper Saxony, the country of Anhalt, and part of Lufacc. In 1332 this line became extinct, and the electorate devolved to the empire. It was then given by the emperor Louis of Bavaria to his fon Louis, who was the firft of the fixth race. Louis the Roman fucceeded his brother; and as he alfo died without children, he was fucceeded by Otho, his third brother, who fold the electorate to the emperor Charles IV. of the houfe of Luxemburg, for 200,000 florins of gold. Charles IV. gave the Marche to his fon Winceflaus, to whom Sigifmund fucceeded. This elector, being embarraffed in his circumftances, fold the New Marche to the knights of the Teutonic order. Joffe fucceeded Sigifmund; but afpiring to the empire, fold the electorate to William duke of Mifnia; who, after he had poffeffed it for one year, fold it again to the emperor Sigifmund. In 1417, Frederic VI. burgrave of Nuremberg, received the inveftiture of the country of Brandenburg at the diet of Conftance from the hands of the emperor Sigifmund; who, two years before, had conferred upon him the dignity of elector, and arch-chamberlain of the Holy Roman empire.

* N° 27, &c.

This prince, the firft of the family of Hohenzollern, found himfelf poffeffed of the Old and Middle Marche, but the dukes of Pomerania had ufurped the Marche Ukraine. Againft them, therefore, the elector immediately declared war, and foon recovered the province. As the New Marche ftill continued in the hands of the Teutonic kights, to whom it had been fold as we have already mentioned, the elector, to make up for this, took poffeffion of Saxony, which at that time happened to be vacant by the death of Albert the laft elector of the Anhalt line. But the emperor, not approving of this ftep, gave the inveftiture of Saxony to the duke of Mifnia; upon which Frederic voluntarily defifted from his acquifitions. This elector made a divifion of his poffeffions by will. His eldeft fon was deprived of his right on account of his having too clofely applied himfelf to fearch for the philofopher's ftone; fo he left him only Voigtland. The electorate was given to his fecond fon Frederic; Albert, furnamed *Achilles*, had the duchies of Franconia; and Frederic, furnamed the *Fat*, had the Old Marche; but by his death it returned to the electorate of Brandenburg.

Frederic I. was fucceeded by his fon, called alfo *Frederic*, and furnamed *Iron-tooth* on account of his ftrength. He might with as great reafon have been furnamed *the Magnanimous*, fince he refufed two crowns, viz. that of Bohemia, which was offered him by the pope, and the kingdom of Poland to which he was invited by the people; but Frederic declared he would not accept of it unlefs Cafimir brother to Ladiflaus the late king refufed it. Thefe inftances of magnanimity had fuch an effect on the neighbouring people, that the ftates of Lower Lufatia made a voluntary furrender of their country to him. But as Lufatia was a fief of Bohemia, the king of that country immediately made war on the elector, in order to recover it. However, he was fo far from being fuccefsful, that, by a treaty of peace concluded in 1462, he was obliged to yield the perpetual fovereignity of Corbus, Peits, Sommerfeld, and fome other places, to the elector. Frederic then, having redeemed the New Marche from the Teutonic order for the fum of 100,000 florins, and ftill further enlarged his dominions, refigned the fovereignty in 1469 to his brother Albert, furnamed *Achilles*. 6

6 Exploits of Albert furnamed *Achilles*.

Albert was 57 years old when his brother refigned the

Pruffia. the electorate to him. Moft of his exploits, for which he had the furname of *Achilles*, had been performed while he was burgrave of Nuremberg. He declared war againft Lewis duke of Bavaria, and defeated and took him prifoner. He gained eight battles againft the Nurembergers, who had rebelled and contefted his rights to the burgraviate. In one of thefe he fought fingly againft 16 men, till his people came up to his affiftance. He made himfelf mafter of the town of Grieffenburg in the fame manner that Alexander the Great took the capital of the Oxydracæ, by leaping from the top of the walls into the town, where he defended himfelf fingly againft the inhabitants till his men forced the gates and refcued him. The confidence which the emperor Frederic III. placed in him, gained him the direction of almoft the whole empire. He commanded the Imperial armies againft Lewis the Rich duke of Bavaria; and againft Charles the Bold duke of Burgundy, who had laid fiege to Nuis, but concluded a peace at the interpofition of Albert. He gained the prize at 17 tournaments, and was never difmounted.

7 Pruffia and Brandenburg united.

All thefe exploits, however, had been performed before Albert obtained the electorate. From that time we meet with no very important tranfactions till the year 1594, when John Sigifmund of Brandenburg, having married Anne the only daughter of Albert duke of Pruffia, this united that duchy to the electorate, to which it has continued to be united ever fince; and obtained pretenfions to the countries of Juliers, Berg, Cleves, Marck, Ravenfburg, and Ravenftein, to the fucceffion of which Anne was heirefs.

8 Unfortunate reign of the elector George William.

Sigifmund died in 1619, and was fucceeded by his fon George William; during whofe government the electorate fuffered the moft miferable calamities. At this time it was that the war commenced between the Proteftants and Catholics, which lafted 30 years. The former, although leagued together, were on the point of being utterly deftroyed by the Imperialifts under the command of Count Tilly and Wallenftein, when Guftavus Adolphus of Sweden turned the fcale in their favour, and threatened the Catholic party with utter deftruction *. But by his death at the battle of Lutzen, the fortune of war was once more changed. At laft, however, peace was concluded with the emperor; and, in 1640, the elector died, leaving his dominions to his fon Frederic William, furnamed the *Great*.

* See *Sweden*.

9 Reign of Frederic William the Great.

This young prince, though only 20 years of age at the time of his acceffion, applied himfelf with the utmoft diligence to repair the loffes and devaftations occafioned by the dreadful wars which had preceded. He received the inveftiture of Pruffia perfonally from the king of Poland, on condition of paying 100,000 florins annually, and not making truce or peace with the enemies of that crown. His envoy likewife received the inveftiture of the electorate from the emperor Ferdinand III. The elector then thought of recovering his provinces from thofe who had ufurped them. He concluded a truce for 20 years with the Swedes, who evacuated the greateft part of his eftates. He likewife paid 140,000 crowns to the Swedifh garrifons, which ftill poffeffed fome of his towns; and he concluded a treaty with the Heffians, who delivered up a part of the duchy of Cleves; and obtained of the Hollanders the evacuation of fome other cities. Pruffia.

In the mean time, the powers of Europe began to be weary of a war which had continued for fuch a length of time with fuch unrelenting fury. The cities of Ofnaburg and Munfter being chofen as the moft proper places for negociation, the conferences were opened in the year 1645; but, by reafon of the multiplicity of bufinefs, they were not concluded till two years after. France, which had efpoufed the interefts of Sweden, demanded that Pomerania fhould be ceded to that kingdom as an indemnification for the expences which the war had coft Guftavus Adolphus and his fucceffors. Although the empire and the elector refufed to give up Pomerania, it was at laft agreed to give up to the Swedes Hither Pomerania, with the ifles of Rugen and Wollin, alfo fome cities; in return for which ceffion, the bifhoprics of Halberftadt, Minden, and Camin, were fecularized in favour of the elector, of which he was put in poffeffion, together with the lordfhips of Hochenftein and Richenftein, with the reverfion of the archbifhopric of Magdeburg. This was the treaty of Weftphalia concluded in 1648, and which ferves as a bafis to all the poffeffions and rights of the German princes. The elector then concluded a new treaty with the Swedes, for the regulation of limits, and for the acquittal of fome debts, of which Sweden would only pay a fourth; and next year the electorate, Pomerania, and the duchies of Cleves, were evacuated by the Swedes.

10 Treaty of Weftphalia concluded.

Notwithftanding all thefe treaties, however, the Swedes foon after invaded Pomerania, but were entirely defeated by the elector near the town of Fehrbellin. Three thoufand were left dead on the fpot, among whom were a great number of officers; and a great many were taken prifoners. The elector then purfued his victory, gained many advantages over the Swedes, and deprived them of the cities of Stralfund and Gripfwald. On this the Swedes, hoping to oblige the elector to evacuate Pomerania, which he had almoft totally fubdued, invaded Pruffia, from Livonia, with 16,000 men; and advancing into the country, they burned the fuburbs of Memel, and took the cities of Tilfe and Infterburg. The elector, to oppofe the invaders, left Berlin on the 10th of January 1679, at the head of 9000 men. The Swedes retired at his approach, and were greatly haraffed by the troops on their march. So fuccefsful indeed was the elector on this occafion, that the Swedes loft almoft one half of their army killed or taken prifoners. At laft, having croffed the bay of Frifch-haff and Courland on the ice, he arrived on the 19th of January, with his infantry, within three miles of Tilfe, where the Swedes had their head-quarters. The fame day, his general, Trefenfeldt, defeated two regiments of the enemy near Splitter; and the Swedes who were in Tilfe abandoned that place, and retired towards Courland. They were purfued by General Gortz, and entirely defeated with fuch flaughter, that fcarce 3000 of them returned to Livonia. Yet, notwithftanding all thefe victories, the elector, being preffed on the other fide by the victorious generals of France, M. Turenne and the prince of Conde, was obliged to make peace with the Swedes. The conditions were, that

11 The elector fucceeds againft the Swedes.

12 Is obliged to conclude a treaty of peace with them.

Pruſſia

that the treaty of Weſtphalia ſhould ſerve for a baſis to the peace; that the elector ſhould have the property of the cuſtoms in all the ports of Further Pomerania, with the cities of Camin, Gartz, Grieffenburg, and Wildenbruck: on his part, he conſented to give up to the Swedes all that he had conquered from them, and to give no aſſiſtance to the king of Denmark, upon condition that France delivered up to him his provinces in Weſtphalia, and paid him 300,000 ducats, as an indemnification for the damages done by the French to his ſtates. This treaty was ſtyled *the peace of St Germain.*

13
A ſtrange embaſſy from the cham of Tartary.

With the treaty of St Germain terminated the military exploits of Frederic William, who paſſed the laſt years of his adminiſtration in peace. His great qualities had rendered him reſpected by all Europe, and had even been heard of in Tartary. He received an embaſſy from Murad Geray, cham of the Tartars, courting his friendſhip. The barbarian ambaſſador appeared in ſuch tattered clothes as ſcarce covered his nakedneſs, ſo that they were obliged to furniſh him with other clothes before he could appear at court. His interpreter had a wooden noſe and no ears. In 1684, Frederic received into his dominions great numbers of Proteſtants who fled out of France from the perſecutions of Louis XIV. after he had revoked the edict of Nantz. Twenty thouſand of them are ſaid to have ſettled at this time in the electorate, where they introduced new arts and manufactures, that were of the utmoſt benefit to the country. By this, however, he diſobliged Louis XIV. for which reaſon he concluded an alliance with the emperor; and having furniſhed him with 8000 troops againſt the Turks in Hungary, the emperor yielded to him the circle of Schwibus in Sileſia, as an equivalent for all his rights in that province.

14
Frederic III. obtains the title of king of Pruſſia.

In 1688, the elector Frederic William died, and was ſucceeded by his ſon Frederic III. This prince was remarkably fond of ſhow and ceremony, which, during the courſe of his government, involved him in much expence. The regal dignity ſeemed to be the greateſt object of his ambition. To obtain this, he joined with the emperor in the alliance againſt France, in which he was engaged by William III. king of Britain. He alſo yielded up the circle of Schwibus, which had been given to his predeceſſor; and, in 1700, obtained from the emperor that dignity which he had ſo earneſtly deſired. The terms on which it was obtained were, 1. That Frederic ſhould never ſeparate from the empire thoſe provinces of his dominions which depended on it. 2. That he ſhould not, in the emperor's preſence, demand any other marks of honour than thoſe which he had hitherto enjoyed. 3. That his Imperial majeſty, when he wrote to him, ſhould only give him the title of *Royal Dilection.* 4. That nevertheleſs the miniſters which he had at Vienna ſhould be treated like thoſe of other crowned heads. 5. That the elector ſhould maintain 6000 men in Italy at his own expence, in caſe the emperor ſhould be obliged to make war on account of the ſucceſſion of the houſe of Bourbon to the crown of Spain. 6. That thoſe troops ſhould continue there as long as the war laſted.

Thus was the kingdom of Pruſſia eſtabliſhed through the friendſhip of the emperor, with whom Frederic I. ſo called as being the firſt king of Pruſſia, continued all his life in ſtrict alliance. Indeed he was a pacific prince; and though contemptible in his perſon, and incapable of atchieving great things, had this merit, that he always preſerved his dominions in peace, and thus conſulted the true intereſt of his ſubjects much more than thoſe monarchs who have dazzled the eyes of the world by their military exploits. He was indeed vain, and fond of ſhow, as we have already obſerved; but had a good heart, and is ſaid never to have violated his conjugal vow; though it does not appear that he was greatly beloved by his royal conſorts (of whom he had three) on that or any other account.

15
Frederic II. of Pruſſia a martial prince.

Frederic I. died in the beginning of 1713, and was ſucceeded by Frederic William. He was in almoſt every thing the reverſe of his father. His diſpoſitions were altogether martial; ſo that he applied himſelf entirely to the augmentation of his army, and perfecting them in their exerciſe, by which means they became the moſt expert ſoldiers in Europe. His foible was an ambition of having his army compoſed of men above the ordinary ſize; but as theſe could not be procured, he compoſed a regiment of the talleſt men he could find; and as his officers made no ſcruple of picking up ſuch men wherever they could find them for his majeſty's uſe, the neighbouring ſtates were frequently offended, and a war was often likely to enſue even from this ridiculous cauſe. However, his Pruſſian majeſty was never engaged in any martial enterpriſe of conſequence: but having put his army on the moſt reſpectable footing of any in the world, and filled his coffers, for he was of a very ſaving diſpoſition, he put it in the power of his ſon to perform thoſe exploits which have been matter of aſtoniſhment to all Europe.

16
Enmity between Pruſſia and Auſtria.

It was in this king's reign that Pruſſia firſt perceived her natural enemy and rival to be the houſe of Auſtria, and not France as had been formerly ſuppoſed. Hence frequent bickerings took place between theſe two powers, for which the perſecution of the Proteſtants by ſome of the Catholic ſtates of the empire afforded a pretence; and though a war never actually place, yet it was eaſy to ſee that both were mortal enemies to each other. But when Frederic William died in 1740, this enmity broke out in full force. The empreſs queen was then left in a very diſagreeable ſituation, as has been obſerved under the article BRITAIN, N° 410, &c. Of this Frederic III. took the advantage to do himſelf juſtice, as he ſaid, with regard to Sileſia, of which his anceſtors had been unjuſtly deprived. This province be ſeized at that time: but it coſt him dear; for the empreſs, having at laſt overcome all difficulties, formed againſt him the moſt terrible combination that ever was known in Europe.

17
Frederic III. ſeizes Sileſia.

The treaty was hardly concluded with the king of Pruſſia, by which ſhe reluctantly yielded up the province of Sileſia, and with it a clear revenue of 800,000l. a-year, before ſhe entered into another with the court of Peterſburg, which was concluded May 22. 1746. This treaty, as far as it was made public, was only of a defenſive nature; but ſix ſecret and ſeparate articles were added to it. By one of theſe it was provided, that in caſe his Pruſſian majeſty ſhould attack the empreſs queen, or the empreſs of Ruſſia, or even the republic of Poland, it ſhould be conſidered as a breach of the treaty of Dreſden, by which Sileſia was given up. It was alſo ſtipulated, that, notwithſtanding that treaty (which indeed had been dictated by the king of Pruſſia himſelf), the

18
Combination againſt him.

Pruffia.

the right of the emprefs-queen to Silefia ftill continued, and for the recovery of that province the contracting powers fhould mutually furnifh an army of 60,000 men. To this treaty, called the treaty of *Peterfburg*, the king of Poland was invited to accede; but he, being in a manner in the power of the king of Pruffia, did not think proper to fign it: however, he verbally acceded to it in fuch a manner, that the other parties were fully convinced of his defign to cooperate with all their meafures; and in confideration of this intention, it was agreed that he fhould have a fhare in the partition of the king of Pruffia's dominions, in cafe of a fuccefsful event of their enterprifes.

In confequence of thefe machinations, every art was ufed to render the king of Pruffia perfonally odious to the emprefs of Ruffia; the queen of Hungary made vaft preparations in Bohemia and Moravia; and the king of Poland, under pretence of a military amufement, drew together 16,000 men, with whom he occupied a ftrong poft at Pirna. The queen of Hungary, ftill further to ftrengthen herfelf, concluded a treaty with the court of France at Verfailles, dated May 1. 1756. But in the mean time, the king of Pruffia having underftood by his emiffaries what was going forward, refolved to be beforehand with his enemies, and at leaft to keep the war out of his own country; and therefore entered Saxony with a confiderable army. At firft he affected only to demand a free paffage for his troops, and an obfervance of the neutrality profeffed by the king of Poland; but, having good reafons to doubt this neutrality, he demanded, as a preliminary, that thefe Saxon troops fhould immediately quit the ftrong poft they occupied, and difperfe themfelves. This demand was refufed; on which his Pruffian majefty blockaded the Saxon camp at Pirna, refolving to reduce it by famine, fince its ftrong fituation rendered an attack very dangerous. At that time there were in Bohemia two Saxon armies, one under the command of M. Brown, and the other under M. Picolomini. To keep thefe in awe, the king had fent M. Schwerin with an army into Bohemia from the country of Glatz, and M. Keith had penetrated into the fame kingdom on the fide of Mifnia. But ftill the king of Pruffia did not entirely confide in thefe difpofitions; and therefore fearing left M. Brown might afford fome affiftance to the Saxons, he joined his forces under Keith, and on December 1. attacked and defeated the Auftrian general, fo that the latter found it impoffible to relieve the Saxons, who, after a vain attempt to retire from their poft, were all taken prifoners. The king of Poland quitted his dominions in Germany, and the Pruffians took up their winter quarters in Saxony. Here they feized on the revenues, levied exorbitant contributions, and obliged the country to furnifh them with recruits. The king of Pruffia at this time made himfelf mafter of the archives of Drefden, by which means he procured the originals of thofe pieces above-mentioned, which, when produced to the world, gave a full proof of the combination that had been formed againft him, and confequently juftified the meafures he had taken for his own defence.

19 He invades Saxony,

20 and takes 16,000 Saxons prifoners.

21 He is profecuted in the Aulic council, and put to the ban of the empire.

No fooner had the king entered Saxony, in the manner already related, than a procefs was commenced againft him in the emperor's Aulic council, and before the diet of the empire, where he was foon condemned for contumacy, and put to the ban of the empire.—The various circles of the empire were ordered to furnifh their contingents of men and money to put this fentence in execution; but thefe came in fo flowly, that, had it not been for the affiftance of the French under the prince de Soubife, the army would probably have never been in a condition to act. The Auftrians, in the mean time, made great preparations, and raifed 100,000 men in Bohemia, whom they committed to the care of Prince Charles of Lorrain, affifted by M. Brown. The Czarina fent a body of 60,000 men under M. Apraxin, to invade the Ducal Pruffia; whilft a ftrong fleet was equipped in the Baltic, in order to co-operate with that army. The king of Sweden alfo acceded to the confederacy, in hopes of recovering the poffeffions in Pomerania which his anceftors had enjoyed; and the duke of Mecklenburg took the fame party, promifing to join the Swedifh army with 6000 men as foon as it fhould be neceffary. On the king of Pruffia's fide appeared nobody excepting an army of between 30,000 and 40,000 Hanoverians commanded by the duke of Cumberland; and thefe were outnumbered and forced to yield to a fuperior army of French commanded by M. d'Etrees.

22 Prodigious preparations againft him.

In the mean time, his Pruffian majefty, finding that he muft depend for affiftance folely on his own abilities, refolved to make the beft ufe of his time. Accordingly, in the fpring 1757, his armies poured into Bohemia from two different quarters, while the king himfelf prepared to enter it from a third. M. Schwerin entered from Silefia; the prince of Bevern from Lufatia, where he defeated an army of 28,000 Auftrians that oppofed his paffage. As the intentions of the king himfelf were not known, the Auftrians detached a body of 20,000 men from their main army to obferve his motions. This was no fooner done than the king cut off all communication between the detachment and the main body; and having joined his two generals with incredible celerity, he engaged the Auftrians near Prague, totally defeated them, took their camp, military cheft, and cannon; but loft the brave General Schwerin, who was killed at the age of 82, with a colonel's ftandard in his hand. On the Auftrian fide, M. Brown was wounded, and died in a fhort time, though it is fuppofed more from the chagrin he fuffered, than from the dangerous nature of the wound itfelf.

23 He invades Bohemia, and totally defeats the Auftrian army.

About 40,000 of the Auftrian army took refuge in Prague, while the reft fled different ways. The city was inftantly invefted by the king, and all fuccours were cut off. The great number of troops which it contained rendered an attack unadvifable, but feemed to render the reduction of it by famine inevitable; however, the king, to accomplifh his purpofe the more fpeedily, prepared to bombard the town. On the 29th of May, after a moft dreadful ftorm of thunder and lightning, four batteries began to play on the city. From thefe were thrown, every 24 hours, 288 bombs, befides a vaft number of red-hot balls, fo that it was foon on fire in every quarter. The garrifon made a vigorous defence, and one well-conducted fally; but had the misfortune to be repulfed with great lofs. The magiftrates, burghers, and clergy, feeing their city on the point of being

24 Befieges and bombards Prague.

Pruſſia

reduced to an heap of rubbiſh, ſupplicated the commander in the moſt earneſt manner to capitulate; but he was deaf to their intreaties, and drove 12,000 of the moſt uſeleſs mouths out of town, who were quickly driven in again by the Pruſſians.

25
Count Daun takes the command of the Auſtrian army.

Thus the affairs of the empreſs queen ſeemed verging to deſtruction, when Leopold count Daun took upon him the command of the remains of M. Brown's army. This general had arrived within a few miles of Prague the day after the great battle. He immediately collected the ſcattered fugitives with the greateſt diligence, and retired with them to a ſtrong poſt in the neighbourhood, from whence he gave the troops in Prague hopes of a ſpeedy relief. It was now the king of Pruſſia's buſineſs, either to have attempted to make himſelf maſter of the city by one deſperate effort, or entirely to have abandoned the enterpriſe, and driven Count Daun from his poſt before his troops had recovered from the terror of their late defeat; but, by attempting to do both, he rendered himſelf incapable of doing either. Though the army of Count Daun already amounted to 60,000 men, and though they were ſtrongly entrenched, and defended by a vaſt train of artillery, his majeſty thought proper to ſend no more than 32,000 men. This body made the arduous attempt on the 18th of June; but though they did all that human courage and conduct could do, and though the king himſelf at laſt charged at the head of his cavalry, the Pruſſians were driven out of the field with great loſs. This engagement was named *the battle of Colin*.

26
Defeats the Pruſſians at Colin.

27
Siege of Prague raiſed.

The firſt conſequence of the battle of Colin was, that the king of Pruſſia was obliged to raiſe the ſiege of Prague; ſoon after which, he was obliged to quit Bohemia, and take refuge in Saxony. The Auſtrians haraſſed him as much as poſſible; but, notwithſtanding their great ſuperiority, their armies were not in a condition to make any deciſive attempt upon him, as the frontiers of Saxony abounded with ſituations eaſily defended. In the mean time, the Ruſſians, who had hitherto been very dilatory in their motions, began to exert themſelves, and entered Ducal Pruſſia, under M. Apraxin and Fermor, where they committed innumerable cruelties and exceſſes. A large body of Auſtrians entered Sileſia, and penetrated as far as Breſlau. Then they made a turn backwards, and beſieged Schweidnitz. Another body entered Luſatia, and made themſelves maſters of Zittau. An army of 22,000 Swedes entered Pruſſian Pomerania, took the towns of Anclam and Demmein, and laid the whole country under contribution. The French, too, being freed from all reſtraint by the capitulation of the duke of Cumberland at Cloſter Seven *, made their way into Halbertſtadt and the Old Marche of Brandenburg, firſt exacting contributions, and then plundering the towns. The army of the empire, being reinforced by that of the prince de Soubiſe, after many delays, was on full march to enter Saxony, which left the Auſtrians at liberty to exert the greateſt part of their force in the reduction of Sileſia. General Haddick penetrated through Luſatia, paſſed by the Pruſſian armies, and ſuddenly appeared before the gates of Berlin, which city he laid under contribution. He retired on the approach of a body of Pruſſians; yet he ſtill found means to keep ſuch a poſt as interrupted the king's communication with Sileſia. The deſtruction of the king of Pruſſia therefore now ſeemed inevitable. Every exertion which he had made, though brave and well-conducted, had been unſucceſsful. His general Lehwald, who oppoſed the Ruſſians, had orders to attack them at all events. He obeyed his orders; and with 30,000 men attacked 60,000 of the enemy ſtrongly entrenched at a place called *Norkitten*. The Pruſſians behaved with the greateſt valour; but after having killed five times more of the enemy than they themſelves loſt, they were obliged to retire, though more formidable after their defeat than the Ruſſians after their victory. The king, in the mean time, exerted himſelf on every ſide, and his enemies fled everywhere before him; but whilſt he purſued one body, another gained upon him in ſome other part, and the winter came on faſt, while his ſtrength decayed, and that of his adverſaries ſeemed to increaſe on every quarter.

* See Britain, n° 441.

28
Berlin laid under contribution.

29
Lehwald a Pruſſian general defeated by the Ruſſians.

The Pruſſian monarch, however, though diſtreſſed, did not abandon himſelf to deſpair, or loſe that wonderful preſence of mind which has ſo eminently diſtinguiſhed him in all his military enterpriſes. He induſtriouſly delayed a deciſive action till the approach of winter; but at laſt, after various movements, on November 5. 1757, he met at Roſbach with the united army of his enemies commanded by the prince of Saxe Hilburghauſen and the prince de Soubiſe. The allied army amounted to 50,000 men complete; but moſt of the troops of the Circles were new raiſed, and many of them not well affected to the cauſe. The Pruſſians did not exceed 25,000 men; but they were ſuperior to any troops in the world, and were inſpired, by the preſence of their king, with the moſt enthuſiaſtic valour. The Auſtrians were defeated with the loſs of 3000 killed, eight generals, 250 officers of different ranks, and 6000 private ſoldiers, taken priſoners, while night alone prevented the total deſtruction of the army.

30
The king gains a great victory at Roſbach.

By this battle the king was ſet free on one ſide; but this only gave him an opportunity of renewing his labours on another. The Auſtrians had a great force, and now began to make a proportionable progreſs in Sileſia. After a ſiege of 16 days, they had reduced the ſtrong fortreſs of Schweidnitz, and obliged the Pruſſian garriſon of 4000 men to ſurrender priſoners of war. Hearing then of the victory at Roſbach, and that the king of Pruſſia was in full march to relieve Sileſia, they reſolved to attack the prince of Bevern in his ſtrong camp under the walls of Breſlau. They attacked the Prince's army on November 22d; but their attack was ſuſtained with the greateſt reſolution. The ſlaughter of the Auſtrians was prodigious. A great part of the enemy had retired from the field of battle, and the reſt were preparing to retire, when all at once the Pruſſian generals took the ſame reſolution. Their army had ſuffered much in the engagement, and they became apprehenſive of a total defeat in caſe their intrenchments ſhould be forced in any part; for which reaſon they quitted their ſtrong poſt, and retired behind the Oder. Two days after, the prince of Bevern, going to reconnoitre without eſcort, attended only by a groom, was taken priſoner by an advanced party of Croats, a ſmall body of whom had croſſed the Oder.

31
Schweidnitz taken by the Auſtrians.

31
Battle with the prince of Bevern.

On

Pruſſia.

33 Breſlau taken by the Auſtrians.

On this the town of Breſlau immediately ſurrendered; where, as well as at Schweidnitz, the Auſtrians found great quantities of proviſions, ammunition, and money. All Sileſia was on the point of falling into their hands, and the Pruſſian affairs were going into the utmoſt diſtraction, when the king himſelf by a moſt rapid march paſſed through Thuringia, Miſnia, and Luſatia, in ſpite of the utmoſt efforts of the generals Haddick and Marſhal, who were placed there to oppoſe him; and, entering Sileſia on the 2d of December, joined the prince of Bevern's corps, who repaſſed the Oder to meet him. The garriſon of Schweidnitz, who, as we have already obſerved, had been made priſoners of war, alſo joined the king's army unexpectedly; and their preſence contributed not a little, notwithſtanding the ſmallneſs of their number, to raiſe the ſpirits of the whole army. They had ſubmitted to the capitulation with the greateſt reluctance; but as the Auſtrians were conducting them to priſon, they happened to receive intelligence of the victory at Roſbach: on which they immediately roſe on the eſcort that conducted them, and entirely diſperſed it; and afterwards marching in ſuch a direction as they thought might moſt readily lead them to their king, they accidentally fell in with his army.

34 Garriſon of Schweidnitz recover their liberty.

35 Count Daun defeated by the king of Pruſſia at Leuthen.

His Pruſſian majeſty now approached Breſlau; on which the Auſtrians, confiding in their ſuperiority, (for they exceeded 70,000, while the Pruſſians ſcarce amounted to 36,000), abandoned their ſtrong camp, the ſame which the prince of Bevern had formerly occupied, and advanced to give him battle. The king did not intend by any means to diſappoint them, but advanced on his part with the greateſt celerity. The two armies met on December 5th, near the village of Leuthen. Count Daun made the beſt diſpoſitions poſſible. The ground occupied by his army was a plain, with ſmall eminences in ſome parts. Theſe eminences they ſurrounded with artillery; and as the ground was alſo interſperſed with thickets, they ſought to turn theſe likewiſe to their advantage. On their right and left were hills, on which they planted batteries of cannon. The ground in their front was interſected by many cauſeways; and to make the whole more impracticable, the Auſtrians had felled a great number of trees, and ſcattered them in the way. It was almoſt impoſſible at the beginning of the engagement for the Pruſſian cavalry to act, on account of theſe impediments; but, by a judicious diſpoſition made by the king himſelf, all difficulties were overcome. His majeſty had placed four battalions behind the cavalry of his right wing; foreſeeing that General Nadaſti, who was placed on the enemy's left with a corps de reſerve, deſigned to attack him in flank. It happened as he had foreſeen: that general's cavalry attacked the Pruſſian right wing with great fury; but he was received with ſuch a ſevere fire from the four battalions, that he was obliged to retire in diſorder. The king's flank then, well covered and ſupported, was enabled to act with ſuch order and vigour as repulſed the enemy. The Auſtrian artillery was alſo ſilenced by that of the Pruſſians; however, the Auſtrians continued to make a gallant reſiſtance during the whole battle. After having been once thrown into diſorder, they rallied all their forces about Leuthen, which was defended on every ſide by entrenchments and redoubts. The Pruſſians attacked them with the utmoſt impetuoſity, and at laſt became maſters of the poſt; on which the enemy fled on all ſides, and a total rout enſued. In this battle the Auſtrians loſt 6000 killed on the ſpot, 15,000 taken priſoners, and upwards of 200 pieces of cannon.

36 Breſlau retaken.

The conſequences of this victory were very great. Breſlau was immediately inveſted, and ſurrendered on December 29th; the garriſon, amounting to 13,000 men, were made priſoners of war. The blockade of Schweidnitz was formed as cloſely as the ſeaſon of the year would permit; while detached Pruſſian parties overran the whole country of Sileſia, and reduced every place of leſs importance. The Ruſſians, who had ravaged and deſtroyed the country in ſuch a manner that they could not ſubſiſt in it, thought proper to retire out of the Pruſſian dominions altogether. Thus General Lehwald was left at liberty to act againſt the Swedes; and them he quickly drove out of Pruſſian Pomerania, the whole of which country he not only recovered, but alſo ſome part of Swediſh Pomerania. Thus the duchy of Mecklenburg being left quite expoſed, the king took ample vengeance on it by exacting the moſt ſevere contributions of men and money. To complete this monarch's good fortune alſo, the French, who had retired after the battle of Roſbach, were now oppoſed by the Hanoverians under Prince Ferdinand, who kept them ſo well employed, that, during the reſt of the war, the king of Pruſſia had no more trouble from them. See Britain, N° 442.

37 Swedes driven out of Pomerania.

38 Schweidnitz retaken.

The beginning of the year 1758 was favourable to the arms of his Pruſſian majeſty. On the 3d of April he commenced his operations againſt Schweidnitz, and puſhed the ſiege ſo vigorouſly, that the place ſurrendered in 13 days. He then diſpoſed his forces in ſuch a manner as might beſt guard his dominions againſt his numerous enemies. For this purpoſe Count Dohna commanded a body of troops on the ſide of Pomerania; another conſiderable body was poſted between Wohlau and Glogau, in order to cover Sileſia from the Ruſſians, in caſe they ſhould make their inroad that way. An army, in a little time after, was formed in Saxony, commanded by the king's brother Prince Henry. This army conſiſted of 30 battalions and 45 ſquadrons, and was deſigned to make head againſt the army of the empire; which, by great efforts made during the winter, and the junction of a large body of Auſtrians, was again in a condition to act. Between all theſe armies a ready communication was kept up by a proper choice of poſts. After the reduction of Schweidnitz, the king having made a ſhow of invading Bohemia, ſuddenly burſt into Moravia, where in a ſhort time he made himſelf maſter of the whole country, and on the 27th of May laid ſiege to Olmutz the capital. Of this M. Daun was no ſooner informed, than he took his route to Moravia through Bohemia: and, though he was not in a condition to riſk a battle, nor indeed would have done ſo unleſs he had had a very conſiderable advantage; yet, by placing himſelf in a ſtrong ſituation where he could not be attacked, by haraſſing the king's troops and cutting off their convoys, he at laſt obliged him to abandon the enterpriſe. The king, however, who frequently owed a good part of his ſucceſs to the impenetrable ſecrecy with which he covered all his deſigns, gave not the leaſt hint of his intention to raiſe the ſiege of Olmutz.

39 The king beſieges Olmutz without ſucceſs.

On

Prussia.

On the contrary, the very day before the siege was raised, the firing continued as brisk as ever; but in the night (July 1.) the whole army took the road to Bohemia in two columns, and gained an entire march upon the Austrians. Thus, notwithstanding the utmost efforts of his enemies, the Prussian army reached Bohemia with very little molestation. Here he seized upon a large magazine at Lieutomissel; defeated some corps of Austrians who had attempted to interrupt his progress; and arrived at Konigsgratz, of which he took possession, after driving from it 7000 Austrians who were intrenched there. This city and several other districts he laid under contribution: but soon after entered Silesia, and marched with the utmost rapidity to encounter the Russians, who had at that time united their forces under generals Brown and Fermor, entered the New Marche of Brandenburg, and laid siege to Custrin.

40 The Russians besiege Custrin.

The king arrived at this city at a very critical period. The Russians had laid siege to it on the 15th of August; and though they were not well skilled in managing artillery, yet, by furious and unremitting discharges at random, they threw in such a number of bombs and red-hot balls, that the town was soon on fire in every quarter. Some of the wretched inhabitants were burned; others buried in the ruins of their houses, or killed by the balls which fell like hail in the streets; while many of the survivors abandoned their habitations, and fled out of the town on that side where it was not invested. The governor did every thing for the defence of the place; but as the walls were built after the old manner, it was impossible that the town could have made a defence for any length of time, especially as the principal magazine of the besieged had been blown up. The avenger of all these injuries, however, was now at hand. The king came in sight of the Russians on the 25th of August, after a march of 56 days, and beheld the country everywhere desolated, and the villages in flames by the depredations of his cruel enemy, who had raised the siege at his approach, and retired towards a neighbouring village named *Zorndorff*. At nine o'clock in the morning, a most terrible fire of cannon and mortars poured destruction on the right wing of the Russian army for two hours without intermission. The slaughter was such as might have been expected; but the Russians kept their ground with astonishing resolution, new regiments still pressing forward to supply the places of those that fell. When the first line had fired away all their charges, they rushed forward on the Prussians with their bayonets; and all at once these brave troops, though encouraged by the presence of their king, gave way and fled before an enemy already half defeated. The Russian generals ought now to have attacked with their cavalry the disordered infantry of their enemies, which would have completed the defeat, and in all probability given the finishing stroke to the king of Prussia's affairs. This opportunity, however, they lost: but the king was not so negligent; for, by a very rapid and masterly motion, he brought all the cavalry of his right wing to the centre, and falling on the Russian foot uncovered by their horse, and even disordered by their own success, they pushed them back with most miserable slaughter, at the same time that the repulsed battalions of infantry, returning from the charge, and exasperated at their late disgrace, rendered the victory no longer doubtful. The Russians were now thrown into the most dreadful confusion. The wind blew the dust and smoke into their faces, so that they could not distinguish friends from foes; they fired on each other, plundered their own baggage which stood between the lines, and intoxicated themselves with brandy: the ranks fell in upon one another; and, being thus crammed together into a narrow space, the fire of the Prussians had a full and dreadful effect, while their enemies kept up only a scattered and ineffectual fire, generally quite over their heads. Yet even in this dismal situation the Russians did not fly; but suffered themselves to be slaughtered till seven at night, when their generals having caused an attack to be made on the Prussian right wing, the attention of the enemy was drawn to that quarter, and they had time to retire a little from the field of battle to recover their order.

41 But are defeated at Zorndorff.

In this engagement, which was called the *battle of Zorndorff*, the Russians lost 21,529 men, while that of the Prussians did not exceed 2000. A vast train of artillery was taken, together with the military chest, and many officers of high rank. The consequence was, that the Russian army retreated as far as Landsperg on the frontiers of Poland, and the king was left at liberty to march with his usual expedition to the relief of Prince Henry of Saxony.

42 Operations of Count Daun,

The prince was at this time sorely pressed by M. Daun. As soon as the king had left Bohemia in the manner already related, M. Daun, considering that it would have been to no purpose to follow him, resolved to turn his arms towards Saxony. Towards that country, therefore, he took his route through Lusatia, by Zittau, Gorlitz, and Bautzen. On the 3d of September he invested the strong fortress of Sonnestein; which unaccountably surrendered, after a single day's resistance, to one of his generals named *Macguire*. He then began to favour the operations of General Laudohn, who had advanced through the Lower Lusatia to the confines of Brandenburg; and, by drawing the attention of the Prussian forces which were left in Silesia to the northward of that duchy, he facilitated the progress of the generals Harsch and De Ville in the southern parts. He then proposed that Prince Henry should be attacked by the army of the empire, while that of the Austrians should pass the Elbe, and, falling at the same time on the Prussians, second the attack of the Imperialists, and cut off the retreat of their enemies from Dresden. The sudden appearance of the king of Prussia, however, put an end to his plan; General Laudohn abandoned all his conquests in Lower Lusatia, and retired towards M. Daun, while that general himself retired from the neighbourhood of Dresden as far as Zittau. The army of the empire only kept its ground; possessing itself of the strong post at Pirna, formerly mentioned, but did not undertake any thing. As for the Swedes, who had directed their motions by those of the Russians, they no sooner heard of the victory of Zorndorff, than they retreated with much more expedition than they had advanced.

43 Rendered abortive by the king of Prussia;

Thus the king of Prussia's affairs seemed to be pretty well retrieved, when by one fatal piece of negligence he was brought to the verge of ruin. M. Daun had possessed himself of an advantageous camp at Stolphen, by by which he preserved a communication with the army of

Pruſſia.

of the empire. On the other hand, the king of Pruſſia, having taken poſſeſſion of an important poſt at Bautzen, extended his right wing to the village of Hochkirchen, by which he preſerved a communication with his brother Prince Henry, protected Brandenburg, and was better ſituated than he could be anywhere elſe for throwing ſuccours into Sileſia. The two armies kept a watchful eye on the motions of each other; and as the principal aim of M. Daun was to cut off the king's communication with Sileſia, and of the king to cut off M. Daun's communication with Bohemia, a battle ſeemed inevitable, though great danger ſeemed to await that party who ſhould begin the attack.

44

Who is ſurpriſed and defeated at Hochkirchen.

In this critical poſture of affairs, the Auſtrian general formed a deſign of attacking the Pruſſian camp in the night. In what manner he came to ſurpriſe ſuch a vigilant enemy has never been accounted for; but that ſuch a ſurpriſe was actually accompliſhed on the 14th of October, is certain. In the dead of the preceding night, the Auſtrian army began to march in three columns towards the camp of the king of Pruſſia: and though the night was exceedingly dark, and they had a conſiderable way to go, they all arrived at the ſame time, in ſafety, without being diſcovered, and without the leaſt confuſion; and at five in the morning began a regular and well-conducted attack. The Pruſſians were in a moment thrown into confuſion; Marſhal Keith, one of their beſt generals, received two muſket-balls, and fell dead on the ſpot. Prince Francis of Brunſwick had his head ſhot off by a cannon-ball as he was mounting his horſe; and every thing ſeemed to announce the total deſtruction of the army. Still, however, the king preſerved his wonderful preſence of mind, which indeed he never appears to have loſt on any occaſion. He ordered ſome detachments from his left to ſupport his right wing; but the moment that theſe orders were received, the left itſelf was furiouſly attacked. General Ketzow, who commanded in that quarter, repulſed the Auſtrians with difficulty, and was not able to afford any conſiderable aſſiſtance to the right; which alone was obliged to ſuſtain the weight of the grand attack. The Auſtrians, in the beginning of the engagement, had driven the Pruſſians out of the village of Hochkirchen; and as the fate of the day depended on the poſſeſſion of that poſt, the hotteſt diſpute was there. The Pruſſians made three bloody and unſucceſsful attacks on the village; on the fourth they carried it; but the Auſtrians continually pouring in freſh troops, at laſt drove them out with prodigious ſlaughter on all ſides. The king then ordered a retreat, which was conducted in good order, without being purſued; however, this bloody action coſt him 7000 men, together with a great number of cannon. The Auſtrians computed their own loſs at 5000.

His Pruſſian majeſty, having thus happily eſcaped ſuch imminent danger, took every poſſible meaſure to prevent the enemy from gaining any conſiderable advantage from his defeat. Perceiving that the only advantage they wiſhed to derive from it was to cover the operations of their armies in Sileſia, and that he had now nothing to fear on the ſide of Saxony, he largely reinforced his own army from that of Prince Henry, and haſtened into Sileſia, in order to raiſe the ſiege of Neiſs, which had been completely inveſted on the 4th of October. On the 24th of that month, therefore, he quitted his camp, and, making a great compaſs, to avoid obſtructions from the enemy, arrived in the plains of Gorlitz. A body of the Auſtrians had in vain attempted to ſecure this poſt before him, and ſome who arrived after him were defeated with the loſs of 800 men. From this place the king purſued his march with the utmoſt diligence; but was followed by General Laudohn, at the head of 24,000 men, who conſtantly hung on his rear, and haraſſed his army. The king, however, knowing the importance of his expedition, continued his march without interruption, and ſuffered his antagoniſt to obtain many little advantages without moleſtation. Daun, however, not content with the oppoſition given by Laudohn, ſent a large body of horſe and foot by another route to reinforce the generals Karſch and De Ville, who had formed the ſiege of Neiſs and the blockade of Coſel, while he himſelf paſſed the Elbe, and advanced towards Dreſden.

All theſe precautions, however, were of little avail. The generals Karſch and De Ville, notwithſtanding their reinforcement, no ſooner heard of the king of Pruſſia's approach, than they raiſed the ſiege of both places, and retired, leaving behind them a conſiderable quantity of military ſtores. The end of the Pruſſian monarch's march being thus accompliſhed, he inſtantly returned by the ſame way he came, and haſtened to the relief of Saxony, the capital of which (Dreſden) was in great danger from Marſhal Daun. The place was but indifferently fortified, and garriſoned only by 12,000 men; ſo that it could not promiſe to hold out long againſt a numerous and well-appointed army. It was beſides commanded by a large ſuburb, of which, if once the enemy got poſſeſſion, all defence of the city muſt then be vain. For this reaſon M. Schmettau, the Pruſſian governor, determined to ſet theſe ſuburbs on fire, which was actually done November 10th, with an incredible loſs to the inhabitants, as in the ſuburbs were carried on moſt of thoſe valuable manufactures which render the city of Dreſden remarkable. This diſappointed the deſigns of M. Daun; but, though the action was agreeable to the laws of war, and had been executed with all the caution and humanity of which ſuch an action was capable, yet the Auſtrians exclaimed againſt it as a piece of the moſt unprovoked and wanton cruelty recorded in hiſtory. 45

Suburbs of Dreſden burnt.

46

Saxony oppreſſed by the king of Pruſſia.

After the king of Pruſſia had approached Dreſden, all the Auſtrian armies retired into Bohemia, where they took up their winter-quarters, as the king of Pruſſia did in Saxony. This unhappy country he ſaid he would now conſider as his own by right of conqueſt. But inſtead of treating the conquered people as his lawful ſubjects, he oppreſſed them in all poſſible ways, by levying the moſt ſevere and exorbitant contributions, ſurrounding the exchange with ſoldiers, and confining the merchants in narrow lodgings on ſtraw-beds, till they drew upon their correſpondents for ſuch ſums as he wanted.

In 1759, as early as the 23d of February, the Pruſſians commenced their military operations. General Woberſow marched with a body of troops into Poland, where he deſtroyed ſeveral very large magazines belonging to the Ruſſians, and returned into Sileſia without any loſs on the 18th of April. In the mean time, by ſome movements of the king of Pruſſia himſelf, the greateſt part of the Auſtrian troops had been drawn

drawn towards the frontiers of Sileſia. Prince Henry immediately took advantage of this opening, and on the 15th of April entered Bohemia with his army divided into two columns. One, commanded by himſelf, marched towards Peterſwade; the other, under General Hulſen, paſſed by the towns of Paſberg and Commottau. That commanded by Prince Henry himſelf penetrated as far as Loboſchutz and Leitmeritz; the enemy flying everywhere before them, and burning or abandoning the vaſt magazines which they had amaſſed in theſe parts. The body under General Hulſen had a more active employment. A ſtrong paſs at Paſberg was defended by a conſiderable body of Auſtrians. General Hulſen, having conducted his cavalry by another way in ſuch a manner as to fall directly on their rear, attacked them in front with his infantry, drove them out of their intrenchments, and totally defeated them with the loſs of a great number killed, and 2000 taken priſoners, while that of the Pruſſians did not exceed 70 in killed and wounded. After this exploit they returned into Saxony, with hoſtages for the contributions which they had largely exacted during the courſe of their expedition.

47 Bohemia invaded by Prince Henry.

48 A body of Auſtrians defeated by General Hulſen.

Some other ſucceſſes obtained by Prince Henry, cleared the country of Franconia of his enemies; but now the approach of the Ruſſians ſeemed once more to bring the affairs of the king of Pruſſia to a criſis. Notwithſtanding the deſtruction of their magazines, they had continued to advance into Sileſia, where they were oppoſed by Count Dohna; but as the troops he had with him were very far inferior to his enemies, he found it impoſſible to do more, at leaſt with any appearance of ſucceſs, than to obſerve their motions and haraſs them on their march. But this was ſo diſpleaſing to the king, that he diſgraced his general, and appointed Wedel to ſucceed him, with orders to attack the Ruſſians at all events. To enable him, however, in ſome meaſure to comply with this deſperate order, he ſent him ſome reinforcements, which brought his army up to near 30,000. With theſe, on the 23d of July 1759, General Wedel attacked 70,000 Ruſſians poſted in the moſt advantageous manner at Zulichau, and defended by a numerous artillery. Though the Pruſſians marched on to certain deſtruction and diſgrace, they ſuſtained the attack for a long time with unparalleled reſolution. At laſt, however, they gave way, and were obliged to retire with the loſs of 4700 killed or taken priſoners, and 3000 wounded.

49 Pruſſians defeated at Zulichau.

50 The Ruſſians take Croſſen and Frankfort on the Oder.

The conſequences of this victory were, that the Ruſſians penetrated into the king's territories, and took poſſeſſion of the towns of Croſſen and Frankfort on the Oder, which made it abſolutely neceſſary for the king to come in perſon to oppoſe them. Accordingly, on the 4th of Auguſt, he joined Wedel with a conſiderable body of forces, having left the greateſt part of his army in Saxony under Prince Henry. But as Marſhal Daun had ſent a body of 12,000 horſe and 8000 foot under General Laudohn to the aſſiſtance of the Ruſſians, the king ſtill found himſelf unable to fight them; as, with this and ſome other reinforcements, their army now amounted to upwards of 90,000. He therefore recalled General Finck, whom he had ſent into Saxony with 9000 men; but with all his reinforcements, it was found impoſſible to augment his army to 50,000 complete. His ſituation, however, was now ſo critical that a battle was unavoidable; and therefore, on the 12th of Auguſt, with this inferiority of number, the king attacked his enemies ſtrongly intrenched, and defended by a prodigious number of cannon. In this action, his principal effort was againſt the left wing of the Ruſſian army. He began the attack, according to cuſtom, with a heavy cannonade; which having produced the deſired effect, he attacked that wing with ſeveral battalions diſpoſed in columns. The Ruſſian intrenchments were forced with great ſlaughter, and 72 pieces of cannon were taken. But ſtill there was a defile to be paſſed, and ſeveral redoubts which covered the village of Cunnerſdorf to be maſtered. Theſe were attacked with the ſame reſolution, and taken one after another. The enemy made another ſtand at the village, and endeavoured to preſerve their ground there by puſhing forward ſeveral battalions of horſe and foot: but this alſo proved unſucceſsful; they were driven from poſt to poſt quite to the laſt redoubts. For upwards of ſix hours the Pruſſians were ſucceſsful, and everywhere broke the enemy with prodigious ſlaughter; drove them from almoſt all the ground they had occupied before the battle, took more than half their artillery, and ſcarce any thing ſeemed wanting to make the victory complete. In theſe circumſtances, the king wrote the following billet to the queen: "Madam, we have beat the Ruſſians from their intrenchments. In two hours expect to hear of a glorious victory." Of this victory, however, he deprived himſelf, by an exceſſive eagerneſs for conqueſt. The enemy, defeated almoſt in every quarter, found their left wing, ſhattered as it was, to be more entire than any other part of their army. Count Soltikoff, the Ruſſian general, therefore aſſembled the remains of his right wing, and, gathering as many as he could from his centre, reinforced the left, and made a ſtand at a redoubt which had been erected on an advantageous eminence in a place called *the Jews burying-ground*. All the king's generals are ſaid to have been of opinion, that he ought to allow the Ruſſians the peaceable poſſeſſion of this poſt. Their army had already ſuffered ſo much, that it would have been impoſſible for them to have attempted any enterpriſe of conſequence after the battle; but their artillery was ſtill numerous, the poſt very ſtrong, and the Pruſſian troops greatly fatigued. Theſe reaſons for a few moments had ſome weight with the king; but the natural impetuoſity of his temper getting the better of his reaſon, he led on his wearied troops again and again; till at laſt, when their ſtrength was in a manner totally exhauſted, they were attacked and utterly routed by the Auſtrian and Ruſſian cavalry, the former of which had hitherto remained quite inactive, and were therefore quite freſh, and irreſiſtible by the enfeebled Pruſſians. The night, and the prudent uſe of ſome eminences, prevented the total deſtruction of the army; however, their loſs amounted to 20,000 men killed and wounded. The king, when he found the victory totally loſt, ſent another billet to the queen, expreſſed in the following manner: "Remove from Berlin with the royal family; let the archives be carried to Potſdam; the town may make conditions with the enemy."

51 King of Pruſſia defeated by the Ruſſians at Cunnerſdorf.

Immediately after this defeat, the king ſet himſelf about repairing his loſſes with the utmoſt diligence. In a few days every thing was again put in order in his camp.

Pruffia.

camp. He replaced his artillery from Berlin; recalled General Klieft with 5000 men from Pomerania; detached 6000 from his own army to the defence of Saxony; and with the remainder put himfelf between the Ruffians and Great Glogau, covering that city which had been the chief object of their defigns; and in fhort, notwithftanding their victory, obliged them to return to Poland without accomplifhing any thing befides the carnage at Cunnerfdorff.

The misfortunes of the Pruffian monarch, however, were not at an end. Prince Henry, indeed, by a moft extraordinary and well-conducted march, entered Saxony, which was now totally overrun by the armies of the enemy. At the fame time, ftrong detachments having been fent into that country under generals Finck and Wunfch, the whole was in a fhort time recovered except Drefden. Towards this place Marfhal Daun retired, and in all probability would foon have been obliged to leave Saxony entirely. But the king's impatience could not be fatisfied without cutting off his retreat, and forcing him to a battle; for which purpofe he fent General Finck with upwards of 12,000 men according to the Pruffian account, but 20,000 according to the Auftrians, to feize fome paffes through which
52 M. Daun could only take his route towards Bohemia. This commiffion was executed with great exactnefs; but the Pruffian general, having probably advanced too far into thefe defiles, and neglected to preferve a communication with the main army, gave his enemy an opportunity of furrounding him, and at laft forcing him and his whole army to furrender prifoners of war. This difafter was foon after followed by another. General Durceke was pofted at the right of the Elbe, oppofite to Meffen; but on the approach of a large body of Auftrians, they prepared to retreat over the river into a place where they hoped to be more fecure. But having been obliged by an hard froft to withdraw their bridge of boats, a thaw fupervened, when they attempted to lay a bridge of pontoons, fo that they were again obliged to have recourfe to their boats. In this fituation, their rear-guard was attacked with great fury by the Auftrians, and all the foldiers who compofed it killed or taken. The lofs of the Pruffians on this occafion was computed at 3000 men.

General Finck with 12,000 Pruffians furrenders to the Auftrians.

The year 1760 fhowed the Pruffian monarch in a more dangerous fituation than he had ever yet experienced.
53 Indeed his affairs now feemed to be altogether defperate. His loffes were not to be meafured by the number of the killed or prifoners, but by armies deftroyed or taken. Forty generals had died or been killed in his fervice fince the beginning of October 1756, exclufive of thofe who were wounded or taken prifoners. This of itfelf would have been an irreparable lofs, had not the very wars which deftroyed thefe furnifhed others equally capable of filling their places. But another deficiency, which could not be remedied, ftill remained.—The king had, by his indefatigable induftry and exertions, fupplied all the deficiencies of men in his armies, but they were not the fame men as before. The hardy veterans, with whom he had originally taken the field, were now no more, and their places were fupplied by others who had neither the fame experience nor difcipline; fo that now he was obliged to fupply this deficiency by his own genius and heroifm.

Defperate fituation of the king of Pruffia.

But whatever abilities the Pruffian monarch might poffefs, and though he undoubtedly exerted them to the utmoft, it feemed only to be contending againft fate, and his enemies gained ftill greater and greater advan- 54
tages. General Laudohn, with whom none but the king himfelf feems to have been able to cope, by a feries of artful movements, drew into a difadvantageous fituation M. Fouquet, one of the Pruffian generals, with a ftrong body of forces. Perceiving it impoffible for them to efcape, Laudohn then made a violent attack on their intrenchments in the dead of the night of June 23d. The Pruffians made a gallant defence, but at laft were all killed or taken prifoners except about 300. Of the Pruffians were killed 4000, and 7000 taken prifoners; 58 pieces of cannon, and a great number of colours, were alfo loft. The victory, however, was dear bought; for the Auftrians loft above 12,000 men in killed and wounded; whom, however, they could better fpare than the Pruffians, on account of their numbers.—This action was called the *battle of Landfhut*.

Pruffians defeated at Landfhut.

Baron Laudohn failed not to improve this victory 55
to the utmoft. He inftantly turned back from Landfhut, and fell upon the city of Glatz; which he took in a very fhort time, with the garrifon who defended it, confifting of 2000 men. In this place were found 101 pieces of brafs cannon, with immenfe quantities of provifions and military ftores. From thence he marched againft Breflau, and immediately invefted it. But, in the mean time, the king of Pruffia, whofe motions had been all this time counteracted by M. Daun in Saxony, marched with his ufual rapidity towards Silefia. By this means he drew M. Daun out of Saxony; and indeed the Auftrian general ufed fuch expedition, that he gained two full days on the king. This was no fooner known to his Pruffian majefty, than he returned with the fame expedition that he 56
had advanced, and fat down before Drefden. Of this M. Daun foon received intelligence, and returned alfo. In the mean time, however, the buildings of the city were terribly fhattered by the king's cannon and bombs which continually played on it. His endeavours, however, proved ineffectual to reduce it before the arrival of M. Daun. The fiege had been begun on the 13th of July, and on the 19th M. Daun appeared within a league of Drefden. The Pruffians then redoubled their efforts. They had that day received reinforcements of heavy cannon and mortars, with which they battered the place inceffantly. The cathedral church, New Square, feveral principal ftreets, and fome palaces, and the noble manufactory of porcelain, were entirely deftroyed. The fiege was continued till the 22d: but, on the night of the 21ft, M. Daun had thrown 16 battalions into the city; which rendered it impoffible for the king to continue longer before it with any profpect of fuccefs. He therefore raifed the fiege, and retired without moleftation, though there were three confiderable armies of the enemy in the neighbourhood. Breflau was fiercely bombarded by Laudohn, but the approach of Prince Henry obliged him to defift from his enterprife on the 5th of Auguft.

Glatz taken by the Auftrians.

Drefden befieged but without fuccefs by the king of Pruffia.

But, in the mean time, the fortune of the king feemed likely to be terminated by one fatal ftroke. Finding it impoffible for him to carry on a defenfive war, he marched towards Silefia with fuch aftonifhing rapidity,

pidity, that before the middle of Auguſt he had advanced 200 miles, leaving Marſhal Daun with his army far behind him. This expedition he undertook in order to engage General Laudohn before he could have time to effect a junction with Daun and Lacy, another Auſtrian general; which triple union ſeemed to threaten him with unavoidable deſtruction at once.

57 Three Auſtrian generals join their forces againſt him.

This, however, he found it impoſſible to prevent: and the three armies, when joined, formed a moſt tremendous line of encampments, extending no leſs than 30 Engliſh miles; at the ſame time that every one of their poſts was ſtrong, and the communication between them eaſy. The king was ſtrongly encamped at Lignitz; and for ſeveral days employed all his military ſkill in attempting to induce one of the bodies to detach itſelf from the reſt, or to attack them at ſome diſadvantage; but without effect. At laſt, the Auſtrian generals, having maturely weighed all circumſtances, reſolved to attack the king's camp itſelf, ſtrong as it was; and Marſhal Daun, remembering the advantage he had gained at Hochkirchen by an attack in the night-time, reſolved to follow the ſame plan now. The plan therefore was laid in the following manner. The whole army, as ſoon as it ſhould begin to grow dark, was to march from their ſeveral poſts to ſuch ſituations as were marked out for each corps: they were to ſtrike their tents, but yet to keep up the fires in their camps, and to have the drums beat the tattoo as uſual, by which means they had a probability of ſurpriſing the enemy; or if not, they judged it abſolutely impoſſible for him to eſcape them, though he ſhould be ever ſo much on his guard. In what manner the king of Pruſſia became acquainted with this plan, is not known. His friends attributed it to his own penetration and knowledge of the ſtratagems of war; the Auſtrians, to intelligence given him by deſerters. But, in whatever way he became acquainted with this deſign, it is certain that he took the moſt effectual methods of preventing it. As the Auſtrian plan was to ſurround his camp, and this could not be done without the diviſion of their army which he had ſo long deſired, he reſolved to intercept one of the parties; and if that ſhould be diſabled from acting, he could then more eaſily deal with the other two. Therefore, in the very evening calculated for the deciſive attack on his camp, he quitted it with the utmoſt privacy, and took an advantageous poſt on the road through which General Laudohn was to paſs. The nature of this poſt was ſuch, that at the ſame time that it ſtopped the progreſs of Laudohn in front, Daun would lie under great difficulties if he ſhould attempt his rear; at the ſame time that, for his further ſecurity, the king ſtrengthened the rear with ſeveral batteries. As ſoon as his army was drawn up, he divided it; leaving his right on the ground where it had been formed, to obſerve Marſhal Daun, and to maintain that poſt; whilſt with his left he turned in order to fall on the corps under General Laudohn. In the mean time, that commander, ignorant of the fate which was awaiting him, advanced with the utmoſt expedition towards the place which had been aſſigned him, in order to ſhare in the glory of deſtroying the Pruſſian monarch; when, at three in the morning, on the 15th of Auguſt, a thick fog which covered the ground, ſuddenly clearing up, diſcovered, like the opening of a great ſcene, the dreadful front of the Pruſſian army regularly embattled, and advantageouſly poſted. Laudohn, though ſurpriſed, made the beſt diſpoſitions that circumſtances would admit of, and an obſtinate engagement enſued; in which, however, he was at laſt obliged to yield to the ſuperior ſkill of his adverſary, with the loſs of 10,000 killed, wounded, and priſoners, 82 pieces of cannon, and 23 pair of colours.

58 He defeats General Laudohn, and intimidates the Ruſſians.

The victory, though complete, gave but a partial relief to the king of Pruſſia. The moſt eſſential ſervice it did was the preventing of the Ruſſians from joining thoſe enemies which he already had. Count Czernichew had been advancing with 24,000 men, and had even paſſed the Oder; but was ſo intimidated by this news, that he inſtantly repaſſed that river on the ſame bridges which he had lately built, even though M. Daun ſent him a ſtrong body of troops in order to encourage him to advance. Soon after this battle, the king joined his brother Prince Henry at New Marche; and marched againſt Daun, who had begun to form the blockade of Schweidnitz, fell upon a corps under General Beck, made two battalions of Croats priſoners, and diſperſed the reſt, which obliged the enemy to abandon the enterpriſe they had juſt undertaken. About the ſame time, General Hulſen gained a conſiderable advantage over the Imperial army in Saxony, with very trifling loſs on his part, by which he effectually prevented them from cutting off his communication with the city of Torgau.

By theſe ſucceſſes the affairs of his Pruſſian majeſty ſeemed to revive: but there was no end of his enemies. The late manœuvres had drawn him ſo far into Sileſia, that his communication with Brandenburg was almoſt wholly cut off. The Ruſſian army, which after it had repaſſed the Oder began to move out of Sileſia, ſent forward a powerful detachment under Count Czernichew towards the marche of Brandenburg. A body of 15,000 Auſtrians, under the generals Lacy and Brentano, and the whole united body of Auſtrians and Imperialiſts which acted in Saxony, began their march in concert with the Ruſſians, and propoſed to unite at the gates of Berlin. Theſe armies amounted to 40,000 men. To oppoſe this formidable power, General Hulſen called to his aſſiſtance General Werner, who had been ſent with a body of troops into Pomerania; but, after being joined by him, their united forces were found not to exceed 15,000 or 16,000 men. To attempt a defence of the capital with this force would have been little ſhort of madneſs: and therefore theſe commanders were obliged to leave Berlin to its fate; which indeed, conſidering the barbarity of the Ruſſians and the animoſity of the Auſtrians, ſeemed to be a dreadful one. However, by the powerful mediation of ſeveral foreign miniſters, the town obtained terms which were not altogether intolerable; but the magazines, arſenals, and founderies were deſtroyed, and an immenſe quantity of military ſtores ſeized, with a number of cannon and other arms. The city was firſt obliged to pay 800,000 guilders, after which a contribution of 1,900,000 crowns was laid on: yet, notwithſtanding this, many violences were committed, and the king's palace was plundered and the furniture abuſed in a ſcandalous manner.

59 Berlin taken by the Auſtrians and Ruſſians.

The combined armies ſtaid in Berlin only four days; dreading the ſevere vengeance of the king of Pruſſia, who

Prussia.

60 Extreme embarrassment of the king.

who they heard was advancing towards that place with great expedition. But so great were the embarrassments which now attended that monarch, that it seemed almost beyond human power to retrieve his affairs. The Imperialists, on their return from Berlin, having no army to oppose them, made themselves masters of Leipsic, Torgau, Meissen, and Wirtemberg; in which last city they found the grand magazine of the Prussians immensely stored with provisions, ammunition, &c. M. Stainville also, with a detachment from Broglio the French general's army, laid the city and duchy of Halberstadt under contribution. In Eastern Pomerania, the Russians had besieged Colberg by sea and land. In the Western Pomerania, the Swedes advanced with great celerity, hoping to share in the plunder of Berlin. In Silesia, the king no sooner began his march to the northward, than Laudohn advanced, and laid siege to the important fortress of Cosel; and, to complete this distress and embarrassment, the king himself was attended at every step by Count Daun with a superior army well prepared to take every advantage.

In this desperate situation the king, being joined by his generals Hulsen and Prince Eugene of Wirtemberg with the corps under their command, advanced up the Elbe, while M. Daun fell back to cover Leipsic and Torgau, but the latter, finding that the Prussians directed their march towards the Elbe, encamped within reach of Torgau; one part of his army extending to the Elbe, by which he was covered on that side, whilst on the other he was covered by hills and woods, so that it was impossible to choose a more advantageous situation. The Prussian army did not amount to 50,000 men, whilst that of the Austrians exceeded 86,000: yet such were the unfortunate circumstances of the king, that he was obliged to fight under all these disadvantages; and therefore he caused his army to be informed, that he was now to lead them to a most desperate attempt, that his affairs required it, and that he was determined to conquer or die. His soldiers unanimously declared that they would die with him.

61 He defeats Count Daun at Torgau.

The 3d of November 1760 was the day on which this important affair was decided. The king divided his forces into three columns. General Hulsen was to take post with one in a wood that lay on the left of the Austrian army, and had orders not to move until he found the rest of the Prussians engaged. General Ziethen was to charge on the right; and the great attack in front was to be conducted by the king in person. His forces were disposed in such a manner, that either his right or left must take the enemy in rear and close them in, so as to disable them from undertaking any thing against the part where he intended to effect his principal attack. On the other hand, M. Daun perceiving the king to be serious in his design of fighting, to prevent confusion, sent all his baggage over the Elbe, across which he threw three bridges in case a retreat should be necessary. At the same time he caused Torgau to be evacuated; and then, extending his first line to a village called *Zinne* on the left, he stretched it to another called *Croswitz* on the right; supporting the right of his second line upon the Elbe. In this disposition he was found, when, about two o'clock in the afternoon, the king began his attack. He was received by the fire of 200 pieces of cannon, which were disposed along the Austrian front. The Prussians were thrice led on to the attack; but were every time repulsed and broken with terrible slaughter. The king at length commanded a fresh body of cavalry to advance, which at first compelled the Austrians to retire; but new reinforcements continually coming in, this cavalry was in its turn obliged to fall back, and the Prussians maintained themselves with extreme difficulty, until General Ziethen, with the right wing, attacked the enemy in the rear, repulsed them, and possessed himself of some eminences which commanded the whole Austrian army. Encouraged by this success, the Prussian infantry once more advanced, mastered several of the enemy's intrenchments, and made way for a new attack of their cavalry, which broke in with irresistible fury on the Austrians, and threw several bodies of them into irreparable disorder. It was now about 9 o'clock, and of consequence both armies were involved in thick darkness; yet the fire continued without intermission, and the battalions with a blind rage discharged at one another without distinguishing friend from foe. M. Daun received a dangerous wound in the thigh, and was carried from the field, which probably hastened the defeat of his troops. The command then devolved on Count O'Donnel; who, finding the greatest part of his troops in disorder, the night advanced, and the enemy possessed of some eminences which commanded his camp, and from which it was in vain to think of driving them, ordered a retreat, which was conducted with wonderful order and exactness; none were lost in passing the bridges, and by far the greater part of their artillery was preserved. The loss of the Prussians was estimated at 10,000 killed and wounded, and 3000 taken prisoners. That of the Austrians in killed and wounded is not known; but 8000 were taken prisoners, with 216 officers, among whom were four generals.

The consequence of the victory of Torgau was, that the king recovered all Saxony except Dresden; and in the mean time General Werner having marched into Pomerania, the Russians raised the siege of Colberg, and retired into Poland, without having effected any thing further than wasting the open country. Werner then flew to the assistance of Western Pomerania, where he defeated a body of Swedes, and at last drove them totally out of the country. General Laudohn too abruptly raised the blockade of Cosel; and afterwards, abandoning Landshut, he retired into the Austrian Silesia, leaving the Prussian part entirely in quiet. M. Daun placed one part of his army in Dresden, and the other in some strong posts which lie to the south and west of it, by which he commanded the Elbe, and preserved his communication with Bohemia. The army of the empire retired into Franconia, and placed its head-quarters at Bamberg.

62 All Saxony except Dresden recovered.

Though these successes had, to appearance, retrieved the king's affairs in some measure, yet his strength seemed now to be wholly exhausted; and in the campaign of 1761, he made no such vigorous efforts as he had formerly done. The Russians, dividing themselves into two bodies, invaded Silesia and Pomerania. In the former country they laid siege to Breslau, and in the latter to Colberg. Tottleben also, who had commanded the Russian armies, was now removed on a suspicion that he had corresponded with the king of Prussia, and General Romanzow put in his place; by which it was

 expected

Pruffia. expected that the Ruffian operations would be more brifk this year than formerly.

The king continued ftrongly encamped near Schweidnitz; where he was fo clofely watched by generals Daun and Laudohn, that he could attempt nothing. However, he defeated the defigns of the Ruffians againft Breflau, by fending General Platen to deftroy their magazines; which he accomplifhed with great fuccefs, at the fame time cutting off a body of 4000 of their troops. But this only brought the more fure deftruction upon Colberg; to which place that body of Ruffians immediately marched, cruelly wafting the country as they went along. The king of Pruffia could do nothing but fend detachments of fmall parties, which, though they could not oppofe their enemies in the field, yet he hoped, by cutting off the convoys of the enemy, might diftrefs them to fuch a degree as to oblige them to abandon the fiege, or at leaft protract it till the feverity of the winter fhould render it impoffible for them to carry on their operations. Thus he weakened his own army fo much, that it was found requifite to draw 4000 men out of Schweidnitz in order to reinforce it; and no fooner was this done, than General Laudohn fuddenly attacked and took that fortrefs by a coup de main. Colberg made a brave defence; but the troops fent to its relief being totally unable to cope with the Ruffian army confifting of 50,000 men, it was obliged to furrender on the 3d of December; and thus the fate of the Pruffian monarch feemed to be decided, and almoft every part of his dominions lay open to the invaders.

63 Schweidnitz and Colberg retaken.

64 Emprefs of Ruffia dies.

In the midft of thefe gloomy appearances the emprefs of Ruffia, the king's moft inveterate and inflexible enemy, died on the 2d of January 1762. Her fucceffor, Peter III. inftead of being the king's enemy, was his moft fanguine friend. As early as the 23d of February, in a memorial delivered to the minifters of the allied courts, he declared, that, "in order to the eftablifhment of peace, he was ready to facrifice all the conquefts made in this war by the arms of Ruffia, in hopes that the allied courts will on their parts equally prefer the reftoration of peace and tranquillity, to the advantages which they might expect from the continuance of the war, but which they cannot obtain but by a continuance of the effufion of human blood."—This addrefs was not fo well relifhed by the allies: however, they were very willing to make peace, provided it was for their own intereft; but they recommended to his attention fidelity to treaties, which conftitutes a no lefs valuable part of the royal character, than humanity and difintereftednefs. This anfwer made no impreffion on the czar; a fufpenfion of hoftilities took place on the 16th of March, which was followed by a treaty of alliance on the 5th of May. In this treaty the czar ftipulated nothing in favour of his former confederates; on the contrary, he agreed to join his troops to thofe of the king of Pruffia, in order to act againft them. Sweden, which had for a long time acted under the direction of Ruffian counfels, now followed the example of her miftrefs, and concluded a peace with Pruffia on the 22d of May.

65 Peace between Ruffia, Sweden, and Pruffia.

66 Succeffes of the king of Pruffia.

It is not to be fuppofed that the king of Pruffia would remain long inactive after fuch an unexpected turn in his favour. His arms were now everywhere attended with fuccefs. Prince Henry drove the Imperialifts from fome important pofts in Saxony, by which he fecured all that part which the Pruffians poffeffed; and though the Auftrians frequently attempted to recover thefe pofts, they were conftantly repulfed with great flaughter. The king was not joined by his new allies till the latter end of June; after which he drove M. Daun before him to the extremity of Silefia, leaving the town of Schweidnitz entirely uncovered, and which the king immediately prepared to inveft. In the mean time, different detachments of Pruffians, fome on the fide of Saxony, and others on that of Silefia, penetrated deep into Bohemia, laid many parts of the country under contribution, and fpread an univerfal alarm. A confiderable body of Ruffian irregulars alfo made an irruption into Bohemia, where they practifed on the Auftrians the fame cruelties which they had long been accuftomed to practife on the Pruffians. Pruffia.

67 A new revolution in Ruffia.

But while the king was thus making the beft ufe of his time, he was all at once threatened with a fatal reverfe of fortune by a new revolution in Ruffia. The emperor was depofed, and his depofition was foon after followed by his death. The emprefs, who fucceeded him, fufpected that her hufband had been mifled by the counfels of his Pruffian majefty, againft whom, therefore, fhe entertained a mortal enmity. She could not, however, in the very beginning of her reign, undertake again a war of fo much importance as that which had been juft concluded. She therefore declared her intention of obferving the peace concluded by the late emperor; but, at the fame time, of recalling her armies from Silefia, Pruffia, and Pomerania; which indeed the unfettled ftate of the kingdom now made in fome degree neceffary. At the fame time a difcovery was made with regard to the king of Pruffia himfelf, which turned the fcale greatly in his favour. The Ruffian fenate, flaming with refentment againft this monarch, and againft their late unfortunate fovereign; and the emprefs, full of fufpicion that the conduct of the latter might have been influenced by the councils of the former, fearched eagerly amongft the papers of the late emperor for an elucidation or proofs of this point. They found indeed many letters from the Pruffian monarch, but in a ftrain abfolutely different from what they had expected. The king had, as far as prudence would permit, kept a referve and diftance with regard to the too rafh advances of this unhappy ally; and, in particular, counfelled him to undertake nothing againft the emprefs his confort. The hearing of thefe letters read is faid to have had fuch an effect upon the emprefs, that fhe burft into tears, and expreffed her gratitude towards the Pruffian monarch in the warmeft terms. Still, however, the Ruffian army was ordered to feparate from the Pruffians; but all the important places which the former had taken during the whole war were faithfully reftored.

The king, finding that the Ruffians were no more to take an active part in his favour, refolved to profit by their appearance in his camp; and therefore, the very day after the order for their return had arrived, he attacked the Auftrian army, and drove their right wing from fome eminences and villages where they were advantageoufly pofted; by which means he entirely cut off their communication with Schweidnitz, fo that nothing could be attempted for its relief. Prince Henry kept them in continual alarms for Bohemia; and a great

Pruſſia.

great part of their attention, and no ſmall part of their forces, were engaged on that ſide. Marſhal Daun, now finding himſelf rendered almoſt incapable of undertaking any thing, detached Geneaal Laudohn, with a force very much ſuperior, to attack the prince of Bevern, and drive him from the advantageous poſt he occupied. But the prince defended himſelf with ſuch reſolution, that all the efforts of Laudohn could not ſucceed before the king had time to come to his aſſiſtance. The Auſtrians, being then put between two fires, were routed and purſued with terrible ſlaughter; after which, the king met with no more diſturbance in his preparations for the ſiege, and the trenches were opened on the 18th of July. Marſhal Daun made no attempts to relieve the place; but the garriſon being very ſtrong, it held out for near two months from the opening of the trenches. It is ſaid that the attack was conducted, and the defence made, by two engineers who had written on the ſubject of the attack and defence of fortified places; and they were now practically engaged to prove the ſuperiority of their ſyſtems. At laſt, however, the garriſon, to the number of 8000 men, ſurrendered priſoners of war; and the whole body, except nine, were ſoon after drowned at the mouth of the Oder, on their paſſage to their intended confinement in Konigſberg.

68 General Laudohn utterly defeated.

The king of Pruſſia, now become maſter of Schweidnitz, turned his attention towards Saxony, where he conſiderably reinforced his brother's army, and made preparations for laying ſiege to Dreſden. In this country the Auſtrians had lately met with ſome ſucceſs, and driven Prince Henry as far back as Freyberg; but on the 29th of October, they were attacked by the Pruſſian army thus reinforced, and totally routed. Great numbers were ſlain, and near 6000 taken priſoners. This victory proved deciſive: and the empreſs-queen, finding herſelf deſerted by all her allies, was glad to conclude a treaty; the ſubſtance of which was, that a mutual reſtitution and oblivion ſhould take place, and both parties ſit down at the end of the war in the ſame ſituation in which they began it. This treaty is called the *peace of Hubertſburg.*

69 The total defeat of the Auſtrians at Freyberg produces a peace.

The war was no ſooner concluded than the king of Pruſſia turned his attention to domeſtic policy, and the recovery of his dominions from thoſe innumerable calamities which had befallen them during the war. He immediately diſtributed lands to his diſbanded ſoldiers, and gave them the horſes of his artillery to aſſiſt them in their cultivation. By his wiſe and prudent management, the horrors of war were ſoon forgotten; and the country was quickly in as flouriſhing a ſtate as ever. Notwithſtanding this pacific diſpoſition, however, the king never ſlackened his endeavours for the defence of his country, by keeping a reſpectable army on foot; which might be able to act on the leaſt emergency.

70 A new war commences, but produces no memorable event.

In the year 1778, a new difference with the houſe of Auſtria took place, concerning the duchy of Bavaria. But though the moſt enormous warlike preparations were made on both ſides, and immenſe armies brought into the field, nothing of conſequence was effected. What little advantage there was, ſeems to have been on the Pruſſian ſide, ſince they made themſelves maſters of ſeveral towns, and kept the war in the enemy's country. However, the emperor acted with ſo much caution, and ſhowed ſo much ſkill in a defenſive war, that all the manœuvres of his Pruſſian majeſty could gain no material advantage; as, on the other hand, his adverſary was too wiſe to venture an engagement. A peace therefore was very ſoon concluded, and ſince that time the hiſtory of Pruſſia, during the remainder of the great Frederic's reign, affords no remarkable event which we have not mentioned in the life of that hero, and in the article POLAND. He left his crown to his nephew, whoſe character was not then much developed; and it was eaſily ſeen that a new kingdom, which had riſen ſuddenly to ſuch unexampled power and greatneſs as to excite the jealouſy or apprehenſion of all its neighbours, would require great abilities to preſerve it from diſmemberment.

71 The great Frederic ſucceeded by his nephew.

The late king had indeed bequeathed the moſt effectual ſecurities to his ſucceſſor for the preſervation of his dominions, that human wiſdom could provide or deviſe; by leaving him a full treaſury, the fineſt army in the world, and a people enthuſiaſtically attached to his memory and government. The new monarch, with theſe advantages, was not wanting to himſelf. The late king's predilection for the French language and French literature were not grateful to his ſubjects. The preſent ſovereign began his reign with declaring in council, " Germans we are, and Germans I mean we ſhall continue;" giving directions, at the ſame time, that their native language ſhould reſume its natural rank and ſtation, from which for near half a century it had been degraded by the French. This was a very popular meaſure, and it was followed by another ſtill more ſo. Obſerving that he had marked with great concern the progreſs of impiety and profaneneſs on the one hand, and of enthuſiaſm on the other, he declared, that he would not have his ſubjects corrupted either by fanatics or atheiſts, and ſtrictly prohibited all publications tending to excite a contempt or indifference for religion.

72 State of the nation, and behaviour of the new king.

Such, on his immediate acceſſion to the throne, was the pacific conduct of the monarch, which endeared him to his ſubjects, and commanded the approbation of all good men. An opportunity ſoon occurred, in which he was thought to have diſplayed ſuch talents in negotiation and in military arrangements, as proclaimed him in every reſpect a worthy ſucceſſor of his uncle. The States of Holland, who had long been jealous of the power of the ſtadtholder, and inclined to a republican government without any permanent chief, had gained ſuch an aſcendency in the ſtates general, that in 1786 and 1787 they in effect diveſted the Prince of Orange of all his prerogatives, (ſee *UNITED Provinces.* They proceeded even to the ſeizure and impriſonment of the princeſs, ſiſter to the king of Pruſſia; and depending upon ſupport from France, treated with inſolence every power connected with them in Europe. The court of Berlin did not witneſs theſe proceedings without indignation; and the king formed his plan for reſtoring the power of the ſtadtholder with ſuch ſecrecy and prudence, that perhaps nothing could ſurpaſs it but the bravery and military ſkill of the duke of Brunſwick, by whom it was carried into execution. In the ſhort ſpace of one month, that accompliſhed general led 18,000 Pruſſians to Amſterdam, and reſtored the juſt prerogatives of the prince of Orange.

73 He aſſiſts the ſtadtholder againſt the ſtates of Holland.

The affairs of Pruſſia during the early period of the French revolution, and the active but unſucceſsful part which that monarch took againſt it, are interwoven with the

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the historical details of that period under the articles FRANCE and BRITAIN, to which we refer our readers. For a number of years he acted the prudent part of standing clear of hostilities as much as possible; and when he did at last interfere, we find little in his conduct which is intitled to the praise either of consistency or honour. Indeed it may perhaps be admitted, that on many occasions he acted rather from necessity than choice; and finding that a contest with France was both absurd and ruinous, he chose to sacrifice a less evil to a greater good. Whether by consent or compulsion is not certainly known, the king of Prussia ceded to France the duchies of Cleves and Berg, March 1806, which were to be governed by Prince Murat, the brother-in-law of Bonaparte, under the title of Joachim, duke of Cleves and Berg.

The king of Prussia likewise took possession of the Hanoverian states 30th October 1806, at the time when Great Britain had no reason to apprehend any such mysterious conduct from that quarter. He entered into a secret treaty with France for the purpose of shutting the northern ports; a measure which gave such offence to this country, that the British minister thought proper to take his leave of Berlin. At one period he came to a final determination to make no separate treaty with the French government, and proposed a treaty of peace and alliance between his court and that of Britain. To give this as much effect as possible, the Prussian princes of the blood began to raise volunteer regiments in Poland and Silesia, the loyalty of the peasantry in these countries far exceeding the most sanguine expectations.

So low, however, were the king of Prussia's finances at the time of Lord Hutchinson's arrival at Memel, March 1807, that his lordship found it necessary to advance 80,000l. for the support of his family and domestic household. This being intimated to the British ministers, his majesty recommended it to parliament to enable him to implement the agreement. Yet not long after this period he actually entered into a treaty of peace with the emperor of France, by virtue of which his territories were so dreadfully mutilated, as to leave him little more of a sovereign than the name. He was required to renounce the whole of his dominions situated between the Rhine and the Elbe; the circle of Rothus, in Lower Lusatia; all the provinces which formerly constituted part of the kingdom of Poland; the city of Dantzic; and he was laid under the necessity of shutting all the ports and harbours in his whole dominions against the trade and navigation of Great Britain. Not above 18 months prior to this treaty, the king of Prussia might have been said to hold the fate of Europe in his hands; but by means of it he was reduced to the very lowest rank among the powers of Europe. Had he taken a decided part against France before the battle of Austerlitz, he might have been able to secure the independence of Europe; but, having suffered this auspicious moment to pass unimproved, the consequences were exactly such as might have been predicted, without any pretensions to uncommon sagacity.

The king of Prussia being thus degraded by means of his own imprudence and want of sound policy, endeavoured to ease the burdens of his remaining subjects by reducing his civil and military establishments. The army was reduced to 24,000 men, and General Knoblesdorf was sent to Paris to procure a diminution of the contributions exacted from him, or to crave that payments might be accepted of by instalments; and, in the mean time, the troops belonging to France were not to be withdrawn from the impoverished kingdom of Prussia. Every decree issued in Holland against the commerce of Great Britain, this humbled monarch was obliged to adopt, and to order the publication of them in every part of his mutilated dominions. This state of insignificance may be expected to continue as it is, till such a revolution takes place in the sentiments of the most powerful European monarchs as shall induce them to throw off the tyrannical yoke of Bonaparte, and oppose to him a force which all his military strength shall not be able to resist; and annihilate his power and influence in Europe. The united forces of Russia, Prussia, and Austria, seconded by the operations of the triumphant navy of Great Britain, might find it possible to accomplish this; and surely it is not only the cause of Europe, but of humanity at large, and calls for the interference of every empire and kingdom capable of affording any effective aid.

The total loss sustained by the king of Prussia in consequence of the peace of Tilsit, has been estimated at 10,000 square miles in extent, containing a population of more than 4,000,000;—a loss which must be very seriously felt, but which at one period, we believe, he had it in his power to have prevented; and it is very uncertain if ever the time shall arrive when it will be in his power to redeem it.

74 Air, soil, and population, of Prussia.

The air of Prussia is wholesome, and the soil fruitful in grain; affording, besides, plenty of pitcoal and other fuel. The rivers and lakes are well stored with fish; and amber is found on its coast towards the Baltic. The principal rivers are the Vistula, Bregel, Memel, the Passarge, and the Elbe; all of which frequently do damage by their inundations.

The inhabitants of this country were, by Dr Busching, computed at 635,998 persons capable of bearing arms; and by another German author, at 450,000. Since the year 1719 it is computed that about 34,000 colonists have removed hither from France, Switzerland, and Germany; of which number one half were Saltzburgers These emigrants have built 400 small villages, 11 towns, 50 new churches, and founded 1000 village-schools. The manners of the people differ but little from those of the Germans. The established religions are those of Luther and Calvin, but chiefly the former; though almost all other sects are tolerated.

75 Commerce and manufactures.

The late king of Prussia, by the assistance of an excellent police, brought the commerce and manufactures of this country to a very flourishing state, which during his life were daily improving. The manufactures of Prussia consist in glass, iron-work, paper, gunpowder, copper and brass-mills, manufactures of cloth, camblet, linen, silk, gold and silver lace, stockings, and other articles. The inhabitants export variety of naval stores, amber, lint-seed and hemp-seed, oat-meal, fish, mead, tallow, and caviar; and it is said that 500 ships are loaded with those commodities every year, chiefly from Koningsberg.

76 Constitution.

His Prussian majesty is absolute through all his dominions; but the late king was too wise to oppress his subjects, though he availed himself to the full of his power. The government of this kingdom is by a regency of four chancellors of state, viz. 1. The great-master;

ster; 2. The great-burgrave; 3. The great-chancellor; and, 4. The great-marshal. There are also some other councils, and 37 bailiwicks. The states consist, 1. Of counsellors of state; 2. Of deputies from the nobility; and, 3. From the commons. Besides these institutions, the late king erected a board for commerce and navigation.

77 Revenues.

His Prussian majesty, by means of the happy situation of his country, its inland navigation, and the excellent regulations of his predecessor, derives an amazing revenue from this country, which, about a century and a half ago, was the seat of boors and barbarism. It is said, that amber alone brings him in 26,000 dollars annually. His other revenues arise from his demesnes, his duties of customs and tolls, and the subsidies yearly granted by the several states; but the exact sum is not known, though we may conclude that it is very considerable, from the immense charges of the late war.

78 Military strength.

The military regulations introduced by the late king had a wonderfully quick operation in forming his troops and recruiting his armies. Every regiment has a particular district assigned it, where the young men proper for bearing arms are registered; and when occasion offers, they join their regiment, and being incorporated with veterans they soon become well disciplined troops. The Prussian army, in the time of peace, consists of 175,000 of the best disciplined troops in the world; and during the last war, that force was augmented to 300,000 men.

As the Prussian army formerly depended chiefly upon the cantons of the different regiments for their recruiting, it must suffer in proportion with the loss of territory a diminution of at least 80,000 men, and be thus reduced to 170,000, which was nearly its strength as far back as the year 1772. We are informed that it is to be still farther reduced to 150,000 regular troops, the whole of them to be natives of the country, one-third of whom are to do duty for one year, so that every man will have a furlough of two years in time of peace, and be in actual service every third year. Besides this regular army, a militia is to be organized of 380,000 men, who are to do garrison duty in time of war, which will enable the whole 150,000 regular troops to take the field against any enemy, when necessity requires it.

79 Royal arms, &c.

The royal arms of Prussia are argent, an eagle displayed sable, crowned or, for Prussia: azure, the Imperial sceptre, or, for Courland: argent, an eagle displayed, gules, with semicircular wreaths, for the marquisate of Brandenburg: to these are added the respective arms of the several provinces subject to the Prussian crown.

There are two orders of knighthood; the first, that of the Black Eagle, instituted by Frederic I. on the day of his coronation at Koningsberg, with this motto, *Suum cuique*. The sovereign is always grand-master; and the number of knights, exclusive of the royal family, is limited to 30. Next to this is the order of Merit, instituted by his late majesty; the motto is, *Pour le merite*.

PRUSSIAN BLUE. See PRUSSIATE OF IRON, CHEMISTRY *Index*.

PRUSSIC ACID. See CHEMISTRY *Index*.

PRYNNE, WILLIAM, an English lawyer, much distinguished in the civil commotions under Charles I. was born at Swainswick in Somersetshire in 1600. His *Histriomastix*, written against stage-plays in 1632, containing some reflections that offended the court, he was sentenced by the star-chamber to pay a fine of 5000l. to stand in the pillory, to lose his ears, and to perpetual imprisonment. During his confinement, he wrote several more books; particularly, in 1637, one entitled *News from Ipswich*, which reflecting severely on the bishops, he was again sentenced by the star-chamber to another fine of 5000l. to lose the remainder of his ears in the pillory, to be branded on both cheeks with S. L. for seditious libeller, and to be perpetually imprisoned in Caernarvon castle. Nothing but cutting off his hands could have prevented Prynne from writing: he wrote still; and in 1640, being set at liberty by the house of commons, he entered London in a kind of triumph, was elected into parliament for Newport in Cornwall, and opposed the bishops with great vigour, being the chief manager of Archbishop Laud's trial. In the long parliament he was zealous in the Presbyterian cause; but when the Independents gained the ascendency, he opposed them warmly, and promoted an agreement with the king. When the army garbled the house and refused him entrance, he became a bitter enemy to them and their leader Cromwell, and attacked them with his pen so severely, that he was again imprisoned: but he pleaded the liberty of the subject so successfully, that he was enlarged, to write more controversial books. Being restored to his seat after Cromwell's death, with the other secluded members, he assisted in promoting the restoration, and was appointed keeper of the Tower records; a place excellently well calculated for him, and where he was very useful by the collections he published from them. He presented 40 volumes of his works, in folio and 4to, to Lincoln's-inn library, of which society he was a member; and, dying in 1669, was buried under the chapel.

PRYTANES, in Grecian antiquity, were the presidents of the senate, whose authority consisted chiefly in assembling the senate; which, for the most part, was done once every day.

The senate consisted of 500, 50 senators being elected out of each tribe: after which, lots were cast to determine in what order the senators of each tribe should preside; which they did by turns, and during their presidentship were called *prytanes*. However, all the 50 prytanes of the tribes did not govern at once, but one at a time, viz. for seven days; and after 35 days, another tribe came into play, and presided for other five weeks; and so of the rest.

PSALM, a divine song or hymn; but chiefly appropriated to the 150 Psalms of David, a canonical book of the Old Testament.

Most of the psalms have a particular title, signifying either the name of the author, the person who was to set it to music or sing it, the instrument that was to be used, or the subject and occasion of it. Some have imagined that David was the sole author of the Book of Psalms; but the titles of many of them prove the contrary, as psalm xix. which appears to have been written by Moses. Many of the psalms are inscribed with the names *Korah*, *Jeduthun*, &c. from the persons who were to sing them.

PSALMANAZAR, GEORGE, the fictitious name of a pretended Formosan, a person of learning and ingenuity. He was born in France, and educated in a free-

Psalmanazar.

free-school, and afterwards in a college of Jesuits, in an archiepiscopal city, the name of which, as likewise those of his birth-place, and of his parents, are unknown. Upon leaving the college, he was recommended as a tutor to a young gentleman; but soon fell into a mean rambling life, that involved him in disappointments and misfortunes. His first pretence was that of being a sufferer for religion. He procured a certificate that he was of Irish extraction, that he left that country for the sake of the Catholic faith, and was going on a pilgrimage to Rome. Being unable to purchase a pilgrim's garb, and observing one in a chapel, dedicated to a miraculous saint, which had been set up as a monument of gratitude by some wandering pilgrim, he contrived to take both the staff and cloak away; and, being thus accoutred, begged his way in fluent Latin, accosting only clergymen or persons of figure; whom he found so generous and credulous, that, before he had gone 20 miles, he might easily have saved money, and put himself in a much better dress: but as soon as he had got what he thought was sufficient, he begged no more; but viewed every thing worth seeing, and then retired to some inn, where he spent his money as freely as he had obtained it. Having heard the Jesuits speak much of China and Japan, he started the wild scheme, when he was in Germany, of passing for a native of the island of Formosa; and what he wanted in knowledge, he supplied by a pregnant invention. He formed a new character and language on grammatical principles, which, like other oriental languages, he wrote from right to left with great readiness; and planned a new religion, and a division of the year into 20 months, with other novelties, to credit his pretensions. He was now a Japanese convert to Christianity, travelling for instruction with an appearance more wretched than even that of common beggars. He then entered as a soldier in the Dutch service: but, still desirous of passing for a Japanese, he altered his plan to that of being an unconverted heathen; and at Sluys, Brigadier Lauder, a Scots colonel, introduced him to the chaplain, who, with the view of recommending himself to the bishop of London, resolved to carry him over to England. At Rotterdam, some persons having put shrewd questions to him, that carried the air of doubt, he took one more whimsical step, which was to live upon raw flesh, roots, and herbs; which strange food he thought would remove all scruples. The bishop of London patronized him with credulous humanity; and Psalmanazar found a large circle of friends, who extolled him as a prodigy. Yet were there some who entertained a just opinion of him, particularly the Drs Halley, Mead, and Woodward; but their endeavours to expose him as a cheat only made others think the better of him, especially as those gentlemen were esteemed no great admirers of revelation. But in this instance at least, easiness of belief was no great evidence of penetration. He was employed to translate the church-catechism into the Formosan language, which was examined, approved, and laid up as a valuable MS; and the author, after writing his well-known *History of Formosa*, was rewarded and sent to Oxford to study what he liked, while his patrons and opponents were learnedly disputing at London on the merits of his work. The learned members of the university were no better agreed in their opinions than those at London; but at length the sceptics triumphed. Some absurdities were discovered in his history, of such a nature as to discredit the whole narration, and saved him the trouble of an open declaration of his imposture; which however he owned at length to his private friends. For the remainder of his life, his learning and ingenuity enabled him to procure a comfortable support by his pen; he being concerned in several works of credit, particularly *The Universal History*. He lived irreproachably for many years, and died in 1763.

Psalmanazar || Psatyrians.

PSALMIST, in the church of Rome, one of the lesser ecclesiastical orders; the same with what among us is called *clerk*, *precentor*, or *singer*.

PSALMODY, the art or act of singing psalms. See PSALM.

Psalmody was always esteemed a considerable part of devotion, and usually performed in the standing posture: and as to the manner of pronunciation, the plain song was sometimes used, being a gentle inflection of the voice, not much different from reading, like the chant in cathedrals; at other times more artificial compositions were used, like our anthems.

As to the persons concerned in singing, sometimes a single person sung along; sometimes the whole assembly joined together, which was the most ancient and general practice. At other times, the psalms were sung alternately, the congregation dividing themselves into two parts, and singing verse about, in their turns. There was also a fourth way of singing pretty common in the fourth century, which was, when a single person began the verse, and the people joined with him in the close: this was often used for variety, in the same service with alternate psalmody.

The use of musical instruments in the singing of psalms, seem to be as ancient as psalmody itself; the first psalm we read of being sung to the timbrel, viz. that of Moses and Miriam, after the deliverance of the Israelies from Egypt; and afterwards, musical instruments were in constant use in the temple of Jerusalem. See ORGAN.

PSALTER, the same with the book of psalms. See the article PSALM.

Among the religious in the Popish countries, the term *psalter* is also given to a large chaplet or rosary, consisting of 150 beads, according to the number of psalms in the psalter.

PSALTERY, a musical instrument, much in use among the ancient Hebrews, who called it *nebel*.

We know little or nothing of the precise form of the ancient psaltery. That now in use is a flat instrument, in form of a trapezium or triangle truncated at top: it is strung with 13 wire-chords, set to unison or octave, and mounted on two bridges, on the two sides: it is struck with a plectrum, or little iron rod, and sometimes with a crooked stick. Its chest or body resembles that of a spinnet.

PSAMMETICUS, or PSAMMITICHUS, a renowned conqueror, who subduing 11 other petty kings of Egypt, became the founder of the kingdom of Egypt, about 670 B. C. He is memorable likewise for taking the city of Azot, after a siege of 29 years; and for discovering the sources of the river Nile. See EGYPT, N° 10.

PSATYRIANS, a sect of Arians, who, in the council of Antioch, held in the year 360, maintained that

that the Son was not like the Father as to will; that he was taken from nothing, or made of nothing; and that in God, generation was not to be distinguished from creation.

Enfield's History of Philosophy.

PSELLUS, Michael, a learned Christian of the 11th century, was, by birth, a Constantinopolitan of consular rank, and flourished under the emperor Constantine Monomachus. His genius and industry raised him far above the level of his cotemporaries; and the female historian Anna Comnena speaks of him as one who had been more indebted for his attainments to his own excellent talent than to the instructions of his preceptors; adding, that having made himself master of all the wisdom of the Greeks and the Chaldeans, he was justly esteemed the most learned man of the age. Thus furnished, he became the chief instructor of the Constantinopolitan youth. He was at the same time the companion and the preceptor of the emperor, who was so captivated by the studies and amusements in which Psellus engaged him, that, according to Zonaras, he neglected the concerns of the empire. The Byzantine historians complain, that the emperor, deluded by the head of the philosophers (the title with which Psellus was honoured), lost the world. Meeting, towards the close of this life, with some disappointment, Psellus retired into a monastery, and soon afterwards died; the time of his death is uncertain. His works, which have been much celebrated, are, Commentaries upon Aristotle's Logic and Physics; a Compendium of Questions and Answers; and an Explanation of the Chaldean Oracles. The two latter works prove him to have been conversant, not only with Grecian, but with Oriental, philosophy.

PSEUDO, from ψευδος, a Greek term used in the composition of many words to denote *false* or *spurious*: as the pseudo-acacia, or bastard acacia; pseudo-fumaria, or bastard-fumitory; pseudo-ruta, or bastard-rue, &c.

We also say, a pseudo-apostle or false apostle; a pseudo-prophet, or false prophet, &c.

Pseudo-China. See Smilax.

Pseudo-Galena. or *Black Jack.* See Zinc, Ores of, Mineralogy *Index*.

Pseudo Tinea, in *Natural History*, the name of a very remarkable species of insect described by M. Reaumur, approaching to the nature of the *tinea*, or *clothes moth*, while in the worm-state, but not making themselves coats of the substance of leaves, cloth, &c. though they form a sort of cases for their defence against a very terrible enemy.

These creatures are of the caterpillar kind, and have, in the manner of many of these insects, 16 legs. They feed on wax, and for food enter the bee-hives; where they boldly engage the bees, and are not to be prevented by them from feeding, though at the expence of their habitations and the cells of their reservoirs of honey: so that it is no uncommon thing for a swarm of bees to be forced to change their place of habitation, and make new combs elsewhere; leaving the old ones to this contemptible victor, whom they know not how to drive out or dispossess.

Virgil and Aristotle, and all the authors who have written on bees, have complained of this destructive animal. It never eats the honey, but feeds only on the wax; attacking principally those waxy cells where the female bee deposites her eggs for the future progeny.

The bees, who are a match for most other creatures by means of their stings, would easily destroy these weak creatures, were it not for the impervious armour they were covered with. They form themselves a coat of armour of a double matter. The first, which immediately covers the body, is of a kind of silk of their own spinning; and the outer covering over this is of the bees-wax: this is laid considerably thick; and the creature, just thrusting out its head to feed, goes on devouring the cells undisturbed, while a whole army of the inhabitants are in vain buzzing about him, and attempting to pierce him with their stings. He never forsakes his covering, but lengthens and enlarges it as he goes; and gnawing down the sides of the cells in his march, without staying to eat them one by one, the havock and destruction he occasions are scarcely to be conceived. When the time of the change of this creature approaches, it contracts its body within its double covering, and there changes into the nymph state; whence, after a proper time, it comes forth in form of a moth, with granulated horns and a crooked proboscis.

The bees have cunning enough to know their destructive enemy in this new form; and as this is a weak and defenceless state, they attack and destroy all the moths of this species they meet with. They seldom are so fortunate, however, as to kill the whole race as soon as produced; and if only one escapes, it is able to lay a foundation of revenge for the death of its brethren. All the flies of the moth kind lay a vast number of eggs, and this is behind hand with none of them in that particular: the young ones produced from the eggs of one surviving female of this species are sufficient to destroy many honey-combs; nay, many hives of them. The moth produced by this caterpillar flies but little; yet it is very nimble in avoiding danger, by running, which it does with great swiftness.

There is a species of these pseudo-tineæ, or wax-eating caterpillars, which infest the subterraneous hives of wasps and other creatures which make wax: the manner of living, feeding, and defending themselves from their enemies, is the same in all the species. These last, if they are at any time distressed for food, will eat their own dung; the wax having passed almost unaltered through their bodies, and being still wax, and capable of affording them more nourishment on a second digestion. These species, though they naturally live on this soft food, yet if by any accident they meet with harder only, they know how to live upon it; and can eat a way into the covers and leaves of books, and make themselves cases and coverings of the fragments of these substances. The accurate author † of these observations describes also a kind of *pseudo-tinea* which feeds on wool, and another that eats leather; both making themselves houses also of the materials they feed on.

† *Reaumur's History of Insects.*

There is also another kind very destructive to corn: these make themselves a covering by fastening together a great number of the grains, and there living and eating in secret. All these creatures, whatever be their food or habitation, finally become *phalenæ*, or moths; and may be distinguished, even in this state, from the other species, by having granulated horns of a remarkable structure, and all of them a proboscis, or trunk, more or less incurvated.

PSEUDONYMUS, among critics, an author who publishes a book under a false or feigned name; as *cryptonymus*

tonymus is given to him who publishes one under a disguised name, and *anonymous* to him who publishes without any name at all.

PSIDIUM, the GUAVA; a genus of plants belonging to the icosandria class, and in the natural method ranking under the 19th order, *Hesperideæ*. See BOTANY *Index*.

A decoction of the roots of guava is employed with success in dysenteries: a bath of a decoction of the leaves is said to cure the itch and other cutaneous eruptions. Guayava, or guava, is distinguished from the colour of the pulp into two species, the white and the red; and, from the figure of the fruit, into the round, and the pear-fashioned or perfumed guava. The latter has a thicker rind, and a more delicate taste than the other. The fruit is about the bigness of a large tennis-ball; the rind or skin generally of a russet stained with red. The pulp within the thick rind is of an agreeable flavour, and interspersed with a number of small white seeds. The rind, when stewed, is eaten with milk, and preferred to any other stewed fruit. From the same part is made marmalade; and from the whole fruit is prepared the finest jelly in the world. The fruit is very astringent, and nearly of the same quality with the pomegranate. The seeds are so hard as to resist the effects of the stomachs of animals; so that when voided with the excrements, they take root, germinate, and produce thriving trees. Whole meadows in the West Indies are covered with guavas, which have been propagated in this manner.

PSITTACUS, or PARROT, a genus of birds belonging to the order of *picæ*. See ORNITHOLOGY *Index*.

PSOAS, in *Anatomy*. See there, *Table of the Muscles*.

PSOPHIA, a genus of birds belonging to the order of *Gallinæ*. See ORNITHOLOGY *Index*.

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

PSYCHOTRIA, a genus of plants belonging to the pentandria class, and in the natural method ranking under the 47th order, *Stellatæ*. See BOTANY *Index*.

PSYLLI, (Strabo, Ptolemy): a people in the south of Cyrenaica, so called from King Psyllus, (Agatharcides, quoted by Pliny): almost all overwhelmed by sand driven by a south wind (Herodotus.) They had something in their bodies fatal to serpents, and their very smell proved a charm against them, according to Pliny, Lucan, &c.

Though we may justly look upon it as fabulous, that these people had any thing in their bodies different from others; it is, however, certain that there are in Egypt at this day some persons who have a method of handling the most poisonous serpents without any hurt. Of these Mr Hasselquist gives the following account:

"They take the most poisonous vipers with their bare hands, play with them, put them in their bosoms, and use a great many more tricks with them, as I have often seen. I have frequently seen them handle those that were three or four feet long, and of the most horrid sort. I inquired and examined whether they had cut out the vipers poisonous teeth; but I have with my own eyes seen they do not. We may therefore conclude, that there are to this day Psylli in Egypt; but what art they use is not easily known. Some people are very superstitious, and the generality believe this to be done by some supernatural art which they obtain from invisible beings. I do not know whether their power is to be ascribed to good or evil; but I am persuaded that those who undertake it use many superstitions.

"The art of fascinating serpents is a secret amongst the Egyptians. It is worthy the endeavours of all naturalists, and the attention of every traveller, to learn something decisive as to this affair. How ancient this art is among the Africans, may be concluded from the ancient Marii and Psylli, who were from Africa, and daily showed proofs of it at Rome. It is very remarkable that this should be kept a secret for more than 2000 years, being known only to a few, when we have seen how many other secrets have within that time been revealed. The circumstances relating to the fascination of serpents in Egypt, related to me, were principally, 1. That the art is only known to certain families, who propagate it to their offspring. 2. The person who knows how to fascinate serpents, never meddles with other poisonous animals, such as scorpions, lizards, &c. There are different persons who know how to fascinate these animals; and they again never meddle with serpents. 3. Those that fascinate serpents, eat them both raw and boiled, and even make broth of them, which they eat very commonly amongst them; but in particular, they eat such a dish when they go out to catch them. I have been told, that serpents fried or boiled are frequently eaten by the Arabians both in Egypt and Arabia, though they know not how to fascinate them, but catch them either alive or dead. 4. After they have eaten their soup, they procure a blessing from their scheik (priest or lawyer), who uses some superstitious ceremonies, and amongst others, spits on them several times with certain gestures. This manner of getting a blessing from the priest is pure superstition, and certainly cannot in the least help to fascinate serpents; but they believe, or will at least persuade others, that the power of fascinating serpents depends upon this circumstance."

Notwithstanding this testimony of Hasselquist, the story of the incantation of serpents, though frequently alluded to in Scripture, has been generally treated as a fable. It is, however, affirmed as a certain truth, both by Mr Bruce and M. Savary. "There is no doubt (says the former of these travellers) of its reality. The Scriptures are full of it. All that have been in Egypt have seen as many different instances as they chose. Some have doubted that it was a trick; and that the animals thus handled had been first trained, and then deprived of their power of hurting; and fond of the discovery, they have rested themselves upon it, without experiment, in the face of all antiquity. But I will not hesitate to aver, that I have seen at Cairo (and this may be seen daily without any trouble or expence), a man who came from the catacombs, where the pits of the mummy birds are kept, who has taken a cerastes with his naked hand from a number of others lying at the bottom of a tub, has put it upon his bare head, covered it with the common red cap he wears, then taken it out, put it in his breast, and tied it about his neck like a necklace; after which it has been applied to a hen, and bit it, which died in a few minutes; and, Psylli. and, to complete the experiment, the man has taken it by the neck, and beginning at his tail, has ate it as one would do a carrot or ftock of celery, without any feeming repugnance.

"We know from hiftory, that where any country has been remarkably infefted with ferpents, there the people have been fcreened by this fecret.

"To leave ancient hiftory, I can myfelf vouch, that all the black people in the kingdom of Sennaar, whether Funge or Nuba, are perfectly armed againft the bite of either fcorpion or viper. They take the ceraftes in their hands at all times, put them in their bofoms, and throw them to one another as children do apples or balls, without having irritated them by this ufage fo much as to bite. The Arabs have not this fecret naturally, but from their infancy they acquire an exemption from the mortal confequences attending the bite of thefe animals, by chewing a certain root, and wafhing themfelves (it is not anointing) with an infufion of certain plants in water."

From this account we fhould be apt to think, that thefe vipers really *would not* bite any who were thus armed againft their poifon; efpecially as he adds, that he "conftantly obferved, that the viper, however lively before, upon being feized by any of thefe barbarians, feemed as if taken with ficknefs and feeblenefs, frequently fhut his eyes, and never turned his mouth towards the arm of the perfon who held him." Yet in another place, fpeaking of the activity of the cerastes, he fays, "I faw one of them at Cairo, in the houfe of Julian and Rofa, crawl up the fide of a box in which there were many, and there lie ftill, as if hiding himfelf, till one of the people who brought them to us came near him; and though in a very difadvantageous pofture, fticking as it were perpendicularly to the fide of the box, he leaped near the diftance of three feet, and faftened between the man's forefinger and thumb, fo as to bring the blood. The fellow fhowed no figns of either pain or fear, and even kept him with us full four hours, without his applying any fort of remedy, or feeming inclined to do fo."

It is difficult to fee how thefe two accounts can be reconciled. If thofe who catch vipers are in danger of being bit by them *after* they are catched, certainly they muft be fo before, and then the whole relation becomes contradictory. Our author tells us, that thefe feats were performed *for a feafon*, by thofe who were artificially armed againft the viper's poifon, as well as thofe who had the exemption naturally; but though put in poffeffion of the drugs, he never had the courage to make the experiment. That he fhould have made fuch a dreadful experiment on *himfelf*, no perfon in his fenfes would expect; but it is indeed very furprifing, that he did not attempt by means of thefe medicines to arm fome of the brute creatures, of the lives of which he was fufficiently prodigal, againft the effects of that deadly poifon by which fo many of them perifhed. As furprifing it is, that he did not try what effect the root or its decoction would have upon the ferpents themfelves; or that, though he fays he had a fmall quantity of this extraordinary root by him, he gave neither drawing nor defcription of it.

Though it is impoffible to reconcile the particulars of this account to one another, the general fact of the incantation is confirmed by the teftimony of M. Savary. This writer tells us, that he faw at the feaft of Sidi Ibrahim, a troop of people, feemingly poffeffed, with naked arms and a fierce look, holding in their hands enormous ferpents, which twined round their body, and endeavoured to efcape. Thefe Pfylli, grafping them ftrongly by the neck, avoided the bite; and notwithftanding their hiffing, tore them with their teeth, and ate them alive, while the blood ftreamed from their mouth.

Pfylli || Pterocarpus.

PTARMIGAN. See Tetrao, Ornithology *Index*.

PTELEA, shrub-trefoil; a genus of plants belonging to the tetrandria clafs; and in the natural method ranking with thofe of which the order is doubtful. See Botany *Index*.

PTERIS, a genus of plants belonging to the order of filices, and to the cryptogamia clafs. See Botany *Index*. The fructifications are in lines under the margin. There are 19 fpecies; the moft remarkable is the aquilina, or common female fern. The root of this is vifcid, naufeous, and bitterifh; and like all the reft of the fern tribe, has a falt, mucilaginous tafte. It creeps under the ground in fome rich foils to the depth of five or fix feet, and is very difficult to be deftroyed. Frequent mowing in pafture-grounds, plentiful dunging in arable lands, but, above all, pouring urine upon it, are the moft approved methods of killing it. It has, however, many good qualities to counterbalance the few bad ones. Fern cut while green, and left to rot upon the ground, is a good improver of land; for its afhes, if burnt, will yield the double quantity of falt that moft other vegetables will. Fern is alfo an excellent manure for potatoes; for if buried beneath their roots, it never fails to produce a good crop.—Its aftringency is fo great, that it is ufed in many places abroad in dreffing and preparing kid and chamois leather.—In feveral places in the north, the inhabitants mow it green, and, burning it to afhes, make thofe afhes up into balls, with a little water, which they dry in the fun, and make ufe of them to wafh their linen with inftead of foap. In many of the Weftern Ifles the people gain a very confiderable profit from the fale of the afhes to foap and glafs makers. In Glen Elg in Invernefsfhire, and other places, the people thatch their houfes with the ftalks of this fern, and faften them down with ropes made either of birk-bark or heath. Sometimes they ufe the whole plant for the fame purpofe, but that does not make fo durable a covering. Swine are fond of the roots, efpecially if boiled in their wafh. In fome parts of Normandy we read that the poor have been reduced to the miferable neceffity of mixing them with their bread. And in Siberia, and fome other northern countries, the inhabitants brew them in their ale, mixing one-third of the roots to two-thirds of malt. The ancients ufed the root of this fern, and the whole plant, in decoctions and diet-drinks, in chronic diforders of all kinds, arifing from obftructions of the vifcera and the fpleen. Some of the moderns have given it a high character in the fame intentions, but it is rarely ufed in the prefent practice. The country people, however, ftill continue to retain fome of its ancient ufes; for they give the powder of it to deftroy worms, and look upon a bed of the green plant as a fovereign cure for the rickets in children.

PTEROCARPUS, a genus of plants belonging to the

the diadelphia claſs; and in the natural method ranking under 32d order, *Papilionaceæ*. See BOTANY *Index*. There are four ſpecies, viz. 1. *Draco;* 2. *Ecaſtaphyllum;* 3. *Lunatus;* and, 4. *Santalinus*. This laſt is by ſome referred to the genus *Santalum*. It is called *red ſaunders;* and the wood is brought from the Eaſt Indies, in large billets, of a compact texture, a dull red almoſt blackiſh colour on the outſide, and a deep brighter red within. This wood has no manifeſt ſmell, and little or no taſte. It has been commended as a mild aſtringent, and a corroborant of the nervous ſyſtem; but theſe are qualities that belong only to the yellow ſort.

The principal uſe of red ſaunders is as a colouring drug; with which intention it is employed in ſome formulæ, particularly in the *tinctura lavendulæ compoſita*. It communicates a deep red to rectified ſpirit, but gives no tinge to aqueous liquors; a ſmall quantity of the reſin, extracted by means of ſpirit, tinges a large one of freſh ſpirit of an elegant blood-red. There is ſcarcely any oil, that of lavender excepted, to which it communicates its colour. Geoffroy and others take notice, that the Brazil woods are ſometimes ſubſtituted for red ſaunders; and the college of Bruſſels are in doubt whether all that is ſold among them for ſaunders be not really a wood of that kind. According to the account which they have given, their ſaunders is certainly the Brazil wood; the diſtinguiſhing character of which is, that it imparts its colour to water.

PTEROCOCEUS, is a ſpecies of plant belonging to the genus Calligonum. See CALLIGONUM, BOTANY *Index*.

PTERONIA, a genus of plants belonging to the monodelphia claſs; and in the natural method ranking under the 37th order *Columniferæ*. See BOTANY *Index*.

PTINUS, a genus of inſects belonging to the order of coleoptera. See ENTOMOLOGY *Index*.

PTISAN, is properly barley decorticated, or deprived of its hulls, by beating in a mortar, as was the ancient practice; though the cooling potion obtained by boiling ſuch barley in water, and afterwards ſweetening the liquor with liquorice-root, is what at preſent goes by the name of *ptiſan;* and to render it laxative, ſome add a little ſena or other ingredient of the ſame intention.

PTOLEMAIC *Syſtem of Aſtronomy*, is that invented by Claudius Ptolemæus. See PTOLEMY, *Claudius*.

PTOLEMAIS, in *Ancient Geography;* the port of Arſinoë, ſituated on the weſt branch of the Nile, which concurs to form the iſland called *Nomos Heracleotes*, to to the ſouth of the vertex of the Delta.

PTOLEMAIS, (Strabo); the largeſt and moſt conſiderable town of the Thebais, or Higher Egypt, and in nothing ſhort of Memphis; governed in the manner of a Greek republic; ſituated on the weſt ſide of the Nile, almoſt oppoſite to Coptos. This town, which was built by Ptolemy Philadelphus, is now known by the name of *Ptolometa*. The walls and gates are ſtill entire, and there are a vaſt number of Greek inſcriptions, but only a few columns of the portico remain. There is likewiſe an Ionic temple, done in the moſt ancient manner of executing that order, of which Mr Bruce took a drawing, which is preſerved in the king's collection. Another, of Cyrenaica, anciently called *Barce*. A third of the Troglodytica, ſurnamed *Epitheras*, from the chace of wild beaſts, as elephants; lying in the ſame parallel with Meroe (Strabo); on the Arabian gulf (Pliny); 4820 ſtadia to the ſouth of Berenice. A fourth, of Galilee, anciently called *Aca*, or *Acon;* made a Roman colony under the emperor Claudius (Pliny). A fifth of Pamphylia; ſituated near the river Melas, on the borders of Cilicia Aſpera.

PTOLEMY SOTER, or *Lagus*, king of Egypt, a renowned warrior, and an excellent prince: he eſtabliſhed an academy at Alexandria, and was himſelf a man of letters. Died 284 B. C. aged 92.

PTOLEMY *Philadelphus*, his ſecond ſon, ſucceeded him to the excluſion of Ptolemy Ceraunus. He was renowned as a conqueror, but more revered for his great virtues and political abilities. He eſtabliſhed and augmented the famous Alexandrian library, which had been begun by his father. He greatly increaſed the commerce of Egypt, and granted conſiderable privileges to the Jews, from whom he obtained a copy of the Old Teſtament, which he cauſed to be tranſlated into Greek, and depoſited in his library. This is ſuppoſed to have been the verſion called the *Septuagint*. He died 246 years B. C. aged 64.

PTOLEMY *Ceraunus*, the elder brother, fled to Seleucus king of Macedon, who received him hoſpitably; in return for which he aſſaſſinated him, and uſurped his crown. He then invited Arſinoë, who was his widow and his own ſiſter, to ſhare the government with him; but as ſoon as he got her in his power, he murdered her and her children. He was at length defeated, killed, and torn limb from limb by the Gauls, 279 B. C.

PTOLEMY, *Claudius*, a celebrated mathematician and aſtrologer, was born at Peluſium, and ſurnamed by the Greeks *Moſt Divine* and *Moſt Wiſe*. He flouriſhed at Alexandria in the ſecond century, under the reigns of Adrian and Marcus Aurelius, about the 138th year before the Chriſtian era. There are ſtill extant his Geography, and ſeveral learned works on aſtronomy. The principal of which are, 1. The Almageſt; 2. *De Judiciis Aſtrologicis;* 3. *Planiſphærium*. His ſyſtem of the world was for many years adopted by the philoſophers and aſtronomers; but the learned have rejected it for the ſyſtem of Copernicus. See ASTRONOMY, nº 16.

PTYALISM, in *Medicine*, a ſalivation, or frequent and copious diſcharge of ſaliva. The word is Greek, formed from πτυω "to ſpit."

PUBERTY, denotes the age at which a perſon is capable of procreating or begetting children. See MAN.

PUBERTY, in *Law*, is fixed at the age of 12 in females, and 14 in males; after which they are reckoned to be fit for marriage. But as to crimes and puniſhments, the age of puberty is fixed at 14 in both ſexes.

PUBES, in *Anatomy*, denotes the middle part of the hypogaſtric region in men or women, lying between the two inguina or groins.

Section af the PUBES. See MIDWIFERY and *SIGAULTIAN Operation*.

PUBES, in *Botany*, the hair or down on the leaves of ſome plants. See HAIR.

PUBLICAN, among the Romans, one who farmed the taxes and public revenues.

PUBLICATION, the art of making a thing known to the world; the ſame with promulgation.

PUBLIUS Syrus, a Syrian mimic poet, who flouriſhed about 44 years before Chriſt. He was originally a ſlave ſold to a Roman patrician, called *Domitius*, who brought him up with great attention, and gave him his freedom when of age. He gained the eſteem of the moſt powerful men at Rome, and reckoned Julius Cæſar among his patrons. He ſoon eclipſed the poet Laberius, whoſe burleſque compoſitions were in general eſteem. There remains of Publius a collection of moral ſentences, written in iambics, and placed in alphabetical order.

Oak PUCERON, a name given by naturaliſts to a very remarkable ſpecies of animal of the puceron kind. They bury themſelves in the clefts of the oak and ſome other trees, and getting into the crevices, where the bark is a little ſeparated from the wood, they there live at eaſe, and feed to their fill, without being expoſed to their common enemies. They are larger than the other pucerons, the winged ones being nearly as large as a common houſe fly; and thoſe without wings are alſo larger than any other ſpecies of the ſame genus. The winged ones are black, and the others of a coffee colour. Their trunk is twice the length of their bodies, and, when walking, it is carried ſtraight along the belly, trailing behind it with the point up. When the creature has a mind to ſuck a part of the tree that is juſt before it, it draws up and ſhortens the trunk, till it brings it to a proper length and direction; but when it ſucks in the common way, it crawls upon the inner ſurface of the bark, and the turned up end of the trunk, which reſembles a tail, fixes itſelf againſt the wood that is behind it, or contiguous to its back, and ſucks there. The extremity of this trunk holds ſo faſt by the wood, that when it is pulled away, it frequently brings a ſmall piece of the wood away with it.

The ants are as fond of theſe as of the other ſpecies of pucerons, and that for the ſame reaſon, not feeding upon them, but on their dung, which is a liquid matter of a ſweet taſte, and is the natural juice of the tree, very little altered. Theſe creatures are the ſureſt guides where to find this ſpecies of puceron; for if we at any time ſee a number of theſe crawling up an oak to a certain part, and there creeping into the clefts of the bark, we may be aſſured that in that place there are quantities of theſe oak pucerons. The ants are ſo extremely fond of the juices of the tree, when prepared for them by paſſing through the body of this animal, that when the puceron has a drop not yet evacuated, but hanging only in part out at the paſſage, an ant will often ſeize on it there.

Pucerons, *Vine fretters*, or *Plant lice*. See Aphis.

PUDENDA, the parts of generation in both ſexes. See Anatomy, n° 107 and 108.

PUERILITY, in diſcourſe, is defined by Longinus to be a thought which, by being too far fetched, becomes flat and inſipid. Puerility, he adds, is the common fault of thoſe who affect to ſay nothing but what is brilliant and extraordinary.

PUFFENDORF, Samuel de, was born in 1631 at Fleh, a little village in Miſnia, a province in Upper Saxony; and was ſon of Elias Puffendorf, miniſter of that place. After having made great progreſs in the ſciences at Leipſic, he turned his thoughts to the ſtudy of the public law, which in Germany conſiſts of the knowledge of the rights of the empire over the princes and ſtates of which it is compoſed, and thoſe of the princes and ſtates with reſpect to each other. But though he uſed his utmoſt efforts to diſtinguiſh himſelf, he deſpiſed thoſe pompous titles which are ſo much ſought for at univerſities, and never would take the degree of doctor. He accepted the place of governor to the ſon of M. Coyet, a Swediſh nobleman, who was then ambaſſador from Sweden to the court of Denmark. For this purpoſe he went to Copenhagen, but continued not long at eaſe there; for the war being renewed ſome time after between Denmark and Sweden, he was ſeized with the whole family of the ambaſſador. During his confinement, which laſted eight months, as he had no books, and was allowed to ſee no perſon, he amuſed himſelf by meditating on what he read in Grotius's treatiſe *De Jure Belli et Pacis*, and the political writings of Mr Hobbes. Out of theſe he drew up a ſhort ſyſtem, to which he added ſome thoughts of his own, and publiſhed it at the Hague in 1660, under the title of *Elementa Juriſprudentiæ Univerſalis*. This recommended him to the elector Palatine, who invited him to the univerſity of Heidelberg, where he founded in his favour a profeſſorſhip of the law of nature and nations, which was the firſt of that kind eſtabliſhed in Germany. Puffendorf remained at Heidelberg till 1673, when Charles XI. of Sweden gave him an invitation to be profeſſor of the law of nature and nations at Lunden; which place the elector Palatine reluctantly allowed him to accept. He went thither the ſame year; and after that time his reputation greatly increaſed. Some years after, the king of Sweden ſent for him to Stockholm, and made him his hiſtoriographer, and one of his counſellors. In 1688, the elector of Brandenburg obtained the conſent of his Swediſh majeſty, that he ſhould come to Berlin, in order to write the hiſtory of the elector William the Great; and in 1694 made him a baron. But he died that ſame year of an inflammation in his feet, occaſioned by cutting his nails; having attained his grand climacteric. Of his works, which are numerous, the following are the principal: 1. A Treatiſe on the Law of Nature and Nations, written in German; of which there is an Engliſh tranſlation with Barbeyrac's Notes. 2. An Introduction to the Hiſtory of the Principal States which at preſent ſubſiſt in Europe; written in German; which has been alſo tranſlated into Engliſh. 3. The Hiſtory of Sweden, from Guſtavus Adolphus's expedition into Germany to the abdication of Queen Chriſtina. 4. The Hiſtory of Charles Guſtavus, two volumes folio, &c.

PUFFIN. See Alca, Ornithology *Index*.

PUGET, Peter Paul, one of the greateſt painters and ſculptors France ever produced, though but little noticed by their own writers, was born at Marſeilles in 1623. In his youth he was the diſciple of Roman, an able ſculptor; and then went to Italy, where he ſtudied painting and architecture. In painting he ſo well imitated the manner of Peter de Cortona, that this painter deſired to ſee him, and entered into a friendſhip with him. In 1657, a dangerous diſorder obliged him to renounce the pencil, and devote himſelf to ſculpture; and his reputation cauſing him to be invited to Paris, he enjoyed a penſion of 1200 crowns, as ſculptor and director of the works relating to veſſels and galleys.

galleys. He died at Marseilles in 1695, and has left a number of admirable statues behind him both in France and Italy.

PUGIL, in *Physic*, &c. such a quantity of flowers, seeds, or the like, as may be taken up between the thumb and two fore-fingers. It is reckoned the eighth part of the manipulus or handful.

PULEGIUM, or *PENNY-Royal*. See MENTHA, BOTANY *Index*.

PULEX, the FLEA, in *Zoology*, a genus of insects belonging to the order of aptera. See ENTOMOLOGY *Index*.

By keeping fleas in a glass tube corked up at both ends, but so as to admit fresh air, their actions and manners may be observed. They are thus seen to lay their eggs, not all at once, but ten or twelve in a day, for several days successively; which eggs will be afterwards found to hatch successively in the same order. The flea may easily be dissected in a drop of water; and by this means the stomach and bowels, with their peristaltic motion, may be discovered very plainly, as also their testes and penis, with the veins and arteries, though minute beyond all conception. Mr Leuwenhoek affirms also, that he has seen innumerable animalcules, shaped like serpents, in the semen masculinum of a flea. This bloodthirsty insect, which fattens at the expence of the human species, prefers the more delicate skin of women; but preys neither upon epileptic persons, nor upon the dead or dying. It loves to nestle in the fur of dogs, cats, and rats. The nests of river-swallows are sometimes plentifully stored with them.

Barbut's Genera of Insects, p. 330, &c.

Fleas are apterous; walk but little, but leap to a height equal to 200 times that of their own body. This amazing motion is performed by means of the elasticity of their feet, the articulations of which are so many springs. Thus it eludes, with surprising agility, the pursuit of the person on whom it riots. Among the memorabilia of fleas, one, they say, has been seen to draw a small silver piece of ordnance to which it was fastened, the firing of the gun nowise daunting its intrepidity. The owner carried it about in a little box lined with velvet, every now and then placing it on her arm to let it feed; but winter put an end to the being of this martial flea. Another flea that became slave to an Englishman, had, for its daily and easy task, to drag its golden chain and padlock, of the weight of one grain. A third flea served as a thrill-horse to an English artist, who had made an ivory coach and six, that carried a coachman and his dog between his legs, a postilion, two footmen, and four inside riders. At Surat fleas, bugs, and other voracious vermin, are in so great veneration, that they have an hospital endowed, where every night a poor fellow, for hire, suffers himself to be preyed upon. He is fastened naked on a bed, when the feast begins at his expence. In Turkey there is a similar foundation for decayed dogs; an institution less ridiculous than the other. Mercurial ointment, brimstone, a fumigation with the leaves of pennyroyal, or fresh-gathered leaves of that plant sewed up in a bag, and laid in the bed, are remedies pointed out as destructive of fleas.

PULEX Arboreus, in *Natural History*, the name given by Mr Reaumur to a very large genus of small animals. They are a kind of half-winged creatures: they have granulated antennæ; and some of them, in their most perfect state, have complete wings. These are distinguished from the others by the name of *musca-pulex* or the *winged-pulex*. See COCCUS, ENTOMOLOGY *Index*.

PULEX Aquaticus auctorum (monoculus pulex of Linnæus) is a species of the genus MONOCULUS; which see, under ENTOMOLOGY *Index*.

PULEX-Eaters, a name given by naturalists to a sort of worms frequently found on the leaves of trees, where they devour the animals called *pulices arborei*.

Of these there are several species, which owe their origin to the eggs of different creatures; for there are none of them in their ultimate state in this their time of feeding. According to the different animals whose eggs they are hatched from, these are of different form and structure. Some are hexapodes, or endued with six feet; these belong to the beetle-tribe, and finally change into beetles like the parent animal from whose eggs they sprung. Others have no legs, and are produced from the eggs of flies of various kinds. And, finally, others are genuine caterpillars, though small; but these are the most rare of all.

The two general kinds are the hexapodes, or beetle-worms; and the apodes, or fly-worms. The fly which gives origin to the last of these is a four-winged one; and takes care always to deposit her eggs in a place where there are plenty of the pulices, usually on the stalk or young branches of a tree in the midst of large families of them. The worm, as soon as hatched, finds itself in the midst of abundance of food, preying at pleasure on these animals, which are wholly defenceless. The stalks of the elder and woodbine are frequently found covered over with these pulices; and among them there may usually be found one or more of these destroyers feeding at will, sucking in the juices from their bodies, and then throwing away the dry skins. Besides the worms of this four-winged fly, there is one of a two-winged wasp-fly, very destructive of these animals.

PULLEY, in *Mechanics*, one of the five mechanical powers. See MECHANICS.

PULMO, the LUNGS, in ANATOMY. See ANATOMY *Index*.

PULMONARIA, LUNGWORT, a genus of plants belonging to the pentandria class, and in the natural method ranking under the 41st order, *Asperifoliæ*. See BOTANY *Index*.

PULO, the name of several Asiatic islands, in the Indian ocean, the principal of which only, it is said, is inhabited. It is denominated

PULO-Condore, an island about 13 miles long and three broad, which was visited by Lord Macartney on his way to China. It has convenient anchoring places during either monsoon. Here his lordship's squadron came to anchor on the 17th of May. The bay is formed by four small islands approaching so near to each other, as to exhibit the appearance of meeting together in different points. They all seem to be the rude fragments of primitive mountains, which have been detached from the great continent in the lapse of ages. Condore lies in 8° 40′ North Lat. and 105° 55′ E. Long.

The English at one period had a settlement here, but being driven from it by some Malay soldiers in their pay, probably for some unjustifiable treatment, no Europeans it is said, have resided in it ever since. When a party went on shore from Lord Macartney's squadron.

they were welcomed by the natives with much urbanity of manners, and conducted to the houſe of their chief. Their dreſs conſiſted chiefly of blue cotton garments hanging looſely about them; and their flat faces and noſes ſeemed to denote that they were deſcended from the Chineſe. A miſſionary being of the party, could not underſtand their language as they ſpoke it; but as ſoon as committed to writing it was perfectly intelligible to him. This led to the concluſion, that the inhabitants of Pulo-Condore were originally Cochin Chineſe, who fled from their own country in conſequence of their attachment to one of its ſovereigns who had been dethroned by a number of his own ſubjects.

Here the ſquadron was to purchaſe proviſions, and the people promiſed to have the propoſed quantity in readineſs, if poſſible, at the appointed time. Next morning, a party of pleaſure went from the Hindoſtan to a ſmall iſland near Pulo-Condore; but being apprehenſive of an approaching ſtorm, they made towards the ſhip with all convenient ſpeed. The weather again becoming favourable, they ſet off for the iſland again, and were aſtoniſhed, on their arrival, to find it wholly abandoned. In the principal cabin a letter was found, written in the Chineſe language, expreſſing their terror at the arrival of ſuch great ſhips and powerful perſons; not being able to ſatisfy their demands as to cattle and other proviſions, the poor inhabitants of Pulo-Condore having ſcarcely any to ſupply, they therefore fled to preſerve their lives; declared themſelves to be few in number, and very poor, but honeſt; and concluded with requeſting the *great people* to have pity on them, as they had left their all behind, and earneſtly implored them not to burn their cabins.

The generous Engliſh left them an intimation that they called merely for refreſhment on fair and equitable terms, without harbouring againſt them any evil deſigns. They claimed a connection to a civilized nation, actuated by principles of humanity, by which they were prohibited from plundering or doing injury to others, who might have the misfortune to be fewer or weaker than themſelves. No doubt the poor terrified inhabitants would be agreeably ſurpriſed to find, on their return, not only that all their tents were in perfect ſafety, but that nothing was either diſturbed or removed, and a ſmall preſent left to their chief in the principal dwelling.

PULO-Lingen, another iſland of the cluſter mentioned above, is of ſome extent, though inferior in ſize to Pulo Condore. It is chiefly remarkable for a mountain in its centre, terminating in a fork like Parnaſſus, but denominated by mariners the *aſſes ears.* The people of Lord Macartney's ſquadron were conſtantly diſcovering new iſlands, many of which were clothed with verdure; ſome had lofty trees growing upon them; others were nothing but naked rocks, the reſort of innumerable birds, and whitened with their dung.

PULO PENANG. See *PRINCE of Wales's Iſland.*

PULP, in *Pharmacy*, the fleſhy and ſucculent parts of fruits extracted by infuſion or boiling, and paſſed through a ſieve.

PULPIT, an elevated place in a church, whence ſermons are delivered. The French give the ſame name to a reading deſk.

PULPITUM, in the Grecian and Roman theatres, was a place where the players performed their parts. It was lower than the ſcena, and higher than the orcheſtra. It nearly anſwered to what we call the ſtage, as diſtinguiſhed from the pit and galleries. *Pulpitum* was alſo a moveable deſk or pulpit, from which diſputants pronounced their diſſertations, and authors recited their works.

PULSE, in the animal economy, denotes the beating or throbbing of the heart and arteries.

No doctrine has been involved in more difficulties than that of pulſes; ſince, in giving a phyſiological account of them, phyſicians have eſpouſed quite oppoſite ſentiments; whilſt ſome doubt whether the pulſe is owing to the ſyſtole or diaſtole; as alſo, whether the motion of the heart and arteries is one and the ſame, for a moment of time.

With regard to motion, the pulſes are reckoned only four; great and little, quick and ſlow. When quickneſs and greatneſs are joined together, it becomes violent; and when it is little and ſlow it is called a *weak pulſe*. They are alſo ſaid to be *frequent* and *rare*, *equal* and *unequal;* but theſe are not the eſſential affections of motion. Frequency and quickneſs are often confounded with each other. A pulſe is ſaid to be *hard* or *ſoft*, with regard to the artery, according as it is tenſe, renitent, and hard, or flaccid, ſoft, and lax: for the diſpoſition of the arteries contributes greatly to the change of the pulſe; wherefore it ſometimes happens, that the pulſe in both arms is not alike, which is very common in a hemiplexy. Add to theſe a convulſive pulſe, which does not proceed from the blood, but from the ſtate of the artery; and is known by a tremulous ſubultory motion, and the artery ſeems to be drawn upwards: this, in acute fevers, is the ſign of death; and is ſaid to be the pulſe in dying perſons, which is likewiſe generally unequal and intermitting. A *great* pulſe ſhows a more copious afflux of the blood to the heart, and from thence into the arteries: a *little* pulſe the contrary.

The pulſes of perſons differ according to the largeneſs of the heart and veſſels, the quantity and temperies of the blood, the elaſtic force of the canals; as alſo with regard to the ſex, age, ſeaſon, air, motion, food, ſleep, watchings, and paſſions of the mind. The pulſe is larger and more quick in men than in women; in the bilious and ſanguineo-bilious, than in the phlegmatic and melancholic. Thoſe who are lean, with tenſe fibres, and large veſſels, have a greater and a ſtronger pulſe, than thoſe that are obeſe, with lax fibres and ſmall veſſels; whence they are more healthy, robuſt, and apt for labour. In children, the pulſe is quick and ſoft; in adults greater and more violent. In the old, it is commonly great, hard, and ſlow. Labour, motion, and exerciſe of the body, increaſe the circulation of the blood, the excretions, and particularly reſpiration; reſt renders the circulation ſlow and weak; intenſe ſpeaking increaſes the circulation, and conſequently renders the pulſe large and quick. In watching, the pulſe is more evident; in ſleep, more ſlow and languid. After drinking hot things, ſuch as coffee and tea, or hot bath-waters, as well as after meals, the pulſe vibrates more quick. But nothing produces a greater change in the pulſe than affections of the mind: in terror, it is unequal, ſmall, and contracted: in joy, frequent and great; in anger, quick and hard; in ſadneſs, ſlow, ſmall, deep, and weak; and in intenſe ſtudy, languid and weak. With regard to the air, when, after the

predominancy

predominancy of a weſt or ſouth wind, it becomes north or eaſt, the pulſe is ſtronger and larger; as alſo when the quickſilver riſes in the barometer. But when the atmoſphere is denſe, humid, rainy, with a long ſouth wind; as alſo where the life is ſedentary, the ſleep long, and the ſeaſon autumnal, the pulſe is languid and ſmall, and the perſpiration decreaſed. In May it is great, and ſometimes violent; in the middle of ſummer, quick but weak; in the autumn, ſlow, ſoft, and weak; in the winter, hard and great. A draſtic purge and an emetic render the pulſe hard, quick, and weak, with loſs of ſtrength; chalybeates, and the bark, render it great and robuſt, and the complexion lively; volatiles amplify and increaſe the pulſe; acids and nitrous remedies refrigerate the body, and appeaſe the pulſe; opiates and the like render it ſmall and weak, and decreaſe the elaſticity of the ſolids; and poiſons render it ſmall, contracted, and hard. When the quantity of the blood is too great, bleeding raiſes the pulſe.

Pulse, is alſo uſed for the ſtroke with which any medium is affected by the motion of light, ſound, &c. through it.

Sir Iſaac Newton demonſtrates, that the velocities of the pulſes in an elaſtic fluid medium (whoſe elaſticity is proportionable to its denſity) are in a ratio compounded of half the ratio of the elaſtic force directly, and half the ratio of the denſity inverſely; ſo that in a medium whoſe elaſticity is equal to its denſity, all pulſes will be equally ſwift.

Pulse, in *Botany*, a term applied to all thoſe grains or ſeeds which are gathered with the hand; in contradiſtinction to corn, &c. which are reaped, or mowed: or, It is the ſeed of the leguminous kind of plants, as beans, vetches, &c.; but is by ſome uſed for artichokes, aſparagus, &c.

PULTENEY, William, the famous oppoſer of Sir Robert Walpole in parliament, and afterward earl of Bath, was deſcended from one of the moſt ancient families in the kingdom, and was born in 1682. Being well qualified in fortune, he early procured a ſeat in the houſe of commons, and diſtinguiſhed himſelf as a warm partiſan againſt Queen Anne's miniſtry; whoſe errors he had ſagacity to detect, and ſpirited eloquence to expoſe. When King George I. came to the throne, Mr Pulteney was made ſecretary at war, and ſoon after cofferer to the king's houſehold; but the good underſtanding between this gentleman and Sir Robert Walpole, who then acted as prime miniſter, was interrupted in 1725, on a ſuſpicion that Walpole was deſirous of extending the limits of prerogative, and of promoting the intereſts of Hanover, to the prejudice of thoſe of Britain. His oppoſition to Sir Robert was indeed carried to ſuch indiſcriminate lengths, that ſome have been of opinion he often acted againſt meaſures beneficial to the public, merely from perſonal motives. It would be impracticable here to trace his parliamentary conduct: ſo it muſt ſuffice to obſerve in general, that he became ſo obnoxious to the crown, that in 1731 the king called for the council-book, and with his own hand ſtruck out his name from the liſt of privy-counſellors; a proceeding that only ſerved to inflame his reſentment and increaſe his popularity. Thus he ſtill continued to attack the miniſter with a ſeverity of eloquence and ſarcaſm that worſted every antagoniſt; ſo that Sir Robert was heard to declare, he dreaded that man's tongue more than another man's ſword. At length, when Walpole found the place of prime miniſter no longer tenable, and reſigned in 1741, among other promotions Mr Pulteney reſumed his place in the privy-council, and was created earl of Bath; a title purchaſed at the expence of that popularity which afterward he naturally enough affected to contemn. In 1760, toward the cloſe of the war, he publiſhed *A Letter to two Great Men*, recommending proper articles to be inſiſted on in a treaty of peace; which, though the writer was then unknown, was greatly applauded, and went through ſeveral impreſſions. He died in 1764; and as his only ſon died before him, the title became extinct.

PULVERIZATION, the art of pulverizing, or reducing a dry body into a fine powder; which is performed in friable bodies by pounding or beating them into a mortar, &c.; but to pulverize malleable ones, other methods muſt be taken. To pulverize lead, or tin, the method is this: Rub a round wooden box all over the inſide with chalk; pour a little of the melted metal nimbly into the box; when ſhutting the lid, and ſhaking the box briſkly, the metal will be reduced to powder.

PUMEX, the Pumice-stone. See Mineralogy *Index*.

Pumice-ſtone is uſed in ſome mechanical arts; as for rubbing and ſmoothing the ſurface of metals, wood, paſteboard, and ſtone; for which it is well fitted by reaſon of its harſh and brittle texture; thus ſcouring and carrying off the little inequalities from the ſurfaces juſt mentioned.

PUMICE-stone. See Mineralogy *Index*.

PUMP, an hydraulic machine for raiſing water by means of the preſſure of the atmoſphere.

1 Of the invention of pumps.

It would be an entertaining and not an uninſtructive piece of information to learn the progreſſive ſteps by which the ingenuity of man has invented the various methods of raiſing water. A pump muſt be conſidered as the laſt ſtep of this progreſs. Common as it is, and overlooked even by the curious, it is a very abſtruſe and refined invention. Nothing like it has been found in any of the rude nations whom the reſtleſs ſpirit of the Europeans has diſcovered, either in the new continent of America, or the iſlands of the Pacific ocean. Nay, it was unknown in the cultivated empire of China at the time of our arrival there by ſea; and it is ſtill a rarity every where in Aſia, in places unfrequented by the Europeans. It does not appear to have been known to the Greeks and Romans in early times; and perhaps it came from Alexandria, where phyſical and mathematical ſcience was much cultivated by the Greek ſchool under the protection of the Ptolemies. The performances of Cteſibius and Hero are ſpoken of by Pliny and Vitruvius as curious novelties (A). It is perhaps not difficult to trace the ſteps by which thoſe mechanicians were led to

(A) In the early Greek writings, it does not appear that the words ἀντλος, ἀντλειν, ἀντλια, &c. were uſed to expreſs any thing like what we call a pump. In all theſe paſſages the words either expreſs generally the drawing of water, to the invention. The Egyptian wheel was a common machine all over Asia, and is still in use in the remotest corners, and was brought by the Saracens into Spain, where it is still very common under its ancient name NORIA. The Danish missionaries found in a remote village in the kingdom of Siam the immediate offspring of the noria (*Lettres Edifiantes et Curieuses*). It was a wheel turned by an ass, and carrying round, not a string of earthen pots, but a string of wisps of hay, which it drew through a wooden trunk. This rude chain-pump was in frequent use for watering the rice fields. It is highly probable that it is of great antiquity, although we do not recollect its being mentioned by any of the Greek or Roman writers. The Arabs and Indians were nothing less than innovators; and we may suppose with great safety, that what arts we now find among them they possessed in very remote periods. Now the step from this to the pump is but short, though it is nice and refined; and the forcing pump of Ctesibius is the easiest and most natural.

Plate CCCCXLIX. Fig. 1.
2
Ctesibius's pump.

Let AB (fig. 1.) be the surface of the water in the well, and D the height where it is to be delivered. Let DC be a long wooden trunk, reaching as deep under water as possible. Let the rope EF be fitted with its knot of hay F. When it is drawn up through the trunk, it will bring up along with it all the water lying between C and A, which will begin to run out by the spout D as soon as the knot gets to G, as far below D as C is below A. All this is very obvious; and it required but little reflection to be assured, that if F was let down again, or pushed down, by a rod instead of a rope, it would again perform the same office. Here is a very simple pump. And if it was ever put in practice, it behoved to show the supporting power of the atmosphere, because the water would not only be lifted by the knot, but would even follow it. The imperfection of this pump behoved to appear at first sight, and to suggest its remedy. By pushing down the knot F, which we shall henceforth call the *piston*, all the force expended in lifting up the water between A and G is thrown away, because it is again let down. A valve G, at the bottom, would prevent this. But then there must be a passage made for the water by a lateral tube KBD (fig. 2.). And if this be also furnished with a valve H, to prevent its losing the water, we have the pump of Ctesibius, as sketched in fig. 2. The valve is the great refinement: but perhaps even this had made its appearance before in the noria. For, in the more perfect kinds of these machines, the pots have a stop or valve in their bottom, which hangs open while the pot descends with its mouth downwards, and then allows it to fill readily in the cistern: whereas, without the valve, it would occasion a double load to the wheel. If we suppose that the valve had made its appearance so early, it is not improbable that the common pump sketched in fig. 3. was as old as that of Ctesibius. In this place we shall first give a short description of the chief varieties of these engines, considering them in their simplest form, and we shall explain in very general terms their mode of operation. We shall then give a concise and popular theory of their operation, furnishing principles to direct us in their construction; and we shall conclude with the description of a few peculiarities which may contribute to their improvement or perfection.

Fig 2.

Fig. 3.

There are but two sorts of pumps which essentially differ; and all the varieties that we see are only modifications of these. One of these original pumps has a solid piston; the other has a piston with a perforation and a valve. We usually call the first a FORCING PUMP, and the second a LIFTING or SUCKING PUMP.

3
Forcing pump described.
Fig. 2.

Fig. 2. is a sketch of the forcing pump in its most simple form and situation. It consists of a hollow cylinder AC*ca*, called the WORKING BARREL, open at both ends, and having a valve G at the bottom, opening upwards. This cylinder is filled by a solid piston EF, covered externally with leather or tow, by which means it fits the box of the cylinder exactly, and allows no water to escape by its sides. There is a pipe KHD, which communicates laterally with this cylinder, and has a valve at some convenient place H, as near as possible to its junction with the cylinder. This valve also opens upwards. This pipe, usually called the RISING PIPE, or MAIN, terminates at the place D, where the water must be delivered.

4
Its mode of operation.

Now suppose this apparatus set into the water, so that the upper end of the cylinder may be under or even with the surface of the water AB; the water will open the valve G, and after filling the barrel and lateral pipe, will also open the valve H, and at last stand at an equal height within and without. Now let the piston be put in at the top of the working barrel, and thrust down to K. It will push the water before it. This will shut the valve G, and the water will make its way through the valve H, and fill a part B*b* of the rising pipe, equal to the internal capacity of the working barrel. When this downward motion of the piston ceases, the valve H will fall down by its own weight and shut this passage. Now let the piston be drawn up again: The valve H hinders the water in the rising pipe from returning into the working barrel. But now the valve G is opened by the pressure of the external water, and the water enters and fills the cylinder as the piston rises. When the piston has got to the top, let it be thrust down again: The valve G will again be shut, and the water will be forced through the passage at H, and rise along the main, pushing before it the water already there, and will now have its surface at L. Repeating this operation, the water must at last arrive at D, however

water, or, more particularly, the drawing it with a bucket or something similar. Ἀντλος, which is the primitive. is a drain, sink, or receptacle for collecting scattered water, either for use, or to get rid of it; hence it came to signify the sink or well of a ship; and ἀντλειν was synonymous with our verb "to bale the boat." (*Odyss.* O. 476 M. 411. *Eurip. Hecuba*, 1025). Ἀντλιον is the *vessel* or *bucket* with which water is drawn. Ἀντλια is the service (generally a punishment) of drawing water. Ἀντλειν "to draw water with a bucket:" hence the force of Aristotle's expression (*Oecon.* 1.) τω γαρ ἠθμω ἀντλειν τουτ' ἐστι. See even the late authority of the New Testament, John ii. 8.; iv. 7. 11. Here ἀντλημα is evidently something which the woman brought along with her; probably a bucket and rope.

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ever remote, and the next stroke would raise it to *e*; so that during the next rise of the piston the water in *e* D will be running off by the spout.

The effect is the same whatever be the position of the working barrel, provided only that it be under water. It may lie horizontally or sloping, or it may be with its mouth and piston rod undermost. It is still the same forcing pump, and operates in the same manner and by the same means, viz. the pressure of the surrounding water.

The external force which must be applied to produce this effect is opposed by the pressure exerted by the water on the opposite face of the piston. It is evident, from the common laws of hydrostatics, that this opposing pressure is equal to the weight of a pillar of water, having the face of the piston for its base, and the perpendicular height *d* A of the place of delivery above the surface of the water AB in the cistern for its height. The form and dimensions of the rising pipe are indifferent in this respect, because heavy fluids press only in the proportion of their perpendicular height. Observe that it is not *d* F, but *d* A, which measures this pressure, which the moving force must balance and surmount. The whole pressure on the under surface F *f* of the piston is indeed equal to the weight of the pillar *d* F *f* ∂; but part of this is balanced by the water AF *f a*. If indeed the water does not get into the upper part of the working barrel, this compensation does not obtain. While we draw up the piston, this pressure is removed, because all communication is cut off by the valve H, which now bears the whole pressure of the water in the main. Nay, the ascent of the piston is even assisted by the pressure of the surrounding water. It is only during the descent of the piston therefore that the external force is necessary.

Observe that the measure now given of the external force is only what is necessary for *balancing* the pressure of the water in the rising pipe. But in order that the pump may perform work, it must *surmount* this pressure, and cause the water to issue at D with such a velocity that the required quantity of water may be delivered in a given time. This requires force, even although there were no opposing pressure; which would be the case if the main were horizontal. The water fills it, but it is at rest. In order that a gallon, for instance, may be delivered in a second, the whole water in the horizontal main must be put in motion with a certain velocity. This requires force. We must therefore always distinguish between the state of equilibrium and the state of actual working. It is the equilibrium only that we consider at present; and no more is necessary for understanding the operation of the different species of pumps. The other force is of much more intricate investigation, and will be considered by itself.

5 Lifting pump.

The simplest form and situation of the lifting pump is represented by the sketch fig. 3. The pump is immersed in the cistern till both the valve G and piston F are under the surface AB of the surrounding water. By this means the water enters the pump, opening both valves, and finally stands on a level within and without.

6 Its mode of operating.

Now draw up the piston to the surface A. It must lift up the water which is above it (because the valve in the piston remains shut by its own weight); so that its surface will now be at *a*, A *a* being made equal to AF. In the mean time, the pressure of the surrounding water forces it into the working barrel, through the valve G; and the barrel is now filled with water. Now, let the piston be pushed down again; the valve G immediately shuts by its own weight, and in opposition to the endeavours which the water in the barrel makes to escape this way. This attempt to compress the water in the barrel causes it to open the valve F in the piston; or rather, this valve yields to our endeavour to push the piston down through the water in the working barrel. By this means we get the piston to the bottom of the barrel; and it has now above it the whole pillar of water reaching to the height *a*. Drawing up the piston to the surface A a second time, must lift this double column along with it, and its surface now will be at *b*. The piston may again be thrust down through the water in the barrel, and again drawn up to the surface; which will raise the water to *c*. Another repetition will raise it to *d*; and it will now show itself at the intended place of delivery. Another repetition will raise it to *e*; and while the piston is now descending to make another stroke, the water in *e d* will be running off through the spout D; and thus a stream will be produced, in some degree continual, but very unequal. This is inconvenient in many cases: thus, in a pump for domestic uses, such a hobbling stream would make it very troublesome to fill a bucket. It is therefore usual to terminate the main by a cistern LMNO, and to make the spout small. By this means the water brought up by the successive strokes of the piston rises to such a height in this cistern, as to produce an efflux by the spout nearly equable. The smaller we make the spout D the more equable will be the stream; for when the piston brings up more water than can be discharged during its descent, some of it remains in the cistern. This, added to the supply of next stroke, makes the water rise higher in the cistern than it did by the preceding stroke. This will cause the efflux to be quicker during the descent of the piston, but perhaps not yet sufficiently quick to discharge the whole supply. It therefore rises higher next stroke; and at last it rises so high, that the increased velocity of efflux makes the discharge precisely balance the supply. Now, the quantity supplied in each stroke is the same, and occupies the same room in the cistern at top; and the surface will sink the same number of inches during the descent of the piston, whether that surface has been high or low at the beginning. But because the velocities of the efflux are as the square roots of the heights of the water above the spout, it is evident that a sink of two or three inches will make a smaller change in the velocity of efflux when this height and velocity are great. This seems but a trifling observation; but it serves to illustrate a thing to be considered afterwards, which is important and abstruse, but perfectly similar to this.

It is evident, that the force necessary for this operation must be equal to the weight of the pillar of water *d* A *a* D, if the pipe be perpendicular. If the pump be standing aslope, the pressure which is to be balanced is still equal to the weight of a pillar of water of this perpendicular height, and having the surface of the piston for its base.

Such is the simplest, and, we may add, by far the best, form of the forcing and lifting pumps; but it is not the most usual. Circumstances of convenience, economy, and more frequently of fancy and habit, have caused the pump-makers to deviate greatly from this form. It is not usual to have the working barrel in the

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the water; this, especially in deep wells, makes it of difficult access for repairs, and requires long piston rods. This would not do in a forcing pump, because they would bend.

7
Effect of giving the piston a longer stroke

We have supposed, in our account of the lifting pump, that the rise of the piston always terminated at the surface of the water in the cistern. This we did in order that the barrel might always be filled by the pressure of the surrounding water. But let us suppose that the rise of the piston does not end here, and that it is gradually drawn up to the very top: it is plain that the pressure of the atmosphere is by this means taken off from the water in the pipe (see PNEUMATICS), while it remains pressing on the water of the cistern. It will therefore cause the water to follow the piston as it rises through the pipe, and it will raise it in this way 33 feet at a medium. If, therefore, the spout D is not more than 33 feet above the surface of the water in the cistern, the pipe will be full of water when the piston is at D. Let it be pushed down to the bottom; the water will remain in the pipe, because the valve G will shut: and thus we may give the piston a stroke of any length not exceeding 33 feet. If we raise it higher than this, the water will not follow; but it will remain in the pipe, to be lifted by the piston, after it has been pushed down through it to the bottom.

8
Inconvenient and unnecessary.

But it is not necessary, and would be very inconvenient, to give the piston so long a stroke. The great use of a pump is to render effectual the reciprocation of a short stroke which we can command, while such a long stroke is generally out of our power. Suppose that the piston is pushed down only to *b*; it will then have a column *bf* incumbent on it, and it will lift this column when again drawn up. And this operation may be repeated like the former, when the piston was always under water; for the pressure of the atmosphere will always cause the water to follow the piston to the height of 33 feet.

Nor is it necessary that the fixed valve G be placed at the lower orifice of the pipe, nor even under water. For, while things are in the state now described, the piston drawn up to *f*, and the whole pipe full of water; if we suppose another valve placed at *b* above the surface of the cistern, this valve can do no harm. Now let the piston descend, both valves G and *b* will shut. G may now be removed, and the water will remain supported in the space *b* G by the air; and now the alternate motions of the piston will produce the same effect as before.

9
Effect of the weight of the water and pressure of the atmosphere.

We found in the former case that the piston was carrying a load equal to the weight of a pillar of water of the height AD, because the surrounding water could only support it at its own level. Let us see what change is produced by the assistance of the pressure of the atmosphere. Let the under surface of the piston be at *b*; when the piston was at *f*, 33 feet above the surface of the cistern, the water was raised to that height by the pressure of the atmosphere. Suppose a partition made at *b* by a thin plate, and all the water above it taken away. Now pierce a hole in this plate. The pressure of the atmosphere was able to carry the whole column *fa*. Part of this column is now removed, and the remainder is not a balance for the air's pressure. This will therefore cause the water to spout up through this hole and rise to *f*. Therefore the under surface of this plate is pressed up by the contiguous water with a force equal to the weight of that pillar of water which it formerly supported; that is, with a force equal to the weight of the pillar *fb*. Now the under surface of the piston, when at *b*, is in the same situation. It is pressed upwards by the water below it, with a force equal to the weight of the column *fb*: But it is pressed downwards by the whole pressure of the atmosphere, which presses on all bodies; that is, with the weight of the pillar *fa*. On the whole, therefore, it is pressed downwards by a force equal to the difference of the weights of the pillars *fa* and *fb*; that is, by a force equal to the weight of the pillar *ba*.

It may be conceived better perhaps in this way. When the piston was under the surface of the water in the cistern, it was equally pressed on both sides, both by the water and atmosphere. The atmosphere exerted its pressure on it by the intervention of the water; which being, to all sense, a perfect fluid, propagates every external pressure undiminished. When the piston is drawn up above the surface of the pit-water, the atmosphere continues to press on its upper surface with its whole weight, through the intervention of the water which lies above it; and its pressure must therefore be added to that of the incumbent water. It also continues to press on the under surface of the piston by the intervention of the water; that is, it presses this water to the piston. But, in doing this, it carries the weight of this water which it is pressing on the piston. The pressure on the piston therefore is only the excess of the whole pressure of the atmosphere above the weight of the column of water which it is supporting. Therefore the difference of atmospheric pressure on the upper and under surfaces of the piston is precisely equal to the weight of the column of water supported in the pipe by the air. It is not, however, the individual weight of this column that loads the piston; it is the part of the pressure of the atmosphere on its upper surface, which is not balanced by its pressure on the under surface.

In attempting, therefore, to draw up the piston, we have to surmount this unbalanced part of the pressure of the atmosphere, and also the weight of the water which lies above the piston, and must be lifted by it: and thus the whole opposing pressure is the same as before, namely, the weight of the whole vertical pillar reaching from the surface of the water in the cistern to the place of delivery. Part of this weight is immediately carried by the pressure of the atmosphere; but, in lieu of it, there is an equal part of this pressure of the atmosphere abstracted from the under surface of the piston, while its upper surface sustains its whole pressure.

So far, then, these two states of the pump agree.— 10
Other circumstances to be attended to.
But they differ exceedingly in their mode of operation; and there are some circumstances not very obvious which must be attended to, in order that the pump may deliver any water at the spout D. This requires, therefore, a serious examination.

Let the fixed valve G (fig. 4.) be supposed at the surface of the cistern water. Let M *m* be the lowest, and N *n* the highest, positions of the piston, and let HA=*h* be the height of a column of water equiponderant with the atmosphere. Fig. 4.

When the pump is filled, not with water, but with air, and the piston is in its lowest position, and all in equilibrio, the internal air has the same density and

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elaſticity with the external. The ſpace MA*am*, therefore, contains air of the common denſity and elaſticity. Theſe may be meaſured by h, or the weight of a column of water whoſe height is h. Now, let the piſton be drawn up to N*n*. The air which occupied the ſpace MA*am* now occupies the ſpace NA*an*, and its denſity is now $\frac{MA\,am}{NA\,an}$. Its elaſticity is now diminiſhed, being proportionable to its denſity (ſee Pneumatics), and no longer balances the preſſure of the atmoſphere. The valve G will therefore be forced up by the water, which will riſe to ſome height SA. Now let the piſton again deſcend to M*m*. It cannot do this with its valve ſhut; for when it comes down ſo far as to reduce the air again to its common denſity, it is not yet at M, becauſe the ſpace below it has been diminiſhed by the water which got into the pipe, and is retained there by the valve G. The piſton valve, therefore, opens by the air which we thus attempt to compreſs, and the ſuperfluous air eſcapes. When the piſton has got to M, the air is again of the common denſity, and occupies the ſpace MS*sm*. Now draw the piſton up to N. This air will expand into the ſpace NS*sn*, and its denſity will be reduced to $\frac{MS\,sm}{NS\,sn}$, and its elaſticity will no longer balance the preſſure of the atmoſphere, and more water will enter, and it will riſe higher. This will go on continually. But it may happen that the water will never riſe ſo high as to reach the piſton, even though not 33 feet above the water in the ciſtern: For the ſucceſſive diminutions of denſity and elaſticity are a ſeries of quantities that decreaſe geometrically, and therefore will have a limit. Let us ſee what determines this limit.

At whatever height the water ſtands in the lower part of the pipe, the weight of the column of water SA*as*, together with the remaining elaſticity of the air above it, exactly balances the preſſure of the atmoſphere (ſee Pneumatics, N° 108.). Now the elaſticity of the air in the ſpace NS*sn* is equal to $h\times\frac{MS\,sm}{NS\,sn}$. Therefore, in the caſe where the limit obtains, and the water riſes no farther, we muſt have $h=AS+h\frac{MS\,sm}{NS\,sn}$, or, becauſe the column is of the ſame diameter throughout, $h=AS+h\frac{MS}{NS}$, and $\frac{MS}{NS}h=h-AS,=HS$, and NS : MS=HA : HS, and NS — MS : NS = HA — HS : HA, or NM : NS=AS : AH, and NM × AH=NS × AS. Therefore, if AN, the diſtance of the piſton in its higheſt poſition from the water in the ciſtern, and NM the length of its ſtroke, be given, there is a certain determined height AS to which the water can be raiſed by the preſſure of the air: For AH is a conſtant quantity; and therefore when MN is given, the rectangle AS × SN is given. If this height AS be leſs than that of the piſton in its loweſt poſition, the pump will raiſe no water, although AN may be leſs than AH. Yet the ſame pump will raiſe water very effectually, if it be firſt of all filled with water; and we have ſeen profeſſional engineers much puzzled by this capricious failure of their pumps. A little knowledge of the principles would have prevented their diſappointment.

To inſure the delivery of water by the pump, the ſtroke muſt be ſuch that the rectangle MN × AH may be greater than any rectangle that can be made of the parts of AN, that is, greater than the ſquare of half AN. Or, if the length of the ſtroke be already fixed by other circumſtances, which is a common caſe, we muſt make AN ſo ſhort that the ſquare of its half, meaſured in feet, ſhall be leſs than 33 times the ſtroke of the piſton.

11 Mode of inſuring the delivery of water.

Suppoſe that the fixed valve, inſtead of being at the ſurface of the water in the ciſtern, is at S, or any where between S and A, the performance of the pump will be the ſame as before: But if it be placed anywhere above S, it will be very different. Let it be at T. It is plain that when the piſton is puſhed down from N to M, the valve at T prevents any air from getting down; and therefore, when the piſton is drawn up again, the air contained in the ſpace MT*tm* will expand into the ſpace NT*tn*, and its denſity will be $\frac{MT}{NT}$. This is leſs than $\frac{MS}{NS}$, which expreſſes the denſity of the air which was left in the ſpace TS*st* by the former operations.—The air, therefore, in TS*st* will alſo expand, will open the valve, and now the water will riſe above S. The proportion of NS to NT may evidently be ſuch that the water will even get above the valve T. This diminiſhes the ſpace NT*tn*; and therefore, when the piſton has been puſhed down to M, and again drawn up to N, the air will be ſtill more rarefied, and the water will riſe ſtill higher. The foregoing reaſoning, however, is ſufficient to ſhow that there may ſtill be a height which the water will not paſs, and that this height depends on the proportion between the ſtroke of the piſton and its diſtance from the water in the ciſtern. We need not give the determination, becauſe it will come in afterwards in combination with other circumſtances. It is enough that the reader ſees the phyſical cauſes of this limitation: And, laſtly, we ſee plainly that the utmoſt ſecurity will be given for the performance of the pump, when the fixed valve is ſo placed that the piſton, when in its loweſt poſition, ſhall come into contact with it. In this caſe, the rarefaction of the air will be the completeſt poſſible; and, if there were no ſpace left between the piſton and valve, and all were perfectly air-tight, the rarefaction would be complete, and the valve might be any thing leſs than 33 feet from the ſurface of the water in the ciſtern.

12 Valves not eaſily kept air-tight.

But this perfect contact and tightneſs is unattainable; and though the pump may be full of water, its continual downward preſſure cauſes it to filtrate ſlowly through every crevice, and the air enters through every pore, and even diſengages itſelf from the water, with which a conſiderable portion had been chemically combined. The pump by this means loſes water, and it requires ſeveral ſtrokes of briſk working to fill it again: and if the leathers have become dry, ſo much admiſſion may be given to the air, that the pump will not fill itſelf with water by *any working*. It is then neceſſary to pour water into it, which ſhuts up theſe paſſages, and ſoon ſets all to rights again. For theſe reaſons, it is always prudent to place the fixed valve as low as other circumſtances will permit, and to make the piſton rod of ſuch a length, that when it is at the bottom of its ſtroke it ſhall be almoſt in contact with the valve. When we

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we are not limited by other circumſtances, it is evident that the beſt poſſible form is to have both the piſton and the fixed valve under the ſurface of the water of the ciſtern. In this ſituation they are always wet and airtight. The chief objection is, that by this diſpoſition they are not eaſily come at when needing repair. This is a material objection in deep mines. In ſuch ſituations, therefore, we muſt make the beſt compenſation of different circumſtances that we can. It is uſual to place the fixed valve at a moderate diſtance from the ſurface of the water, and to have a hole in the ſide of the pipe, by which it may be got out. This is carefully ſhut up by a plate firmly ſcrewed on, with leather or cement between the parts. This is called the *clack door.* It would, in every caſe, be very proper to have a fixed valve in the lower end of the pipe. This would combine all advantages. Being always tight, the pipe would retain the water, and it would leave to the valve above it its full effect of increaſing the rarefaction. A ſimilar hole is made in the working barrel, a little above the higheſt poſition of the piſton. When this needs repair, it can be got at through this hole, without the immenſe trouble of drawing up the whole rods.

Thus we have conducted the reader ſtep by ſtep, from the ſimpleſt form of the pump to that which long experience has at laſt ſelected as the moſt generally convenient. This we ſhall now deſcribe in ſome detail.

13 Deſcription of the ſucking-pump. Fig. 5.

The Sucking Pump conſiſts of two pipes DCCD, BAAB (fig. 5.); of which the former is called the *Barrel*, or the *Working Barrel*, and the other is called the *Suction-pipe*, and is commonly of a ſmaller diameter.—Theſe are joined by means of flanches E, F, pierced with holes to receive ſcrewed bolts. A ring of leather, or of lead, covered with a proper cement, is put between them; which, being ſtrongly compreſſed by the ſcrew-bolts, renders the joint perfectly air-tight.—The lower end A of the ſuction-pipe is commonly ſpread out a little to facilitate the entry of the water, and frequently has a grating acroſs it at AA to keep out filth or gravel. This is immerged in the ſtanding water YZ. The working barrel is cylindrical, as evenly and ſmoothly bored as poſſible, that the piſton may fill it exactly through its whole length, and move along it with as little friction as may be conſiſtent with air-tightneſs.

The piſton is a ſort of truncated cone OPKL, generally made of wood not apt to ſplit, ſuch as elm or beech. The ſmall end of it is cut off at the ſides, ſo as to form a ſort of arch OQP, by which it is faſtened to the iron rod or ſpear. It is exhibited in different poſitions in figures 6, 7. which will give a more diſtinct notion of it than any deſcription. The two ends of the conical part may be hooped with braſs. This cone has its larger end ſurrounded with a ring or band of ſtrong leather faſtened with nails, or by a copper hoop, which is driven on it at the ſmaller end. This band ſhould reach to ſome diſtance beyond the baſe of the cone; the farther the better: and the whole muſt be of uniform thickneſs all round, ſo as to ſuffer equal compreſſion between the cone and the working barrel.

Fig. 6. and 7.

14 Neceſſity of air tightneſs not properly attended to.

The ſeam or joint of the two ends of this band muſt be made very cloſe, but not ſewed or ſtitched together. This would occaſion bumps or inequalities, which would ſpoil its tightneſs; and no harm can reſult from the want of it, becauſe the two edges will be ſqueezed cloſe together by the compreſſion in the barrel. It is by no means neceſſary that this compreſſion be great. This is a very detrimental error of the pump-makers. It occaſions enormous friction, and deſtroys the very purpoſe which they have in view, viz. rendering the piſton air-tight; for it cauſes the leather to wear through very ſoon at the edge of the cone, and it alſo wears the working barrel. This very ſoon becomes wide in that part which is continually paſſed over by the piſton, while the mouth remains of its original diameter, and it becomes impoſſible to thruſt in a piſton which ſhall completely fill the worn part. Now, a very moderate preſſure is ſufficient for rendering the pump perfectly tight, and a piece of glove leather would be ſufficient for this purpoſe, if looſe or detached from the ſolid cone; for ſuppoſe ſuch a looſe and flexible, but impervious, band of leather put round the piſton, and put into the barrel; and let it even be ſuppoſed that the cone does not compreſs it in the ſmalleſt degree to its internal ſurface.—Pour a little water carefully into the inſide of this ſort of cup or diſh; it will cauſe it to ſwell out a little, and apply itſelf cloſe to the barrel all round, and even adjuſt itſelf to all its inequalities. Let us ſuppoſe it to touch the barrel in a ring of an inch broad all round. We can eaſily compute the force with which it is preſſed. It is half the weight of a ring of water an inch deep and an inch broad. This is a trifle, and the friction occaſioned by it not worth regarding; yet this trifling preſſure is ſufficient to make the paſſage perfectly impervious, even by the moſt enormous preſſure of a high column of incumbent water: for let this preſſure be ever ſo great, the preſſure by which the leather adheres to the barrel always exceeds it, becauſe the incumbent fluid has no *preponderating* power by which it can force its way between them, and it muſt inſinuate itſelf preciſely ſo far, that its preſſure on the inſide of the leather ſhall ſtill exceed, and only exceed, the preſſure by which it endeavours to inſinuate itſelf; and thus the piſton becomes perfectly tight with the ſmalleſt poſſible friction. This reaſoning is perhaps too refined for the uninſtructed artiſt, and probably will not perſuade him. To ſuch we would recommend an examination of the piſtons and valves contrived and executed by that artiſt, whoſe ſkill far ſurpaſſes our higheſt conceptions, the all-wiſe Creator of this world. The valves which ſhut up the paſſages of the veins, and this in places where an extravaſation would be followed by inſtant death, are cups of thin membrane, which adhere to the ſides of the channel about half way round, and are detached in the reſt of their circumference. When the blood comes in the oppoſite direction, it puſhes the membrane aſide, and has a paſſage perfectly free. But a ſtagnation of motion allows the tone of the muſcular (perhaps) membrane, to reſtore it to its natural ſhape, and the leaſt *motion* in the oppoſite direction cauſes it inſtantly to clap cloſe to the ſides of the vein, and then no preſſure whatever can force a paſſage. We ſhall recur to this again, when deſcribing the various contrivances of valves, &c. What we have ſaid is enough for ſupporting our directions for conſtructing a tight piſton. But we recommended thick and ſtrong leather, while our preſent reaſoning ſeems to render thin leather preferable. If the leather be thin, and the ſolid piſton in any part does not preſs it gently to the barrel, there will be in this part an unbalanced preſſure of the incumbent column of water, which would inſtantly burſt even a

15 An eaſy mode of rendering pumps tight.

16 Proved to be practicable from the human frame.

17 Beſt form of a piſton recommended.

a strong leather bag; but when the solid piston, covered with leather, exactly fills the barrel, and is even pressed a little to it, there is no such risk; and now that part of the leather band which reaches beyond the solid piston performs its office in the completest manner. We do not hesitate, therefore, to recommend this form of a piston, which is the most common and simple of all, as preferable, when well executed, to any of those more artificial, and frequently very ingenious, constructions, which we have met with in the works of the first engineers. To proceed, then, with our description of the sucking-pump.

18 Further description of the sucking-pump.

At the joining of the working barrel with the suction-pipe there is a hole H, covered with a valve opening upwards. This hole H is either made in a plate which makes a part of the suction-pipe, being cast along with it, or it is made in a separate plate. This last is the most convenient, being easily removed and replaced. Fig. 8. Different views are given of this valve in figs. 8, 9, 10. The diameter EF (fig. 10.) of this plate is the same with that of the flanches, and it has holes corresponding to them, through which their bolts pass which keep all together. A ring of thick leather NKL is applied to this plate, having a part cut out between N and L, to make room for another piece of strong leather NR Fig. 9. (fig. 9.) which composes the valve. The circular part of this valve is broader than the hole in the middle of fig. 10. but not quite so broad as to fill up the inside of the ring of leather OQP of this fig. which is the Fig. 10. same with GKI of fig. 10. The middle of this leather valve is strengthened by two brass (not iron) plates, the uppermost of which is seen at R of fig. 9.: the one on its underside is a little smaller than the hole in the valve-plate, that it may go freely in; and the upper plate R is larger than this hole, that it may compress the leather to its brim all round. It is evident, that when this plate with its leathers is put between the joint flanches, and all is screwed together, the tail of leather N of fig. 9. will be compressed between the plates, and form a hinge, on which the valve can turn, rising and falling. There is a similar valve fastened to the upper side, or broadest base of the piston. This description serves for both valves, and in general for most valves which are to be found in any parts of a pump.

19 Its mode of operation.

The reader will now understand, without any repetition, the process of the whole operation of a sucking-pump. The piston rarefies the air in the working barrel, and that in the suction-pipe expands through the valve into the barrel; and, being no longer a balance for the atmospheric pressure, the water rises into the suction-pipe; another stroke of the piston produces a similar effect, and the water rises farther, but by a smaller step than by the preceeding stroke: by repeating the strokes of the piston, the water gets into the barrel; and when the piston is now pushed down through it, it gets above the piston, and must now be lifted up to any height. The suction-pipe is commonly of smaller size than the working barrel, for the sake of economy. It is not necessary that it be so wide; but it may be, and often is, made too small. It should be of such a size, that the pressure of the atmosphere may be able to fill the barrel with water as fast as the piston rises. If a void is left below the piston, it is evident that the piston must be carrying the whole weight of the atmosphere, besides the water which is lying above it. Nay, if the pipe be only so wide, that the barrels shall fill precisely as fast as the piston rises, it must sustain all this pressure. The suction-pipe should be wider than this, that all the pressure of the atmosphere which exceeds the weight of the pillar in the suction-pipe may be employed in pressing it on the under surface of the piston, and thus diminish the load. It cannot be made too wide; and too strict an economy in this respect may very sensibly diminish the performance of the pump, and more than defeat its own purpose. This is most likely when the suction-pipe is long, because there the length of the pillar of water nearly balances the air's pressure, and leaves very little accelerating force; so that water will rise but slowly even in the widest pipe. All these things will be made the subjects of computation afterwards.

It is plain that there will be limitations to the rise of the water in the suction-pipe, similar to what we found when the whole pump was an uniform cylinder. Let a be the height of the fixed valve above the water in the cistern: let B and b be the spaces in cubic measure between this valve and the piston in its highest and lowest positions, and therefore express the bulks of the air which may occupy these spaces: let y be the distance between the fixed valve and the water in the suction-pipe, when it has attained its greatest height by the rarefaction of the air above it: let h be the height of a column of water in equilibrio, with the whole pressure of the atmosphere, and therefore having its weight in equilibrio with the elasticity of common air; and let x be the height of the column whose weight balances the elasticity of the air in the suction-pipe, when rarefied as much as it can be by the action of the piston, the water standing at the height $a-y$.

Then, because this elasticity, together with the column $a-y$ in the suction-pipe, must balance the whole pressure of the atmosphere, (see Pneumatics, N° 108.), we must have $h=x+a-y$, and $y=a+x-h$.

When the piston was in its lowest position, the bulk of the air between it and the fixed valve was b. Suppose the valve kept shut, and the piston raised to its highest position, the bulk will be B, and its density $\frac{b}{\mathrm{B}}$, and its elasticity, or the height of the column whose weight will balance it, will be $h\frac{b}{\mathrm{B}}$. If the air in the suction-pipe be denser than this, and consequently more elastic, it will lift the valve, and some will come in; therefore, when the pump has rarefied the air as much as it can, so that none does, in fact, come in, the elasticity of the air in the suction-pipe *must* be the same. Therefore $x=h\frac{b}{\mathrm{B}}$.

We had $y=a+x-h$. Therefore $y=a+h\frac{b}{\mathrm{B}}-h, =a+\frac{b-\mathrm{B}}{\mathrm{B}}h, =a-\frac{\mathrm{B}-b}{\mathrm{B}}h$.

Therefore when $\frac{\mathrm{B}-b}{\mathrm{B}}h$ is less than a, the water will stop before it reaches the fixed valve. But when a is less than $\frac{\mathrm{B}-b}{\mathrm{B}}h$, the water will get above the fixed valve, y becoming negative.

But,

Pump.

But it does not follow that the water will reach the piston, that is, will rise so high that the piston will pass through it in its descent. Things now come into the condition of a pump of uniform dimensions from top to bottom; and this point will be determined by what was said when treating of such a pump.

20
The same pump is used in an inverted position; Fig. 11.

There is another form of the sucking pump which is much used in great water works, and is of equal efficacy with the one now described. It is indeed the same pump in an inverted position. It is represented in fig. 11. where ABCD is the working barrel, immersed, with its mouth downwards, in the water of the cistern. It is joined by means of flanches to the rising pipe or MAIN.

This usually consists of two parts. The first, BEFC, is bent to one side, that it may give room for the iron frame TXYV, which carries the rod NO of the piston M, attached to the traverses RS, TOV of this frame. The other part, EGHF, is usually of a less diameter, and is continued to the place of delivery. The piston frame XTVY hangs by the rod Z, at the arm of a lever or working beam, not brought into the figure. The piston is perforated like the former, and is surrounded like it with a band of leather in form of a taper-dish. It has a valve K on its broad or upper base, opening when pressed from below. The upper end of the working barrel is pierced with a hole, covered with a valve I, also opening upwards.

Now suppose this apparatus immersed into the cistern till the water is above it, as marked by the line 2, 3, and the piston drawn up till it touch the end of the barrel. When the piston is allowed to descend by its own weight, the water rises up through its valve K, and fills the barrel. If the piston be now drawn up by the moving power of the machinery with which it is connected, the valve K shuts, and the piston pushes the water before it through the valve I into the main-pipe EFGH. When the piston is again let down, the valve I shuts by its own weight and the pressure of the water incumbent on it, and the barrel is again filled by the water of the cistern. Drawing up the piston pushes this water into the main pipe, &c. and then the water is at length delivered at the place required.

21
and is called a *lifting pump.*

This pump is usually called the *lifting pump;* perhaps the simplest of all in its principle and operation.—It needs no farther explanation: and we proceed to describe

22
Forcing-pump described. Fig. 12.

The FORCING PUMP, represented in fig. 12. It consists of a working barrel ABCD, a suction-pipe CDEF, and a main or rising pipe. This last is usually in three joints. The first GHKI may be considered as making part of the working barrel, and is commonly cast in one piece with it. The second IKLM is joined to it by flanches, and forms the elbow which this pipe must generally have. The third LNOM is properly the beginning of the main, and is continued to the place of delivery. At the joint IK there is a hanging valve or clack S; and there is a valve R on the top of the suction-pipe.

The piston PQTV is solid, and is fastened to a stout iron rod which goes through it, and is fixed by a key drawn through its end. The body of the piston is a sort of double cone, widening from the middle to each end, and is covered with two bands of very strong leather, fitted to it in the manner already described.

23
Its mode of operation.

The operation of this pump is abundantly simple. When the piston is thrust into the pump, it pushes the air before it through the valve S, for the valve R remains shut by its own weight. When it has reached near the bottom, and is drawn up again, the air which filled the small space between the piston and the valve S now expands into the barrel; for as soon as the air begins to expand, it ceases to balance the pressure of the atmosphere, which therefore shuts the valve S. By the expansion of the air in the barrel the equilibrium at the valve R is destroyed, and the air in the suction-pipe lifts the valve, and expands into the barrel; consequently it ceases to be a balance for the pressure of the atmosphere, and the water is forced into the suction-pipe. Pushing the piston down again forces the air in the barrel through the valve S, the valve R in the mean time shutting. When the piston is again drawn up, S shuts, R opens, the air in the suction pipe dilates anew, and the water rises higher in it. Repeating these operations, the water gets at last into the working barrel, and is forced into the main by pushing down the piston, and is pushed along to the place of delivery.

24
Is two-fold.

The operation of this pump is therefore two-fold, sucking and forcing. In the first operation, the same force must be employed as in the sucking-pump, namely, a force equal to the weight of a column of water having the section of the piston for its base, and the height of the piston above the water in the cistern for its height. It is for the sake of this part of the operation that the upper cone is added to the piston. The air and water would pass by the sides of the lower cone while the piston is drawn up; but the leather of the upper cone applies to the surface of the barrel, and prevents this. The space contained between the barrel and the valve S is a great obstruction to this part of the operation, because this air cannot be rarefied to a very great degree. For this reason, the suction-pipe of a forcing-pump must not be made long. It is not indeed necessary; for by placing the pump a few feet lower, the water will rise into it without difficulty, and the labour of suction is as much diminished as that of impulsion is increased. However, an intelligent artist will always endeavour to make this space between the valve S and the lowest place of the piston as small as possible.

The power employed in forcing must evidently surmount the pressure of the whole water in the rising pipe, and (independent of what is necessary for giving the water the required velocity, so that the proper quantity per hour may be delivered), the piston has to withstand a force equal to the weight of a column of water having the section of the piston for its base, and the perpendicular altitude of the place of delivery above the lower surface of the piston for its height. It is quite indifferent in this respect what is the diameter of the rising pipe; because the pressure on the piston depends on the altitude of the water only, independent of its quantity. We shall even see that a small rising pipe will require a greater force to convey the water along it to any given height or distance.

When we would employ a pump to raise water in a crooked pipe, or in any pipe of moderate dimensions, this form of pump, or something equivalent, must be used. In bringing up great quantities of water from mines, the common sucking-pump is generally employed, ed, as really the beſt of them all: but it is the moſt expenſive, becauſe it requires the pipe to be perpendicular, ſtraight, and of great dimenſions, that it may contain the piſton rods. But this is impracticable when the pipe is crooked.

If the forcing pump, conſtructed in the manner now deſcribed, be employed, we cannot uſe forcers with long rods. Theſe would bend when puſhed down by their further extremity. In this caſe, it is uſual to employ only a ſhort and ſtiff rod, and to hang it by a chain, and load it with a weight ſuperior to the weight of water to be raiſed by it. The machinery therefore is employed, not in forcing the water along the riſing-pipe, but in raiſing the weight which is to produce this effect by its ſubſequent deſcent.

In this caſe, it would be much better to employ the lifting-pump of fig. 11. For as the load on the forcers muſt be greater than the reſiſtances which it muſt ſurmount, the force exerted by the machine muſt in like manner be greater than this load. This double exceſs would be avoided by uſing the lifting-pump.

25 Meaſure of the quantity of water delivered by any pump.

It will readily occur to the reader that the quantity of water delivered by any pump will be in the joint proportion of the ſurface or baſe of the piſton and its velocity: for this meaſures the capacity of that part of the working barrel which the piſton paſſes over. The velocity of the water in the conduit pipe, and in its paſſage through every valve, will be greater or leſs than the velocity of the piſton, in the ſame proportion that the area of the piſton or working barrel is greater or leſs than the area of the conduit or valve. For whatever quantity of water paſſes through any ſection of the working-barrel in a ſecond, the ſame quantity muſt go through any one of theſe paſſages. This enables us to modify the velocity of the water as we pleaſe: we can increaſe it to any degree at the place of delivery by diminiſhing the aperture through which it paſſes, provided we apply ſufficient force to the piſton.

26 The operation of pumps not equable;

It is evident that the operation of a pump is by ſtarts, and that the water in the main remains at reſt, preſſing on the valve during the time that the piſton is withdrawn from the bottom of the working barrel. It is in moſt caſes deſirable to have this motion equable, and in ſome caſes it is abſolutely neceſſary. Thus, in the engine for extinguiſhing fires, the ſpout of water going by jerks could never be directed with a certain aim, and half of the water would be loſt by the way; becauſe a body at reſt cannot in an inſtant be put in rapid motion, and the firſt portion of every jerk of water would have but a ſmall velocity. A very ingenious contrivance has been fallen upon for obviating this inconvenience, and procuring a ſtream nearly equable. We have not been able to diſcover the author. At any convenient part of the riſing pipe beyond the valve S there is annexed a capacious veſſel VZ (fig. 13. N° 1 and 2.) cloſe a-top, and of great ſtrength. When the water is forced along this pipe, part of it gets into this veſſel, keeping the air confined above it, and it fills it to ſuch a height V, that the elaſticity of the confined air balances a column reaching to T, we ſhall ſuppoſe, in the riſing pipe. The next ſtroke of the piſton ſends forward more water, which would fill the riſing pipe to ſome height above T. But the preſſure of this additional column cauſes ſome more of it to go into the air veſſel, and compreſs its air ſo much more that its elaſticity now balances a longer column. Every ſucceeding ſtroke of the piſton produces a like effect. The water riſes higher in the main pipe, but ſome more of it goes into the air-veſſel. At laſt the water *appears* at the place of delivery; and the air in the air-veſſel is now ſo much compreſſed that its elaſticity balances the preſſure of the whole column. The next ſtroke of the piſton ſends forward ſome more water. If the diameter of the orifice of the main be ſufficient to let the water flow out with a velocity equal to that of the piſton, it will ſo flow out, riſing no higher, and producing no ſenſible addition to the compreſſion in the air-veſſel. But if the orifice of the main be contracted to half its dimenſions, the water ſent forward by the piſton cannot flow out in the time of the ſtroke without a greater velocity, and therefore a greater force. Part of it, therefore, goes into the air-veſſel, and increaſes the compreſſion. When the piſton has ended its ſtroke, and no more water comes forward, the compreſſion of the air in the air-veſſel being greater than what was ſufficient to balance the preſſure of the water in the main pipe, now forces out ſome of the water which is lying below it. This cannot return towards the pump, becauſe the valve S is now ſhut. It therefore goes forward along the main, and produces an efflux during the time of the piſton's riſing in order to make another ſtroke. In order that this efflux may be very equable, the air-veſſel muſt be very large. If it be ſmall, the quantity of water that is diſcharged by it during the return of the piſton makes ſo great a portion of its capacity, that the elaſticity of the confined air is too much diminiſhed by this enlargement of its bulk, and the rate of efflux muſt diminiſh accordingly. The capacity of the air-veſſel ſhould be ſo great that the change of bulk of the compreſſed air during the inaction of the piſton may be inconſiderable. It muſt therefore be very ſtrong.

27 and the mode of making them ſo.

Fig. 13.

It is pretty indifferent in what way this air-veſſel is connected with the riſing pipe. It may join it laterally, as in fig. 13. N° 1. and the main pipe go on without interruption; or it may be made to *ſurround* an interruption of the main pipe, as in fig. 13. N° 2. It may alſo be in any part of the main-pipe. If the ſole effect intended by it is to produce an equable jet, as in ornamental water-works, it may be near the end of the main. This will require much leſs ſtrength, becauſe there remains but a ſhort column of water to compreſs the air in it. But it is, on the whole, more advantageous to place it as near the pump as poſſible, that it may produce an equable motion in the whole main-pipe. This is of conſiderable advantage: when a column of water ſeveral hundred feet long is at reſt in the main-pipe, and the piſton at one end of it put at once into motion, even with a moderate velocity, the ſtrain on the pipe would be very great. Indeed if it were poſſible to put the piſton inſtantaneouſly into motion with a finite velocity, the ſtrain on the pipe, tending to burſt it, would be next to infinite. But this ſeems impoſſible in nature; all changes of motion *which we obſerve* are gradual, becauſe all impelling bodies have ſome elaſticity or ſoftneſs by which they yield to compreſſion. And, in the way in which piſtons are commonly moved, *viz.* by cranks, or ſomething analogous to them, the motion is *very ſenſibly* gradual. But ſtill the air-veſſel tends to make the motion along the main-pipe leſs deſultory, and therefore diminiſhes thoſe ſtrains which would really take place 28 The deſultory motion of the piſtons.

2

Pump.

place in the main-pipe. It acts like the springs of a travelling-carriage, whose jolts are incomparably less than those of a cart; and by this means really enables a given force to propel a greater quantity of water in the same time.

29
Corrected.

We may here by the way observe, that the attempts of mechanicians to correct this unequal motion of the piston-rod are misplaced, and if it could be done, would greatly hurt a pump. One of the best methods of producing this effect is to make the piston-rod consist of two parallel bars, having teeth in the sides which front each other. Let a toothed wheel be placed between them, having only the half of its circumference furnished with teeth. It is evident, without any farther description, that if this wheel be turned uniformly round its axis, the piston-rod will be moved uniformly up and down without intermission. This has often been put in practice; but the machine always went by jolts, and seldom lasted a few days. Unskilled mechanicians attributed this to defect in the execution: but the fault is essential, and lies in the principle.

30
But on a wrong principle.

The machine could not perform one stroke, if the first mover did not slacken a little, or the different parts of the machine did not yield by bending or by compression; and no strength of materials could withstand the violence of the strains at every reciprocation of the motion. This is chiefly experienced in great works which are put in motion by a water-wheel, or some other equal power exerted on the mass of matter of which the machine consists. The water-wheel being of great weight, moves with considerable steadiness or uniformity; and when an additional resistance is opposed to it by the beginning of a new stroke of the piston, its great quantity of motion is but little affected by this addition, and it proceeds very little retarded; and the machine must either yield a little by bending and compression, or go to pieces, which is the common event. Cranks are free from this inconvenience, because they accelerate the piston gradually, and bring it gradually to rest, while the water-wheel moves round with almost perfect uniformity. The only inconvenience (and it may be considerable) attending this slow motion of the piston at the beginning of its stroke is, that the valves do not shut with rapidity, so that some water gets back through them. But when they are properly formed and loaded, this is but trifling.

31
These equable pumps deliver very little more water than the others.

We must not imagine, that because the stream produced by the assistance of an air barrel is almost perfectly equable, and because as much water runs out during the returning of the piston as during its active stroke, it therefore doubles the quantity of water. No more water can run out than what is sent forward by the piston during its effective stroke. The continued stream is produced only by preventing the whole of this water from being discharged during this time, and by providing a propelling force to act during the piston's return. Nor does it enable the moving force of the piston to produce a double effect: for the compression which is produced in the air-vessel, more than what is necessary for merely balancing the quiescent column of water, reacts on the piston, resisting its compression just as much as the column of water would do which produces a velocity equal to that of the efflux. Thus if the water is made to spout with the velocity of eight feet per second, this would require an additional column of one foot high, and this would just balance the compression in the air-vessel, which maintains this velocity during the non-action of the piston. It is, however, a matter of fact, that a pump furnished with an air-vessel delivers a little more water than it would do without it. But the difference depends on the combination of many very dissimilar circumstances, which it is extremely difficult to bring into calculation. Some of these will be mentioned afterwards.

To describe, or even to enumerate, the immense variety of combinations of these three simple pumps would fill a volume. We shall select a few, which are more deserving of notice.

I. The common sucking-pump may, by a small addition, be converted into a lifting-pump, fitted for propelling the water to any distance, and with any velocity. 32
The sucking pump converted into a lifting pump.
Fig. 14.

Fig. 14. is a sucking-pump, whose working-barrel ACDB has a lateral pipe AEGHF connected with it close to the top. This terminates in a *main* or rising pipe IK, furnished or not with a valve L. The top of the barrel is shut up by a strong plate MN, having a hollow neck terminating in a small flanch. The piston rod QR passes through this neck, and is nicely turned and polished. A number of rings of leather are put over the rod, and strongly compressed round it by another flanch and several screwed bolts, as is represented at OP. By this contrivance the rod is closely grasped by the leathers, but may be easily drawn up and down, while all passage of air or water is effectually prevented.

The piston S is perforated, and furnished with a valve opening upwards. There is also a valve T on the top of the suction-pipe YX; and it will be of advantage, though not absolutely necessary, to put a valve L at the bottom of the rising pipe. Now suppose the piston at the bottom of the working-barrel. When it is drawn up, it tends to compress the air above it, because the valve in the piston remains shut by its own weight. The air therefore is driven through the valve L into the rising pipe, and escapes. In the mean time, the air which occupied the small space between the piston and the valve T expands into the upper part of the working barrel; and its elasticity is so much diminished thereby, that the atmosphere presses the water of the cistern into the suction-pipe, where it will rise till an equilibrium is again produced. The next downward stroke of the piston allows the air, which had come from the suction-pipe into the barrel during the ascent of the piston, to get through its valve. Upon drawing up the piston, this air is also drawn off through the rising pipe. Repeating this process brings the water at last into the working-barrel, and it is then driven along the rising-pipe by the piston.

This is one of the best forms of a pump. The rarefaction may be very perfect, because the piston can be brought so near to the bottom of the working-barrel: and, for forcing water in opposition to great pressures, it appears preferable to the common forcing-pump; because in that the piston rods are compressed and exposed to bending, which greatly hurts the pump by wearing the piston and barrel on one side. This soon renders it less tight, and much water squirts out by the sides of the piston. But in this pump the piston rod is always drawn or pulled, which keeps it straight; and 33
Advantages of this conversion.

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and rods exert a much greater force in oppoſition to a pull than in oppoſition to compreſſion. The collar of leather round the piſton-rods is found by experience to need very little repairs, and is very impervious to water. The whole is very acceſſible for repairs; and in this reſpect much preferable to the common pump in deep mines, where every fault of the piſton obliges us to draw up ſome hundred feet of piſton-rods. By this addition, too, any common pump for the ſervice of a houſe is converted into an engine for extinguiſhing fire, or may be made to convey the water to every part of the houſe; and this without hurting or obſtructing its common uſes. All that is neceſſary is to have a large cock on the upper part of the working barrel oppoſite to the lateral pipe in this figure. This cock ſerves for a ſpout when the pump is uſed for common purpoſes: and the merely ſhutting this cock converts the whole into an engine for extinguiſhing fire or for ſupplying diſtant places with water. It is ſcarcely neceſſary to add, that for theſe ſervices it will be proper to connect an air-veſſel with ſome convenient part of the riſing pipe, in order that the current of the water may be continual.

34 Equable ſtreams produced in great works by combinations.

We have frequently ſpoken of the advantages of a continued current in the main pipe. In all great works a conſiderable degree of uniformity is produced by the manner of diſpoſing the actions of the different pumps; for it is very rarely that a machine works but one pump. In order to maintain ſome uniformity in the reſiſtance, that it may not all be oppoſed at once to the moving power, with intervals of total inaction, which would produce a very hobbling motion, it is uſual to diſtribute the work into portions, which ſucceed alternately; and thus both diminiſh the ſtrain, and give greater uniformity of action, and frequently enable a natural power which we can command, to perform a piece of work, which would be impoſſible if the whole reſiſtance were oppoſed at once. In all pump machines therefore we are obviouſly directed to conſtruct them ſo that they may give motion to at leaſt two pumps, which work alternately. By this means a much greater uniformity of current is produced in the main pipe. It will be rendered ſtill more uniform if four are employed, ſucceeding each other at the interval of one quarter of the time of a complete ſtroke.

35 A ſingle pump for this purpoſe deſcribed.

But ingenious men have attempted the ſame thing with a ſingle pump, and many different conſtructions for this purpoſe have been propoſed and executed. The thing is not of much importance, or of great reſearch. We ſhall content ourſelves therefore with the deſcription of one that appears to us the moſt perfect, both in reſpect of ſimplicity and effect.

Fig. 15.

II. It conſiſts of a working-barrel AB (fig. 15.) cloſe at both ends. The piſton C is ſolid, and the rod OP paſſes through a collar of leathers in the plate, which cloſes the upper end of the working-barrel. This barrel communicates laterally with two pipes H, K; the communications *m* and *n* being as near to the top and bottom of the barrel as poſſible. Adjoining to the paſſage *m* are two valves F and G opening upwards. Similar valves accompany the paſſage *n*. The two pipes H and K unite in a larger riſing pipe L. They are all repreſented as in the ſame plane; but the upper ends muſt be bent backwards, to give room for the motion of the piſton-rod OP.

Suppoſe the piſton cloſe to the entry of the lateral pipe *n*, and that it is drawn up: it compreſſes the air above it, and drives it through the valve G, where it eſcapes along the riſing pipe; at the ſame time it rarefies the air in the ſpace below it. Therefore the weight of the atmoſphere ſhuts the valve E, and cauſes the water of the ciſtern to riſe through the valve D, and fill the lower part of the pump. When the piſton is puſhed down again, this water is firſt driven through the valve E, becauſe D immediately ſhuts; and then moſt of the air which was in this part of the pump at the beginning goes up through it, ſome of the water coming back in its ſtead. In the mean time, the air which remained in the upper part of the pump after the aſcent of the piſton is rarefied by its deſcent; becauſe the valve G ſhuts as ſoon as the piſton begins to deſcend, the valve F opens, the air in this ſuction pipe F *f* expands into the barrel, and the water riſes into the pipes by the preſſure of the atmoſphere. The next riſe of the piſton muſt bring more water into the lower part of the barrel, and muſt drive a little more air through the valve G, namely, part of that which had come out of the ſuction-pipe F *f*; and the next deſcent of the piſton muſt drive more water into the riſing pipe H, and along with it moſt if not all of the air which remained below the piſton, and muſt rarefy ſtill more the air remaining above the piſton; and more water will come in through the pipe F *f*, and get into the barrel. It is evident, that a few repetitions will at laſt fill the barrel on both ſides of the piſton with water. When this is accompliſhed, there is no difficulty in perceiving how, at every riſe of the piſton, the water of the ciſtern will come in by the valve D, and the water in the upper part of the barrel will be driven through the valve G; and, in every deſcent of the piſton, the water of the ciſtern will come into the barrel by the valve F, and the water below the piſton will be driven through the valve E: and thus there will be a continual influx into the barrel through the valves D and F, and a continual diſcharge along the riſing pipe L through the valves E and G.

36 It is equivalent to two forcing-pumps.

This machine is, to be ſure, equivalent to two forcing pumps, although it has but one barrel and one piſton; but it has no ſort of ſuperiority. It is not even more economical in moſt caſes; becauſe we apprehend that the additional workmanſhip will fully compenſate for the barrel and piſton that is ſaved. There is indeed a ſaving in the reſt of the machinery, becauſe one lever produces both motions. We cannot therefore ſay that it is inferior to two pumps; and we acknowledge that there is ſome ingenuity in the contrivance.

37 Authors recommended.

We recommend to our readers the peruſal of Belidor's *Architecture Hydraulique* where is to be found a great variety of combinations and forms of the ſimple pumps; but we muſt caution them with reſpect to his theories, which in this article are extremely defective. Alſo in Leupold's *Theatrum Machinarum Hydraulicarum*, there is a prodigious variety of all kinds of pumps, many of them very ſingular and ingenious, and many which have particular advantages, which may ſuit local circumſtances, and give them a preference. But it would be improper to ſwell a work of this kind with ſo many peculiarities; and a perſon who makes himſelf maſter of the principles delivered here in ſufficient detail, can be at no loſs to ſuit a pump to his particular views,

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views, or to judge of the merit of ſuch as may be propoſed to him.

We muſt now take notice of ſome very conſiderable and important varieties in the form and contrivance of the eſſential parts of a pump.

38 The forcing pump differently conſtructed. Plate CCCCL. Fig. 16.

III. The forcing pump is ſometimes of a very different form from that already deſcribed. Inſtead of a piſton, which applies itſelf to the inſide of the barrel, and ſlides up and down in it, there is a long cylinder POQ (fig. 16.) nicely turned and poliſhed on the outſide, and of a diameter ſomewhat leſs than the inſide of the barrel. This cylinder (called a PLUNGER) ſlides through a collar of leathers on the top of the working-barrel, and is conſtructed as follows. The top of the barrel terminates in a flanch *a b*, pierced with four holes for receiving ſcrew-bolts. There are two rings of metal, *c d*, *e f*, of the ſame diameter, and having holes correſponding to thoſe in the flanch. Four rings of ſoft leather, of the ſame ſize, and ſimilarly pierced with holes, are well ſoaked in a mixture of oil, tallow, and a little roſin. Two of theſe leather rings are laid on the pump flanch, and one of the metal rings above them. The plunger is then thruſt down through them, by which it turns their inner edges downwards. The other two rings are then ſlipped on at the top of the plunger, and the ſecond metal ring is put over them, and then the whole are ſlid down to the metal ring. By this the inner edges of the laſt leather rings are turned upwards. The three metal rings are now forced together by the ſcrewed bolts; and thus the leathern rings are ſtrongly compreſſed between them, and made to graſp the plunger ſo cloſely that no preſſure can force the water through between. The upper metal ring juſt allows the plunger to paſs through it, but without any play; ſo that the turned-up edges of the leathern rings do not come up between the plunger and the upper metal ring, but are lodged in a little conical taper, which is given to the inner edge of the upper plate, its hole being wider below than above. It is on this trifling circumſtance that the great tightneſs of the collar depends. To prevent the leathers from ſhrinking by drought, there is uſually a little ciſtern formed round the head of the pump, and kept full of water. The plunger is either forced down by a rod from a working beam, or by a ſet of metal-weights laid on it, as is repreſented in the figure.

39 Its mode of operation.

It is hardly neceſſary to be particular in explaining the operation of this pump. When the plunger is at the bottom of the barrel, touching the fixed valve M with its lower extremity, it almoſt completely fills it. That it may do it completely, there is ſometimes a ſmall pipe RSZ branching out from the top of the barrel, and fitted with a cock at S. Water is admitted till the barrel is completely filled, and the cock is then ſhut. Now when the plunger is drawn up, the valve N in the riſing pipe muſt remain ſhut by the preſſure of the atmoſphere, and a void muſt be made in the barrel. Therefore the valve M on the top of the ſuction-pipe muſt be opened by the elaſticity of the air in this pipe, and the air muſt expand into the barrel; and being no longer a balance for the atmoſphere, the water in the ciſtern muſt be forced into the ſuction-pipe, and riſe in it to a certain height. When the plunger deſcends, it muſt drive the water through the valve N (for the valve M will immediately ſhut), and along with it moſt of the air which had come into the barrel. And as this air occupied the upper part of the barrel, part of it will remain when the plunger has reached the bottom; but a ſtroke or two will expel it all, and then every ſucceeding ſtroke of the deſcending piſton will drive the water along the riſing pipe, and every aſcent of the plunger will be followed by the water from the ciſtern.

The advantage propoſed by this form of piſton is that it may be more accurately made and poliſhed than the inſide of a working barrel, and it is of much eaſier repair. Yet we do not find that it is much uſed, although an invention of the 17th century (we think by Sir Samuel Morland), and much praiſed by the writers on theſe ſubjects.

40 Sucking-pump ſimilarly varied.

It is eaſy to ſee that the ſucking-pump may be varied in the ſame way. Suppoſe this plunger to be open both at top and bottom, but the bottom filled with a valve opening upward. When this is puſhed to the bottom of the barrel, the air which it tends to compreſs lifts the valve (the lateral pipe FIK being taken away and the paſſage ſhut up), and eſcapes through the plunger. When it is drawn up, it makes the ſame rarefaction as the ſolid plunger, becauſe the valve at O ſhuts, and the water will come up from the ciſtern as in the former caſe. If the plunger be now thruſt down again, the valve M ſhuts, the valve O is forced open, and the plunger is filled with water. This will be lifted by it during its next aſcent; and when it is puſhed down again, the water which filled it muſt now be puſhed out, and will flow over its ſides into the ciſtern at the head of the barrel. Inſtead of making the valve at the bottom of the piſton, it may be made at the top; but this diſpoſition is much inferior, becauſe it cannot rarefy the air in the barrel one half. This is evident; for the capacity of the barrel and plunger together cannot be twice the capacity of the barrel.

41 Another form of the ſucking-pump, Fig. 17.

IV. It may be made after a ſtill different form, as repreſented in fig. 17. Here the ſuction-pipe CO comes up through a ciſtern KMNL deeper or longer than the intended ſtroke of the piſton, and has a valve C at top. The piſton, or what acts in lieu of it, is a tube AHGB, open at both ends, and of a diameter ſomewhat larger than that of the ſuction-pipe. The interval between them is filled up at HG by a ring or belt of ſoft leather, which is faſtened to the *outer* tube, and moves up and down with it, ſliding along the ſmoothly poliſhed ſurface of the ſuction-pipe with very little friction. There is a valve I on the top of this piſton, opening upwards. Water is poured into the outer ciſtern.

42 and its mode of operation.

The outer cylinder or piſton being drawn up from the bottom, there is a great rarefaction of the air which was between them, and the atmoſphere preſſes the water up through the ſuction-pipe to a certain height; for the valve I keeps ſhut by the preſſure of the atmoſphere and its own weight. Puſhing down the piſton cauſes the air, which had expanded from the ſuction-pipe into the piſton, to eſcape through the valve I; drawing it up a ſecond time, allows the atmoſphere to preſs more water into the ſuction-pipe, to fill it, and alſo part of the piſton. When this is puſhed down again, the water which had come through the valve C is now forced out through the valve I into the ciſtern KMNL, and now the whole is full of water. When, therefore, the piſton is drawn up, the water follows, and fills it, if not

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not 33 feet above the water in the ciſtern; and when it is puſhed down again, the water which filled the piſton is all thrown out into the ciſtern; and after this it delivers its full contents of water every ſtroke. The water in the ciſtern KMNL effectually prevents the entry of any air between the two pipes; ſo that a very moderate compreſſion of the belt of ſoft leather at the mouth of the piſton cylinder is ſufficient to make all perfectly tight.

43
The piſton cylinder differently formed.

It might be made differently. The ring of leather might be faſtened round the top of the inner cylinder at DE, and ſlide on the inſide of the piſton cylinder; but the firſt form is moſt eaſily executed. Muſchenbroeck has given a figure of this pump in his large ſyſtem of natural philoſophy, and ſpeaks very highly of its performance. But we do not ſee any advantage which it poſſeſſes over the common ſucking-pump. He indeed ſays that it is without friction, and makes no mention of the ring of leather between the two cylinders. Such a pump will raiſe water extremely well to a ſmall height, and it ſeems to have been a model only which he had examined: But if the ſuction pipe is long, it will by no means do without the leather; for on drawing up the piſton, the water of the upper ciſtern will riſe between the pipes, and fill the piſton, and none will come up through the ſuction-pipe.

44
Pumps without friction not of important uſe.

We may take this opportunity of obſerving, that the many ingenious contrivances of pumps without friction are of little importance in great works; becauſe the friction which is completely ſufficient to prevent all eſcape of water in a well-conſtructed pump is but a very trifling part of the whole force. In the great pumps which are uſed in mines, and are worked by a ſteam-engine, it is very uſual to make the piſtons and valves without any leather whatever. The working barrel is bored truly cylindrical, and the piſton is made of metal of a ſize that will juſt paſs along it without ſticking. When this is drawn up with the velocity competent to a properly loaded machine, the quantity of water which eſcapes round the piſton is inſignificant. The piſton is made without leathers, not to avoid friction, which is alſo inſignificant in ſuch works; but to avoid the neceſſity of frequently drawing it up for repairs through ſuch a length of pipes.

45
Example of a ſimple pump without friction.
Fig. 18.

V. If a pump abſolutely without friction be wanted, the following ſeems preferable for ſimplicity and performance to any we have ſeen, when made uſe of in proper ſituations. Let NO (fig. 18.) be the ſurface of the water in the pit, and K the place of delivery. The pit muſt be as deep in water as from K to NO. ABCD is a wooden trunk, round or ſquare, open at both ends, and having a valve P at the bottom. The top of this trunk muſt be on a level with K, and has a ſmall ciſtern EADF. It alſo communicates laterally with a riſing pipe GHK, furniſhed with a valve at H opening upwards. LM is a beam of timber ſo fitted to the trunk as to fill it without ſticking, and is of at leaſt equal length. It hangs by a chain from a working beam, and is loaded on the top with weights exceeding that of the column of water which it diſplaces. Now ſuppoſe this beam allowed to deſcend from the poſition in which it is drawn in the figure; the water muſt riſe all around it, in the crevice which is between it and the trunk, and alſo in the riſing pipe; becauſe the valve P ſhuts, and H opens; ſo that when the plunger has got to the bottom, the water will ſtand at the level of K. When the plunger is again drawn up to the top by the action of the moving power, the water ſinks again in the trunk, but not in the riſing pipe, becauſe it is ſtopped by the valve H. Then allowing the plunger to deſcend again, the water muſt again riſe in the trunk to the level of K, and it muſt now flow out at K; and the quantity diſcharged will be equal to the part of the beam below the ſurface of the pit-water, deducting the quantity which fills the ſmall ſpace between the beam and the trunk. This quantity may be reduced almoſt to nothing; for if the inſide of the trunk and the outſide of the beam be made tapering, the beam may be let down till they exactly fit; and as this may be done in ſquare work, a good workman can make it exceedingly accurate. But in this caſe, the lower half of the beam and trunk muſt not taper: and this part of the trunk muſt be of ſufficient width round the beam to allow free paſſage into the riſing pipe. Or, which is better, the riſing pipe muſt branch off from the bottom of the trunk. A diſcharge may be made from the ciſtern EADF, ſo that as little water as poſſible may deſcend along the trunk when the piſton is raiſed.

46
Its excellencies are conſiderable,

One great excellence of this pump is, that it is perfectly free from all the deficiencies which in common pumps reſult from want of being air-tight. Another is, that the quantity of water raiſed is preciſely equal to the power expended; for any want of accuracy in the work, while it occaſions a diminution of the quantity of water diſcharged, makes an equal diminution in the weight which is neceſſary for puſhing down the plunger. We have ſeen a machine conſiſting of two ſuch pumps ſuſpended from the arms of a long beam, the upper ſide of which was formed into a walk with a rail on each ſide. A man ſtood on one end till it got to the bottom, and then walked ſoberly up to the other end, the inclination being about twenty-five degrees at firſt, but gradually diminiſhed as he went along, and changed the load of the beam. By this means he made the other end go to the bottom, and ſo on alternately, with the eaſieſt of all exertions, and what we are moſt fitted for by our ſtructure. With this machine, a very feeble old man, weighing 110 pounds, raiſed 7 cubic feet of water 11½ feet high in a minute, and continued working 8 or 10 hours every day. A ſtout young man, weighing nearly 135 pounds, raiſed 8¼ to the ſame height; and when he carried 30 pounds, conveniently ſlung about him, he raiſed 9¼ feet to this height, working 10 hours a-day without fatiguing himſelf. This exceeds Deſagulier's maximum of a hogſhead of water 10 feet high in a minute, in the proportion of 9 to 7 nearly. It is limited to very moderate heights; but in ſuch ſituations it is very effectual. It was the contrivance of an untaught labouring man, poſſeſſed of uncommon mechanical genius. We ſhall have occaſion to mention, with reſpect, ſome other contrivances of the ſame perſon, in the article *WATER-Works*.

47
but it is limited.

48
Haſkin's pump deſcribed.

VI. The moſt ingenious contrivance of a pump without friction is that of Mr Haſkins, deſcribed by Deſaguliers, and called by him the QUICKSILVER PUMP. Its conſtruction and mode of operation are pretty complicated; but the following preliminary obſervations will, we hope, render it abundantly plain.

Let

Pump. Fig. 19.

Let $i\,l\,m\,k$ (fig. 19.) be a cylindrical iron pipe, about fix feet long, open at top. Let $e\,g\,h\,f$ be another cylinder, connected with it at the bottom, and of fmaller diameter. It may either be folid, or, if hollow, it muft be clofe at top. Let $a\,c\,d\,b$ be a third iron cylinder, of an intermediate diameter, fo that it may move up and down between the other two without touching either, but with as little interval as poffible. Let this middle cylinder communicate, by means of the pipe AB, with the upright pipe FE, having valves C and D (both opening upwards) adjoining to the pipe of communication. Suppofe the outer cylinder fufpended by chains from the end of a working beam, and let mercury be poured into the interval between the three cylinders till it fills the fpace to $o\,p$, about $\frac{1}{3}$ of their height. Alfo fuppofe that the lower end of the pipe FE is immerfed into a ciftern of water, and that the valve D is lefs than 33 feet above the furface of this water.

49 Its mode of operation.

Now fuppofe a perforation made fomewhere in the pipe AB, and a communication made with an air-pump. When the air-pump is worked, the air contained in CE, in AB, and in the fpace between the inner and middle cylinders, is rarefied, and is abftracted by the air-pump; for the valve D immediately fhuts. The preffure of the atmofphere will caufe the water to rife in the pipe CE, and will caufe the mercury to rife between the inner and middle cylinders, and fink between the outer and middle cylinders. Let us fuppofe mercury 12 times heavier than water: Then for every foot that the water rifes in EC, the level between the outfide and infide mercury will vary an inch; and if we fuppofe DE to be 30 feet, then if we can rarefy the air fo as to raife the water to D, the outfide mercury will be depreffed to q, r, and the infide mercury will have rifen to s, t, $s\,q$ and $t\,r$, being about 30 inches. In this ftate of things, the water will run over by the pipe BA, and every thing will remain nearly in this pofition. The columns of water and mercury balance each other, and balance the preffure of the atmofphere.

While things are in this ftate of equilibrium, if we allow the cylinders to defcend a little, the water will rife in the pipe FE, which we may now confider as a fuction-pipe; for by this motion the capacity of the whole is enlarged, and therefore the preffure of the atmofphere will ftill keep it full, and the fituation of the mercury will again be fuch that all fhall be in equilibrio. It will be a little lower in the infide fpace and higher in the outfide.

Taking this view of things, we fee clearly how the water is fupported by the atmofphere at a very confiderable height. The apparatus is analogous to a fyphon which has one leg filled with water and the other with mercury. But it was not neceffary to employ an air-pump to fill it. Suppofe it again empty, and all the valves fhut by their own weight. Let the cylinders defcend a little. The capacity of the fpaces below the valve D is enlarged, and therefore the included air is rarefied, and fome of the air in the pipe CE muft diffufe itfelf into the fpace quitted by the inner cylinder. Therefore the atmofphere will prefs fome water up the pipe FE, and fome mercury into the inner fpace between the cylinders. When the cylinders are raifed again, the air which came from the pipe CE would return into it again, but is prevented by the valve C.—Raifing the cylinders to their former height would comprefs this air; it therefore lifts the valve D, and efcapes. Another depreffion of the cylinders will have a fimilar effect. The water will rife higher in FC, and the mercury in the inner fpace; and then, after repeated ftrokes, the water will pafs the valve C, and fill the whole apparatus, as the air-pump had caufed it to do before.—The pofition of the cylinders, when things are in this fituation, is reprefented in fig. 20. the outer and inner cylinders in their loweft pofition having defcended about 30 inches. The mercury in the outer fpace ftands at q, r, a little above the middle of the cylinders, and the mercury in the inner fpace is near the top $t\,s$ of the inner cylinder. Now let the cylinders be drawn up. The water above the mercury cannot get back again through the valve C, which fhuts by its own weight. We therefore attempt to comprefs it; but the mercury yields, and defcends in the inner fpace, and rifes, in the outer till both are quickly on a level, about the height $v\,v$. If we continue to raife the cylinders, the compreffion forces out more mercury, and it now ftands lower in the inner than in the outer fpace. But that there may be fomething to balance this inequality of the mercurial columns, the water goes through the valve D, and the equilibrium is reftored when the height of the water in the pipe ED above the furface of the internal mercury is 12 times the difference of the mercurial columns (on the former fuppofition of fpecific gravity.) If the quantity of water is fuch as to rife two feet in the pipe ED, the mercury in the outer fpace will be two inches higher than that in the inner fpace. Another depreffion of the cylinders will again enlarge the fpace within the apparatus, the mercury will take the pofition of fig. 19. and more water will come in. Raifing the cylinders will fend this water four feet up the pipe ED, and the mercury will be four inches higher in the inner than in the outer fpace. Repeating this operation, the water will be raifed ftill higher in DE; and this will go on till the mercury in the outer fpace reaches the top of the cylinder; and this is the limit of the performance. The dimenfions with which we fet out will enable the machine to raife the water about 30 feet in the pipe ED; which, added to the 30 feet of CF, makes the whole height above the pit-water 60 feet. By making the cylinders longer, we increafe the height of FD. This machine muft be worked with great attention, and but flowly; for at the beginning of the forcing ftroke the mercury very rapidly finks in the inner fpace and rifes in the outer, and will dafh out and be loft. To prevent this as much as poffible, the outer cylinder terminates in a fort of cup or difh, and the inner cylinder fhould be tapered atop.

Pump. Fig. 20.

The machine is exceedingly ingenious and refined; and there is no doubt but that its performance will exceed that of any other pump which raifes the water to the fame height, becaufe friction is completely avoided, and there can be no want of tightnefs of the pifton.— 50 Ingenuity of the contrivance great,

But this is all its advantage; and, from what has been obferved, it is but trifling. The expence would be enormous; for with whatever care the cylinders are made, the interval between the inner and outer cylinders muft contain a very great quantity of mercury. The middle cylinder muft be made of iron plate, and muft be without a feam, for the mercury would diffolve every folder. For 51 but the advantage trifling.

fuch

Pump.

ſuch reaſons, it has never come into general uſe. But it would have been unpardonable to have omitted the deſcription of an invention which is ſo original and ingenious; and there are ſome occaſions where it may be of great uſe, as in nice experiments for illuſtrating the theory of hydraulics, it would give the fineſt piſtons for meaſuring the preſſures of water in pipes, &c. It is on preciſely the ſame principle that the cylinder bellows, deſcribed in the article PNEUMATICS, are conſtructed.

52
Deſcription of another pump without friction.

We beg leave to conclude this part of the ſubject with the deſcription of a pump without friction, which may be conſtructed in a variety of ways by any common carpenter, without the aſſiſtance of the pump-maker or plumber, and will be very effective for raiſing a great quantity of water to ſmall heights, as in draining marſhes, marl pits, quarries, &c. or even for the ſervice of a houſe.

Fig. 21.

VII. ABCD (fig. 21.) is a ſquare trunk of carpenter's work open at both ends, and having a little ciſtern and ſpout at top. Near the bottom there is a partition made of board, perforated with a hole E, and covered with a clack. *ffff* repreſents a long cylindrical bag or pudding, made of leather or of double canvas, with a fold of thin leather ſuch as ſheepſkin between the canvas bags. This is firmly nailed to the board E with ſoft leather between. The upper end of this bag is fixed on a round board, having a hole and valve F. This board may be turned in the lathe with a groove round its edge, and the bag faſtened to it by a cord bound tight round it. The fork of the piſton-rod FG is firmly fixed into this board; the bag is kept diſtended by a number of wooden hoops or rings of ſtrong wire *ff, ff, ff,* &c. put into it at a few inches diſtance from each other. It will be proper to connect theſe hoops before putting them in, by three or four cords from top to bottom, which will keep them at their proper diſtances. Thus will the bag have the form of a barber's bellows powder-puff. The diſtance between the hoops ſhould be about twice the breadth of the rim of the wooden ring to which the upper valve and piſton-rod are fixed.

53
Its mode of operation, &c.

Now let this trunk be immerſed in the water. It is evident that if the bag be ſtretched from the compreſſed form which its own weight will give it by drawing up the piſton-rod, its capacity will be enlarged, the valve F will be ſhut by its own weight, the air in the bag will be rarefied, and the atmoſphere will preſs the water into the bag. When the rod is thruſt down again, this water will come out by the valve F, and fill part of the trunk. A repetition of the operation will have a ſimilar effect; the trunk will be filled, and the water will at laſt be diſcharged by the ſpout.

Here is a pump without friction, and perfectly tight. For the leather between the folds of canvas renders the bag impervious both to air and water. And the canvas has very conſiderable ſtrength. We know from experience that a bag of ſix inches diameter, made of ſail-cloth N° 3. with a ſheep ſkin between, will bear a column of 15 feet of water, and ſtand ſix hours work per day for a month without failure, and that the pump is conſiderably ſuperior in effect to a common pump of the ſame dimenſions. We muſt only obſerve, that the length of the bag muſt be three times the intended length of the ſtroke; ſo that when the piſton-rod is in its higheſt poſition, the angles or ridges of the bag may be pretty acute. If the bag be more ſtretched than this, the force which muſt be exerted by the labourer becomes much greater than the weight of the column of water which he is raiſing. If the pump be laid aſlope, which is very uſual in theſe occaſional and haſty drawings, it is neceſſary to make a guide for the piſton-rod within the trunk, that the bag may play up and down without rubbing on the ſides, which would quickly wear it out.

The experienced reader will ſee that this pump is very like that of Goſſet and De la Deuille, deſcribed by Belidor, vol. ii. p. 120. and moſt writers on hydraulics. It would be ſtill more like it, if the bag were on the under ſide of the partition E, and a valve placed farther down the trunk. But we think that our form is greatly preferable in point of ſtrength. When in the other ſituation, the column of water lifted by the piſton tends to *burſt* the bag, and this with a great force, as the intelligent reader well knows. But in the form recommended here, the bag is *compreſſed,* and the ſtrain on each part may be made much leſs than that which tends to burſt a bag of ſix inches diameter. The nearer the rings are placed to each other the ſmaller will the ſtrain be.

The ſame bag-piſton may be employed for a forcing pump, by placing it below the partition, and inverting the valve; and it will then be equally ſtrong, becauſe the reſiſtance in this caſe too will act by compreſſion.

We now come naturally to the conſideration of the different forms which may be given to the piſtons and valves of a pump. A good deal of what we have been deſcribing already is reducible to this head; but, having a more general appearance, changing as it were the whole form and ſtructure of the pump, it was not improper to keep theſe things together.

The great deſideratum in a piſton is, that it be as tight as poſſible, and have as little friction as is conſiſtent with this indiſpenſable quality. We have already ſaid, that the common form, when carefully executed, has theſe properties in an eminent degree. And accordingly this form has kept its ground amidſt all the improvement which ingenious artiſts have made. Mr Belidor, an author of the firſt reputation, has given the deſcription of a piſton which he highly extols, and is undoubtedly a very good one, conſtructed from principle, and extremely well compoſed.

54
Piſtons ſhould have little friction.

It conſiſts of a hollow cylinder of metal *g h* (fig. 22.) pierced with a number of holes, and having at top a flanch AB, whoſe diameter is nearly equal to that of the working-barrel of the pump. This flanch has a groove round it. There is another flanch IK below, by which this hollow cylinder is faſtened with bolts to the lower end of the piſton, repreſented in fig. 23. This conſiſts of a plate CD, with a grooved edge ſimilar to AB, and an intermediate plate which forms the ſeat of the valve. The compoſition of this part is better underſtood by inſpecting the figure than by any deſcription. The piſton-rod HL is fixed to the upper plate by bolts through its different branches at G, G. This metal body is then covered with a cylindrical bag of leather, faſtened on it by cords bound round it, filling up the grooves in the upper and lower plates. The operation of the piſton is as follows.

55
An improved one by Belidor.
Fig. 22.
Fig. 23.

A little water is poured into the pump, which gets

paſt

Pump.

past the sides of the piston, and lodges below in the fixed valve. The piston being pushed down dips into this water, and it gets into it by the valve. But as the piston in descending compresses the air below it, this compressed air also gets into the inside of the piston, swells out the bag which surrounds it, and compresses it to the sides of the working-barrel. When the piston is drawn up again, it must remain tight, because the valve will shut and keep in the air in its most compressed state; therefore the piston must perform well during the suction. It must act equally well when pushed down again, and acting as a forcer; for however great the resistance may be, it will affect the air within the piston to the same degree, and keep the leather close applied to the barrel. There can be no doubt therefore of the piston's performing both its offices completely; but we imagine that the adhesion to the barrel will be greater than is necessary: it will extend over the whole surface of the piston, and be equally great in every part of its surface; and we suspect that the friction will therefore be very great. We have very high authority for supposing that the adhesion of a piston of the common form, carefully made, will be such as will make it perfectly tight; and it is evident that the adhesion of Belidor's piston will be much greater, and it will be productive of worse consequences. If the leather bag be worn through in any one place, the air escapes, and the piston ceases to be compressed altogether; whereas in the common piston there will very little harm result from the leather being worn through in one place, especially if it project a good way beyond the base of the cone. We still think the common piston preferable. Belidor's piston would do much better inverted as the piston of a sucking pump; and in this situation it would be equal, but not superior, to the common.

56 Its defects.

57 Another by the same author.

Belidor describes another forcing piston, which he had executed with success, and prefers to the common wooden forcer. It consists of a metal cylinder or cone, having a broad flanch united to it at one end, and a similar flanch which is screwed on the other end. Between these two plates are a number of rings of leather strongly compressed by the two flanches, and then turned in a lathe like a block of wood, till the whole fits tight, when dry, into the barrel. It will swell, says he, and soften with the water, and withstand the greatest pressures. We cannot help thinking this but an indifferent piston. When it wears, there is nothing to squeeze it to the barrel. It may indeed be taken out and another ring or two of leather put in, or the flanches may be more strongly screwed together: but all this may be done with any kind of piston; and this has therefore no peculiar merit.

58 Objections to it.

59 Another recommended as preferable. Fig. 24.

The following will, we presume, appear vastly preferable. ABCD (fig. 24.) is the solid wooden or metal block of the piston; EF is a metal plate, which is turned hollow or dish-like below, so as to receive within it the solid block. The piston rod goes through the whole, and has a shoulder above the plate EF, and a nut H below. Four screw-bolts, such as *i k*, *l m*, also go through the whole, have their heads *k*, *m* sunk into the block, and nuts above at *i*, *l*. The packing or stuffing, as it is termed by the workmen, is represented at NO. This it made as solid as possible, and generally consists of soft hempen twine well soaked in a mixture of oil, tallow, and rosin. The plate EF is gently screwed down, and the whole is then put into the barrel, fitting it as tight as may be thought proper. When it wears loose, it may be tightened at any time by screwing down the nuts *i l*, which cause the edges of the dish to squeeze out the packing, and compress it against the barrel to any degree.

60 Difficulties in constructing pistons.

The greatest difficulty in the construction of a piston is to give a sufficient passage through it for the water, and yet allow a firm support for the valve, and fixture for the piston rod. We shall see presently that it occasions a considerable expence of the moving power to force a piston with a narrow perforation through the water lodged in the working barrel. When we are raising water to a small height, such as 10 or 20 feet, the power so expended amounts to a fourth part of the whole, if the water-way in the piston is less than one-half of the section of the barrel, and the velocity of the piston two feet per second, which is very moderate. There can be no doubt, therefore, that metal pistons are preferable, because their greater strength allows much wider apertures.

61 considerably removed in one described by Belidor.

The following piston, described and recommended by Belidor, seems as perfect in these respects as the nature of things will allow. We shall therefore describe it in the author's own words as a model, which may be adopted with confidence in the greatest works.

Plate CCCCLI. Fig. 25. Fig. 26. Fig. 27. Fig. 28.

"The body of the piston is a truncated metal cone (fig. 25.), having a small fillet at the greater end. Fig. 26. shows the profile, and fig. 27. the plan of its upper base; where appears a cross bar DD, pierced with an oblong mortise E for receiving the tail of the piston-rod. A band of thick and uniform leather AA (fig. 26. and 28.) is put round this cone, and secured by a brass hoop BB firmly driven on its smaller end, where it is previously made thinner to give room for the hoop.

"This piston is covered with a leather valve, fortified with metal plates GG (fig. 29.). These plates are wider than the hole of the piston, so as to rest on its rim. There are similar plates below the leather of a smaller size, that they may go into the hollow of the piston; and the leather is firmly held between the metal plates by screws H, H, which go through all. This is represented by the dotted circle I K. Thus the pressure of the incumbent column of water is supported by the plates G G, whose circular edges rest on the brim of the water-way, and their straight edges rest on the cross bar DD of fig. 26. and 27. This valve is laid on the top of the conical box in such a manner that its middle FF rests on the cross bar. To bind all together, the end of the piston-rod is formed like a cross, and the arms MN (fig. 30.) are made to rest on the diameter FF of the valve, the tail EP going through the hole E in the middle of the leather, and through the mortise E of the cross bar of the box; and also through another bar QR (fig. 28. and 29.) which is notched into the lower brim of the box. A key V is then driven into the hole T in the piston-rod; and this wedges all fast. The bar QR is made strong; and its extremities project a little, so as to support the brass hoop BB which binds the leather band to the piston-box. The adjoining scale gives the dimensions of all the parts, as they were executed for a steam-engine near Condé, where the piston gave complete satisfaction."

Fig. 29.

Fig. 30.

This piston has every advantage of strength, tightness, and

Pump.

and large water-way. The form of the valve (which has given it the name of the *butterfly-valve*) is extremely favourable to the paſſage of the water; and as it has but half the motion of a complete circular valve, leſs water goes back while it is ſhutting.

62 Advantages of this piſton.

63 Another ingenious and uſeful piſton deſcribed. Fig. 31.

The following piſton is alſo ingenious, and has a good deal of merit. OPPO (fig. 31.) is the box of the piſton, having a perforation Q, covered above with a flat valve K, which reſts in a metal plate that forms the top of the box. ABCBA is a ſtirrup of iron to which the box is fixed by ſcrews *a, a, a, a*, whoſe heads are ſunk in the wood. This ſtirrup is perforated at C, to receive the end of the piſton-rod, and a nut H is ſcrewed on below to keep it faſt. DEFED is another ſtirrup, whoſe lower part at DD forms a hoop like the ſole of a ſtirrup, which embraces a ſmall part of the top of the wooden box. The lower end of the piſton-rod is ſcrewed; and before it is put into the holes of the two ſtirrups (through which holes it ſlides freely) a broad nut G is ſcrewed on it. It is then put into the holes, and the nut H firmly ſcrewed up. The packing RR is then wound about the piſton as tight as poſſible till it completely fills the working barrel of the pump. When long uſe has rendered it in any degree looſe, it may be tightened again by ſcrewing down the nut G. This cauſes the ring DD to compreſs the packing between it and the projecting ſhoulder of the box at PP; and thus cauſes it to ſwell out, and apply itſelf cloſely to the barrel.

64 Another on a different principle. Fig. 32.

We ſhall add only another form of a perforated piſton; which being on a principle different from all the preceding, will ſuggeſt many others; each of which will have its peculiar advantages. OO in fig. 32. repreſents the box of this piſton, fitted to the working barrel in any of the preceding ways as may be thought beſt. AB is a croſs bar of four arms, which is fixed to the top of the box. CF is the piſton-rod going through a hole in the middle of AB, and reaching a little way beyond the bottom of the box. It has a ſhoulder D, which prevents its going too far through. On the lower end there is a thick metal plate, turned conical on its upper ſide, ſo as to fit a conical ſeat PP in the bottom of the piſton-box.

When the piſton-rod is puſhed down, the friction on the barrel prevents the box from immediately yielding. The rod therefore ſlips through the hole of the croſs bar AB. The plate E, therefore, detaches itſelf from the box. When the ſhoulder D preſſes on the bar AB, the box muſt yield, and be puſhed down the barrels, and the water gets up through the perforation. When the piſton-rod is drawn up again, the box does not move till the plate E lodge in the ſeat PP, and thus ſhuts the water-way; and then the piſton lifts the water which is above it, and acts as the piſton of a ſucking pump.

65 Its advantages.

This is a very ſimple and effective conſtruction, and makes a very tight valve. It has been much recommended by engineers of the firſt reputation, and is frequently uſed; and from its ſimplicity, and the great ſolidity of which it is capable, it ſeems very fit for great works. But it is evident that the water-way is limited to leſs than one-half of the area of the working-barrel. For if the perforation of the piſton be one-half of the area, the diameter of the plate or ball EF muſt be greater; and therefore leſs than half the area will be left for the paſſage of the water by its ſides.

We come now to conſider the forms which may be given to the valves of a hydraulic engine. 66 Obſervations on valves.

The requiſites of a valve are, that it ſhall be tight, of ſufficient ſtrength to reſiſt the great preſſures to which it is expoſed, that it afford a ſufficient paſſage for the water, and that it do not allow much to go back while it is ſhutting.

We have not much to add to what has been ſaid already on this ſubject. The valves which accompany the pump of fig. 5. are called *clack valves*, and are of all the moſt obvious and common; and the conſtruction deſcribed on that occaſion is as perfect as any. We only add, that as the leather is at laſt deſtroyed at the hinge by ſuch inceſſant motion, and it is troubleſome, eſpecially in deep mines, and under water, to undo the joint of the pump in order to put in a new valve, it is frequently annexed to a box like that of a piſton, made a little conical on the outſide, ſo as to fit a conical ſeat made for it in the pipe, as repreſented in fig. 33. and it has an iron handle like that of a baſket, by which it can be laid hold of by means of a long grappling-hook let down from above. Thus it is drawn up; and being very gently tapered on the ſides, it ſticks very faſt in its place. 67 Clack valves. Fig. 33.

The only defect of this valve is, that by opening very wide when puſhed up by the ſtream of water, it allows a good deal to go back during its ſhutting again. In ſome great machines which are worked by a ſlow turning crank, the return of the piſton is ſo very ſlow, that a ſenſible loſs is incurred by this; but it is nothing like what Dr Deſaguliers ſays, one-half of a cylinder whoſe height is equal to the diameter of the valve.—For in ſuch machines, the laſt part of the upward ſtroke is equally ſlow, and the velocity of the water through the valve exceedingly ſmall, ſo that the valve is at this time almoſt ſhut. 68 Defect in them.

The butterfly-valve repreſented in figures 29, &c. is free from moſt of thoſe inconveniences, and ſeems the moſt perfect of the clack valves. Some engineers make their great valves of a pyramidal form, conſiſting of four clacks, whoſe hinges are in the circumference of the water-way, and which meet with their points in the middle, and are ſupported by four ribs which riſe up from the ſides, and unite in the middle. This is an excellent form, affording the moſt ſpacious water-way, and ſhutting very readily. It ſeems to be the beſt poſſible for a piſton. The rod of the piſton is branched out on four ſides, and the branches go through the piſton-box, and are faſtened below with ſcrews. Theſe branches form the ſupport for the four clacks. We have ſeen a valve of this form in a pump of ſix feet diameter, which diſcharged 20 hogſheads of water every ſtroke, and made 12 ſtrokes in a minute, raiſing the water above 22 feet. 69 Utility of the butterfly-valve.

There is another form of valve, called the *button* or *tail valve*. It conſiſts of a plate of metal AB (fig. 34.) turned conical, ſo as exactly to fit the conical cavity *a b* of its box. A tail CD projects from the under ſide, which paſſes through a croſs bar EF in the bottom of the box, and has a little knob at the end, to hinder the valve from riſing too high. 70 Button valves. Fig. 34.

This valve, when nicely made, is unexceptionable. It

Pump.

It has great ſtrength, and is therefore proper for all ſevere ſtrains, and it may be made perfectly tight by grinding. Accordingly it is uſed in all caſes where this is of indiſpenſable conſequence. It is moſt durable, and the only kind that will do for paſſages where ſteam or hot water is to go through. Its only imperfection is a ſmall water-way; which, from what has been ſaid, cannot exceed, or indeed equal, one-half of the area of the pipe.

72 Though ſomewhat imperfect in the water-way.

If we endeavour to enlarge the water-way, by giving the cone very little taper, the valve frequently ſticks ſo faſt in the ſeat that no force can detach them.—And this ſometimes happens during the working of the machine; and the jolts and blows given to the machine in taking it to pieces, in order to diſcover what has been the reaſon that it has diſcharged no water, frequently detach the valve, and we find it quite looſe, and cannot tell what has deranged the pump. When this is guarded againſt, and the diminution of the water-way is not of very great conſequence, this is the beſt form of a valve.

73 A very ſimple valve deſcribed. Fig. 35.

Analogous to this is the ſimpleſt of all valves, repreſented in fig. 35. It is nothing more than a ſphere of metal A, to which is fitted a ſeat with a ſmall portion BC of a ſpherical cavity. Nothing can be more effectual than this valve; it always falls into its proper place, and in every poſition fits it exactly. Its only imperfection is the great diminution of the water-way. If the diameter of the ſphere does not conſiderably exceed that of the hole, the touching parts have very little taper, and it is very apt to ſtick faſt. It oppoſes much leſs reſiſtance to the paſſage of the water than the flat under-ſurface of the button-valve. *N. B.* It would be an improvement of that valve to give it a taper-ſhape below like a boy's top. The ſpherical valve muſt not be made too light, otherwiſe it will be hurried up by the water, and much may go back while it is returning to its place.

74 A valve by Belidor uniting every requiſite.

Belidor deſcribes with great minuteneſs (vol. ii. p. 221, &c.) a valve which unites every requiſite. But it is of ſuch nice and delicate conſtruction, and its defects are ſo great when this exactneſs is not attained, or is impaired by uſe, that we think it hazardous to introduce it into a machine in a ſituation where an intelligent and accurate artiſt is not at hand. For this reaſon we have omitted the deſcription, which cannot be given in few words, nor without many figures; and deſire our curious readers to conſult that author, or peruſe Dr Deſagulier's tranſlation of this paſſage. Its principle is preciſely the ſame with the following rude contrivance, with which we ſhall conclude the deſcriptive part of this article.

75 Another valve on the ſame principle. Fig 36.

Suppoſe ABCD (fig. 36.) to be a ſquare wooden trunk. EF is a piece of oak-board, exactly fitted to the trunk in an oblique poſition, and ſupported by an iron pin which goes through it at I, one-third of its length from its lower extremity E. The two ends of this board are bevelled, ſo as to apply exactly to the ſides of the trunk. It is evident, that if a ſtream of water come in the direction BA, its preſſure on the part IF of this board will be greater than that upon EI. It will therefore force it up and ruſh through, making it ſtand almoſt parallel to the ſides of the trunk. To prevent its riſing ſo far, a pin muſt be put in its way. When this current of water changes its direction, the preſſure on the upper ſide of the board being again greateſt on the portion IF, it is forced back again to its former ſituation, and its two extremities reſting on the oppoſite ſides of the trunk, the paſſage is completely ſtopped. This board therefore performs the office of a valve; and this valve is the moſt perfect that can be, becauſe it offers the freeſt paſſage to the water, and it allows very little to get back while it is ſhutting; for the part IE brings up half as much water as IF allows to go down. It may be made extremely tight, by fixing two thin fillets H and G to the ſides of the trunk, and covering thoſe parts of the board with leather which applies to them; and in this ſtate it perfectly reſembles Belidor's fine valve.

76 Deſcription of an occaſional pump eaſily conſtructed. Fig. 36.

And this conſtruction of the valve ſuggeſts, by the way, a form of an occaſional pump, which may be quickly ſet up by any common carpenter, and will be very effectual in ſmall heights. Let *a b c d e* (fig. 36.) be a ſquare box made to ſlide along this wooden trunk without ſhake, having two of its ſides projecting upwards, terminating like the gable-ends of a houſe. A piece of wood *e* is mortiſed into theſe two ſides, and to this the piſton-rod is fixed. This box being furniſhed with a valve ſimilar to the one below, will perform the office of a piſton. If this pump be immerſed ſo deep in the water that the piſton ſhall alſo be under water, we ſcruple not to ſay that its performance will be equal to any. The piſton may be made abundantly tight by covering its outſide neatly with ſoft leather. And as no pipe can be bored with greater accuracy than a very ordinary workman can make a ſquare trunk, we preſume that this pump will not be very deficient even for a conſiderable ſuction.

77 The motion of water in pumps,

We now proceed to the laſt part of the ſubject, to conſider the motion of water in pumps, in reference to the force which muſt be employed. What we have hitherto ſaid with reſpect to the force which muſt be applied to a piſton, related only to the ſuſtaining the water at a certain height: but in actual ſervice we muſt not only do this, but we muſt diſcharge it at the place of delivery in a certain quantity; and this muſt require a force ſuperadded to what is neceſſary for its mere ſupport at this height.

78 an intricate ſubject.

This is an extremely intricate and difficult ſubject, and very imperfectly underſtood even by profeſſed engineers. The principles on which this knowledge muſt be founded are of a much more abſtruſe nature than the ordinary laws of hydroſtatics; and all the genius of Newton was employed in laying the foundation of this part of phyſical ſcience. It has been much cultivated in the courſe of this century by the firſt mathematicians of Europe. Daniel and John Bernoulli have written very elaborate treatiſes on the ſubject, under the very apposite name of HYDRODYNAMICS; in which, although they have added little or nothing to the fundamental propoſitions eſtabliſhed in ſome ſort by Newton, and acquieſced in by them, yet they have greatly contributed to our progreſs in it by the *methods* which they have purſued in making application of thoſe fundamental propoſitions to the moſt important caſes. It muſt be acknowledged, however, that both theſe propoſitions, and the extenſions given them by theſe authors, are ſupported by a train of argument that is by no means unexceptionable; and that they proceed on aſſumptions or poſtulates which are but nearly true in any

79 The theory denominated *Hydrodynamics*.

any cafe, and in many are inadmiffible: and it remains to this hour a wonder or puzzle how thefe propofitions and their refults correfpond with the phenomena which we obferve.

But fortunately this correfpondence does obtain to a certain extent. And it feems to be this correfpondence chiefly which has given thefe authors, with Newton at their head, the confidence which they place in their refpective principles and methods: for there are confiderable differences among them in thofe refpects; and each feems convinced that the others are in a miftake. Meffieurs d'Alembert and De la Grange have greatly corrected the theories of their predeceffors, and have proceeded on poftulates which come much nearer to the real ftate of the cafe. But their inveftigations involve us in fuch an inextricable maze of analytical inveftigation, that even when we are again conducted to the light of day by the clue which they have given us, we can make no ufe of what we there difcovered.

80 though imperfect is very ufeful.

But this theory, imperfect as it is, is of great fervice. It generalizes our obfervations and experiments, and enables us to compofe a *practical doctrine* from a heap of facts which otherwife muft have remained folitary and unconnected, and as cumberfome in their application as the characters of the Chinefe writing.

81 Fundamental propofition.

The fundamental propofition of this practical hydrodynamics is, that water or any fluid contained in an open veffel of indefinite magnitude, and impelled by its weight only, will flow through a fmall orifice with the velocity which a heavy body would acquire by falling from the horizontal furface of the fluid. Thus, if the orifice is 16 feet under the furface of the water, it will iffue with the velocity of 32 feet in a fecond.

Its velocity correfponding to any other depth h of the orifice under the furface, will be had by this eafy proportion: "As the fquare root of 16 is to the fquare root of h; fo is 32 feet to the velocity required: or, alternately, $\sqrt{16} : 32 = \sqrt{h} : v$, and $v = \frac{32\sqrt{h}}{\sqrt{16}}, = \frac{32}{4}\sqrt{h}, = 8\sqrt{h}$: that is, multiply the fquare root of the height in feet by eight, and the product is the required velocity.

On the other hand, it frequently occurs, that we want to difcover the depth under the furface which will produce a known velocity v. Therefore, $\sqrt{h} = \frac{v}{8}$, and $h = \frac{v^2}{64}$: that is, divide the fquare of the velocity by 64, and the quotient is the depth wanted in feet.

82 Its utility.

This propofition is fufficient for all our purpofes. For fince water is nearly a perfect fluid, and propagates all impreffions undiminifhed, we can, in place of any preffure of a pifton or other caufe, fubftitute a perpendicular column of water whofe weight is equal to this preffure, and will therefore produce the fame efflux.—Thus, if the furface of a pifton is half a fquare foot, and it be preffed down with the weight of 500 pounds, and we would wifh to know with what velocity it would caufe the water to flow through a fmall hole, we know that a column of water of this weight, and of half a foot bafe, would be 16 feet high. And this propofition teaches us, that a veffel of this depth will have a velocity of efflux equal to 32 feet in a fecond.

If therefore our preffing power be of fuch a kind that it can continue to prefs forward the pifton with the force of 500 pounds, the water will flow with this velocity, whatever be the fize of the hole. All that remains is, to determine what change of *actual preffure* on the pifton refults from the motion of the pifton itfelf, and to change the velocity of efflux in the fubduplicate ratio of the change of actual preffure.

83 Remark previous to its application.

But before we can apply this knowledge to the circumftances which take place in the motion of water in pumps, we muft take notice of an important modification of the fundamental propofition, which is but very obfcurely pointed out by any good theory, but is eftablifhed on the moft regular and unexceptionable obfervation.

If the efflux is made through a hole in a thin plate, and the velocity is computed as above, we fhall difcover the quantity of water which iffues in a fecond by obferving, that it is a prifm or cylinder of the length indicated by the velocity, and having its tranfverfe fection equal to that of the orifice. Thus, in the example already given, fuppofing the hole to be a fquare inch, the folid contents of this prifm, or the quantity of water iffuing in a fecond, is $1 \times 32 \times 12$ cubic inches, or 384 cubic inches. This we can eafily meafure by receiving it in a veffel of known dimenfions. Taking this method, we uniformly find a deficiency of nearly 38 parts in 100; that is, if we fhould obtain 100 gallons in any number of feconds, we fhall in fact get only 62. This is a moft regular fact, whether the velocities are great or fmall, and whatever be the fize and form of the orifice. The deficiency increafes indeed in a very minute degree with the velocities. If, for inftance, the depth of the orifice be one foot, the difcharge is $\frac{6213}{10000}$; if it be 15 feet, the difcharge is $\frac{6172}{10000}$.

This deficiency is not owing to a diminution of velocity; for the velocity may be eafily and accurately meafured by the diftance to which the jet will go, if directed horizontally. This is found to correfpond very nearly with the propofition, making a very fmall allowance for friction at the border of the hole, and for the refiftance of the air. Sir Ifaac Newton afcribed the deficiency with great juftice to this, that the lateral columns of water, furrounding the column which is incumbent on the orifice, prefs towards the orifice, and contribute to the expence equally with that column. Thefe lateral filaments, therefore, iffue obliquely, croffing the motion of the central ftream, and produce a contraction of the jet; and the whole ftream does not acquire a parallel motion and its ultimate velocity till it has got to fome diftance from the orifice. Careful obfervation fhowed him that this was really the cafe. But even his genius could not enable him to afcertain the motion of the lateral filaments by theory, and he was obliged to meafure every thing as he faw it. He found the diameter of the jet at the place of the greateft contraction to be precifely fuch as accounted for the deficiency. His explication has been unanimoufly acquiefced in; and experiments have been multiplied to afcertain all thofe circumftances which our theory cannot determine *à priori*. The moft complete fet of experiments are thofe of Michelotti, made at Turin at the expence of the prince of Piedmont.

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Piedmont. Here jets were made of 1, 2, 3, and 4 inches diameter; and the water received into cisterns most accurately formed of brick, and lined with stucco. It is the result of these experiments which we have taken for a measure of the deficiency.

We may therefore consider the water as flowing through a hole of this contracted dimension, or substitute this for the real orifice in all calculations. For it is evident that if a mouth-piece (so to call it) were made, whose internal shape precisely tallied with the form which the jet assumes, and if this mouth-piece be applied to the orifice, the water will flow out without any obstruction. The vessel may therefore be considered as really having this mouth-piece.

Nay, from this we derive a very important observation, " that if, instead of allowing the water to flow through a hole of an inch area made in a thin plate, we make it flow through a hole in a thick plank, so formed that the external orifice shall have an inch area, but be widened internally agreeably to the shape which nature forms, both the velocity and quantity will be that which the fundamental proposition determines. Michelotti measured with great care the form of the great jets of three and four inches diameter, and found that the bounding curve was an elongated trochoid. He then made a mouth-piece of this form for his jet of one inch, and another for his jet of two inches; and he found the discharges to be $\frac{979}{1000}$ and $\frac{987}{1000}$; and he, with justice, ascribed the trifling deficiency which still remained, partly to friction and partly to his not having exactly suited his mouth-piece to the natural form. We imagine that this last circumstance was the sole cause: For, in the first place, the water in his experiments, before getting at his jet-holes, had to pass along a tube of eight inches diameter. Now a jet of four inches bears too great a proportion to this pipe; and its narrowness undoubtedly hindered the lateral columns from contributing to the efflux in their due proportion, and therefore rendered the jet less convergent. And, in the next place, there can be no doubt (and the observations of Daniel Bernoulli confirm it) but that this convergency begins within the vessel, and perhaps at a very considerable distance from the orifice. And we imagine, that if accurate observations could be made on the motion of the remote lateral particles within the vessel, and an internal mouth-piece were shaped according to the curve which is described by the remotest particle that we can observe, the efflux of water would almost perfectly tally with the theory. But indeed the coincidence is already sufficiently near for giving us very valuable information. We learn that the quantity of water which flows through a hole, in consequence of its own weight, or by the action of any force, may be increased one half by properly shaping the passage to this hole; for we see that it may be increased from 62 to near 99.

But there is another modification of the efflux, which we confess our total incapacity to explain. If the water issues through a hole made in a plate whose thickness is about twice the diameter of the hole, or, to express it better, if it issues through a pipe whose length is about twice its diameter, the quantity discharged is nearly $\frac{82}{100}$ of what results from the proposition. If the pipe be longer than this, the quantity is diminished by friction, which increases as the length of the pipe increases. If the pipe be shorter, the water will not fill it, but detaches itself at the very entry of the pipe, and flows with a contracted jet. When the pipe is of this length, and the extremity is stopped with the finger, so that it begins to flow with a full mouth, no subsequent contraction is observed; but merely striking on the pipe with a key or the knuckle is generally sufficient to detach the water in an instant from the sides of the pipe, and reduce the efflux to $\frac{62}{100}$.

This effect is most unaccountable. It certainly arises from the mutual adhesion or attraction between the water and the sides of the pipe; but how this, acting at right angles to the motion, should produce an increase from 62 to 82, nearly $\frac{1}{3}$, we cannot explain. It shows, however, the prodigious force of this attraction, which in the space of two or three inches is able to communicate a great velocity to a very great body of water. Indeed the experiments on capillary tubes show that the mutual attraction of the parts of water is some thousands of times greater than their weight.

We have only further to add, that every increase of pipe beyond two diameters is accompanied with a diminution of the discharge; but in what ratio this is diminished it is very difficult to determine. We shall only observe at present that the diminution is very great. A pipe of 2 inches diameter and 30 feet long has its discharge only $\frac{54}{100}$ of what it would be if only 4 inches long. If its length be 60 feet, its discharge will be no more than $\frac{39}{100}$. A pipe of 1 inch diameter would have a discharge of $\frac{44}{100}$, and $\frac{31}{100}$, in the same situation. Hence we may conclude that the discharge of a 4-inch pipe of 30 feet long will not exceed $\frac{2}{3}$ of what it would be if only 8 inches long. This will suffice for our present purposes; and the determination of the velocities and discharges in long conduits from pump-machines must be referred to the article *WATER-Works*. At present we shall confine our attention to the pump itself, and to what will contribute to its improvement.

Before we can proceed to apply this fundamental proposition to our purpose, we must anticipate in a loose way a proposition of continual use in the construction of *water-works*.

Fig. 37.

Let water be supposed stagnant in a vessel EFGH (fig. 37.), and let it be allowed to flow out by a cylindrical pipe HIKL, divided by any number of partitions B, C, D, &c. Whatever be the areas B, C, D, of these orifices, the velocity in the intermediate parts of the pipe will be the same; for as much passes through any one orifice in a second as passes through any other in the same time, or through any section of the intervening pipe. Let this velocity in the pipe be V, and let the area of the pipe be A. The velocity in the orifices B, C, D, must be $\frac{VA}{B}$, $\frac{VA}{C}$, $\frac{VA}{D}$, &c. Let g be the velocity acquired in a second by a heavy body. Then, by the general proposition, the height of water in the vessel which will produce the velocity $\frac{VA}{B}$ in the first orifice alone, is $\frac{V^2A^2}{2gB^2}$. After this passage the velocity is again reduced to V in the middle of the space between the first and second orifices. In the second orifice this velocity is changed to $\frac{VA}{C}$. This

alone

alone would have required a height of water $\frac{V^2 A^2}{2g C^2}$. But the water is already moving with the velocity V, which would have resulted from a height of water in the vessel (which we shall, in the language of the art, call the HEAD OF WATER) equal to $\frac{V^2}{2g}$. Therefore there is only required a head of water $\frac{V^2 A^2}{2g C^2} - \frac{V^2}{2g}$, or $\frac{V^2}{2g} \times \overline{\frac{A^2}{C^2} - 1}$. Therefore the whole height necessary for producing the efflux through both orifices, so as still to preserve the velocity V in the intervening pipe, is $\frac{V^2}{2g} \times \overline{\frac{A^2}{B^2} + \frac{A^2}{C^2} - 1}$. In like manner the third orifice D would alone require a head of water $\frac{V^2}{2g} \times \overline{\frac{A^2}{D^2} - 1}$; and all the three would require a head $\frac{V^2}{2g} \times \overline{\frac{A^2}{B^2} + \frac{A^2}{C} + \frac{A^2}{D^2} - 2}$. By this induction may easily be seen what head is necessary for producing the efflux through any number of orifices.

Let the expence or quantity of water discharged in an unit of time (suppose a second) be expressed by the symbol Q. This is measured by the product of the velocity by the area of the orifice, and is therefore $= VA$, or $\frac{VA}{B} \times B$, or $\frac{VA}{C} \times C$, &c. and $V^2 = \frac{Q^2}{A^2}$. Therefore we may compute the head of water (which we shall express by H) in reference to the quantity of water discharged, because this is generally the interesting circumstance. In this view we have $H = \frac{Q^2}{2gA} \times \overline{\frac{A^2}{B^2} + \frac{A^2}{C^2} + \frac{A^2}{D^2} - 2}$: which shows that the head of water necessary for producing the discharge increases in the proportion of the square of the quantity of water which is discharged.

84 To determine the motion of water, &c.

These things being premised, it is an easy matter to determine the motion of water in a pump, and the quantity discharged, resulting from the action of any force on the piston, or the force which must be applied to the piston in order to produce any required motion or quantity discharged. We have only to suppose that the force employed is the pressure of a column of water of the diameter of the working barrel; and this is over and above the force which is necessary for merely supporting the water at the height of the place of delivery. The motion of the water will be the same in both cases.

85 In the sucking-pump,

Let us, first of all, consider a sucking-pump. The motion here depends on the pressure of the air, and will be the same as if the pump were lying horizontally, and communicated with a reservoir, in which is a head of water sufficient to overcome all the obstructions to the motion, and produce a velocity of efflux such as we desire. And here it must be noted that there is a limit. No velocity of the piston can make the water rise in the suction-pipe with a greater velocity than what would be produced by the pressure of a column of water 33 feet high; that is, about 46 feet per second.

Let the velocity of the piston be V, and the area of the working barrel be A. Then, if the water fills the barrel as fast as the piston is drawn up, the discharge during the rise of the piston, or the number of cubic feet of water per second, must be $= V \times A$. This is always supposed, and we have already ascertained the circumstances which ensure this to happen. If, therefore, the water arrived with perfect freedom to the piston, the force necessary for giving it this velocity, or for discharging the quantity $V \times A$ in a second, would be equal to the weight of the pillar of water whose height is $\frac{V^2}{2g}$, and base A.

It does not appear at first sight that the force necessary for producing this discharge has any thing to do with the obstructions to the ascent of the water into the pump, because this is produced by the pressure of the atmosphere, and it is the action of this pressure which is measured by the head of water necessary for producing the internal motion in the pump. But we must always recollect that the piston, before bringing up any water, and supporting it at a certain height, was pressed on both sides by the atmosphere. While the air supports the column below the piston, all the pressure expended in this support is abstracted from its pressure on the under part of the piston, while its upper part still supports the whole pressure. The atmosphere continues to press on the under surface of the piston, through the intermedium of the water in the suction-pipe, with the difference of these two forces. Now, while the piston is drawn up with the velocity V, more of the atmospheric pressure must be expended in causing the water to follow the piston; and it is only with the remainder of its whole pressure that it continues to press on the under surface of the piston. Therefore, in order that the piston may be raised with the velocity V, a force must be applied to it, over and above the force necessary for merely supporting the column of water, equal to that part of the atmospheric pressure thus employed; that is, equal to the weight of the head of water necessary for forcing the water up through the suction-pipe, and producing the velocity V in the working barrel.

Therefore let B be the area of the mouth of the suction-pipe, and C the area of the fixed valve, and let the suction-pipe be of equal diameter with the working barrel. The head necessary for producing the velocity V on the working barrel is $\frac{V^2}{2g}\left(\frac{A^2}{B^2} + \frac{A^2}{C^2} - 1\right)$. If d express the density of water; that is, if d be the number of pounds in a cubic foot of water, then $d\,A\frac{V^2}{2g}$ will express the weight of a column whose base is A, and height $\frac{V^2}{2g}$, all being reckoned in feet. Therefore the force which must be applied, when estimated in pounds, will be $p, = \frac{d\,AV^2}{2g}\left(\frac{A^2}{B^2} + \frac{A^2}{C^2} - 1\right)$.

The first general observation to be made on what has been said is, that the power which must be employed to produce the necessary motion, in opposition to all the obstacles, is in the proportion of the square of the velocity

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city which we would produce, or the ſquare of the quanty of water we would diſcharge.

We have hitherto proceeded on the ſuppoſition, that there is no contraction of the jet in paſſing through theſe two orifices. This we know would be very far from the truth. We muſt therefore accommodate things to theſe circumſtances, by diminiſhing B and C in the ratio of the contraction, and calling the diminiſhed areas b and c; then we have $p = \frac{AdV^2}{2g}\left(\frac{A^2}{b^2} + \frac{A^2}{c^2} - 1\right)$.

What this diminution may be, depends on the form of the parts. If the fixed valve, and the entry into the pump, are ſimply holes in thin plates, then $b = \frac{62}{100}$ B and $c = \frac{62}{100}$ C. The entry is commonly widened or trumpet-ſhaped, which diminiſhes greatly the contraction: but there are other obſtacles in the way, ariſing from the ſtrainer uſually put round it to keep out filth. The valve may have its contraction greatly diminiſhed alſo by its box being made bell-ſhaped internally; nay, even giving it a cylindrical box, in the manner of fig. 33. is better than no box at all, as in fig. 5.; for ſuch a cylindrical box will have the unaccountable effect of the the ſhort tube, and make $b = \frac{82}{100}$ B, inſtead of $\frac{62}{100}$ B. Thus we ſee that circumſtances ſeemingly very trifling may produce great effects in the performance of a pump. We ſhould have obſerved that the valve itſelf preſents an obſtacle which diminiſhes the motion, and requires an increaſe of power; and it would ſeem that in this reſpect the clack or butterfly valve is preferable to the button valve.

Example. Suppoſe the velocity of the piſton to be 2 feet or 24 inches per ſecond, and that the two contracted areas are each $\frac{1}{5}$ of the area of the pump, which is not much leſs than what obtains in ordinary pumps. We have $\frac{V^2}{2g}\left(\frac{A^2}{b^2} + \frac{A^2}{c^2} - 1\right) = \frac{576}{768}(25 + 25 - 1)$ $= 36{,}75$ inches, and the force which we muſt add to what will merely ſupport the column is the weight of a pillar of water incumbent on the piſton, and ſomething more than three feet high. This would be a ſenſible portion of the whole force in raiſing water to ſmall heights.

We have ſuppoſed the ſuction-pipe to be of the ſame diameter with the working barrel; but it is uſual to make it of ſmaller diameter, generally equal to the water way of the fixed valve. This makes a conſiderable change in the force neceſſary to be applied to the piſton. Let a be the area of the ſuction-pipe, the area of the entry being ſtill B; and the equivalent entry without contraction being ſtill b, we have the velocity at the entrance $= \frac{AV}{b}$, and the producing head of water $= \frac{A^2V^2}{2g\,b^2}$. After this the velocity is changed to $\frac{AV}{a}$ in the ſuction-pipe, with which the water arrives at the valve, where it is again changed to $\frac{AV}{c}$, and requires for this change a head of water equal to $\frac{A^2V^2}{2g\,c^2}$. But the velocity retained in the ſuction-pipe is equivalent to the effect of a head of water $\frac{A^2V^2}{2g\,a^2}$. Therefore the head neceſſary for producing ſuch a current through the fixed valve, that the water may follow the piſton with the velocity V, is $\frac{A^2V^2}{2g\,b^2} + \frac{A^2V^2}{2g\,c^2} - \frac{A^2V^2}{2g\,a^2}$, or $= \frac{V^2}{2g}\left(\frac{A^2}{b^2} + \frac{A^2}{c^2} - \frac{A^2}{a^2}\right)$. This is evidently leſs than before, becauſe a is leſs than A, and therefore $\frac{A^2}{a^2}$ is greater than unity, which was the laſt term of the former formula. There is ſome advantage, therefore, derived from making the diameter of the ſuction-pipe leſs than that of the working barrel: but this is only becauſe the paſſage of the fixed valve is ſmaller, and the inſpection of the formula plainly points out that the area of the ſuction-pipe ſhould be equal to that of the fixed valve. When it is larger, the water muſt be accelerated in its paſſage through the valve; which is an uſeleſs expence of force, becauſe this velocity is to be immediately reduced to V in the working-barrel. If the foregoing example be computed with a equal to $\frac{1}{4}$ of A, we ſhall find the head H equal to 29 inches inſtead of 37.

But this advantage of a ſmaller ſuction pipe is in all caſes very moderate; and the pump is always inferior to one of uniform dimenſions throughout, having the orifice at the fixed valve of the ſame area. And if theſe orifices are conſiderably diminiſhed in any proportion, the head neceſſary for overcoming the obſtacles, ſo that the required velocity V may ſtill be produced in the working barrel, is greatly increaſed. If we ſuppoſe the area a $\frac{1}{9}$ of A, which is frequently done in houſe pumps, where the diameter of the ſuction-pipe does ſeldom exceed $\frac{1}{3}$ of that of the working-barrel; and ſuppoſe every thing made in proportion to this, which is alſo uſual, becauſe the unſkilled pump-makers ſtudy a ſymmetry which ſatisfies the eye; we ſhall find that the pump taken as an example will require a head of water $=$ 13 feet and upwards. Beſides, it muſt be obſerved that the friction of the ſuction-pipe itſelf has not been taken into the account. This alone is greater, in moſt caſes, than all the obſtructions we have been ſpeaking of; for if this pipe is three inches diameter, and that of the working-barrel is ſix, which is reckoned a liberal allowance for a ſuction-pipe, and if the fixed valve is 25 feet above the ſurface of the pit-water; the friction of this pipe will amount to one-third of the whole propelling force.

Thus we have enabled the reader to aſcertain the force neceſſary for producing any required diſcharge of water from a pump of known dimenſions: and the converſe of this determination gives us the diſcharge which will be produced by any given force. For making $\frac{A^2}{b^2} + \frac{A^2}{c^2} - \frac{A^2}{a^2}$ (which is a known quantity, reſulting from the dimenſions of the pump) $=$ M, we have $H = \frac{V^2}{2g}M$, and $V^2 = \frac{2gH}{M}$, and $V = \sqrt{\frac{2gH}{M}}$. Now H is that part of the natural power which we have at command which exceeds what is neceſſary for merely ſupporting the column of water. Thus, if we have a pump whoſe piſton has an area of $\frac{1}{4}$ of a ſquare foot, its diameter being $6\frac{3}{4}$ inches; and we have to raiſe the water 32 feet, and can apply a power of 525 pounds to the piſton; we wiſh to know at what rate the piſton will be moved, and the quantity of water diſcharged?

Merely

Merely to ſupport the column of water of this height and diameter, requires 500 pounds. Therefore the remaining power, which is to produce the motion, is 25 pounds. This is the weight of a column 1 foot 4 inches high, and H = 1,333 feet. Let us ſuppoſe the diameter of the ſuction-pipe $\frac{1}{2}$ of that of the working-barrel, ſo that $\frac{A}{B} = 4$. We may ſuppoſe it executed in the beſt manner, having its lower extremity trumpet-ſhaped, formed by the revolution of the proper trochoid. The contraction at the entry may therefore be conſidered as nothing, and $\frac{A}{b} = 4$, and $\frac{A^2}{b^2} = 16$. We may alſo ſuppoſe the orifice of the fixed valve equal to the area of the ſuction-pipe, ſo that $\frac{A^2}{C^2}$ is alſo = 16, and there is no contraction here; and therefore $\frac{A^2}{c^2}$ is alſo 16. And laſtly, $\frac{A^2}{a^2}$ is alſo 16. Therefore $\frac{A^2}{b^2} + \frac{A^2}{c^2} - \frac{A^2}{a^2}$ or M, = 16 + 16 − 16, = 16. We have alſo $2g = 64$. Now $N = \sqrt{\frac{2gH}{M}}$. $= \sqrt{\frac{64 \times 1,333}{16}}$, = 2,309 feet, and the piſton will move with the velocity of 2 feet 4 inches nearly. Its velocity will be leſs than this, on account both of the friction of the piſton and the friction of the water in the ſuction-pipe. Theſe two circumſtances will probably reduce it to one foot eight inches; and it can hardly be leſs than this.

We have taken no notice of the friction of the water in the working-barrel, or in the ſpace above the piſton; becauſe it is in all caſes quite inſignificant. The longeſt pipes employed in our deep mines do not require more than a few inches of head to overcome it.

But there is another circumſtance which muſt not be omitted. This is the reſiſtance given to the piſton in its deſcent. The piſtons of an engine for drawing water from deep mines muſt deſcend again by their own weight in order to repeat their ſtroke. This muſt require a preponderance on that end of the working-beam to which they are attached, and this muſt be overcome by the moving power during the effective ſtroke. It makes, therefore, part of the whole work to be done, and muſt be added to the weight of the column of water which muſt be raiſed.

This is very eaſily aſcertained. Let the velocity of the piſton in its deſcent be V, the area of the pump-barrel A, and the area of the piſton-valve *a*. It is evident, that while the piſton deſcends with the velocity V, the water which is diſplaced by the piſton in a ſecond is (A—*a*) V. This muſt paſs though the hole of the piſton, in order to occupy the ſpace above, which is left by the piſton. If there were no contraction, the water would go through with the velocity $\frac{A-a}{a}V$; but as there will always be ſome contraction, let the diminiſhed area of the hole (to be diſcovered by experiment) be *b*, the velocity therefore will be $V\frac{A-a}{b}$. This requires for its production a head of water $\frac{V^2}{2g}\left(\frac{A-a}{b}\right)^2$. This is the height of a column of water whoſe baſe is not A but A—*a*. Calling the denſity of water *d*, we have for the weight of this column, and the force *p* in $d \times \overline{A-a} + \left(\frac{A-a}{b}\right) \times \frac{V^2}{2g}, = \frac{dV^2(A-a)^3}{2gb^2}$. This, we ſee again, is proportional to the ſquare of the velocity of the piſton in its deſcent, and has no relation to the height to which the water is raiſed.

If the piſton has a button valve, its ſurface is at leaſt equal to *a*; and therefore the preſſure is exerted on the water by the whole ſurface of the piſton. In this caſe we ſhall have $p = \frac{dV^2A^3}{2gb^2}$ conſiderably greater than before. We cannot aſcertain this value with great preciſion, becauſe it is extremely difficult, if poſſible, to determine the reſiſtance in ſo complicated a caſe. But the formula is exact, if *b* can be given exactly; and we know within very moderate limits what it may amount to. In a pump of the very beſt conſtruction, with a button valve, *b* cannot exceed one-half of A; and therefore $\frac{A^3}{b^2}$ cannot be leſs than 8. In this caſe, $\frac{V^2A^3}{2gb^2}$ will be $\frac{V^2}{8}$. In a good ſteam-engine pump V is about three feet per ſecond, and $\frac{V^2}{8}$ is about $1\frac{1}{8}$ feet, which is but a ſmall matter.

We have hitherto been conſidering the ſucking-pump alone: but the forcing pump is of more importance, and apparently more difficult of inveſtigation.—Here we have to overcome the obſtructions in long pipes, with many bends, contractions, and other obſtructions. But the conſideration of what relates merely to the pump is abundantly ſimple. In moſt caſes we have only to force the water into an air-veſſel, in oppoſition to the elaſticity of the air compreſſed in it, and to ſend it thither with a certain velocity, regulated by the quantity of water diſcharged in a given time. The elaſticity of the air in the air-veſſel propels it along the *Main*. We are not now ſpeaking of the force neceſſary for counterbalancing this preſſure of the air in the air-veſſel, *which is equivalent to all the ſubſequent obſtructions*, but only of the force neceſſary for propelling the water out of the pump with the proper velocity. 86 and in the forcing-pump.

We have in a manner determined this already. The piſton is ſolid, and the water which it forces has to paſs through a valve in the lateral pipe, and then to move in the direction of the main. The change of direction requires an addition of force to what is neceſſary for merely impelling the water through the valve. Its quantity is not eaſily determined by any theory, and it varies according to the abruptneſs of the turn. It appears from experiment, that when a pipe is bent to a right angle, without any curvature or rounding, the velocity is diminiſhed about $\frac{1}{18}$. This would augment the head of water about $\frac{1}{9}$. This may be added to the contraction of the valve hole. Let *c* be its natural area, and whatever is the contraction competent to its form increaſe it $\frac{1}{18}$, and call the contracted area *c*. Then this will require a head of water $= \frac{V^2A^2}{2gc^2}$.

This

This muſt be added to the head $\frac{V^2}{2g}$, neceſſary for merely giving the velocity V to the water. Therefore the whole is $\frac{V^2}{2g}\left(\frac{A^2}{c^2}+1\right)$; and the power p neceſſary for for this purpoſe is $\frac{d\,AV^2}{2g}\left(\frac{A^2}{c^2}+1\right)$.

It cannot eſcape the obſervation of the reader, that in all theſe formulæ, expreſſing the height of the column of water which would produce the velocity V in the working barrel of the pump the quantity which multiplies the conſtant factor $\frac{d\,AV^2}{2g}$ depends on the contracted paſſages which are in different parts of the pump, and increaſes in the duplicate proportion of the ſum of thoſe contractions. It is therefore of the utmoſt conſequence to avoid all ſuch, and to make the main which leads from the forcing-pump equal to the working barrel. If it be only of half the diameter, it has but one-fourth of the area, the velocity in the main is four times greater than that of the piſton, and the force neceſſary for diſcharging the ſame quantity of water is 16 times greater.

It is not, however, poſſible to avoid theſe contractions altogether, without making the main pipe wider than the barrel. For if only ſo wide, with an entry of the ſame ſize, the valve makes a conſiderable obſtruction. Unſkilful engineers endeavour to obviate this by making an enlargement in that part of the main which contains the valve. This is ſeen in fig. 14. at the valve L. If this be not done with great judgement, it will increaſe the obſtructions. For if this enlargement is full of water, the water muſt move in the direction of its axis with a diminiſhed velocity; and when it comes into the main, it muſt again be accelerated. In ſhort, any abrupt enlargement which is to be afterwards contracted, does as much harm as a contraction, unleſs it be ſo ſhort that the water in the axis keeps its velocity till it reaches the contraction. Nothing would do more ſervice to an artiſt, who is not well founded in the theory of hydrodynamics, than to make a few ſimple and cheap experiments with a veſſel like that of fig. 37. Let the horizontal pipe be about three inches diameter, and made in joints which can be added to each other. Let the joints be about ſix inches long, and the holes from one-fourth to a whole inch in diameter. Fill the veſſel with water, and obſerve the time of its ſinking three or four inches. Each joint ſhould have a ſmall hole in its upper ſide to let out the air; and when the water runs out by it, let it be ſtopped by a peg. He will ſee that the larger the pipe is in proportion to the orifices made in the partitions, the efflux is *more diminiſhed*. We believe that no perſon would ſuſpect this who has not conſidered the ſubject minutely.

87 Uſe of experiments.

All angular enlargements, all boxes, into which the pipes from different working barrels, unite their water before it goes into a main, muſt therefore be avoided by an artiſt who would execute a good machine; and the different contractions which are unavoidable at the ſeats of valves and the perforations of piſtons, &c. ſhould be diminiſhed by giving the parts a trumpet-ſhape.

In the air-veſſels repreſented in fig. 13. this is of very great conſequence. The throat O, through which the water is forced by the expanſion of the confined air, ſhould always be formed in this manner. For it is this which produces the motion during the returning part of the ſtroke in the pump conſtructed like fig. 13. N° 1. and during the whole ſtroke in N° 2. Neglecting this ſeemingly trifling circumſtance will diminiſh the performance at leaſt one-fifth. The conſtruction of N° 1. is the beſt, for it is hardly poſſible to make the paſſage of the other ſo free from the effects of contraction. The motion of the water during the returning ſtroke is very much contorted.

88 Acceleration of the motion of water in pumps.

There is one circumſtance that we have not taken any notice of, viz. the gradual acceleration of the motion of water in pumps. When a force is applied to the piſton, it does not in an inſtant communicate all the velocity which it acquires. It acts as gravity acts on heavy bodies; and if the reſiſtances remained the ſame, it would produce, like gravity, an uniformly accelerated motion. But we have ſeen that the reſiſtances (which are always meaſured by the force which juſt overcomes them) increaſe as the ſquare of the velocity increaſes. They therefore quickly balance the action of the moving power, and the motion becomes uniform, in a time ſo ſhort that we commit no error of any conſequence by ſuppoſing it uniform from the beginning. It would have prodigiouſly embarraſſed our inveſtigations to have introduced this circumſtance; and it is a matter of mere ſpeculative curioſity: for moſt of our moving powers are unequal in their exertions, and theſe exertions are regulated by other laws. The preſſure on a piſton moved by a crank is as variable as its velocity, and in moſt caſes is nearly in the inverſe proportion of its velocity, as any mechanician will readily diſcover. The only caſe in which we could conſider this matter with any degree of comprehenſibility is that of a ſteam-engine, or of a piſton which forces by means of a weight lying on it. In both, the velocity becomes uniform in a very ſmall fraction of a ſecond.

89 Deficiency of elementary books on this ſubject.

We have been very minute on this ſubject. For although it is the only view of a pump which is of any importance, it is hardly ever underſtood even by profeſſed engineers. And this is not peculiar to hydraulics, but is ſeen in all the branches of practical mechanics. The elementary knowledge to be met with in ſuch books as are generally peruſed by them, goes no farther than to ſtate the forces which are in equilibrio by the intervention of a machine, or the proportion of the parts of a machine which will ſet two known forces in equilibrio. But when this equilibrium is deſtroyed by the ſuperiority of one of the forces, the machine muſt move; and the only intereſting queſtion is, *what will be the motion?* Till this is anſwered with ſome preciſion, we have learned nothing of any importance. Few engineers are able to anſwer this queſtion even in the ſimpleſt caſes; and they cannot, from any confident ſcience, ſay what will be the performance of an untried machine. They gueſs at it with a ſucceſs proportioned to the multiplicity of their experience and their own ſagacity. Yet this part of mechanics is as ſuſceptible of accurate computation as the caſes of equilibrium.—We therefore thought it our duty to point out the manner of proceeding ſo circumſtantially, that every ſtep ſhould be plain and eaſy, and that conviction ſhould always accompany our progreſs. This we think it has been in our power to do, by the very ſimple method of ſubſtituting a column

lumn of water acting by its weight in lieu of any natural power which we may chance to employ.

To ſuch as wiſh to proſecute the ſtudy of this important part of hydraulics in its moſt abſtruſe parts, we recommend the peruſal of the diſſertations of Mr Pitot and Mr Boſſut, in the Memoirs of the Academy of Paris; alſo the diſſertations of the Chevalier de la Borda, 1766 and 1767; alſo the *Hydraulique* of the Chevalier De Buat. We ſhall have occaſion to conſider the motion of the water in the mains of forcing or lifting pumps which ſend the water to a diſtance, in the article *WATER-Works*; where the reader will ſee how ſmall is the performance of all hydraulic machines, in compariſon of what the uſual theories, founded on equilibrium only, would make him expect.

PUN, or PUNN, an expreſſion where a word has at once different meanings. The practice of punning is the miſerable refuge of thoſe who wiſh to paſs for wits, without having a grain of wit in their compoſition. James the I. of England delighted in punning; and the taſte of the ſovereign was ſtudied by the courtiers, and even by the clergy. Hence the ſermons of that age abound with this ſpecies of falſe wit. It continued to be more or leſs faſhionable till the reign of Queen Anne, when Addiſon, Swift, Pope, and Arbuthnot, with the other real wits of that claſſical age, united their efforts to baniſh punning from polite compoſition. It is ſtill admitted ſparingly in converſation; and no one will deny that a happy pun, when it comes unſought, contributes to excite mirth in a company. A profeſſed *punſter*, however, who is always pouring forth his ſenſeleſs quibbles, as Sancho Pança poured forth his proverbs, is ſuch an intolerable nuiſance in ſociety, that we do not wonder at Pope or Swift having written a pamphlet with the title of *God's Revenge againſt Punning*.

PUNCH, an inſtrument of iron or ſteel, uſed in ſeveral arts, for the piercing or ſtamping holes in plates of metals, &c. being ſo contrived as not only to perforate, but to cut out and take away the piece. The punch is a principal inſtrument of the metal-button makers, ſhoemakers, &c.

PUNCH is alſo a name for a ſort of compound drink, much uſed here, and in many parts abroad, particularly in Jamaica, and ſeveral other parts of the Weſt Indies.

Its baſis is ſpring-water; which being rendered cooler, briſker, and more acid, with lemon or lime juice, and ſweetened again to the palate with fine ſugar, makes what they call *ſherbet*; to which a proper quantity of ſpirituous liquor, as brandy, rum, or arrack, being added, the liquor commences punch.

PUNCHEON, PUNCHIN, or *Punchion*, a little block or piece of ſteel, on one end whereof is ſome figure, letter, or mark, engraven either in creux or relievo, impreſſions whereof are taken on metal, or ſome other matter, by ſtriking it with a hammer on the end not engraved. There are various kinds of theſe puncheons uſed in the mechanical arts; ſuch, for inſtance, are thoſe of the goldſmiths, cutlers, pewterers, &c.

The puncheon, in coining, is a piece of iron ſteeled, whereon the engraver has cut in relievo the ſeveral figures, arms, effigy, inſcription, &c. that there are to be in the matrices, wherewith the ſpecies are to be marked. Minters diſtinguiſh three kinds of puncheons, according to the three kinds of matrices to be made; that of the effigy, that of the croſs or arms, and that of the legend or inſcription. The firſt includes the whole portrait in relievo; the ſecond are ſmall, ſuch only containing a piece of the croſs or arms; for inſtance, a fleur-de-lis, an harp, a coronet, &c. by the aſſemblage of all which the entire matrice is formed. The puncheons of the legend only contain each one letter, and ſerve equally for the legend on the effigy ſide and the croſs ſide. See the article COINAGE.

For the puncheons uſed in ſtamping the matrices wherein the types of printing characters are caſt, ſee *LETTER-Foundery*.

PUNCHEON is alſo uſed for ſeveral iron tools, of various ſizes and figures, uſed by the engravers en creux on metals. Seal-engravers particularly uſe a great number for the ſeveral pieces of arms, &c. to be engraven, and many ſtamp the whole ſeal from a ſingle puncheon.

PUNCHEON is alſo a common name for all thoſe iron inſtruments uſed by ſtone-cutters, ſculptors, blackſmiths, &c. for the cutting, inciding, or piercing their ſeveral matters.

Thoſe of ſculptors and ſtatuaries ſerve for the repairing of ſtatues when taken out of the moulds. The lockſmiths uſe the greateſt variety of puncheons; ſome for piercing hot, others for piercing cold; ſome flat, ſome ſquare, ſome round, others oval, each to pierce holes of its reſpective figure in the ſeveral parts of locks.

PUNCHEON, in *Carpentry*, is a piece of timber placed upright between two poſts, whoſe bearing is too great; ſerving, together with them, to ſuſtain ſome large weights.

This term is alſo uſed for a piece of timber raiſed upright, under the ridge of a building, wherein the legs of a couple, &c. are jointed.

PUNCHEON, is alſo the name of a meaſure for liquids. Rum is brought from the colonies in puncheons, which are large caſks containing about 130 gallons.

PUNCTUATION, in *Grammar*, the art of pointing, or of dividing a diſcourſe into periods, by points expreſſing the pauſes to be made therein.

The points uſed are four, viz. the period, colon, ſemicolon, and comma. See the particular uſe of each under its proper article, COMMA, COLON, PERIOD, and SEMICOLON.

In general, we ſhall only here obſerve, that the comma is to diſtinguiſh nouns from nouns, verbs from verbs, and ſuch other parts of a period as are not neceſſarily joined together. The ſemi-colon ſerves to ſuſpend and ſuſtain the period when too long: the colon, to add ſome new ſupernumerary reaſon, or conſequence, to what is already ſaid: and the period, to cloſe up the ſenſe and conſtruction, and releaſe the voice.

It has been aſſerted, that punctuation is a modern art, and that the ancients were entirely unacquainted with the uſe of our commas, colons, &c. and wrote not only without any diſtinction of numbers and periods, but alſo without diſtinction of words: which cuſtom, Lipſius obſerves, continued till the hundred and fourth Olympiad;

PUMP. Plate CCCCXLIX.

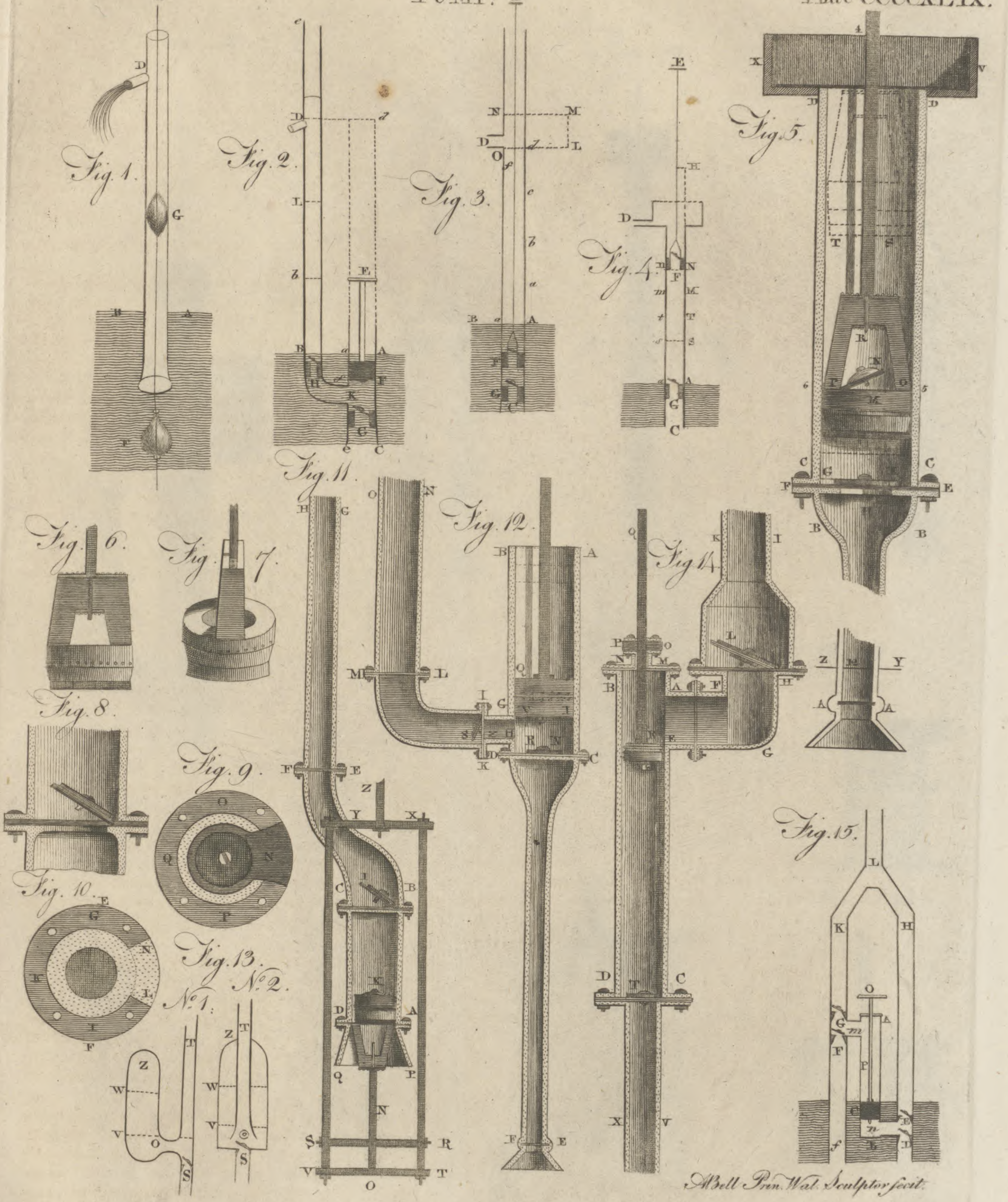


Fig. 16.

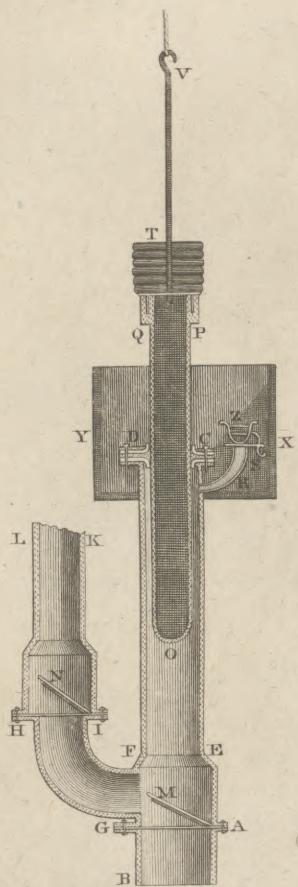


Fig. 17.

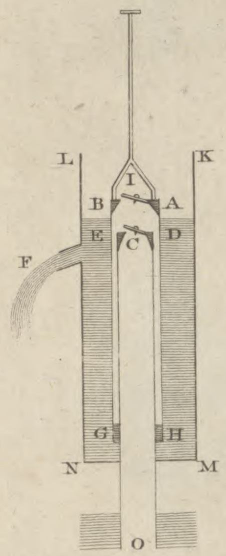


Fig. 18.

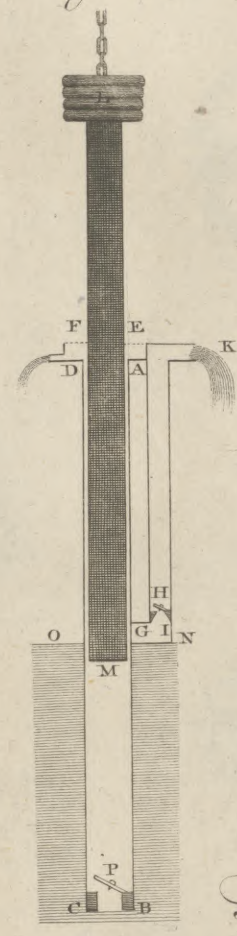


Fig. 19.

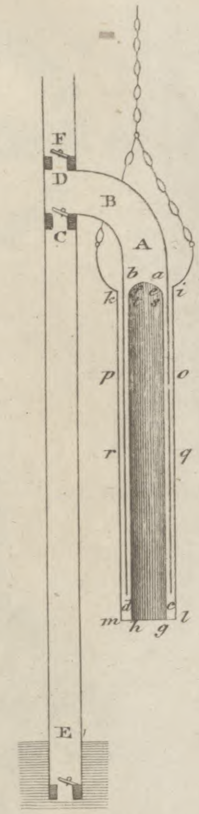


Fig. 20.

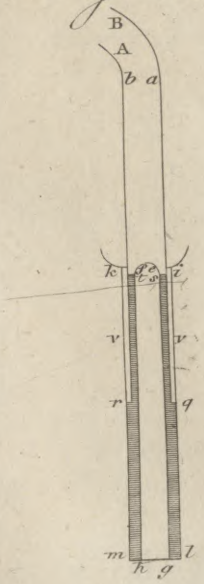


Fig. 21.

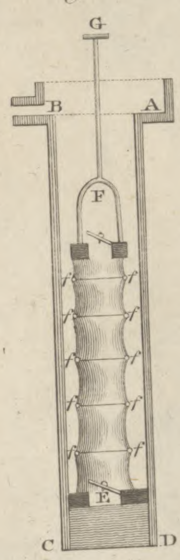


Fig. 22.

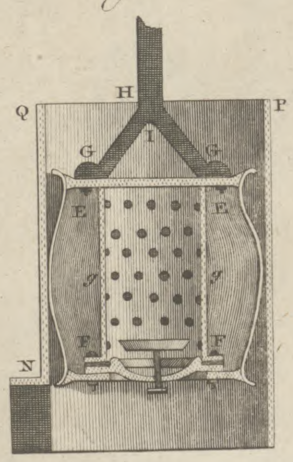


Fig. 23.

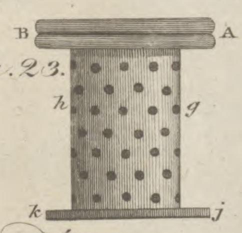
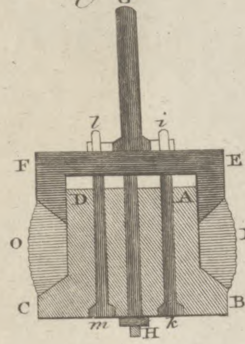
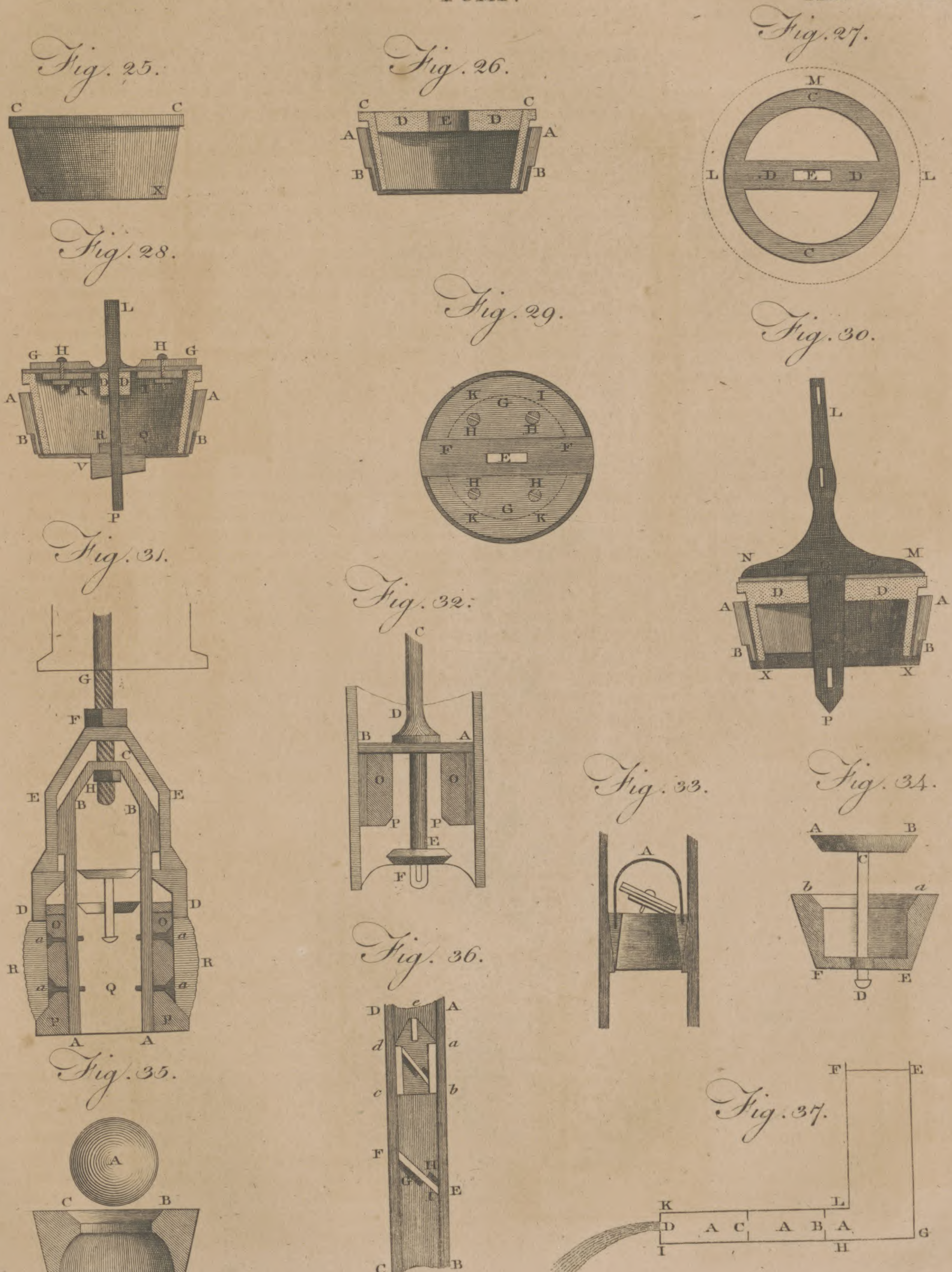


Fig. 24.



A. Bell Prin. Wal. Sculptor fecit.



A. Bell Prin. Wal. Sculptor fecit.

Punctuation.

lympiad; during which time the ſenſe alone divided the diſcourſe.

What within our own knowledge at this day puts this beyond diſpute, is the Alexandrian manuſcript, which is at preſent in the king's library, at the Britiſh Muſæum. Whoever examines this, will find that the whole is written *continuo ductu*, without diſtinction of words or ſentences. How the ancients read their works written in this manner, it is not eaſy to conceive.

After the practice of joining words together ceaſed, notes of diſtinction were placed at the end of every word. In all the editions of the *Faſti Capitolini* theſe points occur. The ſame are to be ſeen on the *Columna Roſtrata*. For want of theſe, we find much confuſion in the *Chronicon Marmoreum*, and the covenant between the Smyrnæans and Magneſians, which are both now at Oxford. In Salmaſius's edition of *Dedicatio ſtatuæ rigillæ Herodis*, the like confuſion occurs, where we find ΔΕΥΡΙΤΕ and Δευϱ ιτε.

Of theſe marks of diſtinction, the Walcote inſcription found near Bath may ſerve as a ſpecimen:

IVLIUSv VITALISv FABRI
CESISv LEGv XXVv Vv V
STIPENDIORUMv &c.

After every word here, except at the end of a line, we ſee this mark v. There is an inſcription in Montfaucon, which has a capital letter laid in an horizontal poſition, by way of interſtitial mark, which makes one apt to think that this way of pointing was ſometimes according to the fancy of the graver.

P. FERRARIVS HERMES
CAECINIAE ⊣ DIGNAE
CONIVGI ⊣ KARISSIMAE
NVMERIAE ⊣ &c.

Here we obſerve after the words a T laid horizontally, but not after each word, which proves this to be of a much later age than the former.

As the improvement of ſtops appears not to have taken place while manuſcripts and monumental inſcriptions were the only known methods to convey knowledge, it is conjectured that it was introduced with the art of printing. The 14th century, to which we are ſuppoſed to be indebted for this invention, did not, however, beſtow thoſe appendages we call *ſtops*: whoever will be at the pains of examining the firſt printed books, will diſcover no ſtops of any kind; but arbitrary marks here and there, according to the humour of the printer. In the 16th century, we obſerve their firſt appearance. We find, from the books of this age, that they were not all produced at the ſame time; thoſe we meet with there in uſe, being only the comma, the parentheſis, the interrogation, and the full point. To prove this, we need but look into Bale's Acts of Engliſh Votaries, black letter, printed 1550. Indeed, in the dedication of this book, which is to Edward VI. we diſcover a colon: but, as this is the only one of the kind throughout the work, it is plain this ſtop was not eſtabliſhed at this time, and ſo warily put in by the printer; or if it was, that it was not in common uſe. Thirty years after this time, in that ſenſible and judicious performance of Sir Thomas Elyot, entitled *The Governour*, imprinted 1580, we ſee the colon as frequently introduced as any other ſtop; but the ſemicolon and the admiration were ſtill wanting, neither of theſe being viſible in this book. In Hackluyt's Voyages, printed 1599, we ſee the ſemicolon: and, as if the editors did not fully apprehend the propriety of its general admiſſion, it is but ſparingly introduced. It has been ſaid, indeed, that the ſemicolon was brought into uſe at a much earlier period; but it appears that it was only for the purpoſe of an abbreviation, as in (*namq;*) (*neq;*) for *namque*, *neque*, and not in the ſenſe in which it is now employed, *Month. Mag.* v. 411.

The ſemicolon, indeed, as well as all the ordinary points, is uſed in a work entitled "Imagines Deorum," printed at Leyden, in the year 1581, in Roman characters. We likewiſe meet with them in the tranſlation of a juſtly celebrated book, written in French by that wiſe and good man, Philip Mornay, lord of Pleſſis; in the "Schoolmaſter" of Roger Aſcham, printed in 1570, with the exception of the ſemicolon; and in the "Trewneſſe of the Chriſtian Religion," by Sir Philip Sidney, publiſhed in 1587, in which we find the aſteriſk, brackets, the interrogation, the comma and the ſemicolon, all as we now uſe them; and the colon and period are ſquare dots.

In an alchemical manuſcript of the date of 1572, the ſemicolon is ſaid to be met with, as well as the other three points which are in common uſe. The colon and period are abundant in a work entitled "Dioniſius de Situ Orbis," printed at Venice in 1498, but none of the other ſtops or points. The ſingle point (.) appears to be the moſt ancient. Since the year 1485 the colon was introduced; the comma is firſt ſeen about the year 1521; and the more refined ſemicolon was brought into uſe about the year 1570.

The invention of the ſemicolon is moſt probably due to the Engliſh; for from the Leyden edition of Pliny, 1553, it is evident that the Dutch printers were not then in the practice of uſing it; and if in 1570, they were, Roger Aſcham would probably have employed it; for the Dutch were the principal claſſical printers in his time; but we find that ſome Engliſh books were marked with it at that period.

The admiration was the laſt ſtop that was invented. and ſeems to have been added to the reſt in a period not ſo far diſtant from our own time.

Thus we ſee that theſe notes of diſtinction came into uſe as learning was gradually advanced and improved; one invention indeed, but enlarged by ſeveral additions.

But notwithſtanding what has been ſaid relative to the uſe of ſtops as being a modern invention, we ſhall find reaſon to be ſatisfied that the ancients were not unacquainted with the method of making pauſes in ſpeaking and writing, if we attend to the following elaborate inveſtigation of Mr Warburton, which we ſhall lay before our readers in the words of the author.

"Some ſpecies of pauſes and diviſions of ſentences in ſpeaking and writing muſt have been coeval with the knowledge of communicating ideas by ſound or by ſymbols.

"Suidas * ſays, that the *period* and the *colon* were diſcovered and explained by Thraſymachus, about 380 years before the Chriſtian æra. Cicero † ſays, that Thraſymachus was the firſt who ſtudied oratorical numbers, which entirely conſiſted in the artificial ſtructure of periods and colons. It appears from a paſſage in Ariſtotle ‡, that punctuation was known in his time. The learned

* *De Thraſymacho.*

† *Cicero Orat.* § 33.

‡ *Rhet.* lib. iii. c. 5.

Punctuation.

learned Dr Edward Bernard * refers the knowledge of pointing to the time of that philoſopher, and ſays, that it conſiſted in the different poſition of one ſingle point. At the bottom of a letter; thus, (A.) it was equivalent to a comma; in the middle (A·) it was equal to a colon; at the top (A˙) it denoted a period, or the concluſion of a ſentence.

* *Bern. Orbis erud. Literat.* tab 30. edit. 1689.

"This mode was eaſily practiſed in Greek manuſcripts, while they were written in capitals. But when the ſmall letters were adopted, that is, about the ninth century, this diſtinction could not be obſerved; a change was therefore made in the ſcheme of punctuation. *Unciales literas hodierno uſu dicimus eas in vetuſtis codicibus, quæ priſcam formam ſervant, ac ſolutæ ſunt, nec mutuò colligantur. Hujus modi literæ unciales obſervantur in libris omnibus ad nonum uſque ſæculum.* Montf. Palæog. Recens. p. xii.

"According to Cicero, the ancient Romans as well as the Greeks made uſe of points. He mentions them under the appellation of *librariorum notæ;* and in ſeveral parts of his works he ſpeaks of '*interpunctæ clauſulæ in orationibus*', of '*clauſulæ atque interpunctæ verborum*', of *interpunctiones verborum, &c* †.

"Seneca, who died A. D. 65, expreſsly ſays, that Latin writers in his time, had been uſed to punctuation. '*Nos* ‡, *cum ſcribimus interpungere conſuevimus.*' Muretus and Lipſius imagined that theſe words alluded to the inſertion of a point after each word; but they certainly were miſtaken, for they muſt neceſſarily refer to marks of punctuation in the diviſion of ſentences, becauſe in the paſſage in which theſe words occur, Seneca is ſpeaking of one Q. Haterius, who made no pauſes in his orations.

† *Cic. de Orat.* lib. iii § 26. *Ibid.* 7. *Orat. pro Muraena,* § 2c.

‡ *Sen. Epiſt.* 40.

"According to Suetonius in his Illuſt. Gram. Valerius Probus procured copies of many old books, and employed himſelf in correcting, pointing and illuſtrating them; devoting his time to this and no other part of grammar. *Multa exemplaria contracta emendare, ac diſtinguere et adnotare curavit; ſoli huic, nec ulli præterea, grammatices parti deditus.*

"It appears from hence that in the time of Probus, or about the year 68, that Latin manuſcripts had not been uſually pointed; and that grammarians made it their buſineſs to ſupply this deficiency.

"Quintilian, who wrote his celebrated treatiſe on Oratory, about the year 88, ſpeaks of commas, colons, and periods; but it muſt be obſerved, that by theſe terms he means clauſes, members, and complete ſentences, and not the marks of punctuation §.

§ *Quinct.* lib. ix. c. 4.

"Ælius Donatus ‖ publiſhed a treatiſe on Grammar in the fourth century, in which he explains the *diſtinctio*, the *media diſtinctio*, and the *ſubdiſtinctio*: that is, the uſe of a ſingle point in the various poſitions already mentioned.

‖ A. D. 340.

"Jerom *, who had been the pupil of Donatus, in his Latin Verſion of the ſcriptures, made uſe of certain diſtinctions or diviſions, which he calls *cola* and *commata*. It has however been thought probable, that theſe diviſions were not made by the addition of any points or ſtops; but were formed by writing, in one line, as many words as conſtituted a clauſe, equivalent to what we diſtinguiſh by a comma or a colon. Theſe diviſions were called στιχοι or ῥηματα; and had the appearance of ſhort irregular verſes in poetry. There are ſome Greek manuſcripts ſtill extant, which are written in this manner †.

* *Hieron. Præf. in Eſaiam.* Vide etiam *Præf. in Joſuam,* &c. tom. iii. p. 26.

† Vide *Montf. Palæog. Græca,* lib. iii. c. 4.

"The beſt treatiſe upon punctuation I have ſeen, and from which theſe authorities are partly taken, was publiſhed ſome years ſince and dedicated to Sir Clifton Wintringham, Bart. the name of the author I know not *."

Punctum ‖ Puniſhment

* *Month. Mag.* vi. 186.

PUNCTUM SALIENS, in *Anatomy*, the firſt rudiments of the heart in the formation of the fœtus, where a throbbing motion is perceived. This is ſaid to be eaſily obſerved with a microſcope in a brood-egg, wherein after conception, we ſee a little ſpeck or cloud, in the middle whereof is a ſpot that appears to beat or leap a conſiderable time before the fœtus is formed for hatching. See the articles FOETUS and ANATOMY.

PUNCTUM ſtans, a phraſe by which the ſchoolmen vainly attempt to bring within the reach of human comprehenſion the poſitive eternity of God. Thoſe ſubtile reaſoners ſeem to have diſcovered that nothing, which is made up of parts, whether continuous or diſcrete, can be abſolutely infinite, and that therefore eternity cannot conſiſt of a boundleſs ſeries of ſucceſſive moments. Yet, as if ſuch a ſeries had always exiſted, and were commenſurate in duration with the ſupreme Being, they compared his eternity to one of the moments which compoſe the flux of time arreſted in its courſe: and to this eternal moment they gave the name of *punctum ſtans*, becauſe it was ſuppoſed to ſtand ſtill, whilſt the reſt followed each other in ſucceſſion, all vaniſhing as ſoon as they appeared. We need not waſte time or room in expoſing the abſurdity of this conceit, as we have elſewhere endeavoured, in the beſt manner we can, to aſcertain the meaning of the words *eternity* and *infinity*, and to ſhow that they cannot be predicated of time or ſpace, of points or moments, whether flowing or ſtanding ſtill. See METAPHYSICS, Part II. chap. 7. 8. and Part III. chap. 6.

PUNCTURE, in *Surgery*, any wound made by a ſharp-pointed inſtrument.

PUNDITS, or PENDITS, learned Bramins devoted to the ſtudy of the Sanſcrit language, and to the ancient ſcience, laws, and religion of Hindoſtan. See PHILOSOPHY, n° 4—12.

PUNICA, the POMEGRANATE TREE, a genus of plants belonging to the icoſandria claſs, and in the natural method ranking under the 36th order, *Pomaceæ*. See BOTANY *Index*.

PUNISHMENT, in *Law*, the penalty which a perſon incurs on the commiſſion of a crime. See the article *CRIME and Puniſhment*.

The ingenuity of men has been much exerted to torment each other; but the following are the puniſhments that have been uſually adopted in the different countries of the world. The capital puniſhments have been beheading, crucifixion, burning, roaſting, drowning, ſcalping, hanging by the neck, the arm, or the leg, ſtarving, ſawing, expoſing to wild beaſts, rending aſunder by horſes drawing oppoſite ways, burying alive, ſhooting, blowing from the mouth of a cannon, compulſory deprivation of ſleep, rolling in a barrel ſtuck with nails pointed inwards, poiſoning, preſſing ſlowly to death by a weight laid on the breaſt, caſting headlong from a rock, tearing out the bowels, pulling to pieces with red-hot pincers, the rack, the wheel, impaling, flaying alive, &c. &c.

The puniſhments ſhort of death have been fine, pillory, impriſonment, compulſory labour at the mines, galleys,

leys, highways, or correction-houfe; whipping, baftinading, mutilation by cutting away the ears, the nofe, the tongue, the breafts of women, the foot, the hand; fqueezing the marrow from the bones with fcrews or wedges, caftration, putting out the eyes, banifhment, running the gauntlet, drumming, fhaving off the hair, burning on the hand or forehead, &c.

PUNNING. See PUN.

PUPIL, in the *Civil Law*, a boy or girl not yet arrived at the age of puberty; i. e. the boy under 14 years, the girl under 12.

PUPIL, is alfo ufed in univerfities, &c. for a youth under the education or difcipline of any perfon.

PUPIL, in *Anatomy*, a little aperture in the middle of the uvea and iris of the eye, through which the rays of light pafs to the cryftalline humour, in order to be painted on the retina, and caufe vifion. See ANATOMY *Index*.

PURCELL, HENRY, a juftly celebrated mafter of mufic, began early to diftinguifh himfelf. As his genius was original, it wanted but little forming, and he rofe to the height of his profeffion with more eafe than others pafs through their rudiments. He was made organift to Weftminfter abbey in the latter end of the reign of Charles II. In that of William, he fet feveral fongs for Dryden's *Amphytrion* and his *King Arthur*, which were received with juft applaufe. His notes in his operas were admirably adapted to his words, and fo echoed to the fenfe, that the founds alone feemed capable of exciting thofe paffions which they never failed to do in conjunction. His mufic was very different from the Italian. It was entirely Englifh, and perfectly mafculine. His principal works have been publifhed under the title of *Orpheus Britannicus*. He died in 1695, in the 37th year of his age, and was interred in Weftminfter abbey, where a monument is erected to his memory.

PURCHAS, SAMUEL, an Englifh divine, famous for compiling a valuable collection of voyages, was born in 1577, at Thackfted in Effex. After ftudying at Cambridge, he obtained the vicarage of Eaftwood in his native county; but leaving that cure to his brother, he fettled in London, in order to carry on the great work in which he was engaged. He publifhed the firft volume in folio 1613, and the four laft, 12 years after, under the title of *Purchas his Pilgrimage, or Relations of the world, and the Religions obferved in all ages and places.* Meanwhile he was collated to the rectory of St Martin's, Ludgate, in London, and made chaplain to Dr Abbot, archbifhop of Canterbury. His *Pilgrimage*, and the learned Hackluyt's *Voyages*, led the way to all the other collections of that kind, and have been juftly valued and efteemed. But unhappily, by his publifhing, he involved himfelf in debt: he did not, however, die in prifon, as fome have afferted; but at his own houfe, about the year 1628.

PURCHASE, in *Law*, the buying or acquiring of lands, &c. with money, by deed or agreement, and not by defcent or right of inheritance.

PURCHASE, in the fea-language, is the fame as *draw in*: thus, when they fay, the capftan purchafes a-pace, they only mean it draws in the cable a-pace.

PURE, fomething free from any admixture of foreign or heterogeneous matters.

PURFLEW, a term in heraldry, expreffing ermins, peans, or any of the furs, when they compofe a bordure round a coat of arms: thus they fay, He beareth gules, a bordure, purflew, vairy; meaning, that the bordure is vairy.

PURGATION, the art of purging, fcouring, or purifying a thing, by feparating, or carrying off any impurities found therein. Thus,

In pharmacy, purgation is the cleanfing of a medicine by retrenching its fuperfluities. In chemiftry, it is ufed for the feveral preparations of metals and minerals intended to clear them of their impurities, more ufually called *purification* and *refining*.

In medicine, purgation is an excretory motion arifing from a quick and orderly contraction of the flefhy fibres of the ftomach and inteftines, whereby the chyle, corrupted humours, and excrements lodged therein, are protruded farther and further, and at length quite excluded the body by ftool. See MATERIA MEDICA.

PURGATION, in *Law*, fignifies the clearing a perfon's felf of a crime of which he is fufpected and accufed before a judge. This purgation is either canonical or vulgar. Canonical purgation is prefcribed by the canon-law, and the form thereof in the fpiritual court is ufually thus: The perfon fufpected takes his oath that he is innocent of the crime charged againft him; and at the fame time brings fome of his neighbours to make oath that they believe he fwears truly. Vulgar purgation was anciently by fire or water, or elfe by combat, and was practifed here till abolifhed by our canons. See BATTEL, *in law*; ORDEAL, &c.

PURGATIVE, or *PURGING Medicines*, medicaments, which evacuate the impurities of the body by ftool, called alfo *cathartics*.

PURGATORY, a place in which the juft, who depart out of this life, are fuppofed to expiate certain offences which do not merit eternal damnation. Broughton has endeavoured to prove, that this notion has been held by Pagans, Jews, and Mahometans, as well as by Chriftians; and that in the days of the Maccabees the Jews believed that fin might be expiated by facrifice after the death of the finner, cannot be queftioned.

Papift mifreprefented and reprefented.

Much abufe has been poured upon the church of Rome for her doctrine of purgatory, and many falfe reprefentations have been made of the doctrine itfelf. The following view of it is taken from a work which is confidered as a ftandard by the Britifh Catholics. 1. Every fin, how flight foever, though no more than an idle word, as it is an offence to God, deferves punifhment from him, and will be punifhed by him hereafter, if not cancelled by repentance here. 2. Such fmall fins do not deferve eternal punifhment. 3. Few depart this life fo pure as to be totally exempt from fpots of this nature, and from every kind of debt due to God's juftice. 4. Therefore few will efcape without fuffering fomething from his juftice for fuch debts as they have carried with them out of this world; according to that rule of divine juftice, by which he treats every foul hereafter according to its works, and according to the ftate in which he finds it in death. From thefe propofitions, which the Papift confiders as fo many felf-evident truths, he infers that there muft be fome third place of punifhment; for, fince the infinite goodnefs of God can admit nothing into heaven which is not clean and pure from all fin both great and fmall; and his infinite juftice can permit none to receive the reward of blifs, who

who as yet are not out of debt, but have ſomething in juſtice to ſuffer; there muſt of neceſſity be ſome place or ſtate, where ſouls, departing this life, pardoned as to the eternal guilt or pain, yet obnoxious to ſome temporal penalty, or with the guilt of ſome venial faults, are purged and purified before their admittance into heaven. And this is what he is taught concerning purgatory. Which, though he knows not where it is, of what nature the pains are, or how long each ſoul is detained there; yet he believes, that thoſe that are in this place, being the living members of Jeſus Chriſt, are relieved by the prayers of their fellow members here on earth, as alſo by alms and maſſes offered up to God for their ſouls. And as for ſuch as have no relations or friends to pray for them, or give alms, or procure maſſes for their relief; they are not neglected by the church, which makes a general commemoration of all the faithful departed in every maſs, and in every one of the canonical hours of the divine office.

Such is the Popiſh doctrine of purgatory, which is built chiefly upon 2 Macc. xii. 43, 44, 45; St Matth. xii. 31, 32; and 1 Cor. iii. 15. By Proteſtants the books of Maccabees are not acknowledged to be inſpired ſcripture; but if they were, the texts referred to would rather prove that there is no ſuch place as purgatory, ſince Judas did not expect the ſouls departed to reap any benefit from his ſin-offering till the reſurrection. Our Saviour, in St Luke, ſpeaks of remiſſion in *this world*, and in the world to *come;* but ſurely neither of theſe is purgatory. The world to come is the ſtate after the reſurrection, and the remiſſion ſpoken of is the ſentence of abſolution to be pronounced on the penitent from the ſeat of general judgement. In the obſcure verſe referred to in the epiſtle to the Corinthians, the apoſtle is, by the beſt interpreters, thought to ſpeak of the difficulty with which Chriſtians ſhould be ſaved from the deſtruction of Jeruſalem. Of the ſtate of ſouls departed he cannot well be ſuppoſed to ſpeak, as upon diſembodied ſpirits fire could make no impreſſion. We cannot help, therefore, thinking with the church of England, that "the Romiſh doctrine of purgatory is a fond thing, vainly invented, and grounded on no warranty of ſcripture;" but we muſt confeſs at the ſame time, that it appears to us to be a very harmleſs error, neither hoſtile to virtue nor dangerous to ſociety. See RESURRECTION.

PURIFICATION, in matters of religion, a ceremony which conſiſts in cleanſing any thing from a ſuppoſed pollution or defilement.

The Pagans, before they ſacrificed, uſually bathed or waſhed themſelves in water; and they were particularly careful to waſh their hands, becauſe with theſe they were to touch the victims conſecrated to the gods. It was alſo cuſtomary to waſh the veſſel with which they made their libations. The Mahometans alſo uſe purifications previous to the duty of prayer; which are alſo of two kinds, either bathing, or only waſhing the face, hands, and feet. The firſt is required only in extraordinary caſes, as after having lain with a woman, touched a dead body, &c. But leſt ſo neceſſary a preparation for their devotions ſhould be omitted, either where water cannot be had, or when it may be of prejudice to a perſon's health, they are allowed in ſuch caſes to make uſe of fine ſand, or duſt, inſtead of it; and then they perform this duty by clapping their open hands on the ſand, and paſſing them over the parts, in the ſame manner as if they were dipped in water.

There were alſo many legal purifications among the Hebrews. When a woman was brought to bed of a male child, ſhe was eſteemed impure for 40 days; and when of a female, for 60: at the end of which time ſhe carried a lamb to the door of the temple to be offered for a burnt-offering, and a young pigeon or turtle for a ſin-offering; and by this ceremony ſhe was cleanſed or purified.

PURIM, or *The FEAST of LOTS*, a ſolemn feſtival of the Jews, inſtituted in memory of the deliverance they received, by means of Mordecai and Eſther, from Haman's wicked attempt to deſtroy them.

PURITAN, a name formerly given in deriſion to the diſſenters from the church of England, on account of the profeſſion to follow the pure word of God, in oppoſition to all traditions and human conſtitutions. It was likewiſe given in the primitive church to the Novatian ſchiſmatics, becauſe they would never admit to communion any one who from dread of death had apoſtatized from the faith.

PURITY, the freedom of any thing from foreign admixture.

PURITY of Style. See ORATORY, p. 411, &c.

PURLIEU, ſignifies all that ground near any foreſt, which being made foreſt by King Henry II. Richard I. and King John, was afterwards by perambulations and grants of Henry III. ſevered again from the ſame, and made purlieu; that is to ſay, pure and free from the laws of the foreſt.—The word is derived from the French *pur* "pure," and *lieu* "place."

PURLINS, in building, thoſe pieces of timber that lie acroſs the rafters on the inſide, to keep them from ſinking in the middle of their length.

By the act of parliament for rebuilding London, it is provided, that all purlins from 15 feet 6 inches to 18 feet 6 inches long, be in their ſquare 9 inches and 8 inches; and all in length from 18 feet 6 inches to 21 feet 6 inches, be in their ſquare 12 inches and 9 inches.

PURPLE, a colour compoſed of a mixture of red and blue. See *COLOUR-Making*, N° 29, and DYEING, *Index*.

PURPURA, in *Natural Hiſtory*. See MUREX, CONCHOLOGY *Index*. The Tyrian method of dyeing purple was with a liquid extracted from this fiſh. It has been affirmed, however, that no ſuch method was ever practiſed. "At Tyre (ſays Mr Bruce) I engaged two fiſhermen, at the expence of their nets, to drag in thoſe places where they ſaid ſhell-fiſh might be caught, in hopes to have brought out one of the famous purple-fiſh. I did not ſuceed; but in this I was, I believe as lucky as the old fiſhers had ever been. The purple-fiſh at Tyre ſeems to have been only a concealment of their knowledge of cochineal; as, had they depended upon the fiſh for their dye, if the whole city of Tyre applied to nothing elſe but fiſhing, they would not have coloured 20 yards of cloth in a year."

PURPURE, in *Heraldry*. The colour ſo called, which ſignifies *purple*, is in engraving repreſented by diagonal lines, from the left to the right. See HERALDRY.

It may ſerve to denote an adminiſtrator of juſtice, a lawgiver, or a governor equal to a ſovereign: and according to G. Leigh, if it is compounded with

Or,	it ſignifies	Riches.
Arg.		Quietneſs.
Gul.		Politics.
Az.		Fidelity.
Ver.		Cruelty.
Sab.		Sadneſs.

PURRE, or PERKIN. See AGRICULTURE *Index*.

PURSER, an officer aboard a man of war, who receives her victuals from the victualler, ſees that it be well ſtowed, and keeps an account of what he every day delivers to the ſteward. He alſo keeps a liſt of the ſhip's company, and ſets down exactly the day of each man's admiſſion, in order to regulate the quantity of proviſions to be delivered out, and that the paymaſter or treaſurer of the navy may iſſue out the deburſements, and pay off the men, according to his book.

PURSLAIN. See PORTULACA, BOTANY *Index*.

PURVIEW, a term uſed by ſome lawyers for the body of an act of parliament, or that part which begins with "Be it enacted &c." as contradiſtinguiſhed from the preamble.

PURULENT, in *Medicine*, ſomething mixed with, or partaking of, pus or matter.

PUS, in *Medicine*, a white or yellowiſh matter deſigned by nature for the healing and cementing of wounds and ſores.

The origin and formation of pus is as much unknown as that of any other animal fluid. In an inaugural diſſertation publiſhed at Edinburgh by Dr Hendy, the author ſuppoſes pus to be a ſecreted fluid. It has been thought by many, that pus is either a ſediment from ſerum when beginning to putrefy, or that it is the ſame fluid inſpiſſated by the heat of the body. But both theſe opinions are refuted by ſome experiments of our author, which ſhow, that pus is much leſs inclined to putrefaction than ſerum, and the putrefaction of both is haſtened by an addition of ſome of the red part of the blood. Some other experiments were made in order to try whether pus could be artificially produced. A thin piece of lamb's fleſh, applied to an ulcer diſcharging laudable pus, and covered over with lead, did not aſſume the appearance of pus, but became fetid, and was much leſſened. Serum, in its inflammatory and in its ordinary ſtate, and lymph in different ſtates, were applied to the ſame ulcer, which ſtill diſcharged good pus; but none of theſe were converted into pus; on the contrary, they became very putrid.

In oppoſition to theſe arguments of our author, however, it may be alleged, that if pus was a ſecreted fluid, the veſſels by which it was ſecreted would certainly be viſible; but no ſuch thing has ever been obſerved: on the contrary, it is certain that pus cannot be formed unleſs the air is excluded from the wound. Theſe diſputes, however, are of no great conſequence: but in ſome caſes it becomes a matter of real importance to diſtinguiſh pus from mucus; as thus we may be enabled to know whether a cough is conſumptive, or merely catarrhous. See MUCUS. Mr Home, in a diſſertation on the properties of pus, in which he avails himſelf of the experiments of Mr Hunter, as delivered in his *Phyſiological Lectures*, ſays, "that the characteriſtic of pus is its being compoſed of globules; and he thinks that the preſence of globules ſeems to depend upon the pus being in a perfect ſtate. It differs from the blood in the colour of the globules; in their not being ſoluble in water, which thoſe of the blood are; and from the fluid in which they ſwim being coagulable by a ſolution of ſal ammoniac, which ſerum is not." Reſpecting the formation of pus, our author adopts the idea ſuggeſted by Mr Hunter, that the veſſels of the part aſſume the nature of a gland, and ſecrete a fluid which becomes pus. Mr Home aſcertains, by experiment, that pus, at its formation, is not globular, but a tranſparent fluid, of a conſiſtence, in ſome ſort, reſembling jelly; and that the globules are formed while lying upon the ſurface of the ſore; requiring, in ſome inſtances, while the influence of the external air is excluded, fifteen minutes for that purpoſe.

PUSTULE, a pimple, or ſmall eruption on the ſkin full of pus; ſuch as the eruptions of the ſmallpox.

PUTAMINEÆ, (from *putamen* "a ſhell,") the name of the 25th order of Linnæus's fragments of a natural method; conſiſting of a few genera of plants allied in habit, whoſe fleſhy ſeed-veſſel or fruit is frequently covered with a hard woody ſhell. See BOTANY.

PUTEOLI, (Livy, Strabo): a town of Campania; ſo called either from its wells, there being many hot and cold ſprings thereabouts; or from its ſtench, *putor*, cauſed by ſulphureous exhalations, (Varro, Strabo). It is now called *Puzzuoli*, and is pleaſantly and advantageouſly ſituated for trade. In a very remote age, the Cumeans made it their arſenal and dockyard; and to this naval eſtabliſhment gave the ſublime appellation of *Dicearchia* or *Juſt Power*.

Swinburne's Travels in the Two Sicilies.

The Romans were well aware of the utility of this port, and took great pains to improve its natural advantages. Nothing remains of their works but a line of piers, built to break the force of a rolling ſea: they are vulgarly called the *bridge of Caligula*, becauſe that madman is ſaid to have marched in triumph from Puzzuoli to Baia on a bridge; but his was a bridge of boats.

The ruins of its ancient edifices are widely ſpread along the adjacent hills and ſhores. An amphitheatre ſtill exiſts entire in moſt of its parts, and the temple of Serapis offers many curious ſubjects of obſervation; half of its buildings are ſtill buried under the earth thrown upon it by volcanical commotions, or accumulated by the crumblings of the hill; the incloſure is ſquare, environed with buildings for prieſts and baths for votaries; in the centre remains a circular platform, with four flights of ſteps up to it, vaſes for fire, a centrical altar, rings for victims, and other appendages of ſacrifice, entire and not diſplaced; but the columns that held its roof have been removed to the new palace of Caſerta (ſee CASERTA). Behind this round place of worſhip ſtand three pillars without capitals, part of the pronaos of a large temple; they are of cipoline marble, and at the middle of their height are full of holes eaten in them by the file-fiſh *.

The preſent city contains near 10,000 inhabitants, and occupies a ſmall peninſula; the cathedral was a pagan temple, dedicated to the divinities that preſided over commerce and navigation. E. Long. 14. 40. N. Lat. 41. 15.

* *Pholas Dactylus*, Linn.

In the neighbourhood of Puteoli are many relicks of ancient grandeur, of which none deserves more attention than the Campanian way paved with lava, and lined on each side with venerable towers, the repositories of the dead, which are richly adorned with stucco in the inside. This road was made in a most solid expensive manner by order of Domitian, and is frequently the subject of encomium in the poems of Statius.

PUTI CARAJA, in *Botany*, is a genus of Indian plants, of which the characters, as given by Sir William Jones in the Asiatic Researches, vol. ii. p. 351. are these. The calyx is five-cleft, the corolla has five equal petals, the pericarpium a thorny legumen and two seeds, the leaves oval and pinnated, and the stem armed. "The seeds (says the learned President) are very bitter, and perhaps tonic; since one of them, bruised and given in two dozes, will, as the Hindoos assert, cure an intermittent fever."

PUTORIUS, See MUSTELA, MAMMALIA *Index*.

PUTREFACTION, is the natural process by which organized bodies are dissolved, and reduced to what may be called their *original elements*.

Putrefaction differs from chemical solution; because in the latter, the dissolved bodies are kept in their state of solution by being combined with a certain agent from which they cannot easily be separated; but in putrefaction, the agent which dissolves the body appears not to combine with it in any manner of way, but merely to separate the parts from each other. It differs also from the resolution of bodies by distillation with violent fire; because, in distillation new and permanent compounds are formed, but by putrefaction every thing seems to be resolved into substances much more simple and indestructible than those which are the result of any chemical process.

The bodies most liable to putrefaction are those of animals and vegetables, especially when full of juices. Stones, though by the action of the weather they will moulder into dust, yet seem not to be subject to any thing like a real putrefaction, as they are not resolved into any other substance than sand, or small dust, which still preserves its lapideous nature. In like manner, vegetables of any kind, when deprived of their juices by drying, may be preserved for many ages without being subjected to any thing like a putrefactive process. The same holds good with respect to animals; the parts of which, by simple drying, may be preserved in a sound state for a much longer time than they could be without the previous exhalation of their juices.

Putrefaction is generally allowed to be a kind of fermentation, or rather to be the last stage of that process; which, beginning with the vinous fermentation, goes on through the acetous, to the stage of putridity, where it stops. It is argued, however, and seemingly not without a great deal of reason, that if putrefaction be a fermentation, it must necessarily be a kind distinct from either the vinous or acetous; since we frequently observe that it takes place where neither the vinous nor the acetous stages have gone before; of consequence, it must be, in some cases at least, entirely independent of and unconnected with them. In several other respects it differs so much from these processes, that it seems in some degree doubtful whether it can with propriety be called a *fermentation* or not. Both the vinous and acetous fermentations are attended with a considerable degree of heat: but in the putrefaction of animal matters especially, the heat is for the most part so small, that we cannot be certain whether there is any degree of it or not produced by the process. In cases, indeed, where the quantity of corrupting animal matter is very great, some heat may be perceived: and accordingly Dr Monro tells us, that he was sensible of heat on thrusting his hand into the flesh of a dead and corrupting whale. But the most remarkable difference between the putrefactive fermentation and that of the vinous and acetous kinds is, that the end of both these processes is to produce a new and permanent compound; but that of the putrefactive process is not to produce any new form, but to destroy, and resolve one which already exists into the original principles from which all things seem to proceed. Thus, the vinous fermentation produces ardent spirits; the acetous, vinegar: but putrefaction produces nothing but earth, and some effluvia, which, though most disagreeable, and even poisonous to the human body, yet, being imbibed by the earth and vegetable creation, give life to a new race of beings. It is commonly supposed, indeed, that volatile alkali is a production of the putrefactive process: but this seems liable to dispute. The vapour of pure volatile alkali is not hurtful to the human frame, but that of putrefying substances is exceedingly so; and, excepting in the case of urine, the generation of volatile alkali in putrid substances is very equivocal. This substance, which produces more alkali than any other, is much less offensive by its putrid fetor than others; and all animal substances produce a volatile alkali on being exposed to the action of fire, of quicklime, or of alkaline salts. In these cases the volatile alkali is not supposed to be produced by the quicklime or fixed salt, but only to be extricated from a kind of ammoniacal salt pre-existing in the animal matters; the probability is the same in the other case, viz. that volatile alkali is not produced, but only extricated, from these substances by putrefaction.

The only thing in which the putrefactive fermentation agrees with the other kinds is, that in all the three there is an extrication of fixed air. In the putrefactive process, it has been thought that this escape of the fixed air deprives the body of its cohesion: and Dr Macbride has written a treatise, in which he endeavours to prove, that fixed air is the very power of cohesion itself, and that all bodies when deprived of their fixed air entirely lose their cohesion. According to this hypothesis, the cause of putrefaction is the escape of fixed air; but it is impossible to give a reason why fixed air, after having so long remained in a body, and preserved its cohesion, should of a sudden begin to fly off without being acted upon by something else. To a similar objection the hypothesis of those is liable, who suppose putrefaction to be occasioned by the escape of phlogiston; for phlogiston is now known to be a chimera: and though it were a reality, it would not fly off without something to carry it off, any more than fixed air. Animalcules have been thought to be the cause of putrefaction: but if animal substances are covered so as to exclude the access of flies or other insects, no such animalcules are to be discovered though putrefaction has taken place; and indeed it requires little proof to convince us, that animals are produced in corrupted bodies only because such substances prove a proper nidus for the eggs of the parent insects.

To

Putrefaction.

To underſtand the true cauſe of putrefaction, we muſt take notice of the circumſtances in which the proceſs goes on moſt rapidly. Theſe are, heat, a little moiſture, and confined air. Extreme cold prevents putrefaction, as well as perfect dryneſs; and a free circulation of air carries off the putrid effluvia; a ſtagnation of which ſeems to be neceſſary for carrying on the proceſs. It ſeems alſo to hold pretty generally, that putrefying bodies ſwell and become ſpecifically lighter; for which reaſon the carcaſes of dead animals, after having ſunk in water, riſe to the top and float. This laſt phenomenon, as has been obſerved under the article BLOOD, n° 29. ſhows that theſe bodies have received a certain quantity of an elaſtic principle from the air, which thus ſwells them up to ſuch a ſize. It may be ſaid indeed, that this increaſe of ſize in putrefying bodies is owing only to the extrication of air within themſelves: but this amounts to the ſame thing; for the air which exiſts internally in the body of any animal, is entirely diveſted of elaſticity while it remains there, and only ſhows its elaſtic properties upon being extricated. The elaſtic principle which combines with the air fixed in the animal ſubſtance, therefore, muſt come from the external atmoſphere; and conſequently the agent in putrefaction muſt be the elaſtic principle of the atmoſphere itſelf, probably the ſame with elementary fire.

But, granting this to be true, it is difficult to ſhow why putrefaction ſhould not take place in a living body as well as in a dead one; ſeeing the one is as much expoſed to the action of the air as the other. This difficulty, however, is not peculiar to the preſent hypotheſis; but will equally occur whatever we may ſuppoſe the cauſe of putrefaction to be. The difficulty ſeems to be a little cleared up by Dr Prieſtley, who ſhows, that, by means of reſpiration, the body is freed from many noxious effluvia which would undoubtedly deſtroy it; and by the retention of which, he thinks, a living body would putrefy as ſoon as a dead one. The way in which reſpiration prevents the putrefaction of the body, is evidently the ſame with that in which the wind prevents fiſh or fleſh hung up in it from becoming putrid. The conſtant inſpiration of the air is like a ſtream of that element continually blown upon the body, and that not only upon its ſurface, but into it; by which means putrefaction is prevented in thoſe parts that are moſt liable to become putrid. On the other hand, the elaſtic principle received from the air by the blood *, by invigorating the powers of life, quickening the circulation, and increaſing perſpiration, enables the body to expel noxious particles from other parts of the body which cannot conveniently be expelled by the lungs.

* See *Blood*, n° 29.

This leads us to conſider the reaſon why a free expoſure to the air prevents the coming on of putrefaction, or why the confining of the putrid effluvia ſhould be ſo neceſſary to this proceſs. Here it will be proper to recollect, that putrefaction is a ſimple reſolution of the body into earth, air, &c. of which it ſeems originally to have been compoſed. This reſolution is evidently performed by an expanſive power ſeemingly ſituated in every particle of the body. In conſequence of this principle, the body firſt ſwells, then burſts, flies off in vapour, and its particles fall aſunder from each other. The action of the putrefactive proceſs, then, is analogous to that of fire, ſince theſe are the very properties of fire, and the very effects which follow the action of fire upon any combuſtible body. It is therefore exceedingly probable, that the agent in the air, which we have all along conſidered as the cauſe of putrefaction, is no other than fire itſelf; that is, the ethereal fluid expanding itſelf everywhere, as from a centre to a circumference. The force of the fluid, indeed, is much leſs in putrefaction than in actual ignition; and therefore the effects alſo take place in a much ſmaller degree, and require a much longer time: nevertheleſs, the ſame circumſtances that are neceſſary for keeping up the action of fire, are alſo neceſſary for keeping up the putrefactive proceſs. One of theſe is a free acceſs of air, yet without too violent a blaſt; for as fire cannot burn without air, neither can it endure too much of it: thus a candle goes out if put under a receiver, and the air exhauſted; and it will do the ſame if we blow violently upon it. In like manner, putrefaction requires a certain quantity of air, much leſs indeed than fire: and as it requires leſs to ſupport it, ſo it can alſo endure much leſs air than fire; for a ſtream of air which would not put out a fire, will effectually prevent putrefaction. The cauſe of this in both is the ſame. Fire cannot burn becauſe the vapour is carried off too faſt; and thus the latent heat, which ought to ſupport the flâme, is entirely diſſipated. In like manner putrefaction is as certainly attended with an emiſſion of azotic gas as fire is with an emiſſion of flame. Theſe gaſes contain a great quantity of latent heat, or of the expanſive principle already mentioned; and if theſe are carried off with greater rapidity than the heat of the atmoſphere can produce them, the conſequence muſt be, that an oppoſite principle to that which produces putrefaction, namely, a principle of cold, or condenſation, inſtead of expanſion, muſt take place, and the body cannot putrefy. That this muſt be the caſe, is evident from the property which all evaporations have of producing cold; and it is well known that a briſk current of air promotes evaporation to a great degree. Hence alſo the reaſon is evident why bodies are preſerved uncorrupted by cold; for thus the action of the expanſive principle is totally overcome and ſuſpended, ſo that none of its effects can be perceived.

Thus we may ſee, that one reaſon why an animal body does not putrefy while alive, is its ventilation, as we may call it, by reſpiration; and another is, the continual acceſſion of new particles, leſs diſpoſed to putrefy than itſelf, by the food and drink which is conſtantly taken in. But if either of theſe ways of preventing the commencement of this proceſs are omitted, then putrefaction will take place as well in a living as in a dead body. Of the truth of this laſt fact we have innumerable inſtances. When air is infected with the putrid effluvia of marſhes, and thus the natural effluvia are not carried off from the human body, but, on the contrary, ſome enter into it which are not natural to it, the moſt putrid diſeaſes are produced. The ſame thing happens from the putrid effluvia of dead bodies. Of this we have a remarkable inſtance in the fever which took place in Germany in the war of 1755: one reaſon of which is ſaid to have been an infection of the air by the vaſt numbers of people killed in battle, to which was added a calm in the atmoſphere for a long time; the putrid effluvia being by this prevented from flying off *. When Mr Howell with 145 others were impriſoned in the black-hole at Calcutta, after paſſing a

* See *Medicine*, n° 167.

Putrefaction.

a night in that difmal habitation, he found himfelf in a high putrid fever. When failors in long voyages are obliged to feed upon putrid aliments; when, through ftormy weather, they are much expofed to wet; in the one cafe the putrefcent effluvia being kept from flying off, and in the other a greater quantity being thrown into the body than what it naturally contains, the fcurvy, malignant fevers, &c. make their appearance (A). Neither can thefe difeafes be removed without removing every one of the caufes juft now mentioned: for as putrid difeafes will be the confequence of confined air, naftinefs, &c. though the provifions be ever fo good; fo, on the other hand, if the provifions be bad, the beft air, and moft exact cleanlinefs, nay, the beft medicines in the world, will be of no fervice; as hath been often obferved in the fcurvy.

From this account of the nature, caufe, and method of preventing putrefaction by means of a current of air, we may eafily fee the reafon why it does not take place in fome other cafes alfo. Bodies will not putrefy *in vacuo*, becaufe there the atmofphere has not accefs to impart its elaftic principle; and though in the vacuum itfelf the principle we fpeak of does undoubtedly exift, yet its action there is by far too weak to decompofe the ftructure of an animal body. In extreme cold, the reafon why putrefaction does not take place has been already fhown. If the heat is extremely great, the procefs of ignition or burning takes place inftead of putrefaction. If the body is very dry, putrefaction cannot take place, becaufe the texture is too firm to be decompofed by the weak action of the elaftic principle. Putrefaction may alfo be prevented by the addition of certain fubftances; but they are all of them fuch as either harden the texture of the body, and thus render it proof againft the action of the elaftic fluid, or, by diffolving its texture entirely, bring it into a ftate fimilar to what it would be brought by the utmoft power of putrefaction, fo that the procefs cannot then take place. Thus various kinds of falts and acids harden the texture of animal fubftances, and thus are fuccefsfully ufed as antifeptics. The fame thing may be faid of ardent fpirits; while oils and gums of various kinds prove antifeptic by a total exclufion of air, which is neceffary in fome degree for carrying on the procefs of putrefaction. Many vegetables, by the aftringent qualities they poffefs, harden the texture of animal fubftances, and thus prove powerfully antifeptic; while, on the other hand, fixed alkaline falts, quicklime, and cauftic volatile alkali, though they prevent putrefaction, yet they do it by diffolving the fubftances in fuch a manner that putrefaction could do no more though it had exerted its utmoft force. There is only one other antifeptic fubftance whofe effects deferve to be confidered, and that is fugar. This, though neither acid nor alkaline, is yet one of the moft effectual means of preventing putrefaction: and this feems to be owing to its great tendency to run into the vinous fermentation, which is totally inconfiftent with that of putrefaction; and this tendency is fo great, that it can fcarce be counteracted, by the tendency of animal fubftances to putrefy in any circumftances whatever.

Some kinds of air are remarkably antifeptic, though this fubject has not been fo fully inquired into as could be wifhed. The moft powerful of them in this refpect is the nitrous air; next to it, is fixed air; but the powers of the other airs are not fo well known. It is probable that the antifeptic properties of fixed and nitrous air, are owing to their quality of extinguifhing fire, or at leaft that the principle is the fame; but, till the nature of thefe two kinds of air are better known, little can be faid with certainty on the fubject.

Sir John Pringle has made experiments to determine the powers of certain fubftances to promote or to prevent putrefaction. From thefe experiments he has formed the following Table, fhowing the relative antifeptic powers of the faline fubftances mentioned. Having found that two drams of beef put in a phial with two ounces of water, and placed in a heat equal to 90° of Fahrenheit's

(A) This aeriform fluid, which is exhaled from animal bodies in a ftate of putrefaction, acts at certain times more powerfully than at others, and is indeed in one ftage of the procefs infinitely more noxious than any other elaftic fluid yet difcovered. In the Gentleman's Magazine for Auguft 1788, Dr St John, informs us, that he knew a gentleman who, by flightly touching the inteftines of a human body beginning to liberate this corrofive gas, was affected with a violent inflammation, which in a very fhort fpace of time extended up almoft the entire length of his arm, producing an extenfive ulcer of the moft foul and frightful appearance, which continued for feveral months, and reduced him to a miferable ftate of emaciation. The fame writer mentions a celebrated profeffor who was attacked with a violent inflammation of the nerves and fauces, from which he with difficulty recovered, merely by ftooping for an inftant over a body which was beginning to give forth this deleterious fluid. Hence he infers, that the fame gas modified or mixed, or united with others, may be the occafion of the plague, which has fo often threatened to annihilate the human fpecies. It is happy, however, for mankind that this particular ftage of putrefaction continues but for a few hours; and, what may appear very remarkable, this deftructive gas is not very difagreeable in fmell, and has nothing of that abominable and loathfome fetor produced by dead bodies in a lefs dangerous ftate of corruption; but has a certain fmell totally peculiar to itfelf, by which it may be inftantly difcovered by any one that ever fmelled it before. This is an object very worthy the attention of phyficians: it is both extremely interefting, and very little known; but at the fame time it is a ftudy in the higheft degree unpleafant, from the deteftable fmell and naftinefs which attend the putrefaction of animal bodies; and a man muft be armed with uncommon philanthropy and refolution to attempt it.

Dr St John thinks it probable that there is a rapid fixation of the bafis of vital air in dead bodies at a certain ftate of putrefaction, on account of the luminous appearance which they fometimes make, and which exifts but for a few hours: but whether this luminous appearance takes place in every body, or whether it precedes or follows the exhalations of the corrofive gas above-mentioned, he had not, when he wrote his paper, been able to difcover.

2

Fahrenheit's thermometer, became putrid in 14 hours, and that 60 grains of sea-salt preserved a similar mixture of beef and water more than 30 hours, he made the antiseptic power of the sea-salt a standard, to which he compared the powers of the other salts. The algebraic character + signifies, that the substance to which it is annexed had a greater antiseptic power than is expressed by the numbers:

Sea-salt, or the standard	1
Sal-gem	1+
Vitriolated tartar	2
Spiritus Mindereri	2
Soluble tartar	2
Sal diureticus	2+
Crude sal ammoniac	3
Saline mixture	3
Nitre	4+
Salt of hartshorn	4+
Salt of wormwood	4+
Borax	12
Salt of amber	20
Alum	30

N. B. The quantities of spiritus Mindereri and of the saline mixture were such, that each of them contained as much alkaline salt as the other neutral salts.

Myrrh, aloes, asafœtida, and terra Japonica, were found to have an antiseptic power 30 times greater than the standard. Gum ammoniacum and sagapenum showed little antiseptic power.

Of all resinous substances, camphor was found to resist putrefaction most powerfully. Sir John Pringle believes that its antiseptic power is 300 times greater than that of sea-salt.

Chamomile flowers, Virginian snake-root, pepper, ginger, saffron, contrayerva root, and galls, were found to be 12 times more antiseptic than sea-salt.

Infusions of large quantities of mint, angelica, ground-ivy, green tea, red-roses, common wormwood, mustard, and horse-radish, and also decoctions of poppy-heads, were more antiseptic than sea-salt.

Decoctions of wheat, barley, and other farinaceous grains, checked the putrefaction by becoming sour.

Chalk, and other absorbent powders, accelerated the putrefaction, and resolved meat into a perfect mucus. The same powders prevented an infusion of farinaceous grains from becoming mucilaginous and sour.

One dram of sea-salt was found to preserve two drams of fresh beef in two ounces of water, above 30 hours, uncorrupted, in a heat equal to that of the human body, or above 20 hours longer than meat is preserved in water without salt: but half a dram of salt did not preserve it more than two hours longer than pure water. Twenty-five grains of salt had little or no antiseptic quality. Twenty grains, 15 grains, but especially 10 grains only of sea-salt, were found to accelerate and heighten the putrefaction of two drams of flesh. These small quantities of sea salt did also soften the flesh more than pure water.

The same learned and ingenious physician made experiments to discover the effects of mixing vegetable with animal matters.

Two drams of raw beef, as much bread, and an ounce of water, being beat to the consistence of pap, and exposed to 90° of heat according to Fahrenheit's thermometer, began to ferment in a few hours, and continued in fermentation during two days. When it began to ferment and swell, the putrefaction had begun; and in a few hours afterwards, the smell was offensive. Next day the putrid smell ceased, and an acid taste and smell succeeded. Fresh alimentary vegetables, as spinach, asparagus, scurvy-grass, produced similar effects as bread on flesh, but in a weaker degree. From several other experiments he found, that animal substances excite the fermentation of vegetable substances, and that the latter substances correct the putrescency of the former.

By adding saliva to a similar mixture of flesh, bread, and water, the fermentation was retarded, moderated, but rendered of twice the usual duration, and the acid produced at last was weaker than when no saliva was used.

By adding an oily substance to the common mixture of flesh, bread, and water, a stronger fermentation was produced, which could not be moderated by the quantity of saliva used in the former experiment, till some fixed alkaline salt was added; which salt was found, without saliva, to stop suddenly very high fermentations.

He did not find that small quantities of the following salts, sal ammoniac, nitre, vitriolated tartar, sal diureticus, salt of hartshorn, salt of wormwood, were septic, as small quantities of sea-salt were.

Sugar was found to resist putrefaction at first, as other salts do, and also to check the putrefaction after it had begun by its own fermentative quality, like bread and other fermentative vegetables.

Lime-water made some small resistance to putrefaction.

Port-wine, small-beer, infusions of bitter vegetables, of bark, and the juice of antiscorbutic plants, retarded the fermentation of mixtures of flesh and bread. But an unstrained decoction of bark considerably increased that fermentation.

Crab-eyes accelerated and increased the fermentation of a mixture of flesh and bread.

Lime-water neither retarded nor hastened the fermentation of such a mixture: but when the fermentation ceased, the liquor was neither putrid nor acid, but smelt agreeably.

Flesh pounded in a mortar was found to ferment sooner than that which had not been bruised.

The tough inflammatory crust of blood was found to be most putrescent; next to which the crassamentum, or red coagulated mass; and lastly the serum.

Dr Macbride's experiments confirm many of those above related, especially those which show that the fermentation of vegetable substances is increased by a mixture of animal or putrescent matter; that the putrescency of the latter is corrected by the fermentative quality of the former; and that the putrefaction and fermentation of mixtures of animal and vegetable substances were accelerated by additions of absorbent earths and of Peruvian bark. He also found, that although unburnt calcareous earths were septic, quicklime and lime-water prevented putrefaction, but that they destroyed or dissolved the texture of flesh.

The experiments of the author of the *Essai pour servir à l'Histoire de la Putrefaction*, show that metallic salts,

salts, resinous powders, extracts of bark, and opium, are very powerfully antiseptic, and that salts with earthy bases are less antiseptic than any other salts.

PUTTOCK-SHROUDS. See *Puttock-SHROUDS*.

PUTTY, in its popular sense, is a kind of paste compounded of whiting and lintseed oil, beaten together to the consistence of a thick dough.

It is used by glaziers for the fastening in the squares of glass in sash-windows, and by painters for stopping up the crevices and clefts in timber and wainscots, &c.

PUTTY sometimes also denotes the powder of calcined tin, used in polishing and giving the last gloss to works of iron and steel.

TERRA PUZZULANA, or POZZOLANA, is a grayish kind of earth used in Italy for building under water. The best is found about Puteoli, Baiæ, and Cumæ, in the kingdom of Naples, from the first of which places it derives its name. It is a volcanic product, composed of heterogeneous substances, thrown out from the burning mouths of volcanoes in the form of ashes; sometimes in such large quantities, and with so great violence, that whole provinces have been covered with it at a considerable distance. In the year 79 of the common era, the cities of Herculaneum, Pompeia, and Stabia, although at the distance of many miles from Vesuvius, were, nevertheless, buried under the matters of these dreadful eruptions; as Bergman relates in his Treatise of the Volcanic Products. This volcanic earth is of a gray, brown, or blackish colour; of a loose, granular, or dusty and rough, porous or spongy texture, resembling a clay hardened by fire, and then reduced to a gross powder. It contains various heterogeneous substances mixed with it. Its specific gravity is from 2500 to 2800; and it is, in some degree, magnetic: it scarcely effervesces with acids, though partially soluble in them. It easily melts *per se;* but its most distinguishing property is, that it hardens very suddenly when mixed with $\frac{1}{7}$ of its weight of lime and water; and forms a cement, which is more durable in water than any other.

According to Bergman's Analysis, 100 parts of it contain from 55 to 60 of siliceous earth, 20 of argillaceous, five or six of calcareous, and from 15 to 20 of iron. Its effects, however, in cement may perhaps depend only on the iron which has been reduced into a particular substance by means of subterraneous fires; evident signs of which are observable in the places where it is obtained. If the slate in Henneberg, or Kennekulle in the province of Westergottland, should happen to get fire, the uppermost stratum, which now consists of a mixture of iron and different kinds of rocks, called *graberg* in the account given of them, they might perhaps be changed partly into slag and partly into *terra puzzolana*.

It is evidently a martial argillaceous marl, that has suffered a moderate heat. Its hardening power arises from the dry state of the half-baked argillaceous particles, which makes them imbibe water very rapidly, and thus accelerates the deficcation of the calcareous part; and also from the quantity and semiphlogisticated state of the iron contained in it. It is found not only in Italy but in France, in the provinces of Auvergne and Limoges; and also in England and elsewhere.

PUZZUOLI. See PUTEOLI.

PYANEPSIA, in antiquity, an Athenian festival celebrated on the seventh day of the month *Pyanepsion;* which, according to the generality of critics, was the same with our September.

Plutarch refers the institution of this feast to Theseus, who, after the funeral of his father, on this day paid his vows to Apollo, because the youths who returned with him safe from Crete then made their entry into the city. On this occasion, these young men putting all that was left of their provisions into one kettle, feasted together on it, and made great rejoicing. Hence was derived the custom of boiling pulse on this festival. The Athenians likewise carried about an olive branch, bound about with wood, and crowned with all sorts of first-fruits, to signify that scarcity and barrenness were ceased, singing in procession a song. And when the solemnity was over, it was usual to erect the olive-branch before their doors, as a preservative against scarcity and want.

PYCNOSTYLE, in the ancient architecture, is a building where the columns stand very close to each other; only one diameter and a half of the column being allowed for the intercolumniations.

According to Mr Evelyn, the pycnostyle chiefly belonged to the composite order, and was used in the most magnificent buildings; as at present in the peristyle at St Peter's at Rome, which consists of near 300 columns; and in such as yet remain of the ancients, among the ruins of Palmyra.

PYGARGUS, a species of falco. See ORNITHOLOGY *Index*.

PYGMALION, in fabulous history, a king of Cyprus, who, being disgusted at the dissolute lives of the women of his island, resolved to live in perpetual celibacy; but making a statue of ivory, he fell so passionately in love with it, that the high festival of Venus being come, he fell down before the altar of that goddess, and besought her to give him a wife like the statue he loved. At his return home, he embraced, as usual, his ivory form, when he perceived that it became sensible by degrees, and was at last a living maid, who found herself in her lover's arms the moment she saw the light. Venus blessed their union; and, at the end of nine months, she was delivered of a boy, who was named *Paphos*.

PYGMY, a person not exceeding a cubit in height. This appellation was given by the ancients to a fabulous nation inhabiting Thrace; who brought forth young at five years of age, and were old at eight: these were famous for the bloody war they waged with the cranes. As to this story, and for the natural history of the true pygmy, see SIMIA, MAMMALIA *Index*.

PYKAR, a broker in India, inferior to those called *dallals*, who transacts the business at first hand with the manufacturer, and sometimes carries goods about for sale.

PYKE, a watchman in India, employed as a guard at night. Likewise a footman or runner on business. They are generally armed with a spear.

PYLADES, a son of Strophius, king of Phocis, by one of the sisters of Agamemnon. He was educated together with his cousin Orestes, with whom he formed the most inviolable friendship, and whom he assisted to revenge the murder of Agamemnon, by assassinating Clytemnestra and Ægysthus. He also accompanied him into Taurica Chersonesus; and for his services

vices Oreſtes rewarded him, by giving him his ſiſter Electra in marriage. Pylades had by her two ſons, Medon and Strophius. The friendſhip of Oreſtes and Pylades became proverbial.

PYLORUS, in *Anatomy*, the under orifice of the ſtomach. See ANATOMY, N° 91.

PYLUS, in *Ancient Geography*, a town of Elis; its ruins to be ſeen on the road from Olympia to Elis, (Pauſanias); ſituated between the mouths of the Peneus and Selles, near Mount Scollis, (Strabo). Built by Pylas of Megara, and deſtroyed by Hercules, (Pauſanias). Another Pylus in Triphylia, (Strabo); by which the Alpheus runs, (Pauſanias); on the confines of Arcadia, and not in Arcadia itſelf, (id.)—A third in Meſſenia, (Strabo, Ptolemy); ſituated at the foot of Mount Ægaleus on the ſea-coaſt, over-againſt the iſland Sphagea or Sphacteria: built by Pylas, and ſettled by a colony of Leleges from Megara; but thence expelled by Neleus and the Pelaſgi, and therefore called *Nelea*, (Homer). A ſandy territory. The royal reſidence of Neleus, and of Neſtor his ſon: the more ancient and more excellent Pylus; whence the proverb *Pylus ante Pylum*, (Ariſtophanes, Plutarch), uſed when we want to repreſs the arrogance and pride of any one: ſaid to be afterwards called *Coryphaſium*. It made a figure in the Peloponneſian war; for being rebuilt by the Athenians, it proved of great benefit to them for the ſpace of 15 years, and of much annoyance to the Lacedemonians, (Thucydides). All the three *Pyli* were ſubject to Neſtor, (Strabo).

PYRAMID, in *Geometry*, a ſolid ſtanding on a triangular, ſquare, or polygonal baſis, and terminating in a point at the top; or, according to Euclid, it is a ſolid figure, conſiſting of ſeveral triangles, whoſe baſes are all in the ſame plane, and have one common vertex.

Pyramids are ſometimes uſed to preſerve the memory of ſingular events, and ſometimes to tranſmit to poſterity the glory and magnificence of princes. But as they are eſteemed a ſymbol of immortality, they are moſt commonly uſed as funeral monuments and temples to the gods. Such is that of Ceſtius at Rome; the pyramids of Daſhur drawn by Pocock; and thoſe other celebrated ones of Egypt, as famous for the enormity of their ſize as their antiquty. Of theſe the largeſt are the pyramids of *Geeza*, ſo called from a village of that name on the banks of the Nile, diſtant from them about 11 miles. The three which moſt attract the attention of travellers ſtand near one another on the weſt ſide of the river, almoſt oppoſite to Grand Cairo, and not far from the place where the ancient Memphis ſtood. They were viſited by M. Savary, of whoſe deſcription of them we ſhall here give an abſtract.

He took his journey in the night-time, in order to get up to the top of the great one by ſunriſe. Having got within ſight of the two great ones, while the full moon ſhone upon them, he informs us, that they appeared, at the diſtance of three leagues, like two points of rock crowned by the clouds.

It is in the rich territory which ſurrounds them that fable has placed the Elyſian fields. The canals which interſect them are the Styx and Lethe.

" The aſpects of the pyramids, varied according to the circuits he made in the plain, and the poſition of the clouds, diſplayed themſelves more and more to view.

At half paſt three in the morning we arrived (ſays he) at the foot of the greateſt. We left our clothes at the gate of the paſſage which leads to the inſide, and deſcended, carrying each of us a flambeau in his hand. Towards the bottom you muſt creep like ſerpents to get into the interior paſſage, which correſponds with the former. We mounted it on our knees, ſupporting ourſelves with our hands againſt the ſides. Without this precaution one runs the riſk of ſlipping on the inclined plane, where the ſlight notches are inſufficient to ſtop the foot, and one might fall to the bottom. Towards the middle we fired a piſtol, the frightful noiſe of which, repeated in the cavities of this immenſe edifice, continued a long time, and awakened thouſands of bats, which flying round us, ſtruck againſt our hands and faces, and extinguiſhed ſeveral of our wax candles. They are much larger than the European bats. Arrived above, we entered a great hall, the gate of which is very low. It is an oblong ſquare, wholly compoſed of granite. Seven enormous ſtones extend from one wall to the other, and form the roof. A ſarcophagus made of a ſingle block of marble lies at one end of it. It is empty; and the lid of it has been wrenched off. Some pieces of earthen vaſes lie around it. Under this beautiful hall is a chamber not ſo large, where you find the entrance to a conduit filled with rubbiſh. After examining theſe caves, where daylight never penetrated, we deſcended the ſame way, taking care not to fall into a well, which is on the left, and goes to the very foundations of the pyramid. Pliny makes mention of this well, and ſays it is 26 cubits deep. The internal air of this edifice never being renewed, is ſo hot and mephitic that one is almoſt ſuffocated. When we came out of it, we were dropping with ſweat, and pale as death. After refreſhing ourſelves with the external air, we loſt no time in aſcending the pyramid. It is compoſed of more than 200 layers of ſtone. They overlap each other in proportion to their elevation, which is from two to four feet. It is neceſſary to climb up all theſe enormous ſteps to reach the top. We undertook it at the north-eaſt angle, which is the leaſt damaged. It took us, however, half an hour with great pains and many efforts to effect it.

" The ſun was riſing, and we enjoyed a pure air, with a moſt delicious coolneſs. After admiring the proſpect around us, and engraving our names on the ſummit of the pyramid, we deſcended cautiouſly, for we had the abyſs before us. A piece of ſtone detaching itſelf under our feet or hands might have ſent us to the bottom.

" Arrived at the foot of the pyramid, we made the tour of it, contemplating it with a ſort of horror. When viewed cloſe, it ſeems to be made of maſſes of rocks; but at a hundred paces diſtance, the largeneſs of the ſtones is loſt in the immenſity of the whole, and they appear very ſmall.

" To determine its dimenſions is ſtill a problem. From the time of Herodotus to our days it has been meaſured by a great number of travellers and learned men, and their different calculations, far from clearing up doubts, have only increaſed the uncertainty. The following table will ſerve at leaſt to prove how difficult it is to come at the truth.

Pyramid.

Height of the great Pyramid.		*Width of one of its sides.*
Ancients.		French Feet.
Herodotus -	800 -	800
Strabo -	625 -	600
Diodorus Siculus	600 and a fraction.	700
Pliny -	- -	708
Moderns.		
Le Bruyn	616 -	704
Prosper Alpinus	625 - -	750
Thevenot -	520 -	682
Niebuhr -	440 - -	710
Greaves -	444 -	648

Number of layers of Stone which form it.

Greaves - -	207
Maillet - -	208
Albert Liewenstein -	260
Pococke - -	212
Belon - -	250
Thevenot - -	208

"It appears that Messrs Greaves and Niebuhr have prodigiously deceived themselves in measuring the perpendicular height of the great pyramid. All the travellers allow that it has at least 200 layers of stone. These layers are from two to four feet high. According to Pococke, they are from four feet and a half to four feet high, being not so high at the top as at the base. Prosper Alpinus informs us, that the elevation of the first layer is five feet, but it diminishes insensibly in proportion as one mounts. Thevenot mentions 208 steps of large stones, the thickness of which makes the height of them about two feet and a half one with another: He measured some of them more than three feet high. I have measured several of them which were more than three feet high, and I found none less than two; the least height of them we can take as a medium therefore is two feet and a half, which, even according to Mr Greaves's calculation, who reckons 207 layers, would make 517 feet 6 inches perpendicular height. Messrs Greaves, Maillet, Thevenot, and Pococke, who only differ in the number of the layers from 207 to 212, all mounted by the north-east angle, as the least injured. I followed the same route, and counted only 208 steps. But if we reflect that the pyramid has been open on the side next the desert, that the stones on that side have been thrown down, that the sand which covers them has formed a considerable hill, we shall not be astonished that Albert Liewenstein, Belon, and Prosper Alpinus, who must have mounted by the south-east or south-west angle, which are less exposed to the sands of Libya, should have found a greater number of steps: so that the calculation of these travellers, agreeing with that of Diodorus Siculus and Strabo, appears to be nearest the true height of the pyramid taken at its natural base; whence we may conclude with reason that it is at least 600 feet high. Indeed this is authenticated by a passage of Strabo. These are his words: : Towards the middle of the height of one of the sides is a stone that may be raised up. It shuts an oblique passage which leads to a coffin placed in the centre of the pyramid.' This passage, open in our days, and which in the time of Strabo was towards the middle of one face of the pyramid, is at present only 100 feet from the base. So that the ruins of the covering of the pyramid, and of the stones brought from within, buried by the sand, have formed a hill in this place 200 feet high. Pliny confirms this opinion. The great sphynx was in his time upwards of 62 feet above the surface of the ground. Its whole body is at present buried under the sand. Nothing more appears of it than the neck and head, which are 27 feet high. If even the sphynx, though defended by the pyramids against the northerly winds, which bring torrents of sand from Libya, be covered as high as 38 feet, what an immense quantity must have been heaped up to the northward of an edifice whose base is upwards of 700 feet long? It is to this we must attribute the prodigious difference between the accounts of the historians who have measured the great pyramid at distant periods, and at opposite angles. Herodotus, who saw it in the age nearest to its foundation, when its true base was still uncovered, makes it 800 feet square. This opinion appears very probable. Pliny also says that it covered the space of eight acres.

"Messrs Shaw, Thevenot, and the other travellers who pretend that this pyramid was never finished, because it is open and without coating, are in an error. It is only necessary to observe the remains of the mortar, with the splinters of white marble which are to be found in many parts of the steps, to see that it has been coated. After reading attentively the description given of it by the ancients, every doubt vanishes, and the truth is as clear as day-light. Herodotus tells us, 'The great pyramid was covered with polished stones, perfectly well jointed, the smallest of which was 30 feet long. It was built in the form of steps, on each of which were placed wooden machines to raise the stones from one to another.' According to Diodorus, 'The great pyramid is built of stones, very difficult of workmanship, but of an eternal duration. It is preserved to our days (towards the middle of the Augustan age) without being in the least injured. The marble was brought from the quarries of Arabia.' This historian thought that the whole building was composed of stones, similar to those of the coating, which were of very hard marble. Had there been some pieces torn off, he would have perceived under that covering a calcareous stone rather soft. Pliny says that it 'is formed of stones brought from the quarries of Arabia. It is not far from the village of Busiris (which still exists under the name of *Bousir*), where those persons reside who are so skilful as to climb up to the top.'

"This passage shows that Pliny, deceived by the appearance, was in the same error with Diodorus Siculus. It demonstrates also that it was covered: for what difficulty would there have been for the inhabitants of Busiris to scale a building raised by steps? but it was really a prodigy for them to get up it when it formed a mountain, the four inclined planes of which presented a surface covered with polished marble. It is indeed an incontestable fact, that the great pyramid was coated. It is as certain too that it has been shut, as Strabo gives us to understand; and that by removing a stone placed in the middle of one of the sides, one found a passage which led to the tomb of the king. But I shall leave Mr Maillet, who visited it 40 times with all imaginable

Pyramid. imaginable attention, the honour of relating the means employed to open it. I have examined the inside of it in two different journeys; twice I have mounted it: and I cannot help admiring the sagacity with which that author has developed the mechanism of that astonishing edifice."

Our author next proceeds to give a particular description of the methods by which it is most probable that the pyramids were closed, and the immense labour requisite to open them. We must remark, that the final outlet to the workmen he supposes to have been the well at the entrance formerly mentioned. This well descends towards the bottom of the pyramid by a line not quite perpendicular to the horizon, but slanting a little, in such a manner as to resemble the figure of the Hebrew letter Lamed. About 60 feet from the aperture there is a square window in this passage, from whence we enter a small grotto hewn out of the mountain; which in this place is not a solid stone, but a kind of gravel concreted together. The grotto extends about 15 feet from east to west, where there is another groove hollowed likewise, but almost perpendicular. It is two feet four inches wide by two and a half in height. It descends through a space of 123 feet, after which we meet with nothing but sand and stones. M. Savary is convinced that the only use of this passage was to serve as a retreat for the labourers who constructed the pyramid; and of this he looks upon the slope of the conduit, its winding road, its smallness, and its depth, to be certain proofs. The way out of it he supposes to have been formed by a passage over which hung a row of stones, which they had discovered the secret of suspending, and which falling down into the passage by the means of some spring they set in motion, shut up the entrance for ever, as soon as the workmen were withdrawn from the pyramid.

It seems to be an unquestionable fact, that this pyramid was a mausoleum of one of the kings of Egypt, and it is very probable that all the rest answered similar purposes. We do not, however, think that this was their primary use or the original design of their builders. Mr Bryant is of opinion that they were temples erected in honour of the Deity; and a very ingenious writer in the Gentleman's Magazine for June 1794 has done much to prove that they were altars dedicated to the sun, the first and greatest god in every pagan kalendar.

"Our English word pyramid (says he) is directly derived from the Latin *pyramis*, and mediately from the Greek πυραμις; all denoting the same mathematical figure. The original of the whole seems to be the Egyptian word *pyramoua*, which, we are told by Oriental scholars, signifies light, or a ray of light. From this Coptic vocable the word πυρ in Greek, signifying fire, is probably descended; as the flames of fire assume that conical or pyramidal form which the solar rays commonly display; and as it is natural for the mind to distinguish its objects rather by their external qualities, and those obvious and interesting appearances which they exhibit to the senses, than by their constituent and inseparable properties.

"The ancient Egyptians seem to have penetrated very far into the mysteries of nature; and although their superstition appears at first sight to be extremely gross and absurd, yet it is very probable that their deities were only emblematical personages, representing by sensible images the grand effects or presiding principles which they supposed to exist in the universe. Thus the moon was called *Isis*, and the sun *Osiris*; and to the honour of this last deity, from whose visible influence and creative energy all things seem to spring into existence, it is not improbable that the Egyptians erected those stupendous monuments, and dedicated them to him as temples or altars. It was natural to build them in that shape which the rays of the sun display when discovered to the eye, and which they observed to be the same in terrestrial flame, because this circumstance was combined in their imaginations with the attribute which they adored. If they were temples dedicated to the sun, it seems a natural consequence that they should likewise be places of sepulture for kings and illustrious men, as the space which they covered would be considered as consecrated ground. This hypothesis is common, and is not contradicted by the present reasoning. But, considering them as altars, and as most travellers agree that they were never finished, but terminate in a square horizontal surface, it would not be refining too much to venture an assertion that, in great and solemn acts of adoration, the Egyptians constructed fires, the flames of which should terminate in the vertex of the pyramid, and so complete that emanation of their deity which they admired and adored. As far, therefore, as we are justified in forming any conclusion on so dark a subject, we may venture to say, that the Egyptian pyramids were temples or altars dedicated to the sun, as the material representative of that invisible power which creates, governs, and pervades, the whole system of nature."

This reasoning has some force; and it certainly receives additional strength from the undoubted fact, that the first statues for idolatrous worship were erected on the tops of mountains, and of a pyramidal or conical form. (See POLYTHEISM, N° 13 and 21.). It is likewise corroborated by other circumstances discovered by the members of the Asiatic Society. In the second volume of their transactions we have an account of several large statues of the gods SEEVA and MCHEDEO, all of a conical or pyramidal figure; but it has been shown in the article already referred to, that the idolatry of Hindostan was probably of Egyptian original.

It is not known in Europe when the pyramids were built; but we have reason to expect a history of them soon from Shanscrit records examined by Mr Wilford lieutenant of engineers. It is as little known at what time, or from what motive, the great pyramid was opened. Some think it was done by one of the khalifs about the beginning of the eighth century, in expectation of finding a great treasure; but all he met with was the king's body, with some golden idols which had been buried along with it.—By others it is supposed to have been done by the celebrated Harun Al Raschid khalif of Bagdad; but all are agreed that this pyramid was opened in the time of the Arabs. The second pyramid has likewise been opened; and an attempt was made not long ago upon the third by one of the Beys of Cairo: but after removing a number of stones at a considerable expence, he thought proper to desist from the enterprise.—My Bryant is of opinion that the pyramids, at least the three great ones, are not artificial structures of stone and mortar, but solid rocks cut into a pyramidal shape, and afterwards cased with stone; and to this

this we find that Mr Bruce likewife affents. The reafon given for this opinion is, that the paffages within it feem rather to anfwer to the natural cavities and rents in rocks than to the artificial ones in buildings. The opinion, however, we think fufficiently confuted by Savary and Maillet: and, as an acute critic obferves, it is in itfelf as improbable as that the caverns inhabited by the *Troglodytes* were dug by the hands of man. See TROGLODYTES.

On the eaft fide of the fecond pyramid is the fphynx, an enormous mafs of one folid ftone, but fo buried in the fand that only the top of the back is vifible, which is 100 feet long. Its head rifes, as we have feen, 27 feet above the fand; and its face has been disfigured by the Arabs, who hold all reprefentations of men and living animals in deteftation. Other travellers fay that this fphynx is a huge mifhapen rock, by no means worthy of the attention which has been beftowed upon it.

In the defert of Saccara there is a great number of pyramids, which, in Mr Bruce's opinion, are compofed of clay. They terminate in what the inhabitants call a *dagiour* or *falfe pyramid*, about two miles from the Nile, between Suf and Woodan. This is no other than a hill cut into the fhape of a pyramid, or naturally fo formed, for a confiderable height; on the top of which is a pyramidal building of brick terminating in a point, and having its bafis fo exactly adapted to the top of the hill, that at a diftance the difference cannot be perceived; efpecially as the face of the ftones refembles very nearly the clay of which the pyramids of the Saccara are compofed.

But a very different opinion concerning the purpofes to which the great pyramid was originally deftined, and the period in which that extraordinary edifice was erected, is held by Mr Gabb, who has not long fince publifhed an elaborate treatife on this fubject. According to this author not only the great pyramid, but alfo the fmaller pyramids are of antediluvian origin; the immenfe accumulation of fand around thofe ftupendous ftructures took place at the time of the deluge; the height of this fand, when the waters fubfided, probably reached the fummit of the pyramid, and the apex of the great pyramid was torn off by the violent agitation of the waters. The author contends that the fand round the pyramids could not have been collected by the force of the winds; and that it is equally improbable that it could have been depofited from the waters of the Nile during the inundations of that river; for the Nile was never known to rife to fuch a height, and the organized remains, fuch as fhells and petrified oyfters, found in the fands about the pyramids, are quite different from any fhell-fifh that inhabit the Nile. From all this the author concludes, that the great pyramid was erected by the Antediluvians, that the remarkable depofition of fand on the furface of the extenfive rock on which that immenfe fabric ftands can only be fatisfactorily accounted for from the effects of the univerfal deluge or flood of Noah; and that the accumulation of fand is diminifhing rather than increafing by the force of the wind. The author fuppofes that the other pyramids were alfo built before the flood, but at a later period than that of the great pyramid, which latter he thinks was the work of the immediate defcendants of Seth. In proof of this, Jofephus is quoted, who notices a memorial of an ancient tradition preferved among the Jews, that the direct defcendants of Seth were much employed in aftronomical obfervations. The perfect geometrical figure of the pyramid, the commenfurability of its parts to the whole, the fcientific approach of the fide of its bafe to a meridional degree of the circumference of the earth, and the ufeful folutions of problems deducible from it, lead to the fame inference.

But the moft curious part of this author's difquifition concerning the pyramid relates to the purpofe for which that ftupendous fabric was raifed; and here he is decidedly of opinion, that it was originally intended as a ftandard of meafure, and not as has been more generally fuppofed as a fepulchral momument; and farther that the excavation of the celebrated granite cheft in the interior of the pyramid was intended not for the repofitory of a corpfe, but for a ftandard meafure of capacity, as its length was for linear meafure. This is alfo the opinion of the French fçavans who accompanied the army of Bonaparte to Egypt, and very fuccefsfully afcertained the dimenfions of that remarkable building. The plan of the pyramid is a geometrical fquare, the fide of which is equal to 400 cubits of Cairo, or the great Egyptian ftadium. The length of the granite cheft in the upper chamber of the pyramid is exactly four cubits, which is precifely one hundredth part of the bafe of the fide of the pyramid. The commenfurability of the component parts of the pyramid now mentioned, as well as of others difcuffed by the author, is undoubtedly a curious circumftance. But we muft refer our readers to the work itfelf, and for farther information concerning the pyramids, to *Denon's Travels*, &c.

PYRAMIDALES, in *Anatomy*, one of the mufcles of the abdomen. See ANATOMY, *Table of the Mufcles*.

PYRAMIDOID, a term which is occafionally employed to denote the parabolic fpindle, or the folid formed by the rotation of a femiparabola about its bafe or greateft ordinate.

PYRENEAN MOUNTAINS, or PYRENEES, are the mountains which divide France from Spain, and are the moft celebrated in Europe, except the Alps. They reach from the Mediterranean fea as far as the ocean, and are about 212 miles in length. They have different names, according to the different places wherein they ftand. Some think they are as high as the Alps; but the paffages over them are not fo difficult, whatever fome travellers may think who have not croffed the former.

PYRITES, a metallic fubftance combined with fulphur, as iron pyprites, compofed of fulphur and iron; copper pyrites, of fulphur and copper. See MINERALOGY *Index*.

PYRMONT, a town of Lippe in Germany, in the circle of Weftphalia, and capital of a country of the fame name. It has a caftle, kept by a governor, who is under the counts of Waldeck. At a fmall diftance from hence there are mineral waters, which are much efteemed. The Proteftants have here the free exercife of their religion. It is feated on the confines of the duchy of Brunfwick, 40 miles fouth-weft of Hanover. E Long. 9. 0. N. Lat. 52. 0.

PYROLA, a genus of plants belonging to the decandria clafs, and in the natural method ranking under the 18th order, *Bicornes*. See BOTANY *Index*.

PYROMANCY,

Pyromancy, Pyrometer.

PYROMANCY, a kind of divination by means of fire. See DIVINATION, N° 6.

PYROMETER, an instrument for measuring the expansion of bodies by heat. See CHEMISTRY *Index*. Muschenbroeck, who was the original inventor of this machine, has given a table of the expansion of the different metals in the same degree of heat. Having prepared cylindric rods of iron, steel, copper, brass, tin, and lead, he exposed them first to a pyrometer with one flame in the middle; then with two flames; and successively to one with three, four, and five flames. But previous to this trial, he took care to cool them equally, by exposing them some time upon the same stone, when it began to freeze, and Fahrenheit's thermometer was at 32 degrees. The effects of which experiment are digested in the following table, where the degrees of expansion are marked in parts equal to the $\frac{1}{12500}$ part of an inch.

Expansion of	Iron.	Steel.	Copper.	Brass.	Tin.	Lead.
By one flame	80	85	89	110	153	155
By two flames placed close together.	117	123	115	220		274
By two flames $2\frac{1}{2}$ inches distant.	109	94	92	141	219	263
By three flames placed close together.	142	168	193	275		
By four flames placed close together.	211	270	270	361		
By five flames.	230	310	310	377		

It is to be observed of tin, that it will easily melt when heated by two flames placed together. Lead commonly melts with three flames placed together, especially if they burn long.

From these experiments, it appears at first view that iron is the least rarefied of any of these metals, whether it be heated by one or more flames; and therefore is most proper for making machines or instruments which we would have free from any alterations by heat or cold, as the rods of pendulums for clocks, &c. So likewise the measures of yards or feet should be made of iron, that their length may be as nearly as possible the same summer and winter.

The expansion of lead and tin, by only one flame, is nearly the same; that is, almost double of the expansion of iron. It is likewise observable, that the flames placed together, cause a greater rarefaction than when they have a sensible interval between them; iron in the former case, being expanded 117 degrees, and only 109 in the latter; the reason of which difference is obvious.

By comparing the expansions of the same metal produced by one, two, three, or more flames, it appears that two flames do not cause double the expansion of one, nor three flames three times that expansion, but always less; and these expansions differ so much the more from the ratio of the number of flames as there are more flames acting at the same time.

Pyrometer.

It is also observable, that metals are not expanded equally at the time of their melting, but some more some less. Thus tin began to run when rarefied 219 degrees; whereas brass was expanded 377 degrees, and yet was far from melting.

Mr Ellicot found, upon a medium, that the expansion of bars of different metals, as nearly of the same dimensions as possible, by the same degree of heat, were as follow:

Gold,	Silver,	Brass,	Copper,	Iron,	Steel,	Lead,
73	103	95	89	60	56	149

The great difference between the expansions of iron and brass has been applied with good success to remedy the irregularities in pendulums arising from heat. See PENDULUM.

Mr Graham used to measure the minute alterations, in length, of metal bars, by advancing the point of a micrometer-screw, till it sensibly stopped against the end of the bar to be measured. This screw, being small and very lightly hung, was capable of agreement within the three or four-thousandth part of an inch. On this general principle Mr Smeaton contrived his pyrometer, in which the measures are determined by the contact of a piece of metal with the point of a micrometer-screw.

The following table shows how much a foot in length of each metal grows longer by an increase of heat, corresponding to 180° of Fahrenheit's thermometer, or to the difference between freezing and boiling water, expressed in such parts of which the unit is equal to the 10,000th part of an inch.

1.	White-glass barometer tube, -	100
2.	Martial regulus of antimony, -	130
3.	Blistered steel, - - -	138
4.	Hard steel, - -	147
5.	Iron, - - -	151
6.	Bismuth, - - -	167
7.	Copper hammered, - -	204
8.	Copper eight parts, with tin one,	218
9.	Cast brass, - - -	225
10.	Brass sixteen parts, with tin one, -	229
11.	Brass-wire, - - -	232
12.	Speculum metal, - -	232
13.	Spelter solder, viz. brass two parts, zinc one,	247
14.	Fine pewter, - -	274
15.	Grain tin, - - -	298
16.	Soft solder, viz. lead two, tin one, -	301
17.	Zinc eight parts, with tin one, a little hammered, - -	323
18.	Lead, - - -	344
19.	Zinc or spelter, -	353
20.	Zinc hammered half an inch per foot,	373

We shall close this article with a brief description of a pyrometer invented by M. De Luc, in consequence of a hint suggested to him by Mr Ramsden. The basis of this instrument is a rectangular piece of deal-board two feet and a half long, 15 inches broad, and one inch and a half thick; and to this all the other parts are fixed. This is mounted in the manner of a table, with four deal legs, each a foot long and an inch

Pyrometer. inch and a half square, well fitted near its four angles, and kept together at the other ends by four firm cross-pieces. This small table is suspended by a hook to a stand; the board being in a vertical situation in the direction of its grain, and bearing its legs forward in such a manner as that the cross-pieces which join them may form a frame, placed vertically facing the observer. This frame sustains a microscope, which is firmly fixed in another frame that moves in the former by means of grooves, but with a very considerable degree of tightness; the friction of which may be increased by the pressure of four screws. The inner sliding frame, which is likewise of deal, keeps the tube of the microscope in a horizontal position, and in great part without the frame, insomuch that the end which carries the lens is but little within the space between the frame and the board. This microscope is constructed in such a manner as that the object observed may be an inch distant from the lens; and it has a wire which is situated in the focus of the glasses, in which the objects appear reversed. At the top of the apparatus there is a piece of deal, an inch and a half thick and two inches broad, laid in a horizontal direction from the board to the top of the frame. To this piece the rods of the different substances, whose expansion by heat is to be measured, are suspended: one end of it slides into a socket, which is cut in the thickness of the board; and the other end, which rests upon the frame, meets there with a screw, which makes the piece move backward and forward, to bring the objects to the focus of the microscope. There is a cork very strongly driven through a hole bored vertically through this piece; and in another vertical hole made through the cork, the rods are fixed at the top; so that they hang only, and their dilatation is not counteracted by any pressure. In order to heat the rods, a cylindrical bottle of thin glass, about 21 inches high, and four inches in diameter, is placed in the inside of the machine, upon a stand independent of the rest of the apparatus. In this bottle the rods are suspended at a little less than an inch distance from one of the insides, in order to have them near the microscope. Into this bottle is poured water of different degrees of heat, which must be stirred about, by moving upwards and downwards, at one of the sides of the bottle, a little piece of wood, fastened horizontally at the end of a stick: in this water is hung a thermometer, the ball of which reaches to the middle of the height of the rods. During these operations the water rises to the cork, which thus determines the length of the heated part; the bottle is covered, to prevent the water from cooling too rapidly at the surface; and a thin case of brass prevents the vapour from fixing upon the piece of deal to which the rods are fixed.

Pyrometer, Pyrophorus.

PYROPHORUS, formed of πυρ, *fire*, and φερω, *I bear*, in chemistry, the name usually given to that substance called by some black phosphorus; a chemical preparation possessing the singular property of kindling spontaneously when exposed to the air. See CHEMISTRY *Index*.

PYROTECHNY,

1 Definition.

LITERALLY signifies the art of fire, and is derived from πυρ, "fire," and τεχνη, "art." The term is now, however, generally confined to denote the art of making artificial fire-works, which has become a particular trade.

As this art depends chiefly on chemical principles, and as the objects about which it is employed afford some of the most gratifying spectacles on occasions of public rejoicing, we have not considered it unworthy of a place in our Encyclopædia; and we shall endeavour to give such an account of the operations and principles of the art as may satisfy those who wish to practise it by way of rational amusement.

2 Origin of the art uncertain.

Of the origin of artificial fire-works nothing certain appears to be recorded. We know that in Europe their invention is of a recent date, and appears due to the Italians. The use of fire-works in China seems to have been very general long before their invention in Europe, and that ingenious people have carried these exhibitions to a degree of perfection which European artists have yet scarcely attained. The following description of a Chinese display of fire-works by one of the gentlemen who accompanied Lord Macartney's embassy to Pekin, will give our readers some idea of the state of the art among that people.

3 Description of Chinese fire-works.

"The fire-works in some particulars, exceeded any thing of the kind I had ever seen. In grandeur, magnificence, and variety, they were, I own, inferior to the Chinese fire-works we had seen at Batavia, but infinitely superior in point of novelty, neatness, and ingenuity of contrivance. One piece of machinery I greatly admired; a green chest of five feet square was hoisted up by a pulley to the height of 50 or 60 feet from the ground; the bottom was so constructed as then suddenly to fall out, and make way for 20 or 30 strings of lanterns enclosed in the box to descend from it, unfolding themselves from one another by degrees, so as at last to form a collection of at least 500, each having a light of a beautifully coloured flame burning brightly within it. This devolution and developement of lanterns (which appeared to me to be composed of gauze and paper) were several times repeated, and every time exhibited a difference of colour and figure. On each side was a correspondence of smaller boxes, which opened in like manner as the others, and let down an immense net-work of fire, with divisions and compartments of various forms and dimensions, round and square, hexagons, octagons, and lozenges, which shone like the brightest burnished copper, and flashed like prismatic lightning, with every impulse of the wind. The diversity of colours indeed with which the Chinese have the secret of cloathing fire seems one of the chief merits of their pyrotechny. The whole concluded with a volcano, or general explosion and discharge of suns and stars, squibs, bouncers, crackers, rockets, and grenadoes, which involved the gardens for above an hour after in a cloud of intolerable smoke." *.

* Barrow's Travels in China, p. 206.

4 Till of late the French and Italian makers of fireworks

Apparatus, Materials, &c. of Fire-works. works much excelled our British artists, and even now, though the practice of the art is well underſtood among us, its principles are almoſt entirely unknown; and no Engliſh work of any reſpectability has appeared on the ſubject. In France, the art has been more fortunate, and ſeveral men of eminent literary abilities have condeſcended to make it an object of their attention. It will be ſufficient, in proof of this, to mention the names of Ozanam and Montucla. The following works are recommended by the latter, as containing the beſt account of this amuſing art; viz.

Traité des Feux d'Artifice (Treatiſe on Artificial Fire-Works), by M. Frezier, a new edition of which appeared in 1745.

Traité des Feux d'Artifice pour le Spectacle et pour la Guerre, (Treatiſe on Artificial Fire-Works, employed in Exhibitions and in War), by M. Perrinet d'Orval.

Manuel d'Artificier, (Artificial Fire-Work-Maker's Manual), publiſhed at Paris in 1757, by Father d'Incarville.

Indeed moſt of the written information which we poſſeſs on the making of fire-works, is derived from the French; and many of theſe productions ſtill retain French names, ſuch as *gerbes*, *balloons*, *marroons*, *tourbillons*, *fauciſſons*, &c.

5 We ſhall divide this article into two chapters; in the firſt of which we ſhall conſider the apparatus required for forming the caſes or ſhells of artificial fire-works, and the materials employed in their conſtruction; and in the ſecond we ſhall deſcribe the different kinds of fire-works and the moſt approved methods of conſtructing them.

Chap. I. *Of the Apparatus and Materials employed in making Fire-Works.*

Sect. I. *Of Apparatus.*

6 Apparatus. THE apparatus uſed in making fire-works conſiſts chiefly of ſolid wooden cylinders, called *formers*, for rolling the caſes on; ſimilar cylinders either of wood or metal for ramming down the compoſition; moulds for holding the caſes while filling, a machine for *choaking* or contracting the cavity of the caſes, another for grinding the materials, and a particular apparatus for boring ſome caſes after they are filled.

We ſhall begin with deſcribing the moulds, as on the ſize of theſe depends that of the *formers* and *rammers*.

7 Rocket moulds. As the performance of rockets depends much on their moulds, it is requiſite to give a deſcription of them and their proportions: They are made and proportioned by the diameter of their orifice, which is divided into equal parts. Fig. 1. repreſents a mould made by its diameter AB: its height from C to D is ſix diameters and two-thirds; from D to E is the height of the foot, which is one diameter and two-thirds; F the *choak* or cylinder, whoſe height is one diameter and one-third; it muſt be made out of the ſame piece as the foot, and fit tight in the mould; G is an iron pin that goes through the cylinder to keep the foot faſt; H the nipple, which is half a diameter high, and two-thirds thick, and of the ſame piece of metal as the *piercer* I, whoſe height is three diameters and a half, and at the bottom it is one-third of the diameter thick, from thence tapering to one-ſixth of the diameter. The piercer is an iron pin riſing from the nipple, and intended to preſerve a vacuity in the centre of the charge. The beſt way to fix the piercer in the cylinder, is to make that part below the nipple long enough to go quite through the foot, and rivet it at bottom. Fig. 2. is a *former* or roller for the caſes, whoſe length from the handle is ſeven diameters and a half, and its diameter two thirds of the bore. Fig. 3. is a part attached to the former, which is of the ſame thickneſs, and one diameter and two thirds long; the ſmall part, which fits into the hole in the end of the roller when the caſe is pinching is one-ſixth, and one half of the mould's diameter thick. Fig. 4. the firſt drift or rammer, which muſt be ſix diameters from the handle; and this, as well as all other rammers, muſt be a little thinner than the former, to prevent the ſacking of the paper when driving in the charge. In the end of this rammer is a hole to fit over the piercer: the line K marked on this is two diameters and one-third from the handle; ſo that, when filling the rocket, this line appears at top of the caſe: you muſt then take the ſecond rammer, (fig. 5.) which from the handle is four diameters, and the hole for the piercer is one diameter and a half long. Fig. 6. is the ſhort and ſolid drift which is uſed when the caſe has been filled as high as the top of the piercer.

Fig. 1.

Plate CCCCLII.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5, 6.

Rammers muſt have a collar of braſs at the bottom, to keep the wood from ſpreading or ſplitting, and the ſame proportion muſt be given to all moulds, from one ounce to ſix pounds. We mentioned nothing concerning the handles of the rammers; however, if their diameters be equal to the bore of the mould, and two diameters long, it will be a very good proportion: but the ſhorter they can be uſed, the better; for the longer the drift, the leſs will be the preſſure on the compoſition by the blow given with the mallet.

The following are the dimenſions for rocket moulds, when the rockets are rammed ſolid.

Weight of Rockets.		Length of the moulds without their feet.	Interior diameter of the moulds.	Height of the nipples.
lb.	oz.	Inches.	Inches.	Inches.
6	0	34,7	3,5	1,5
4	0	38,6	2,9	1,4
2	0	13,35	2,1	1,0
1	0	12,25	1,7	0,85
0	8	10,125	1,333	0,6
0	4	7,75	1,125	0,5
0	2	6,2	0,9	0,45
0	1	4,9	0,7	0,33
0	½	3,9	0,55	0,25
6 drams		3,5	0,5	0,225
4 drams		2,2	0,3	0,2

N. B. The diameter of the nipple muſt always be equal to that of the former.

We ſhall now ſhow the method of finding the diameters or calibres of rockets, according to their weight; but we muſt firſt obſerve, that a pound rocket, is that juſt

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juſt capable of admitting a leaden bullet of a pound weight, and ſo of the reſt. The calibre for the different ſizes may be found in the two following tables, one of which is calculated for rockets of a pound weight and under; and the other for thoſe from a pound to 50 pounds.

8 Method of finding the diameters of rockets according to their weight.

Table I. *Of the Calibre of Moulds of a pound weight and below.*

Ounces	Lines.	Drams.	Lines.
16	19½	14	7¼
12	17	12	7
8	15	10	6⅓
7	14¾	8	6¼
6	14¼	6	5⅔
5	13	4	4½
4	12⅓	2	3¾
3	11½		
2	9⅙		
1	6½		

The uſe of this table will be underſtood merely by inſpection; for it is evident that the mould for a rocket of 12 ounces ought to be 17 lines in diameter; one of eight ounces, 15 lines; one of 10 drams, 6⅓ lines; and ſo of the reſt.

On the other hand, if the diameter of the rocket be given, it will be eaſy to find the weight of the ball correſponding to that calibre. For example, if the diameter be 13 lines, it will be immediately ſeen, by looking for that number in the column of lines, that it correſponds to a ball of five ounces.

II. *Table of the Calibre of Moulds from one to 50 pounds ball.*

Pounds.	Calibre.	Pounds.	Calibre.	Pounds.	Calibre.
1	100	18	262	35	326
2	126	19	267	36	330
3	144	20	271	37	333
4	158	21	275	38	336
5	171	22	280	39	339
6	181	23	284	40	341
7	191	24	288	41	344
8	200	25	292	42	347
9	208	26	296	43	350
10	215	27	300	44	353
11	222	28	304	45	355
12	228	29	307	46	358
13	235	30	310	47	361
14	241	31	314	48	363
15	247	32	317	49	366
16	252	33	320	50	368
17	257	34	323		

The uſe of this ſecond table is as follows: If the weight of the ball be given, which we ſhall ſuppoſe to be 24 pounds, ſeek for that number in the column of pounds, and oppoſite to it, in the column of calibres, will be found the number 288. Then ſay, as 100 is to 19½, ſo is 288 to a fourth term, which will be the number of lines of the calibre required; or multiply the number found, that is 288, by 19½, and from the produce 5616, cut off the two laſt figures; the required calibre, therefore, will be 56,16 lines, or four inches eight lines.

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On the other hand, the calibre being given in lines, the weight of the ball may be found with equal eaſe. If the calibre, for example, be 28 lines, ſay as 19½ is to 28, ſo is 100 to a fourth term, which will be 143.5, or nearly 144. But in the above table, oppoſite to 144 in the ſecond column, will be found the number 3 in the firſt; which ſhows that a rocket, the diameter or calibre of which is 28 lines, is a rocket of a three pounds ball.

Fig. 7. repreſents a mould, in which the caſes are driven ſolid; L the nipple, with a braſs point at top, (flat at top, and of the ſame length as the neck of the caſe), which, when the caſe is filling, ſerves to ſtop the neck, and prevent the compoſition from falling out, as without this point it would; and, in conſequence, the air would get into the vacancy in the charge, and at the time of firing cauſe the caſe to be burſt. Theſe moulds are made of any length or diameter, according as the caſes are required; but the diameter of the rollers muſt be equal to half the bore, and the rammers made quite ſolid. The nipple and cylinders muſt bear the ſame proportion as thoſe for rockets.

Fig. 7. 9 Moulds for ſerpents, or wheel-caſes.

The rolling and formation of caſes is ſo intimately connected with the conſtruction of *moulds* and *formers*, that we ſhall introduce what we have to ſay on that ſubject into the ſame ſection.

Sky-rocket caſes are to be made 6½ of their exterior diameter long; and all other caſes that are to be filled in moulds muſt be as long as the moulds, within half its interior diameter.

10 Method of rolling caſes.

Rocket caſes, from the ſmalleſt to four or ſix pounds, are generally made of the ſtrongeſt ſort of cartridge paper, and rolled dry; but the large ſort are made of paſted paſteboard. As it is very difficult to roll the ends of the caſes quite even, the beſt way will be to keep a pattern of the paper for the different ſorts of caſes; which pattern ſhould be ſomewhat longer than the caſe it is deſigned for, and on it marked the number of ſheets required, which will prevent any paper being cut to waſte. Having cut the papers of a proper ſize, and the laſt ſheet for each caſe with a ſlope at one end, ſo that when the caſes are rolled it may form a ſpiral line round the outſide, and that this ſlope may always be the ſame, let the pattern be ſo cut for a guide. Before you begin to roll, fold down one end of the firſt ſheet, ſo far that the fold will go two or three times round the former: then, on the double edge, lay the former with its handle off the table; and when you have rolled on the paper within two or three turns, lay the next ſheet on that part which is looſe, and roll it all on.

Having thus done, you muſt have a ſmooth board, about 20 inches long, and equal in breadth to the length of the caſe. In the middle of this board muſt be a handle placed lengthwiſe. Under this board lay the caſe, and let one end of the board lie on the table; then preſs hard on it, and puſh it forwards, which will roll the paper very tight; do this three or four times before you roll on any more paper. This muſt be repeated with every other ſheet of paper, till the caſe is thick enough;

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enough; but if the rolling board be drawn backwards, it will looſen the paper: you are to obſerve, when you roll on the laſt ſheet, that the point of the ſlope be placed at the ſmall end of the roller. Having rolled your caſe to fit the mould, puſh in the ſmall end of the former F, about one diameter from the end of the caſe, and put in the end-piece within a little diſtance of the former; then give the pinching cord one turn round the caſe, between the former and the end-piece; at firſt pull gently, and keep moving the caſe, which will make the neck ſmooth, and without large wrinkles. When the caſes are hard to choak, let each ſheet of paper (except the firſt and laſt, in that part where the neck is formed) be a little moiſtened with water: immediately after you have ſtruck the concave ſtroke, bind the neck of the caſe round with ſmall twine, which muſt not be tied in a knot, but faſtened with two or three hitches.

Having thus pinched and tied the caſe ſo as not to give way, put it into the mould without its foot, and with a mallet drive the former hard on the end-piece, which will force the neck cloſe and ſmooth. This done, cut the caſe to its proper length, allowing from the neck to the edge of the mouth half a diameter, which is equal to the height of the nipple; then take out the former, and drive the caſe over the piercer with the long rammer, and the vent will be of a proper ſize. Wheel-caſes muſt be driven on a nipple with a point to cloſe the neck, and make the vent of the ſize required; which, in moſt caſes, is generally one-fourth of their interior diameter. As it is very often difficult, when the caſes are rolled, to draw the roller out, you may make a hole through the handle, and put in it a ſmall iron pin, by which you may eaſily turn the former round and pull it out. Fig. 8. ſhows the method of pinching caſes; P a treddle, which, when preſſed hard with the foot, will draw the cord tight, and force the neck as cloſe as you pleaſe; Q a ſmall wheel or pulley, with a groove round it for the cord to run in. (Fig. 8.)

Caſes for wheels and fixed pieces are commonly rolled wet; and when they are required to contain a great length of charge, the method of making thoſe caſes is this: The paper muſt be cut as uſual, only the laſt ſheet muſt not be cut with a ſlope: Having the paper ready, paſte each ſheet on one ſide; then fold down the firſt ſheet as before directed: but be careful that the paſte does not touch the upper part of the fold; for if the roller be wetted, it will tear the paper in drawing it out. In paſting the laſt ſheet, obſerve not to wet the laſt turn or two in that part where it is to be pinched; for if that part be damp, the pinching cord will ſtick to it, and tear the paper; therefore, when you choke thoſe caſes, roll a bit of dry paper once round the caſe, before you put on the pinching cord; but this bit of paper muſt be taken off after the caſe is choked. The rolling board, and all other methods, according to the former directions for the rolling and pinching of caſes, muſt be uſed to theſe as well as all other caſes.

11 Tourbillon caſes.

Tourbillon caſes are generally made about eight diameters long; but if very large, ſeven will be ſufficient: tourbillons will anſwer very well from four ounces to two pounds; but when larger there is no certainty. The caſes are beſt rolled wet with paſte, and the laſt ſheet muſt have a ſtraight edge, ſo that the caſe may be all of a thickneſs: when the caſes have been rolled in the manner of wheel caſes, pinch them at one end quite cloſe; then with the rammer drive the ends down flat, and afterwards ram in about one-third of a diameter of dried clay. The diameter of the former for theſe caſes muſt be the ſame as of that for ſky-rockets.

N. B. Tourbillons are to be rammed in moulds without a nipple, or in a mould without its foot.

12 Balloon caſes, or paper ſhells.

For *balloons*, firſt prepare an oval former turned of ſmooth wood; over which, paſting a quantity of brown or cartridge paper, let it lie till the paſte has quite ſoaked through; this done, rub the former with ſoap or greaſe, to prevent the paper from ſticking to it; then lay the paper on in ſmall ſlips, till you have made it one-third of the thickneſs of the intended ſhell. This being done, ſet it to dry; and when dry, cut it round the middle, and the two halves will eaſily come off: but obſerve, when you cut, to leave about one inch uncut, which will make the halves join much better than if they had been quite ſeparated. When there are ſome ready to join, place the halves evenly together, paſte a ſlip of paper round the opening to hold them together, and let that dry; then lay on paper all over as before, everywhere equal, excepting that end which goes downwards in the mortar, which may be a little thicker than the reſt; for that part which receives the impulſe from the powder in the chamber of the mortar requires the greateſt ſtrength. When the ſhell is thoroughly dry, burn a round hole at top, with ſquare iron, large enough for the fuze: this method will do for balloons from four inches two-fifths, to eight inches diameter; but if they are larger, or required to be thrown a great height, let the firſt ſhell be turned of elm, inſtead of being made of paper.

For a balloon of four inches two fifths, let the *former* be three inches one-eighth diameter, and five inches and a half long. For a balloon of five inches and a half, the diameter of the *former* muſt be four inches, and eight inches long. For a balloon of eight inches, let the diameter of the *former* be five inches and 15-16ths, and 11 inches ſeven-eights long. For a 10-inch balloon, let the *former* be ſeven inches three-ſixteenths diameter, and 14 inches and a half long. The thickneſs of a ſhell for a balloon of four inches two-fifths, muſt be one-half inch. For a balloon of five inches and a half, let the thickneſs of the paper be five-eighths of an inch. For an eight-inch balloon, ſeven-eighths of an inch. And for a 10-inch balloon, let the ſhell be one inch one-eighth thick.

Shells that are deſigned for ſtars only, may be made quite round, and the thinner they are at the opening, the better; for if they are too ſtrong, the ſtars are apt to break at the burſting of the ſhell: when making the ſhell, uſe a pair of calibre compaſſes, or a round gage, ſo that the paper may not be laid thicker in one place than another; and alſo to know when the ſhell is of a proper thickneſs. Balloons muſt always be made to go eaſy into the mortars.

13 Caſes for port-fires.

Port-fire caſes muſt be made very thin, and rolled on *formers*, from two inches to $\frac{5}{8}$ of an inch diameter, and from two to ſix inches long: they are pinched cloſe at one end, and left open at the other. When they are to be filled, put in but little compoſition at a time, and ram it lightly, ſo as not to break the caſe: three or four rounds of paper, with the laſt round paſted, will be ſtrong enough for theſe caſes.

Common portfires are intended for the purpoſe of firing

ing the works, their fire being very ſlow, and the heat of the flame ſo intenſe, that, if applied to rockets, leaders, &c. it will fire them immediately. Portfires may be made of any length, but are ſeldom made more than 21 inches long: the interior diameter of portfire moulds ſhould be 10-16ths of an inch, and the diameter of the former half an inch. The caſes muſt be rolled wet with paſte, and one end pinched, or folded down. The moulds ſhould be made of braſs, and ſuch as will take in two pieces lengthwiſe; when the caſe is in the two ſides, they are held together by braſs rings, or hoops, which are made to fit over the outſide. The bore of the mould muſt not be made quite through, ſo that there will be no occaſion for a foot. Theſe portfires, when uſed, are held in copper ſockets, fixed on the end of a long ſtick: theſe ſockets are made like port-crayons, only with a ſcrew inſtead of a ring.

14 For common portfires.

15 Method of grinding the ingredients.

There have been many methods contrived for grinding the ingredients for fire-works to a powder, ſuch as large mortars and peſtles made of ebony and other hard wood, and horizontal mills with braſs barrels; but none have proved ſo effectual and ſpeedy, as that of the mealing-table, repreſented in fig. 9. made of elm, with a rim round its edge four or five inches high; and at the narrow end A, furniſhed with a ſlider that runs in a groove, and forms part of the rim: ſo that when you have taken out of the table as much powder as you can with the copper ſhovel (fig. 10.), ſweep all clean out at the ſlider A. When about to meal a quantity of powder, obſerve not to put too much in the table at once; but when you have put in a good proportion, take the muller (fig. 11.) and rub it till all the grains are broken; then ſift it in a lawn ſieve that has a receiver and top to it, ſuch as is uſed by apothecaries, and that which does not paſs through the ſieve, muſt be returned again to the table, and ground till it is fine enough to go through the ſieve. Sulphur and charcoal are ground in the ſame manner, only the muller muſt be made of ebony; for theſe ingredients being harder than powder, would ſtick in the grain of elm, and be difficult to grind. As ſulphur is apt to ſtick and clod to the table, it will be beſt to keep one for that purpoſe, by which means you will always have your brimſtone clean and well ground.

Fig. 9. Fig. 10. Fig. 11.

Fig. 12. 16 Apparatus for boring rockets that are rammed ſolid.

Fig. 12. repreſents the plan of an apparatus, or lathe, for boring rockets. A the large wheel, which turns the ſmall one B, that works the rammer C: theſe rammers are of different ſizes according to the rockets; they muſt be of the ſame diameter as the top of the intended bore, and continue that thickneſs a little longer than the depth of the bore required, and their points muſt be like that of an augre: the thick end of each rammer muſt be made ſquare, and all of the ſame ſize, ſo as to fit into one ſocket, into which they are faſtened by a ſcrew D. E the guide for the rammer, which is made to move backwards and forwards; ſo that, after the rammer has been marked three diameters and a half of the rocket from the point, ſet the guide, allowing for the thickneſs of the fronts of the rocket boxes, and the neck and mouth of the rocket; ſo that when the front of the large box is cloſe to the guide, the rammer may not go too far up the charge. F, boxes for holding the rockets, which are made ſo as to fit one within; their ſides muſt be equal in thickneſs to the difference of the diameters of the rockets, and their interior diameters equal to the exterior diameters of the rockets. To prevent the rocket from turning round while boring, a piece of wood muſt be placed againſt the end of the box in the inſide, and preſſed againſt the tail of the rocket. This will alſo hinder the rammer from forcing the rocket backwards. G, a rocket in the box. H, a box that ſlides under the rocket-boxes to receive the borings for the rockets, which fall through holes made on purpoſe in the boxes; theſe holes muſt be juſt under the mouth of the rocket, one in each box, and all to correſpond with each other.

Fig. 13. is a front view of the large rocket-box. I, an iron-plate, in which are holes of different ſizes, through which the rammer paſſes; this plate is faſtened with a ſcrew in the centre, ſo that when the rammer is changed, the plate is turned round, but the hole you are going to uſe muſt always be at the bottom: the fronts of the other boxes muſt have holes in them to correſpond with thoſe in the plate. K, the lower part of the large box; which is made to fit the inſide of the lathe, that all the boxes may move quite ſteadily. Fig. 13.

Fig. 14. is a perſpective view of the lathe. L, the guide for the rammer, which is ſet by the ſcrew at bottom. Fig. 14.

Fig. 15. A view of the front of the guide facing the rammer. M, an iron plate, of the ſame dimenſions as that on the front of the box, and placed in the ſame direction, and alſo to turn on a ſcrew in the centre. N, the rocket-box which ſlides backwards and forwards: when a rocket is fixed in the box, it is to be puſhed forwards againſt the rammer; and when the ſcoop of the rammer appears to be full, draw the box back, and knock out the compoſition: this muſt be done till the rocket is bored, or it will be in danger of taking fire; and if the boring be done in a hurry, wet the end of the rammer now and then with oil to keep it cool. Fig. 15.

Having bored a number of rockets, you muſt have taps of different ſorts according to the rockets. Theſe taps are a little longer than the bore: but when uſed they muſt be marked 3½ diameters from the point, allowing for the thickneſs of the rocket's neck; then, holding the rocket in one hand, tap it with the other. One of theſe taps is repreſented by fig. 16. They are made in the ſame proportion as the fixed piercers, and are hollowed their whole length. Fig. 16.

17 Hand machine for boring.

There are hand machines for boring, which anſwer very well, though not ſo expeditious as the lathes. But they are not ſo expenſive, and they may be worked by one man; whereas the lathe will require three. Fig. 17. repreſents the machine. O, the rocket boxes, which are to be fixed, and not to ſlide as thoſe in the lathe. PQ are guides for the rammers, that are made to ſlide together, as the rammer moves forward: the rammers for theſe machines muſt be made of a proper length, allowing for the thickneſs of the front of the boxes, and the length of the mouth and neck of the caſe; on the ſquare end of theſe rammers muſt be a round ſhoulder of iron, to turn againſt the outſide of the guide Q, by which means the guides are forced forwards. R, the ſtock which turns the rammer, and which, while turning, muſt be preſſed towards the rocket by the body of the man who works it; all the rammers are to be made to fit one ſtock. Fig. 17.

SECT. II. *Of the Ingredients for composing the Charges of Fire-works.*

18 Ingredients for the charges of fire-works.

THE charges or compositions with which the cases that we have described are to be filled, consist chiefly of gunpowder, or of a powder composed of the same materials in various proportions, and some other combustible substances, intended either to give the composition a stronger impelling force, or to increase the beauty and splendour of the exhibition. As the nature and composition of gunpowder have been fully explained under the article GUNPOWDER, it is unnecessary to consider them in this place; but as the makers of fire-works commonly employ considerable quantities of the substances of which gunpowder is composed, it may be proper to give some directions for obtaining these in the greatest purity. We may also notice, that gunpowder, in its ordinary state, is called *corn powder;* while, when ground down, as directed in N° 15. it is denominated *meal powder.*

19 Nitre.

The ingredient on which the force of the compositions chiefly depends, is nitre, or saltpetre; but as this substance, in its usual state, is very impure, being much contaminated with earthy matter, and as pure nitre is now become very expensive, it is of consequence to know how the nitre of commerce may be purified.

20 Method of purifying nitre.

Nitre, like most other saline bodies, is much more soluble in boiling water, than in water of the ordinary temperature. If, therefore, the nitre of commerce be dissolved in a small quantity of boiling water, and the solution be properly strained, the liquor, when cold, will afford crystals that are very pure. The following is the most convenient method of proceeding. Dissolve the nitre in boiling water, in the proportion of about an English quart, or Scotch chopin, to each pound of nitre; and that the solution may be more easily effected, let the nitre be reduced to powder, and let the vessel containing the nitre and water be kept at the boiling heat till all the salt is dissolved. Then strain the liquor while hot through thick blotting paper, placed in a clean funnel, and set by the filtered liquor in a shallow vessel, in some cold place, till crystals are formed. These must be removed from the liquor, and dried with a gentle heat; and if the remaining liquor be slowly evaporated over the fire, in an earthen unglazed vessel, till a film appears on the top, and then set by to crystallize as before, an additional quantity of pure nitre will be procured; and thus, by repeated evaporations and crystallizations, the whole of the salt will be obtained.

21 Method of procuring nitre from damaged gun-powder.

Nitre may be obtained in great purity from damaged gunpowder, which may often be bought at a cheap rate. The damaged powder must be ground with a small quantity of hot water, in a large wooden or stone mortar, or it may be boiled over a gentle fire, with as much water as will cover it. When the water seems to have dissolved as much of the nitre as it will retain, it is to be poured off from the sediment, and filtered or strained through a flannel bag, then heated again, and, while hot, filtered through blotting paper, and set by to crystallize, as in the former case. Fresh quantities of hot water are to be successively added to the sediment, and strained as before, till the whole of the nitre is obtained.

Nitre may be speedily reduced to a fine powder, by dissolving it in a little more than its own weight of boiling water, in a kettle with a round bottom, keeping the solution over a gentle fire, and continually stirring it with a wooden spatula till all the water is evaporated, and the remaining powder is pretty well dried. Care must be taken, however, not to suffer it to remain too long, or expose it to too great a heat, otherwise it will be melted into a firm cake. The drying may be completed by suffering it to lie for a sufficient time on paper before the fire. 22 Speedy method of powdering nitre.

23 Sulphur.

Sulphur or brimstone, may be employed in three states. 1. As it is brought from the neighbourhood of volcanoes, or what is called *sulphur vivum.* 2. Roll brimstone, which is sold by most grocers, and is employed for making matches; and, 3. Flowers of sulphur, or sublimed sulphur. The first of these is the cheapest, and answers very well for coarse fire-works; the second is considered as the strongest, and is most used; but the third is the purest sulphur, and will answer best for the nicer and more delicate fire-works. It also has the advantage of being in a state of fine powder, whereas the the two former require to be ground or mealed, as directed in N° 15.

24 Charcoal.

Charcoal may, in general, be procured at the shops of founders and hardware dealers; but when this is not the case, it may easily be prepared by putting a quantity of small pieces of wood into a large earthen crucible or iron pot, and covering them to the head with sand, and placing the crucible or the pot in the middle of a strong fire, where it must be kept red hot for an hour or two, in proportion to the quantity of wood. Charcoal should be chosen soft and light, and such as may easily be reduced to powder. It should be kept in a dry place, but is always best when fresh burned.

25

Several other ingredients are employed in the composition of fire-works, such as camphor, antimony (*sulphuret of antimony*), raspings of ivory, yellow amber, sal ammoniac, verdigris, common pitch, and Greek pitch, all of which are used on different occasions, to produce a change of colour in the fire; filings of iron and copper, for giving a sparkling appearance to the flame, and salt of benjamin (*benzoic acid*) to produce an agreeable odour.

26 Method of powdering cast iron.

Iron filings answer very well for ordinary fire-works; but they do not produce such a brilliant appearance as powdered cast-iron. The introduction of this latter is an improvement of the Chinese, and its use is now very general.

Cast-iron being of so hard a nature as not to be cut by a file, we are obliged to reduce it into grains, though this is rather difficult to perform; but if we consider what beautiful sparks this iron yields, no pains should be spared to granulate such an essential material: to do this, procure at an iron-foundery some thin pieces of iron, such as generally run over the mould at the time of casting: then have a square block made of cast-iron, and an iron square hammer about four lb. weight; then, having covered the floor with cloth or something to catch the beatings, lay the thin pieces of iron on the block, and beat them with the hammer till reduced into small grains; which afterwards sift with a very fine sieve, to separate the fine dust, which is sometimes used in small cases of brilliant fire, instead of steel dust; and when you have got out all the dust, sift what remains with a

sieve

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sieve a little larger, and so on with sieves of different sizes, till the iron passes through about the bigness of small bird-shot: the iron, thus beaten and sifted, is to be put separately, according to its fineness, into wooden boxes or oiled paper, to keep it from rusting. When used, observe the difference of its size, in proportion to the cases for which the charge is intended; for the coarse sort is proper only for very large gerbes of six or eight pounds.

When these pieces of iron cannot be procured, an old cast-iron pot may be employed; but care must be taken that its surface be perfectly freed from rust. This pulverized cast iron is sometimes called *iron sand*, and is denominated, according to its fineness, sand of the first, second, third, &c. order, that of the first order being the finest.

It sometimes happens, that fire-works may be required to be kept a long time, or sent abroad; neither of which could be done with brilliant fires, if made with filings unprepared, for this reason; that the saltpetre being of a damp nature, it causes the iron to rust; the consequence of which is, that when the works are fired, there will appear but very few brilliant sparks, but instead of them a number of red and drossy sparks; and besides, the charge will be so much weakened, that if this were to take place in wheels, the fire would scarcely be strong enough to force them round. But to prevent such accidents, the filings may be thus prepared: Melt in a glazed earthen pan some brimstone over a slow fire, and when melted throw in some filings; which keep stirring till they are covered with brimstone: this must be done while it is on the fire; then take it off, and stir it very quickly till cold, when it must be rolled on a board with a wooden roller, till broken as fine as corn powder; after which sift from it as much of the brimstone as possible. There is another method of preparing filings, so as to keep two or three months in winter; this may be done by rubbing them between strong brown paper, which before has been moistened with linseed oil.

N. B. If the brimstone should take fire, it may be extinguished, by covering the pan close at top: it does not signify what quantity of brimstone is used, provided there is enough to give each grain of iron a coat; but as much as will cover the bottom of a pan of about one foot diameter, will do for five or six pounds of filings or cast-iron for gerbes.

28 Chinese fire.

Before we enumerate the various compositions generally employed in filling cases for rockets, wheels, &c. we shall describe two compositions that are much valued for the brilliancy of their appearance. One of these is called *Chinese fire*, and is either red or white. The following tables shew the proportions of the different ingredients for each of these compositions; as they are adapted to rockets (in the construction of which the Chinese fire is much employed) of from 12 to 36 lbs.

Composition of Red Chinese Fire.

Calibres.	Saltpetre.	Sulphur.	Charcoal.	Sand of the first order.	
Pounds.	Pounds.	Ounces.	Ounces.	Oz.	Dr.
12 to 15	1	3	4	7	0
18 to 21	1	3	5	7	8
24 to 36	1	4	6	8	0

For White Chinese Fire.

Calibres.	Saltpetre.	Bruised Gunpowder.	Charcoal.		Sand of the third order.	
Pounds.	Pounds.	Ounces.	Oz.	Dr.	Oz.	Dr.
12 to 15	1	12	7	8	11	0
18 to 21	1	11	8	0	11	8
24 to 36	1	11	8	8	12	0

The other composition is called spur fire, because the sparks yielded by it have a starry appearance like the rowel of a spur. 29 Spur fire.

Spur-fire.—This fire is the most beautiful and curious of any yet known; and was invented by the Chinese, but now is in greater perfection in England than in China. As it requires great trouble to make it to perfection, it will be necessary that beginners should have full instructions; therefore care should be taken that all the ingredients are of the best, that the lamp-black is not damp and clodded, that the saltpetre and brimstone are thoroughly refined. This composition is generally rammed in one or two ounce cases about five or six inches long, but not drove very hard; and the cases must have their concave stroke struck very smooth, and the choak or vent not quite so large as the usual proportion: this charge, when driven and kept a few months, will be much better than when rammed; and will not spoil, if kept dry, in many years.

As the beauty of this composition cannot be seen at so great a distance as brilliant fire, it has a better effect in a room than in the open air, and may be fired in a chamber without any danger: it is of so innocent a nature, that, though with an improper phrase, it may be called a *cold fire;* and so extraordinary is the fire produced from this composition, that, if well made, the sparks will not burn a handkerchief when held in the midst of them; you may hold them in your hand while burning, with as much safety as a candle; and if you put your hand within a foot of the mouth of the case, you will feel the sparks like drops of rain.—When any of these spur-fires are fired singly, they are called *artificial flower-pots;* but some of them placed round a transparent pyramid of paper, and fired in a large room, make a very pretty appearance.

The composition consists of saltpetre, four pounds eight ounces; sulphur two pounds, and lamp-black one pound eight ounces; or, saltpetre one pound, sulphur half a pound, and lamp-black four quarts.—This composition is very difficult to mix. The saltpetre and brimstone must be first sifted together, and then put into a marble mortar, and the lamp-black with them, which you work down by degrees with a wooden pestle, till all the ingredients appear of one colour, which will be something grayish, but very near black: then drive a little into a case for trial, and fire it in a dark place; and if the sparks, which are called *stars*, or *pinks*, come out in clusters, and afterwards spread well without any other sparks, it is a sign of its being good, otherwise not; for if any drossy sparks appear, and the stars not full, it is then not mixed enough; but if the pinks are very small, and soon break, it is a sign that it has been rubbed too much.

This

Apparatus, Materials, &c. of Fire-works. This mixture, when rubbed too much, will be too fierce, and hardly ſhow any ſtars; and, on the contrary, when not mixed enough, will be too weak, and throw out an obſcure ſmoke, and lumps of droſs, without any ſtars.

The following compoſitions are thoſe commonly employed in ordinary fire-works.

30 Charges for ſky-rockets. *Rockets of four ounces.*—Mealed powder 1 lb. 4 oz. ſaltpetre 4 oz. and charcoal 2 oz.

Rockets of eight ounces.—I. Mealed powder 1 lb. ſaltpetre 4 oz. brimſtone 3 oz. and charcoal $1\frac{1}{2}$ oz. II. Meal-powder $1\frac{1}{2}$ lb. and charcoal $4\frac{1}{4}$ oz.

Rockets of one pound.—Meal-powder 2 lb. ſaltpetre 8 oz. brimſtone 4 oz. charcoal 2 oz. and ſteel-filings $1\frac{1}{2}$ oz.

Sky-rockets in general.—I. Saltpetre 4 lb. brimſtone 1 lb. and charcoal $1\frac{1}{2}$ lb. II. Saltpetre 4 lb. brimſtone $1\frac{1}{2}$ lb. charcoal 1 lb. 12 oz. and meal-powder 2 oz.

Large ſky-rockets.—Saltpetre 4 lb. meal-powder 1 lb. and brimſtone 1 lb.

Rockets of a middling ſize.—I. Saltpetre 8 lb. ſulphur 3 lb. meal-powder 3 lb. II. Saltpetre 3 lb. ſulphur 2 lb. meal-powder 1 lb. charcoal 1 lb.

31 For rocket ſtars. *White ſtars.* Meal-powder 4 oz. ſaltpetre 12 oz. ſulphur vivum 6 oz. oil of ſpike 2 oz. and camphor 5 oz.

Blue ſtars.—Meal-powder 8 oz. ſaltpetre 4, ſulphur 2, ſpirit of wine 2, and oil of ſpike 2.

Coloured or variegated ſtars. Meal-powder 8 drams, rochpetre 4 oz. ſulphur vivum 2, and camphor 2.

Brilliant ſtars.—Saltpetre $3\frac{1}{2}$ oz. ſulphur $1\frac{1}{2}$, and meal-powder $\frac{3}{4}$, worked up with ſpirits of wine only.

Common ſtars.—Saltpetre 1 lb. brimſtone 4 oz. antimony $4\frac{2}{3}$, iſinglaſs $\frac{1}{2}$, camphor $\frac{1}{2}$, and ſpirit of wine $\frac{3}{4}$.

Tailed ſtars.—Meal-powder 3 oz. brimſtone 2, ſaltpetre 1, and charcoal (coarſely ground) $\frac{3}{4}$.

Drove ſtars.—I. Saltpetre 3 lb. ſulphur 1 lb. braſs duſt 12 oz. antimony 3. II. Saltpetre 1 lb. antimony 4 oz. and ſulphur 8.

Fixed pointed ſtars.—Saltpetre $8\frac{1}{2}$ oz. ſulphur 2, antimony 1 oz. 10 dr.

Stars of a fine colour.—Sulphur 1 oz. meal-powder 1, ſaltpetre 1, camphor 4 dr. oil of turpentine 4 dr.

32 Rains. *Gold rain for ſky-rockets.*—I. Saltpetre 1 lb. meal-powder 4 oz. ſulphur 4, braſs-duſt 1, ſaw-duſt $2\frac{1}{4}$, and glaſs-duſt 6 dr. II. Meal-powder 12 oz. ſaltpetre 2, charcoal 4. III. Saltpetre 8 oz. brimſtone 2, glaſs-duſt 1, antimony $\frac{3}{4}$, braſs-duſt $\frac{1}{4}$, and ſaw-duſt 12 dr.

Silver rain. I. Saltpetre 4 oz. ſulphur, meal-powder, and antimony, of each 2 oz. ſal prunella $\frac{1}{2}$ oz. II. Saltpetre $\frac{1}{2}$ lb. brimſtone 2 oz. and charcoal 4. III. Saltpetre 1 lb. brimſtone $\frac{1}{4}$ lb. antimony 6 oz. IV. Saltpetre 4 oz. brimſtone 1, powder 2, and ſteel-duſt $\frac{1}{4}$ oz.

33 For water rockets. I. Meal-powder 6 lb. ſaltpetre 4, brimſtone 3, charcoal 5. II. Saltpetre 1 lb. brimſtone $4\frac{1}{2}$ oz. charcoal 6. III. Saltpetre 1 lb. brimſtone 4 oz. charcoal 12. IV. Saltpetre 4 lb. brimſtone $1\frac{1}{2}$ lb. charcoal 1 lb. 12 oz. V. Brimſtone 2 lb. ſaltpetre 4 lb. and meal-powder 4. VI. Saltpetre 1 lb. meal-powder 4 oz. brimſtone $8\frac{1}{2}$, charcoal 2. VII. Meal-powder 1 lb. ſaltpetre 3, brimſtone 1; ſea-coal 1 oz. charcoal $8\frac{1}{2}$, ſaw-duſt $\frac{1}{4}$, ſteel-duſt $\frac{1}{2}$, and coarſe charcoal $\frac{1}{4}$ oz. VIII. Meal-powder $1\frac{1}{4}$ lb. ſaltpetre 3, ſulphur $1\frac{1}{2}$, charcoal 12 oz. ſaw-duſt 2.

Sinking charge for water-rockets.—Meal-powder 8 oz. charcoal $\frac{3}{4}$ oz.

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Wheel-caſes from two ounces to four pounds.—I. Meal-powder 2 lb. ſaltpetre 4 oz. iron-filings 7. II. Meal-powder 2 lb. ſaltpetre 12 oz. ſulphur 4, ſteel-duſt 3. III. Meal-powder 4 lb. ſaltpetre 1 lb. brimſtone 8 oz. charcoal $4\frac{1}{2}$. IV. Meal-powder 8 oz. ſaltpetre 4, ſaw-duſt $1\frac{1}{2}$, ſea-coal $\frac{1}{2}$. V. Meal-powder 1 lb. 4 oz. 34 For wheels. brimſtone 4 oz. 10 dr. ſaltpetre 8 oz. glaſs-duſt $2\frac{1}{2}$. VI. Meal-powder 12 oz. charcoal 1, ſaw-duſt $\frac{1}{2}$. VII. Saltpetre 1 lb. 9 oz. brimſtone 4 oz. charcoal $4\frac{1}{2}$. VIII. Meal-powder 2 lb. ſaltpetre 1, brimſtone $\frac{1}{2}$, and ſea-coal 2 oz. IX. Saltpetre 2 lb. brimſtone 1, meal-powder 4, and glaſs-duſt 4 oz. X. Meal-powder 1 lb, ſaltpetre 2 oz. and ſteel-duſt $3\frac{1}{2}$. XI. Meal-powder 2 lb. and ſteel-duſt 2 and a half oz. with 2 and a half of the fine duſt of beat iron. XII. Saltpetre 2 lb. 13 oz. brimſtone 8 oz. and charcoal.

Slow fire for wheels.—I. Saltpetre 4 oz. brimſtone 2, and meal-powder 1 and a half. II. Saltpetre 4 oz. brimſtone 1, and antimony 1 oz. 6 dr. III. Saltpetre 4 oz. and a half, brimſtone 1 oz. and mealed powder 1 and a half.

Dead fire for wheels. I. Saltpetre $1\frac{1}{4}$ oz. brimſtone $\frac{1}{4}$, lapis-calaminaris $\frac{1}{4}$, and antimony 2 dr.

I. Meal-powder 4 lb. ſaltpetre 2, brimſtone and charcoal 1. 35 For fixed or ſtanding caſes. II. Meal-powder 2 lb. ſaltpetre 1, and ſteel-duſt 8 oz. III. Meal-powder 1 lb. 4 oz. and charcoal 4 oz. IV. Meal-powder 1 lb. and ſteel-duſt 4 oz. V. Meal-powder $2\frac{1}{2}$ lb. brimſtone 4 oz. and ſea coal 6. VI. Meal-powder 3 lb. charcoal 5 oz. and ſaw-duſt 1 and a half.

I. Meal-powder $8\frac{1}{2}$ lb. ſaltpetre 1 lb. 2 oz. ſteel-duſt 36 For ſun caſes. 2 lb. 10 oz. brimſtone 4. II. Meal-powder 3 lb. ſaltpetre 6 oz. and ſteel-duſt $7\frac{1}{2}$.

Meal-powder 11 lb. ſaltpetre 1, brimſtone 4 oz. ſteel- 37 For a brilliant fire. duſt 1 lb. and a half.

Meal-powder 6 lb. and beat-iron 2 lb. 1 oz. and a half. 38 For gerbes.

Charge for four ounce Tourbillons.—Meal powder 2 39 For tourbillons. lb. 4 oz. and charcoal 4 oz. and a half.

Eight ounce Tourbillons.—Meal-powder 2 lb. and charcoal $4\frac{1}{4}$ oz.

Large Tourbillons.—Meal-powder 2 lb. ſaltpetre 1, brimſtone 8 oz. and beat iron 8.

N. B. Tourbillons may be made very large, and of different-coloured fires: only you are to obſerve, that the larger they are, the weaker muſt be the charge; and, on the contrary, the ſmaller, the ſtronger their charge.

I. Saltpetre 4 lb. brimſtone 2, meal-powder 2, anti- 40 For water balloons. mony 4 oz. ſaw-duſt 4, and glaſs-duſt 1 and a fourth. II. Saltpetre 9 lb. brimſtone 3 lb. meal-powder 6 lb. roſin 12 oz. and antimony 8 oz.

I. Meal-powder 1 lb. and charcoal 1 lb. II. Meal- 41 For water ſquibs. powder 1 lb. and charcoal 9 oz.

I. Meal-powder 1 lb. and charcoal 1 oz. II. Meal- 42 Mine ports or ſerpents. power 9 oz. charcoal 1 oz.

For firing rockets, &c. I. Saltpetre 12 oz. brimſtone 4 oz. and meal-powder 2 oz. II. Saltpetre 8 oz. 43 Port fires. brimſtone 4 oz. and meal-powder 2 oz. III. Saltpetre 1 lb. 2 oz. meal-powder 1 lb. and a half, and brimſtone 10 oz. This compoſition muſt be moiſtened with one gill of linſeed oil. IV. Meal-powder 6 oz. ſalt-petre 2 lb. 2 oz. and brimſtone 10 oz. V. Saltpetre 1 lb. 4 oz. meal-powder 4 oz. brimſtone 5 oz. ſaw-duſt 8 oz. VI. Saltpetre 8 oz. brimſtone 2 oz. and meal-powder 2 oz.

For illuminations.—Saltpetre 1 lb. brimſtone 8 oz. and meal-powder 6 oz.

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Saltpetre 1 lb. and a half, brimſtone 6 oz. meal-powder 14 oz. and glaſs-duſt 14 oz.

Saltpetre 6 oz. brimſtone 2 lb. antimony 4 oz. and camphor 2 oz.

44 Cones or ſpiral wheels.

I. Saltpetre 1 lb. 10 oz. brimſtone 8 oz. and meal-powder 1 lb. 6 oz. II. Saltpetre 1 lb. and a half, brimſtone 8 oz. and meal-powder 1 lb. 8. oz.

45 Crowns or globes.

Meal-powder 1 lb. 8 oz. ſaltpetre 12 oz. and charcoal 2 oz.

46 Air balloon fuzes.

I. Saltpetre 5 lb. brimſtone 1 lb. meal-powder 1 lb. and a half, and glaſs duſt 1 lb. II. Saltpetre 5 lb. 8 oz. brimſtone 2 lb. meal-powder 1 lb. 8 oz. and glaſs-duſt 1 lb. 8 oz.

47 Serpents for pots des brin.

I. Saltpetre 2 lb. brimſtone 3 lb. antimony 1 lb. II. Saltpetre 3½ lb. ſulphur 2½ lb. meal-powder 1 lb. antimony half a lb. glaſs-duſt 4 oz. braſs-duſt 1 oz.

48 Fire pumps.

N. B. Theſe compoſitions, driven 1¼ inch in a 1 oz. caſe, will burn one minute, which is much longer time than an equal quantity of any compoſition yet known will laſt.

49 A ſlow white flame.

50 Amber lights.

Meal-powder 9 oz. amber 3 oz. This charge may be drove in ſmall caſes, for illuminations.

51 Other lights.

Saltpetre 3 lb. brimſtone 1 lb. meal-powder 1 lb. antimony 10½ oz. All theſe muſt be mixed with the oil of ſpike.

52 A red fire.

Meal-powder 3 lb. charcoal 12 oz. and ſaw-duſt 8 oz.

53 A common fire.

Saltpetre 3 lb. charcoal 10 oz. and brimſtone 2 oz.

54 For ſtars of different colours.

I. Meal powder 4 oz. ſaltpetre 2 oz. brimſtone 2 oz. ſteel-duſt 1 oz. and a half, and camphor, white amber, antimony, and mercury-ſublimate, of each ½ oz. II. Rochepetre 10 oz. brimſtone, charcoal, antimony, meal-powder, and camphor, of each ¾ oz. moiſtened with oil of turpentine. Theſe compoſitions are made into ſtars, by being worked to a paſte with aqua vitæ, in which has been diſſolved ſome gum-tragacanth; and after you have rolled them in powder, make a hole through the middle of each, and ſtring them on quick-match, leaving about 2 inches between each. III. Saltpetre 8 oz. brimſtone 2 oz. yellow amber 1 oz. antimony 1 oz. and powder 3 oz. IV. Brimſtone 2½ oz. ſaltpetre 6 oz. olibanum or frankincenſe in drops 4 oz.; maſtick, and mercury-ſublimate, of each 4 oz. meal-powder 5 oz. white amber, yellow amber, and camphor, of each 1 oz. antimony and orpiment half a oz. each. V. Saltpetre 1 lb. brimſtone half a lb. and meal-powder 8 oz. moiſtened with petrolio-oil. VI. Powder half a lb. brimſtone and ſaltpetre, of each 4 oz. VII. Saltpetre 4 oz. brimſtone 2 oz. and meal-powder 1 oz.

Stars that carry tails of ſparks.—I. Brimſtone 6 oz. crude antimony 2 oz. ſaltpetre 4 oz. and roſin 4 oz. II. Saltpetre, roſin, and charcoal, of each 2 oz. brimſtone 1 oz. and pitch 1 oz.

Theſe compoſitions are ſometimes melted in an earthen pan, and mixed with chopped cotton-match, before they are rolled into ſtars; but will do as well if wetted, and worked up in the uſual manner.

Stars that yield ſome ſparks.—I. Camphor 2 oz. ſaltpetre 1 oz. meal-powder 1 oz. II. Saltpetre 1 oz. ditto melted half a oz. and camphor 2 oz. When you would make ſtars of either of theſe compoſitions, you muſt wet them with gum-water, or weak ſpirits, in which has been diſſolved ſome gum-arabic, or gum-tragacanth, that the whole may have the conſiſtence of a pretty thick liquid; having thus done, take 1 oz. of lint, and ſtir it about in the compoſition till it becomes dry enough to roll into ſtars.

Stars of a yellowiſh colour.—Take 4 oz. of gum-tragacanth or gum-arabic, pounded and ſifted through a fine ſieve, camphor diſſolved in brandy 2 oz. ſaltpetre 1 lb. ſulphur half a lb. coarſe powder of glaſs 4 oz. white amber 1 oz. and a half, orpiment 2 oz. Being well incorporated, make them into ſtars after the common method.

Stars of another kind.—Take 4 oz. of camphor, and melt it in half a pint of ſpirit of wine over a ſlow fire; then add to it ½ lb. of gum-arabic that has been diſſolved; with this liquor mix 1 lb. of ſaltpetre, 6 oz. of ſulphur, and 5 oz. of meal-powder; and after you have ſtirred them well together, roll them into ſtars proportionable to the rockets for which you intend them.

55 Colours produced by the different compoſitions.

As variety of fires adds greatly to a collection of works, it is neceſſary that every artiſt ſhould know the different effect of each ingredient. For which reaſon, we ſhall here explain the colours they produce of themſelves; and likewiſe how to make them retain the ſame when mixed with other bodies: as for example, ſulphur gives a blue, camphor a white or pale colour, ſaltpetre a clear white-yellow, amber a colour inclining to yellow, ſal-ammoniac a green, antimony a reddiſh, roſin a copper colour, and Greek-pitch a kind of bronze, or between red and yellow. All theſe ingredients are ſuch as ſhow themſelves in a flame, viz.

White flame.—Saltpetre, ſulphur, meal-powder, and camphor; the ſaltpetre muſt be the chief part.

Blue flame.—Meal-powder, ſaltpetre, and ſulphur vivum; ſulphur muſt be the chief: or meal-powder, ſaltpetre, brimſtone, ſpirit of wine, and oil of ſpike; but let the powder be the principal part.

Flame inclining to red.—Saltpetre, ſulphur, antimony, and Greek-pitch; ſaltpetre the chief.

By the above method may be made various colours of fire, as the practitioner pleaſes; for, by making a few trials, he may cauſe any ingredient to be predominant in colour.

56 Sparkling compoſition for choaked caſes.

The ſet colours of fire produced by ſparks are divided into four ſorts, viz. the black, white, grey, and red. The black charges are compoſed of two ingredients, which are meal-powder and charcoal; the white of three, viz. ſaltpetre, ſulphur, and charcoal; the grey of four, viz. meal-powder, ſalt-petre, brimſtone, and charcoal; and the red of three, viz. meal-powder, charcoal, and ſaw-duſt.

There are, beſides theſe four regular or ſet charges, two others, which are diſtinguiſhed by the names of *compound* and *brilliant charges;* the compound being made of many ingredients, ſuch as meal-powder, ſaltpetre, brimſtone, charcoal, ſaw-duſt, ſea-coal, antimony, glaſs-duſt, braſs-duſt, ſteel-filings, caſt-iron, tanner's duſt, &c. or any thing that will yield ſparks; all which muſt be managed with diſcretion. The brilliant fires are compoſed of meal-powder, ſaltpetre, brimſtone, and ſteel-duſt; or with meal-powder and ſteel-filings only.

57 Of mixing the compoſitions.

The beauty of fire-works depends much on the compoſitions being well mixed; therefore great care muſt be taken in this part of the work, particularly for the compoſition for ſky-rockets. When there are 4 or five pounds of ingredients to be mixed, which is a ſufficient quantity at a time (for a larger proportion will not do

Apparatus, Materials, &c. of Fire-Works.

so well), first put the different ingredients together; then work them with your hands, till you think they are pretty well incorporated: after which put them into a lawn sieve with a receiver and top to it; and if, after it is sifted, any remains that will not pass through the sieve, grind it again till fine enough; and if it be twice sifted, it will not be amiss; but the compositions for wheels and common works are not so material, and need not be so fine. But in all fixed works, from which the fire is to play regularly, the ingredients must be very fine, and great care taken in mixing them well together; and in all compositions in which are iron filings, the hands must not touch; nor will any works which have iron or steel in their charge keep long in damp weather, unless properly prepared, according to the former directions.

58 Cotton quick match.

Cotton quick match is generally made of such cotton as is put in candles, of several sizes, from one to six threads thick, according to the pipe for which it is designed; which pipe must be large enough for the match, when made, to be pushed in easily without breaking. Having doubled the cotton into as many threads as is proper, coil it very lightly into a flat-bottomed copper or earthen pan; then put in the saltpetre and the liquor, and boil them about 20 minutes; after which coil it again into another pan, as in fig. , and pour on it what liquor remains; then put in some meal powder, and press it down with the hand till it is quite wet; afterwards place the pan before the wooden frame (fig. 18.) which must be suspended by a point in the centre of each end; and place yourself before the pan, tying the upper end of the cotton to the end of one of the sides of the frame.

When every thing is ready, an assistant must turn the frame round, while the cotton passes through the hand, holding it very lightly, and at the same time keeping the hand full of the wet powder; but if the powder should be too wet to stick to the cotton, more must be added, so as to keep a continual supply till the match is all wound up; it may be wound as close on the frame as you please, so that it may not stick together; when the frame is full, take it off the points, and sift dry meal-powder on both sides the match, till it seem quite dry: in winter the match will be a fortnight before it is fit for use; when it is thoroughly dry, cut it along the outside of one of the sides of the frame, and tie it up in skains for use.

N. B. The match must be wound tight on the frames.

The ingredients for the match, are, cotton 1 lb. 12 oz. saltpetre 1 lb. spirit of wine 2 quarts, water 3 quarts, isinglass 3 gills, and meal-powder 10 lb. To dissolve 4 oz. of isinglass, take 3 pints of water.

59 Touch paper for capping fire-works.

Dissolve, in spirit of wine or vinegar, a little saltpetre; then take some purple or blue paper, and wet it with this liquor, and when dry it will be fit for use; when this paper is to be pasted on any fire-works, take care that the paste does not touch that part which is to burn. The method of using this paper is by cutting it into slips, long enough to go once round the mouth of a serpent, cracker, &c. When these slips are pasted on, leave a little above the mouth of the case not pasted; then prime the case with meal-powder, and twist the paper to a point.

60 Paste for representing objects in fire.

We are indebted to the Chinese for the contrivance of a paste which may be employed for representing animals and other objects in fire. To prepare this paste, take sulphur reduced to a very fine powder, or flowers of sulphur, and having formed it into a paste with starch, cover with it the figure you are desirous of representing on fire: it is here to be observed, that the figure must first be coated over with clay, to prevent it from being burnt.

When the figure has been covered with this paste, besprinkle it while still moist with pulverized gunpowder; and when the whole is perfectly dry, arrange some small matches on the principal parts of it, that the fire may be speedily communicated to it on all sides.

The same paste may be employed on figures of clay, to form devices and various designs. Thus, for example, festoons, garlands, and other ornaments, the flowers of which might be imitated by fire of different colours, could be formed on the frieze of a piece of architecture covered with plaster. The Chinese imitate grapes exceedingly well, by mixing pounded sulphur with the pulp of the jujube, instead of flour paste.

It is usual to paint the frames or stands of large fire-works of some dark colour, but this renders them very combustible. It would be better to wash them with the following composition, which will both give them a proper colour, and render them less combustible. Take equal parts of brick-dust, coal-ashes, and iron-filings, and mix them with a double size while hot. With this wash over the frames, &c. and when dry repeat the washing. 61 Method of preserving fire-works from being easily burnt by accident.

CHAP. II. *Of the principal varieties of Fire-Works, and the most approved Methods of constructing them.*

62 Division of fire-works.

ARTIFICIAL fire-works differ from each other very much in point of simplicity of construction. Some require very little dexterity in the preparation; and are either employed as appendages to works of greater importance, or, if used by themselves, are confined to the sports of schoolboys. Of this nature are *squibs*, *serpents*, *crackers*, *stars*, *sparks*, *marrons*, *saucissons*, *pin-wheels*, *leaders*, and *gerbes* or *Roman candles*. Others are very complex in their structure, require considerable address and ingenuity, and form the amusement of fashionable circles on occasion of public rejoicings or private festivity: Such are *rockets* of various kinds, *wheels*, *suns*, *globes*, *balloons*, *pyramids*, &c. We shall first describe the more simple kinds, and then give an account of the method of constructing those of a more complex nature.

SECT. I. *Of Simple Fire-works.*

63 Leaders.

As in the subsequent directions for fire-works, we shall have frequent occasion to mention pipes of communication commonly called *leaders*, by which the several parts of a compound fire-work are connected with each other, it will be proper to show how these are constructed. Leaders consist of small tubes of paper of different lengths, according to the distance to which they must extend; and these tubes are filled with a combustible composition that will not burn too fast.

The best paper for leaders is that called elephant; which is cut into long slips 2 or 3 inches broad, so that they may go 3 or 4 times round the *former*, but not more: when they are very thick, they are too strong for

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for the paper which fastens them to the works, and will sometimes fly off without leading the fire. The *formers* for these leaders are made from 2 to 6-16ths of an inch diameter; but 4-16ths is the size generally used. The *formers* are made of smooth brass wire: when used, rub them over with grease, or keep them wet with paste, to prevent their sticking to the paper, which must be pasted all over. In rolling pipes, make use of a rolling-board, but use it lightly: having rolled a pipe, draw out the former with one hand, holding the pipe as light as possible with the other; for if it press against the former, it will stick and tear the paper.

N. B. Make the leaders of different lengths, or in clothing works many will be wasted. Leaders for marron batteries must be made of strong cartridge paper.

Joining and placing leaders is a very essential part of fire-works, as it is on the leaders that the performance of all complex works depend; for which reason the method of conducting pipes of communication shall be here explained in as plain a manner as possible. Your works being ready to be clothed, proceed thus: Cut your pipes of a sufficient length to reach from one case to the other; then put in the quick-match, which must always be made to go in very easy: when the match is in, cut it off within about an inch of the end of the pipe, and let it project as much at the other end; then fasten the pipe to the mouth of each case with a pin, and put the loose ends of the match into the mouths of the cases, with a little meal-powder: this done to all the cases, paste over the mouth of each two or three bits of paper. The preceding method is used for large cases, and the following for small, and for illuminations: First thread a long pipe; then lay it on the tops of the cases, and cut a bit off the under side, over the mouth of each case, so that the match may appear: then pin the pipe to every other case; but before you put on the pipes, put a little meal-powder in the mouth of each case. If the cases thus clothed are port-fires on illuminated works, cover the mouth of each case with a single paper; but if they are choked cases, situated so that a number of sparks from other works may fall on them before they are fired, secure them with three or four papers, which must be pasted on very smooth, that there may be no creases for the sparks to lodge in, which often set fire to the works before their time. Avoid as much as possible placing the leaders too near, or one across the other so as to touch, as it may happen that the flash of one will fire the other; therefore if your works should be so formed that the leaders must cross or touch, be sure to make them very strong, and secure at the joints, and at every opening.

When a great length of pipe is required, it must be made by joining several pipes in this manner: Having put on one length of match as many pipes as it will hold, paste paper over every joint; but, if a still greater length is required, more pipes must be joined, by cutting about an inch off one side of each pipe near the end, and laying the quick-match together, and tying them fast with small twine; after which, cover the joining with pasted paper.

64 Serpents.

One of the simplest fire-works is what is called a *serpent*, which consists of a cylindrical paper case, about 4 or 5 inches long, and not made very thick. AC, fig. 19. represents the usual form of the serpent, except that in general they have not the contraction in the middle, represented in this figure. The name serpent has been given to this fire-work, either from the hissing noise which it makes when fired, or from the zig zag or undulating direction in which it moves, when properly constructed. The case or cartridge is rolled round a cylindrical stick, rather larger than a goose quill, and provided at one end with a narrow appendage, such as that used for rockets, fig. 3. by means of which it is choaked at one end. This case is filled about half way with some of the compositions described for making small rockets, see N° 30, rammed moderately hard in the proper mould, and then it is either choaked in the middle, or some obstructing body, such as a small piece of paper, is introduced, and the remainder of the case is filled with grained or corn powder. Lastly, this other extremity is well secured with twine, and commonly dipt into melted pitch; a little moistened meal powder is introduced into the extremity next the choak, and a piece of touch paper being properly fastened on this end, the serpent is complete. 65

Crackers are composed of a pretty long paper case, Crackers.
filled with the proper composition, as will be described immediately, and folded up in such a manner as, when fired, to make successive reports at short intervals. To construct these crackers, cut some cartridge paper into pieces $3\frac{1}{2}$ inches broad, and one foot long; one edge of each fold down length-wise about $\frac{3}{4}$ of an inch broad; then fold the double edge down $\frac{1}{4}$ of an inch, and turn the single edge back half over the double fold; then open it, and lay all along the channel, which is formed by the folding of the paper, some meal-powder; then fold it over and over till all the paper is doubled up, rubbing it down every turn; this done, bend it backwards and forwards, 2 inches and a half, or thereabouts, at a time, as oft as the paper will allow; then hold all these folds flat and close, and with a small pinching cord give one turn round the middle of the cracker, and pinch it close; then bind it with a packthread as tight as possible; then, in the place where it was pinched, prime one end of it, and cap it with touch-paper. When these crackers are fired, they will give a report at every turn of the paper: if you would have a great number of reports, the paper must be cut longer, or join them after they are made; but if they are made very long before they are pinched, you must have a piece of wood with a groove in it, deep enough to let in half the cracker; this will hold it straight while it is pinching. Fig. 20. represents a cracker complete. Plate CCCCLIII. 66

Stars are small balls, prepared of a composition which Stars.
emits a brilliant, radiating light, and are much employed in the construction of rockets, Roman candles, and similar fire-works. They are made of various sizes, but generally about as large as a musket bullet. Compositions for stars have been described in N° 31. and 54. The ingredients must be thoroughly incorporated, and in forming the ball, unless the paste is sufficiently glutinous, it must be wrapped up in a piece of paper, or linen rag, tied closely round with pack thread, and a hole must be pierced through its middle for the insertion of a piece of match. These stars, when lighted, will exhibit a most beautiful appearance; for the fire, as it issues from the two ends of the hole in the middle, will extend to a

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a great diſtance, and thus make the fiery ball appear much larger.

Strung ſtars. Firſt take ſome thin paper, and cut it into pieces of one inch and a half ſquare, or thereabouts; then on each piece lay as much dry ſtar-compoſition as the paper will eaſily contain; then twiſt up the paper as tight as poſſible; when done, rub ſome paſte on your hands, and roll the ſtars between them; then ſet them to dry: the ſtars being thus made, get ſome flax or fine tow, and roll a little of it over each ſtar; then paſte the hand and roll the ſtars as before, and ſet them again to dry; when they are quite dry, with a piercer make a hole through the middle of each, into which run a cotton quick-match, long enough to hold 10 or 12 ſtars at 3 or 4 inches diſtance: but any number of ſtars may be ſtrung together by joining the match.

Tailed ſtars. Theſe are called *tailed ſtars*, becauſe there are a great number of ſparks iſſuing from them, which repreſent a tail like that of a comet. Of theſe there are two ſorts; which are *rolled*, and *driven*: when rolled, they muſt be moiſtened with a liquor made of half a pint of ſpirit of wine and half a gill of thin ſize, of this as much as will wet the compoſition enough to make it roll eaſy; when they are rolled, ſift meal-powder over them, and ſet them to dry.

When tailed ſtars are driven, the compoſition muſt be moiſtened with ſpirit of wine only, and not made ſo wet as for rolling: 1 and 2 oz. caſes, rolled dry, are beſt for this purpoſe; and when they are filled, unroll the caſe within 3 or 4 rounds of the charge, and all that are unrolled cut off; then paſte down the looſe edge: 2 or 3 days after the caſes are filled, cut them in pieces 5 or 6 8ths of an inch in length: then melt ſome wax, and dip one end of each piece into it, ſo as to cover the compoſition: the other end muſt be rubbed with meal-powder wetted with ſpirit of wine.

Driven ſtars. Caſes for driven ſtars are rolled with paſte, but are made of paper very thin. Before they are filled, damp the compoſition with ſpirit of wine that has had ſome camphor diſſolved in it: ram them indifferently hard, ſo that the caſe be not broken or ſacked; to prevent which, they ſhould fit tight in the mould. They are driven in caſes of ſeveral ſizes, from 8 drams to four oz. When they are filled in half ounce caſes, cut them in pieces of three fourths of an inch long; if 1 oz. caſes, cut them in pieces of 1 inch; if 2 oz. caſes, cut them in pieces of 1 and one fourth inch long; and if 4 oz. caſes, cut them in pieces of 1 inch and a half long: having cut the ſtars of a proper ſize, prime both ends with wet meal-powder. Theſe ſtars are ſeldom put in rockets, they being chiefly intended for air balloons, and driven in caſes, to prevent the compoſition from being broken by the force of the blowing powder in the ſhell.

Rolling ſtars are commonly made about the ſize of a muſket ball; though they are rolled of ſeveral ſizes, from the bigneſs of a piſtol ball to 1 inch diameter; and ſometimes very ſmall, but are then called *ſparks*. Great care muſt be taken in making ſtars, firſt, that the ſeveral ingredients are reduced to a fine powder; ſecondly, that the compoſition may be well worked and mixed. Before beginning to roll, take about a pound of compoſition, and wet it with the following liquid, enough to make it ſtick together and roll eaſy: Spirit of wine 1 quart, in which diſſolve one fourth of an ounce of iſinglaſs. If a great quantity of compoſition be wetted at once, the ſpirit will evaporate, and leave it dry, before it is rolled into ſtars: having rolled up one proportion, ſhake the ſtars in meal-powder, and ſet them to dry, which they will do in 3 or 4 days; but if they ſhould be wanted for immediate uſe, dry them in an earthen pan over a ſlow heat, or in an oven. It is very difficult to make the ſtars all of an equal ſize when the compoſition is taken up promiſcuouſly with the fingers; but by the following method they may be made very exactly. When the mixture is moiſtened properly, roll it on a flat ſmooth ſtone and cut it into ſquare pieces, making each ſquare large enough for the ſtars intended. There is another method uſed by ſome to make ſtars, which is by rolling the compoſition in long pieces, and then cutting off the ſtar, ſo that each ſtar will be of a cylindrical form: but this method is not ſo good as the former; for, to make the compoſition roll this way, it muſt be made very wet, which makes the ſtars heavy, as well as weakens them. All ſtars muſt be kept as much from air as poſſible, otherwiſe they will grow weak and bad.

67 Sparks.

Sparks differ from ſtars, only in their ſize and duration, as they are made ſmaller than ſtars, and are ſooner extinguiſhed. The following is the moſt approved method of making them. Having put into an earthen veſſel an ounce of mealed gunpowder, 3 oz. of powdered ſaltpetre, and 4 oz. of camphor, reduced to powder by rubbing it in a mortar with a little ſpirit of wine; pour over this mixture ſome weak gum water, or ſome weak brandy, in which ſome gum dragant has been diſſolved, till the compoſition acquires the conſiſtence of thick ſoup. Then take ſome lint or caddice, which has been boiled in brandy, vinegar, or with ſaltpetre, and afterwards dried and unravelled, and throw into the compoſition as much of it as is neceſſary to abſorb the whole, taking care to ſtir it well. This matter is to be formed into ſmall balls of about the ſize of a pea, which being dried in the air, are to be ſprinkled with meal gunpowder, that they may more readily take fire.

Another method of making ſparks is, to take ſome ſaw duſt of any wood that burns readily, ſuch as fir, and boil it in water that has been ſaturated with ſaltpetre. When it has been boiled for ſome time, the veſſel is to be removed from the fire, and the ſolution of nitre poured off, ſo as to leave the ſaw duſt at the bottom. The ſaw duſt thus impregnated with nitre, is then to be poured on a table, and, while moiſt, to be ſprinkled with powdered ſulphur, to which a little bruiſed gunpowder has been added; and when the whole is well mixed, and of a proper conſiſtence, ſparks are to be made of it as before.

68 Marroons.

Marroons are ſmall boxes made either of paper or paſteboard, and of a roundiſh or cubical form, ſo prepared as when fired to make a loud and ſudden report. They are uſually employed, either as appendages to other fire-works, or a great many of them are ſo arranged, as to explode ſucceſſively at certain intervals.

Formers for marroons are from three fourths of an inch to one and a half diameter; but the paper for the caſes twice the diameter of the *former* broad, and long enough to go three times round. When you have rolled a caſe, paſte down the edge and tie one end cloſe; then with the *former* drive it down to take away the wrinkles,

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kles, and make it flat at bottom; then fill the case with corn-powder one diameter and one fourth high, and fold down the rest of the case tight on the powder. The marroon being thus made, wax some strong pack-thread with shoemakers wax: this thread wind up in a ball, then unwind two or three yards of it, and that part which is near the ball make fast to a hook; then take a marroon, and stand as far from the hook as the packthread will reach, and wind it lengthwise round the marroon as close as possible, till it will hold no more that way; then turn it, and wind the packthread on the short way, then lengthwise again, and so on till the paper is all covered; then make fast the end of the packthread, and beat down both ends of the marroon to bring it in shape. The method of firing marroons is by making a hole at one end with an awl, and putting in a piece of quick-match; then taking a piece of strong paper, in which wrap up the marroon with two leaders, which must be put down to the vent, and the paper tied tight round them with small twine: these leaders are bent on each side, and their loose ends tied to the other marroons, and are nailed in the middle to the rail of the stand, as in fig. 21. The use of winding the packthread in a ball is, that it may be let out as wanted, according to the quantity the marroon may require; and that it may not be tied in knots, which would spoil the marroon. These oblong marroons are, by the French, called *Saucissons*, as they are supposed to resemble a sausage.

Fig. 21.

69 Marroon batteries.

Batteries of Marroons.—These, if well managed, will keep time to a march, or a slow piece of music. Marroon batteries are made of several stands, with a number of cross rails for the marroons; which are regulated by leaders, by cutting them of different lengths, and nailing them tight, or loose, according to the time of the music. In marroon batteries you must use the large and small marroons, and the nails for the pipes must have flat heads.

The proper marroon boxes are made of strong pasteboard, cut as represented in fig. 22., so as to fold up in the form of a cube, one side of which is to be left uncemented till the box be filled. The cavity being filled with gun-powder, strong paper is to be pasted over the box in various directions, and the whole is to be wrapped round with strong pack thread dipt in glue. Lastly, a hole is to be made in the corner of the box, and a piece of match introduced, by which it may be fired.

Sometimes it is required to render marroons luminous, or to prepare them in such a way, that they shall emit a brilliant light before they burst. To effect this, they are to be covered on the outside with one of the compositions directed for stars, and then rolled in bruised gunpowder.

70 Pin wheels.

For Pin-Wheels.—First roll some paper pipes, about 14 inches long each; these pipes must not be made thick of paper, two or three rounds of elephant paper being sufficient. When the pipes are thoroughly dried, you must have a tin tube 12 inches long, to fit easy into the pipes; at one end of this tube fix a small conical cup, called a *funnel;* then bend one end of one of the pipes, and put the funnel in at the other as far as it will reach, and fill the cup with composition: then draw out the funnel by a little at a time, shaking it up and down, and it will fill the pipe as it comes out. Having filled some pipes, have some small circular blocks made about one inch diameter and half an inch thick: round one of these blocks wind and paste a pipe, and to the end of this pipe join another; which must be done by twisting the end of one pipe to a point, and putting it into the end of the other with a little paste: in this manner join four or five pipes, winding them one upon the other so as to form a spiral line. Having wound on your pipes, paste two slips of paper across them to hold them together: besides these slips of paper, the pipes must be pasted together.

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There is another method of making these wheels, viz. by winding on the pipes without paste, and sticking them together with sealing-wax at every half turn; so that when they are fired, the end will fall loose every time the fire passes the wax, by which means the circle of fire will be considerably increased. The formers for these pipes are made from one and a half to 4-16ths of an inch diameter; and the composition for them is as follows: Meal-powder 8 oz. saltpetre 2 oz. and sulphur 1: among these ingredients may be mixed a little steel-filings or the dust of cast iron: this composition should be very dry, and not made too fine, or it will stick in the funnel. These wheels may be fired on a large pin, and held in the hand with safety.

There is a pleasing decoration frequently added to rockets, called a *shower of fire*, rain, or rain fall, and it is called gold or silver rain, according as its colour is more or less intense. It consists of several small cases filled with a brilliant composition, such as the following variety of Chinese fire, viz. meal powder 1 pound, flower of sulphur 2 oz. and iron sand of the first order, 5 oz. 71 Shower of fire or rain.

Gold and silver rain compositions are rammed in cases that are pinched quite close at one end: if rolled dry, 4 or 5 rounds of paper will be strong enough; but if they are pasted, 3 rounds will do; and the thin sort of cartridge-paper is best for those small cases, in rolling which you must not turn down the inside edge as in other cases, for a double edge would be too thick for so small a bore. The moulds for rain-falls should be made of brass, and turned very smooth in the inside; or the cases, which are so very thin, would tear in coming out; for the charge must be rammed in tight; and the better the case fits the mould, the more driving it will bear. These moulds have no nipple, but instead of it they are made flat. As it would be very tedious and troublesome to shake the composition out of such small ladles as are used for these cases, it will be necessary to have a funnel made of thin tin, to fit on the top of the case, by the help of which they may be filled very fast. For single rain-falls for 4 oz. rockets, let the diameter of the former be 2-16ths of an inch, and the length of the case 2 inches; for 8 oz. rockets, 4-16ths and 2 diameters of the rocket long; for 1 lb. rockets, 5-16ths, and 2 diameters of the rocket long; for 2 lb. rockets, 5-16ths, and 3 inches and a half long; for 4 lb. rockets, 6-16ths, and 4 inches and a half long; and for 6-pounders, 7-16ths diameter, and 5 inches long.

Of double rain-falls there are two sorts. For example, some appear first like a star, and then the rain; and some appear first like rain, and then like a star. When you would have stars first, you must fill the cases, within half an inch of the top, with rain-composition, and the remainder with star-composition; but when you intend

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72 Gerbes. Gerbes consist of a strong case of thick paper or pasteboard, filled with a brilliant composition, and generally with stars or balls placed at small distances, so that the composition and the balls are introduced alternately. Immediately below each ball is placed a little grained powder. These last gerbes are sometimes called Roman candles. When fired, they first throw up a beautiful jet of flame, which in some measure resembles a water-spout, whence the name. Gerbes are either employed singly, or batteries are formed of them, and frequently those filled with brilliant fire without balls, are placed in rows along the front of the frames of large compound fire-works. They are sometimes made perfectly cylindrical; at others they have a contracted part at the top called the *neck*.

Fig. 23. and 24. Fig. 23. represents a wooden *former;* fig. 24. a gerbe complete, with its foot or stand. The cases for gerbes are made very strong, on account of the strength of the composition; which, when fired, comes out with great velocity; therefore, to prevent their bursting, the paper should be pasted, and the cases made as thick at the top as at the bottom. They should also have very long necks, for this reason; first, that the particles of iron will have more time to be heated, by meeting with greater resistance in getting out, than with a short neck, which would be burnt too wide before the charge be consumed, and spoil the effect: secondly, that with long necks the stars will be thrown to a great height, and will not fall before they are spent, or spread too much; but, when made to perfection, will rise and spread in such a manner as to form exactly a wheat sheaf.

In ramming of gerbes, there will be no need of a mould, the cases being sufficiently strong to support themselves. But you must be careful, before you begin to ram, to have a piece of wood made to fit in the neck; for if this be not done, the composition will fall into the neck, and leave a vacancy in the case, which will cause the case to burst as soon as the fire arrives at the vacancy. You must likewise observe, that the first ladleful of charge, or second, if proper, be of some weak composition. When the case is filled, take out the piece of wood, and fill the neck with some slow charge. Gerbes are generally made about six diameters long, from the bottom to the top of the neck; their bore must be one-fifth narrower at top than at bottom. The neck S is one-sixth diameter and three-fourths long. T, a wooden foot or stand, on which the gerbe is fixed. This may be made with a choak or cylinder four or five inches long to fit the inside of the case, or with a hole in it to put in the gerbe; both these methods will answer the same purpose. Gerbes produce a most brilliant fire, and are very beautiful when a number of them are fixed in the front of a building or a collection of fire-works.

N. B. Gerbes are made by their diameters, and their cases at bottom one-fourth thick. The method of finding the interior diameter of a gerbe is this: Supposing the exterior diameter of the case, when made, to be five inches, then, by taking two-fourths for the sides of the case, there will remain $2\frac{1}{2}$ inches for the bore, which will be a very good size. These gerbes should be rammed very hard. Varieties of Construction.

Small Gerbes, or *white Fountains*,

May be made of four ounces, eight ounces, or one pound cases, pasted and made very strong, of any length: but before they are filled, drive in clay one diameter of their orifice high; and when the case is filled, bore a vent through the centre of the clay to the composition: the common proportion will do for the vent, which must be primed with a slow charge. These cases, without the clay, may be filled with Chinese fire.

Sect. II. *Of Compound Fire-works.*

Among the most pleasing compound fire-works are rockets, which are of various kinds. Some are made to ascend to a great height in the air, where they burst, and throw out the contents of the head with which they are provided. These are called *sky-rockets*. Others are so constructed as to run with great velocity along a line, and are called *line-rockets*. Some are arranged at the extremities of the spokes of a wheel, and are denominated *wheel-rockets;* while a fourth variety have their cases made water tight, and are filled with a very strong composition, so as to admit of their burning below water. These last are called *water rockets*. Sky-rockets are tied to a stick, which renders their ascent into the air more equable and steady. 73 Rockets.

Fig. 25. represents a rocket complete without its stick. Its length from the neck is five diameters one-sixth: the cases should always be cut to this length after they are filled. M is the head, which is two diameters high, and one diameter one-sixth and a half in breadth; N the cone or cap, whose perpendicular height must be one diameter one-third. Fig. 26. the collar to which the head is fixed: this is turned out of fir or any light wood, and its exterior diameter must be equal to the interior diameter of the head; one-sixth will be sufficient for its thickness, and round the outside edge must be a groove; the interior diameter of the collar must not be quite so wide as the exterior diameter of the rocket: when this is to be glued on the rocket, two or three rounds of paper must be cut off the case, which will make a shoulder for it to rest upon. Fig. 27. a *former* for the head: two or three rounds of paper well pasted will be enough for the head, which, when rolled, put the collar on that part of the *former* marked O, which must fit the inside of it; then, with the pinching cord pinch the bottom of the head into the groove, and tie it with small twine. Fig. 28. a *former* for the cone. To make the caps, cut the paper in round pieces, equal in diameter to twice the length of the cone to be made; which pieces being cut into halves, will make two caps each, without wasting any paper; having formed the caps, paste over each of them a thin white paper, which must be a little longer than the cone, so as to project about half an inch below the bottom: this projection of paper, being notched and pasted, serves to fasten the cap to the head. 74 Sky-rockets. Fig. 25. Fig. 26. Fig. 27. Fig. 28.

When

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When you load the heads of the rockets with ftars, rains, ferpents, crackers, or any thing elfe, according to fancy, remember always to put one ladleful of meal-powder into each head, which will be enough to burft the head, and difperfe the ftars, or whatever it contains: when the heads are loaded with any cafes, let their mouths be placed downwards; and after the heads are filled, pafte on the top of them a piece of paper before putting on the caps. As the fize of the ftars often differs, it would be needlefs to give an exact number for each rocket; but this rule may be obferved, that the heads may be nearly filled with whatever they are to contain.

75 Dimenfions and poife of rocket-fticks.

Dimenfions and Poife of Rocket-fticks.

Weight of the Rocket.	Length of the ftick.	Thicknefs at top.	Breadth at top.	Square at bottom	Poife from the point of the cone.
lb oz.	Ft in.	Inches.	Inches.	Inches.	Ft. in.
6 0	14 0	1,5	1,85	0,75	4 1,5
4 0	12 10	1,25	1,40	0,625	3 9,
2 0	9 4	1,125	1,	0,525	2 9,
1 0	8 2	0,725	0,80	0,375	2 1,
8	6 6	0,5	0,70	0,25	1 10,5
4	5 3	0,3750	0,55	0,35	1 8,5
2	4 1	0,3	0,45	0,15	1 3,
1	3 6	0,25	0,35	0,10	11 0,
½	2 4	0,125	0,20	0,16	8 0,
¼	1 10½	0,1	0,15	0,5	5 0,5

Fig. 29. The laft column on the right, in the above table, expreffes the diftance from the top of the cone, where the ftick, when tied on, fhould balance the rocket, fo as to ftand in an equilibrium on one's finger, or the edge of a knife. The beft wood for the fticks is dry fir, and they are thus made: When you have cut and planed the ftick according to the dimenfions given in the table, cut, on one of the flat fides at the top, a groove the length of the rocket, and as broad as the ftick will allow; then on the oppofite flat fide, cut two notches for the cord, which ties on the rocket, to lie in: one of thefe notches muft be near the top of the ftick, and the other facing the neck of the rockets; the diftance between thefe notches may eafily be known, for the top of the ftick fhould always touch the head of the rocket. When the rockets and fticks are ready, lay the rockets in the grooves in the fticks, and tie them on. Thofe who, merely for curiofity, may choofe to make rockets of different fizes from thofe expreffed in the table of dimenfions, may find the length of their fticks, by making them for rockets, from half an ounce to one pound, 60 diameters of the rocket long; and for rockets above one pound 50 or 52 diameters will be a good length; their thicknefs at top may be about half a diameter, and their breadth a very little more; their fquare at bottom is generally equal to half the thicknefs at top. But although the dimenfions of the fticks be very nicely obferved, we can depend only on their balance; for, without a proper counterpoife, the rockets, inftead of mounting perpendicularly, will take an oblique direction, and fall to the ground before they are burnt out.

Rockets rammed over a piercer muft not have fo much compofition put into them at a time as when rammed folid; for the piercer, taking up great part of the bore of the cafe, would caufe the rammer to rife too high; fo that the preffure of it would not be fo great on the compofition, nor would it be rammed everywhere equal. To prevent this, obferve the following rule: That for thofe rockets which are rammed over a piercer, let the ladle hold as much compofition as, when drove, will raife the drift one-half the interior diameter of the cafe, and for thofe rammed folid to contain as much as will raife it one-half the exterior diameter of the cafe: ladles are generally made to go eafy in the cafe, and the length of the fcoop about one and a half of its own diameter.

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76 Method of ramming rockets.

The charge of rockets muft always be rammed one diameter above the piercer, and on it muft be rammed one-third of a diameter of clay; through the middle of which bore a fmall hole to the compofition, that, when the charge is burnt to the top, it may communicate its fire, through the hole, to the ftars in the head. Great care muft be taken to ftrike with the mallet, and with an equal force, the fame number of ftrokes to each ladleful of charge; otherwife the rockets will not rife with an uniform motion, nor will the compofition burn equally and regularly: for which reafon they cannot carry a proper tail: for it will break before the rocket has got half way up, inftead of reaching from the ground to the top, where the rocket breaks and difperfes the ftars, rains, or whatever is contained in the head. When ramming, keep the drift conftantly turning or moving; and when you ufe the hollow rammers, knock out of them the compofition now and then, or the piercer will fplit them. To a rocket of four ounces, give to each ladleful of charge, 16 ftrokes; to a rocket of one pound, 28; to a two pounder, 36; to a four pounder, 42; and to a fix pounder, 56: but rockets of a larger fort cannot be rammed well by hand, but muft be rammed with a machine made in the fame manner as thofe for driving piles.

The method of ramming wheel cafes, or any other fort, in which the charge is rammed folid, is much the fame as in fky-rockets; for the fame proportion may be obferved in the ladle, and the fame number of ftrokes given, according to their diameters, all cafes being diftinguifhed by their diameters. In this manner, a cafe, whofe bore is equal to a rocket of four ounces, is called a four ounce cafe, and that which is equal to an eight ounce rocket an eight ounce cafe, and fo on, according to the different rockets.

Having taught the method of ramming cafes in moulds, we fhall here fay fomething concerning thofe filled without moulds; which method, for ftrong pafted cafes, will do extremely well, and fave the expence of making fo many moulds. The reader muft here obferve, when filling any cafes, to place the mould on a perpendicular block of wood, and not on any place that is hollow; for we have found by experience, that when cafes were rammed on driving benches, which were formerly ufed, the works frequently mifcarried, on account of the hollow refiftance of the benches, which often jarred and loofened the change in the cafes; but this accident never happens when the driving blocks are ufed.

When cafes are to be filled without moulds, proceed thus: Have fome nipples made of brafs or iron,

of

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of feveral fizes, in proportion to the cafes, and to fcrew or fix in the top of the driving block; when you have fixed in a nipple, make, at about one inch and a half from it, a fquare hole in the block, fix inches deep and one inch diameter; then have a piece of wood, fix inches longer than the cafe intended to be filled, and two inches fquare; on one fide of it cut a groove almoft the length of the cafe, whofe breadth and depth muft be fufficient to cover near one-half of the cafe; then cut the other end to fit the hole in the block, but take care to cut it fo that the groove may be of a proper diftance from the nipple; this half mould being made and fixed tight in the block, cut, in another piece of wood nearly of the fame length as the cafe, a groove of the fame dimenfions as that in the fixed piece; then put the cafe on the nipple, and with a cord tie it and the two half moulds together, and the cafe will be ready for filling.

The dimenfions of the above-defcribed half-moulds are proportionable for cafes of eight ounces, but notice muft be taken, that they differ in fize in proportion to the cafes.

The beft wood for mallets is dry beech. If a perfon ufes a mallet of a moderate fize, in proportion to the rocket, according to his judgement, and if the rocket fucceeds, he may depend on the reft, by ufing the fame mallet; yet it will be neceffary that cafes of different forts be driven with mallets of different fizes.

The following proportion of the mallets for rockets of any fize, from one oz. to fix lb. may be obferved; but as rockets are feldom made lefs than one oz. or larger than fix lb. we fhall leave the management of them to the curious; but all cafes under one oz. may be rammed with an ounce rocket mallet. The mallets will ftrike more folid, by having their handles turned out of the fame piece with the head, and made in a cylindrical form. Let their dimenfions be worked by the diameters of the rockets: for example; let the thicknefs of the head be three diameters, and its length four, and the length of the handle five diameters, whofe thicknefs muft be in proportion to the hand.

77 Afcent of fky-rockets explained.

As the caufe which occafions the afcent of a rocket into the air is the fame as that which makes a mufket recoil when fired, it will be proper, before explaining the afcent of rockets, to fhow how the recoil of fire-arms is produced. When the powder is fuddenly inflamed in the chamber, or at the bottom of the barrel, it neceffarily exercifes an action two ways at the fame time; that is to fay, againft the breech of the piece, and againft the bullet or wadding, which is placed above it. Befides this, it acts alfo againft the fides of the chamber which it occupies; and as they oppofe a refiftance almoft infurmountable, the whole effort of the elaftic fluid, produced by the inflammation, is exerted in the two directions above mentioned. But the refiftance oppofed by the bullet, being much lefs than that oppofed by the mafs of the barrel or cannon, the bullet is forced out with great velocity. It is impoffible, however, that the body of the piece itfelf fhould not experience a movement backwards; for if a fpring is fuddenly let loofe, between two moveable obftacles, it will impel them both, and communicate to them velocities in the inverfe ratio of their maffes; the piece, therefore, muft acquire a velocity backwards nearly in the inverfe ratio of its mafs to that of the bullet. We make ufe of the term *nearly*, becaufe there are various circumftances which give to this ratio certain modifications; but it is always true that the body of the piece is driven backwards, and that if it weighs with its carriage a 1000 times more than the bullet, it acquires a velocity which is 1000 times lefs, and which is foon annihilated by the friction of the wheels againft the ground, &c.

The caufe of the afcent of a rocket is nearly the fame. At the moment when the powder begins to inflame, its expanfion produces a torrent of elaftic fluid, which acts in every direction; that is, againft the air which oppofes its efcape from the cartridge, and againft the upper part of the rocket; but the refiftance of the air is more confiderable than the weight of the rocket, on account of the extreme rapidity with which the elaftic fluid iffues through the neck of the rocket to throw itfelf downwards, and therefore the rocket afcends by the excefs of the one of thefe forces above the other.

This however would not be the cafe, unlefs the rocket were pierced to a certain depth. A fufficient quantity of elaftic fluid would not be produced; for the compofition would inflame only in circular coats of a diameter equal to that of the rocket; and experience fhews that this is not fufficient. Recourfe then is had to the very ingenious idea of piercing the rocket with a conical hole, which makes the compofition burn in conical ftrata which have much greater furface, and therefore produce a much greater quantity of inflamed matter and fluid. This expedient was certainly not the work of a moment. *

* *Hutton's Recreations*, vol. iii. p 461.

78 To fix one rocket on the top of another.

When fky-rockets are fixed one on the top of another, they are called *towering rockets*, on account of their mounting fo very high. Towering rockets are made after this manner: Fix on a pound-rocket a head without a collar; then take a four ounce rocket, which may be headed or bounced, and rub the mouth of it with meal-powder wetted with fpirit of wine: this done, put it in the head of the large rocket with its mouth downwards; but before it is put in, ftick a bit of quick-match in the hole of the clay of the pound-rocket, which match fhould be long enough to go a little way up the bore of the fmall rocket, to fire it when the large rocket is burnt out. As the four ounce rocket is too fmall to fill the head of the other, roll round it as much tow as will make it ftand upright in the centre of the head: the rocket being thus fixed, pafte a fingle paper round the opening of the top of the head of the large rocket. The large rocket muft have only half a diameter of charge rammed above the piercer; for, if filled to the ufual height, it would turn before the fmall one takes fire, and entirely deftroy the intended effect: when one rocket is headed with another, there will be no occafion for any blowing powder; for the force with which it goes off will be fufficient to difengage it from the head of the firft fired rocket. The fticks for thefe rockets muft be a little longer than for thofe headed with ftars, rains, &c.

79 Caduceus rockets.

Caduceus rockets are fuch as, in rifing, form two fpiral lines, by reafon of their being placed obliquely, one oppofite to the other; and their counterpoife in their centre, which caufes them to rife in a vertical direction. Rockets for this purpofe muft have their ends choaked clofe, without either head or bounce, for a weight at top would be a great obftruction to their mounting. No caduceus rockets afcend fo high as fingle, becaufe of their

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their ſerpentine motion, and likewiſe the reſiſtance of air, which is much greater than two rockets of the ſame ſize would meet with if fired ſingly.

Fig. 30. ſhews the method of fixing theſe rockets: the ſticks for this purpoſe muſt have all their ſides equal, and the ſides ſhould be equal to the breadth of a ſtick proper for a ſky-rocket of the ſame weight as thoſe you intend to uſe, and made to taper downwards as uſual, long enough to balance them, one length of a rocket from the croſs ſtick; which muſt be placed from the large ſtick ſix diameters of one of the rockets, and its length ſeven diameters; ſo that each rocket, when tied on, may form with the large ſtick an angle of 60 degrees. In tying on the rockets, place their heads on the oppoſite ſides of the croſs ſtick, and their ends on the oppoſite ſides of the long ſtick; then carry a leader from the mouth of one into that of the other. When theſe rockets are to be fired, ſuſpend them between two hooks or nails, then burn the leader through the middle, and both will take fire at the ſame time. Rockets of one lb. are a good ſize for this uſe.

80 Honorary rockets.

Honorary rockets are the ſame as ſky-rockets, except that they carry no head nor report, but are cloſed at top, on which is fixed a cone: then on the caſe, cloſe to the top of the ſtick is tied on a two ounce caſe, about five or ſix inches long, filled with a ſtrong charge, and pinched cloſe at both ends; then in the reverſe ſides, at each end, bore a hole in the ſame manner as in tourbillons, to be preſently deſcribed; from each hole carry a leader into the top of the rocket. When the rocket is fired, and arrived to its proper height, it will give fire to the caſe at top; which will cauſe both rocket and ſtick to ſpin very faſt in their return, and repreſent a worm of fire deſcending to the ground.

There is another method of placing the ſmall caſe, which is by letting the ſtick riſe a little above the top of the rocket, and tying the caſe to it, ſo as to reſt on the rocket: theſe rockets have no cones.

A third method by which they are managed is this: In the top of a rocket fix a piece of wood, in which drive a ſmall iron ſpindle; then make a hole in the middle of the ſmall caſe, through which put the ſpindle: then fix on the top of it a nut, to keep the caſe from falling off; when this is done, the caſe will turn very faſt, without the rocket: but this method does not anſwer ſo well as either of the former.

Fig. 31. is the honorary rocket complete. The beſt ſized rockets for this purpoſe are thoſe of one lb.

81 To make a rocket form an arch in riſing.

Having ſome rockets made, and headed according to fancy, and tied on their ſticks; get ſome ſheet tin, and cut it into round pieces about three or four inches diameter; then on the ſtick of each rocket, under the mouth of the caſe, fix one of theſe pieces of tin 16 inches from the rocket's neck, and ſupport it by a wooden bracket, as ſtrong as poſſible: the uſe of this is, that when the rocket is aſcending the fire may play with great force on the tin, which will divide the tail in ſuch a manner that it will form an arch as it mounts, and will have a very good effect when well managed: if there is a ſhort piece of port-fire, of a ſtrong charge, tied to the end of the ſtick, it will make a great addition; but this muſt be lighted before the rocket is fired.

82 To make ſeveral rockets riſe in the ſame direction, and at the ſame diſtance.

Take ſix, or any number of ſky-rockets, of any ſize; then cut ſome ſtrong packthread into pieces of three or four yards long, and tie each end of theſe pieces to a rocket in this manner: Having tied one end of the packthread round the body of one rocket, and the other end to another, take a ſecond piece of packthread and make one end of it faſt to one of the rockets already tied, and the other end to a third rocket, ſo that all the rockets, except the two on the outſide, will be faſtened to two pieces of packthread: the length of thread from one rocket to the other may be what the maker pleaſes; but the rockets muſt be all of a ſize, and their heads filled with the ſame weight of ſtars, rains, &c.

Having thus done, fix in the mouth of each rocket a leader of the ſame length; and when about to fire them, hang them almoſt cloſe; then tie the ends of the leaders together, and prime them: this prime being fired, all the rockets will mount at the ſame time, and divide as far as the ſtrings will allow; and this diviſion they will keep, provided they are all rammed alike, and well made. They are ſometimes called *chained rockets*.

83 Signal rockets.

Signal rockets are made of ſeveral kinds, according to the different ſignals intended to be given; but in artificial fire-works, two ſorts are only uſed, which are one with reports and the other without; but thoſe for the uſe of the navy and army are headed with ſtars, ſerpents, &c.——Rockets which are to be bounced muſt have their caſes made one and a half or two diameters longer than the common proportion; and after they are filled, drive in a double quantity of clay, then bounce and pinch them after the uſual manner, and fix on each a cap.

Signal ſky-rockets without bounces, are only ſky-rockets cloſed and capped: theſe are very light, therefore do not require ſuch heavy ſticks as thoſe with loaded heads; for which reaſon the rocket may be cut from the ſtick, or elſe be made thinner.

Signal rockets with reports are fired in ſmall flights; and often both theſe, and thoſe without reports, are uſed for a ſignal to begin firing a collection of works.

84 To fix ſeveral rockets to the ſame ſtick.

Two, three, or ſix ſky-rockets, fixed on one ſtick, and fired together, make a grand and beautiful appearance; for the tails of all will ſeem but as one of an immenſe ſize, and the breaking of ſo many heads at once will reſemble the burſting of an air-balloon. The management of this device requires a ſkilful hand; but if the following inſtructions be well obſerved, even by thoſe who have not made a great progreſs in this art, there will be no doubt of the rockets having the deſired effect.

Rockets for this purpoſe muſt be made with the greateſt exactneſs, all rammed by the ſame hand, in the ſame mould, and filled with the ſame proportion of compoſition; and after they are filled and headed, muſt all be of the ſame weight. The ſtick muſt alſo be well made (and proportioned) to the following directions: firſt, ſuppoſing the rockets to be half pounders, whoſe ſticks are ſix feet ſix inches long, then if two, three, or ſix of theſe are to be fixed on one ſtick, let the length of it be nine feet nine inches: then cut the top of it into as many ſides as there are rockets, and let the length of each ſide be equal to the length of one of the rockets without its head; and in each ſide cut a groove (as uſual); then from the grooves plane it round, down to the bottom, where its thickneſs muſt be equal to half the top of the round part. As their thickneſs cannot be exactly aſcertained, we ſhall give a rule which generally anſwers for

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for any number of rockets above two: the rule is this; that the ſtick at top muſt be thick enough, when the grooves are cut, for all the rockets to lie, without preſſing each other, though as near as poſſible.

When only two rockets are to be fixed on one ſtick, let the length of the ſtick be the laſt given proportion, but ſhaped after the common method, and the breadth and thickneſs double the uſual dimenſions. The point of poiſe muſt be in the uſual place (let the number of rockets be what they will): if ſticks made by the above directions ſhould be too heavy, plane them thinner; and if too light, make them thicker; but always make them of the ſame length.

When more than two rockets are tied on one ſtick, there will be ſome danger of their flying up without the ſtick, unleſs the following precaution is taken: For caſes being placed on all ſides, there can be no notches for the cord which ties on the rockets to lie in; therefore, inſtead of notches, drive a ſmall nail in each ſide of the ſtick, between the necks of the caſes: and let the cord, which goes round their necks, be brought cloſe under the nails; by this means the rockets will be as ſecure as when tied on ſingly. The rockets being thus fixed, carry a quick-match, without a pipe, from the mouth of one rocket to the other; this match being lighted will give fire to all at once.

Though the directions already given may be ſufficient for theſe rockets, we ſhall here add an improvement on a very eſſential part of this device, which is, that of hanging the rockets to be fired; for before the following method was contrived, many attempts proved unſucceſsful. Inſtead, therefore, of the old and common manner of hanging them on nails or hooks, make uſe of the following contrivance: Have a ring made of ſtrong iron wire large enough for the ſtick to go in as far as the mouths of the rockets; then have another ring ſupported by a ſmall iron, at ſome diſtance from the poſt or ſtand to which it is fixed: then have another ring fit to receive and guide the ſmall end of the ſtick. Rockets thus ſuſpended will have nothing to obſtruct their fire; but when they are hung on nails or hooks, in ſuch a manner that ſome of their mouths are againſt or upon a rail, there can be no certainty of their riſing in a vertical direction.

85 To fire rockets without ſticks.

To fire rockets without ſticks, you muſt have a ſtand, of a block of wood, a foot diameter, and make the bottom flat, ſo that it may ſtand ſteady: in the centre of the top of this block draw a circle two inches and a half diameter, and divide the circumference of it into three equal parts; then take three pieces of thick iron wire, each about three feet long, and drive them into the block, one at each point made on the circle; when theſe wires are driven in deep enough to hold them faſt and upright, ſo that the diſtance from one to the other is the ſame at top as at bottom, the ſtand is complete.

The ſtand being thus made, prepare the rockets thus: Take ſome common ſky-rockets of any ſize, and head them as you pleaſe; then get ſome balls of lead, and tie to each a ſmall wire two or two feet and a half long, and the other end of each wire tie to the neck of a rocket. Theſe balls anſwer the purpoſe of ſticks when made of a proper weight, which is about two-thirds the weight of the rocket; but when they are of a proper ſize, they will balance the rocket in the ſame manner as a ſtick, at the uſual point of poiſe. To fire theſe, hang them, one at a time, between the tops of the wires, letting their heads reſt on the point of the wires, and the balls hang down between them: if the wires ſhould be too wide for the rockets, preſs them together till they fit; and if too cloſe, force them open; the wires for this purpoſe muſt be ſoftened, ſo as not to have any ſpring, or they will not keep their poſition when preſſed cloſe or opened.

86 Scrolls for rockets.

Caſes for ſcrolls ſhould be made four or five inches in length, and their interior diameters three-eighths of an inch: one end of theſe caſes muſt be pinched quite cloſe before beginning to fill; and when filled cloſe, the other end: then in the oppoſite ſides make a ſmall hole at each end, to the compoſition, as in tourbillons; and prime them with wet meal-powder. You may put in the head of a rocket as many of theſe caſes as it will contain: being fired they turn very quick in the air, and form a ſcroll or ſpiral line. They are generally filled with a ſtrong charge, as that of ſerpents or brilliant fire.

87 Swarmers.

Rockets that paſs under the denomination of *ſwarmers*, are thoſe from two ounces downwards. Theſe rockets are fired ſometimes in flights, and in large water-works, &c. Swarmers of one and two ounces are bored, and made in the ſame manner as large rockets, except that, when headed, their heads muſt be put on without a collar: the number of ſtrokes for driving one ounce muſt be eight, and for two ounces twelve.

All rockets under one ounce are not bored, but muſt be filled to the uſual height with compoſition, which generally conſiſts of fine meal-powder four ounces, and charcoal or ſteel-duſt two drams: the number of ſtrokes for ramming theſe ſmall ſwarmers is not material, provided they are rammed truly, and moderately hard. The necks of unbored rockets muſt be in the ſame proportion as in common caſes.

88 Stands for rockets.

Care muſt be taken, in placing the rockets, when they are to be fired, to give them a vertical direction at their firſt ſetting out; which may be managed thus: Have two rails of wood, of any length, ſupported at each end by a perpendicular leg, ſo that the rails may be horizontal, and let the diſtance from one to the other be almoſt equal to the length of the ſticks of the rockets intended to be fired; then in the front of the top rail drive ſquare hooks at eight inches diſtance, with their points turning ſidewiſe, ſo that when the rockets are hung on them, the points will be before the ſticks and keep them from falling or being blown off by the wind; in the front of the rail at bottom muſt be ſtaples, driven perpendicular under the hooks at top; through theſe ſtaples put the ſmall ends of the rocket ſticks. Rockets are fired by applying a lighted port-fire to their mouths.

N. B. When ſky-rockets are made to perfection, and fired, they will ſtand two or three ſeconds on the hook before they riſe, and then mount up briſkly, with a ſteady motion, carrying a large tail from the ground all the way up, and juſt as they turn, break, and diſperſe the ſtars.

89 Girandole cheſts for flights of rockets.

Girandole cheſts are generally compoſed of four ſides of equal dimenſions; but may be made of any diameter, according to the number of rockets deſigned to be fired; their height muſt be in proportion to the rockets, but muſt always be a little higher than the rockets with their ſticks. When the ſides are joined, fix in the top as

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as far down the cheſt as the length of one of the rockets with its cap on. In this top, make as many ſquare or round holes to receive the rocket ſticks as there are to be rockets; but let the diſtance between them be ſufficient for the rockets to ſtand without touching one another; then from one hole to another cut a groove large enough for a quick match to lie in: the top being thus fixed, put in the bottom, at about one foot and a half diſtance from the bottom of the cheſt; in this bottom muſt be as many holes as in the top, and all to correſpond: but theſe holes need not be ſo large as thoſe in the top.

To prepare the cheſt, a quick match muſt be laid in all the grooves, from hole to hole: then take ſome ſky-rockets, and rub them in the mouth with wet meal-powder, and put a bit of match up the cavity of each; which match muſt be long enough to hang a little below the mouth of the rocket. The rockets and cheſt being prepared according to the above directions, put the ſticks of the rockets through the holes in the top and bottom of the cheſt, ſo that their mouths may reſt on the quick-match in the grooves: by which all the rockets will be fired at once; for by giving fire to any part of the match, it will communicate to all the rockets in an inſtant. As it would be rather troubleſome to direct the ſticks from the top to the proper holes in the bottom, it will be neceſſary to have a ſmall door in one of the ſides, through which, when opened, you may ſee how to place the ſticks. Flights of rockets being ſeldom ſet off at the beginning of any fire-works, they are in danger of being fired by the ſparks from wheels, &c.; therefore, to preſerve them, a cover ſhould be made to fit on the cheſt, and the door in the ſide kept ſhut.

90 Line-rockets.

Line-rockets are made and rammed as the ſky-rockets, but have no heads, and the caſes muſt be cut cloſe to the clay; they are ſometimes made with ſix or ſeven changes, but in general not more than four or five. The method of managing theſe rockets is the following: Firſt, have a piece of light wood, the length of one of the rockets turned round about two inches and a half diameter, with a hole through the middle lengthwiſe, large enough for the line to go eaſily through; if four changes are intended, have four grooves cut in the ſwivel, one oppoſite the other, in which to lay the rockets.

The mouths of the rockets being rubbed with wet meal-powder, lay them in the grooves head to tail, and tie them faſt; from the tail of the firſt rocket carry a leader to the mouth of the ſecond, and from the ſecond to the third, and ſo on to as many as there are on the ſwivel, making every leader very ſecure; but in fixing theſe pipes, take care that the quick-match does not enter the bores of the rockets: the rockets being fixed on the ſwivel and ready to be fired, have a line 100 yards long, ſtretched and fixed up tight, at any height from the ground; but be ſure to place it horizontally: this length of line will do for half-pound rockets; but if larger, the line muſt be longer. Before you put up the line, put one end of it through the ſwivel; and when you fire the line rocket, let the mouth of that rocket which is firſt fired face that end of the line where you ſtand; then the firſt rocket will carry the reſt to the other end of the line, and the ſecond will bring them back; and ſo they will run out and in according to the number of rockets: at each end of the line there muſt be a piece of flat wood for the rocket to ſtrike againſt, or its force will cut the line. Let the line be well ſoaped, and the hole in the ſwivel very ſmooth.

91 Different decorations for line rockets.

To line rockets may be fixed a great variety of figures, ſuch as flying dragons, Mercuries, ſhips, &c.; or they may be made to run on the line like a wheel; which is done in this manner. Have a flat ſwivel made very exactly, and on it tie two rockets obliquely one on each ſide, which will make it turn round as it goes, and form a circle of fire; the charge for theſe rockets ſhould be a little weaker than common. If you would ſhow two dragons fighting, get two ſwivels made ſquare, and on each tie three rockets together on the under ſide; then have two flying dragons made of tin, and fix one of them on the top of each ſwivel, ſo as to ſtand upright; in the mouth of each dragon put a ſmall caſe of common fire, and another at the end of the tail; put two or three port-fires, of a ſtrong charge, on one ſide of their bodies, to ſhow them. This done, put them on the line, one at each end; but let there be a ſwivel in the middle of the line to keep the dragons from ſtriking together: before firing the rockets, light the caſes on the dragons; and if care be taken in firing both at the ſame time, they will meet in the middle of the line, and ſeem to fight. Then they will run back and return with great violence, which will have a very pleaſing effect, The line for theſe rockets muſt be very long, or they will ſtrike too hard together.

92 Caſes for Chineſe flyers.

Caſes for Chineſe flyers may be made of different ſizes, from one to eight ounces: they muſt be made thick of paper, and eight interior diameters long; they are rolled in the ſame manner as tourbillons, with a ſtraight paſted edge, and pinched cloſe at one end. The method of filling them is, the caſe being put in a mould, whoſe cylinder, or foot, muſt be flat at top without a nipple, fill it within half a diameter of the middle; then ram in half a diameter of clay, on that as much compoſition as before, on which drive half a diameter of clay; then pinch the caſe cloſe, and drive it down flat: after this is done, bore a hole exactly through the centre of the clay in the middle; then in the oppoſite ſides, at both ends, make a vent; and in that ſide intended to be fired firſt make a ſmall hole to the compoſition near the clay in the middle, from which carry a quick-match, covered with a ſingle paper, to the vent at the other end; then, when the charge is burnt on one ſide, it will, by means of the quick-match, communicate to the charge on the other (which may be of a different ſort). The flyers being thus made, put an iron pin, that muſt be fixed in the work on which they are to be fired, and on which they are to run, through the hole in the middle; on the end of this pin muſt be a nut to keep the flyer from running off. If they are to turn back again after they are burnt, make both the vents at the ends on the ſame ſide, which will alter its courſe the contrary way.

93 Table rockets.

Table rockets are deſigned merely to ſhow the truth of driving, and the judgment of a fire-worker; they having no other effect, when fired, than ſpinning round in the ſame place where they begin, till they are burnt out, and ſhowing nothing more than an horizontal circle of fire.

The method of making theſe rockets is,—Have a cone turned out of hard wood two inches and a half in diameter, and as much high; round the baſe of it drive a line;

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line; on this line fix four ſpokes, each two inches long, ſo as to ſtand one oppoſite the other; then fill four nine-inch one pound caſes with any ſtrong compoſition, within two inches of the top: theſe caſes are made like tourbillons, and muſt be rammed with the greateſt exactneſs.

The rockets being filled, fix their open ends on the ſhort ſpokes; then in the ſide of each caſe bore a hole near the clay; all theſe holes, or vents, muſt be ſo made that the fire of each caſe may act the ſame way; from theſe vents carry leaders to the top of the cone, and tie them together. When the rockets are to be fired, ſet them on a ſmooth table, and light the leaders in the middle, and all the caſes will fire together (ſee fig. 32.) and ſpin on the point of the cone.

Theſe rockets may be made to riſe like tourbillons, by making the caſes ſhorter, and boring four holes in the under ſide of each at equal diſtances: this being done they are called *double tourbillons.*

Note, All the vents in the under ſide of the caſes muſt be lighted at once; and the ſharp point of the cone cut off, at which place make it ſpherical.

94 Aërial globes or bombs.

Fireworks called aërial globes or bombs conſiſt of a ſpherical caſe made of ſtrong paper, or of wood, prepared as will be immediately deſcribed, and thrown from a mortar commonly made of paſteboard, with a copper chamber to contain the charge, ſuch as AB, fig. 33. (Fig. 33.) This ſmall mortar muſt be made of light wood, or of paper paſted together, and rolled up in the form of a cylinder, or truncated cone, the bottom excepted; which, as already ſaid, muſt be of wood. The chamber for the powder AC muſt be pierced obliquely, with a ſmall gimlet, as ſeen at BC; ſo that the aperture B correſponding to the aperture of the metal mortar, in which this paper mortar muſt be placed when the globe is fired, the fire applied to the latter may be communited to the powder which is at the bottom of the chamber AC, immediately below the globe. By theſe means the globe will catch fire and make an agreeable noiſe as it riſes into the air; but it would not ſucceed ſo well if any vacuity were left between the powder and the globe.

A profile or perpendicular ſection of ſuch a globe is repreſented by the right-angled parallelogram ABCD, fig. 34.; the breadth of which AB is nearly equal to the height AD. The thickneſs of the wood towards the two ſides L, M, is equal to about the twelfth part of the diameter of the globe; and the thickneſs E, F, of the cover, is double the preceding, or equal to a ſixth part of the diameter. The height GK, or HI of the chamber GHIK, where the match is applied, and which is terminated by the ſemicircle LGKM, is equal to the fourth part of the breadth AB, and its breadth GH is equal to the ſixth part of AB.

We muſt here obſerve, that it is dangerous to put wooden covers, ſuch as EF, on aërial balloons or globes, for theſe covers may be ſo heavy as to wound thoſe on whom they happen to fall. It will be ſufficient to place turf or hay above the globe, in order that the powder may experience ſome reſiſtance.

The globe muſt be filled with ſeveral pieces of cane or common reed, equal in length to the interior height of the globe, and charged with a ſlow compoſition, made of three ounces of pounded gunpowder, an ounce of ſulphur moiſtened with a ſmall quantity of petroleum oil, and two ounces of charcoal; and in order that theſe reeds or canes may catch fire ſooner, and with more facility, they muſt be charged at the lower ends, which reſt on the bottom of the globe, with pulverized gunpowder moiſtened in the ſame manner with petroleum oil, or well beſprinkled with brandy, and then dried.

The bottom of the globe ought to be covered with a little gunpowder half pulverized and half grained; which, when ſet on fire by means of a match applied to the end of the chamber GH, will ſet fire to the lower part of the reed. But care muſt have been taken to fill the chamber with a compoſition ſimilar to that in the reeds, or with another ſlow compoſition made of eight ounces of gunpowder, four ounces of ſaltpetre, two ounces of ſulphur, and one ounce of charcoal: the whole muſt be well pounded and mixed.

Inſtead of reeds, the globe may be charged with running rockets, or paper petards, and a quantity of fiery ſtars or ſparks mixed with the pulveriſed gunpowder, placed without any order above theſe petards, which muſt be choaked at unequal heights, that they may perform their effect at different times.

Theſe globes may be conſtructed in various other ways, which it would be tedious here to enumerate. We ſhall only obſerve, that when loaded they muſt be well covered at the top; they muſt be wrapped up in a piece of cloth dipped in glue, and a piece of woollen cloth muſt be tied round them, ſo as to cover the hole which contains the match.

95 Fuzes for globes or air balloons.

Fuzes for air balloons are ſometimes turned out of dry beech, with a cup at top to hold the quick match, or other firing material; but if made with paſted paper, they will do as well: the diameter of the *former* for fuzes for coehorn balloons muſt be half an inch; for a royal fuze, five-eighths of an inch; for an eight inch fuze, three-fourths of an inch; and for a ten inch fuze, ſeven-eighths of an inch. Having rolled the caſes, pinch and tie them almoſt cloſe at one end: then drive them down, and let them dry. Before beginning to fill them, mark on the outſide of the caſe the length of the charge required, allowing for the thickneſs of the bottom; and when the compoſition is rammed in, take two pieces of quick-match about ſix inches long, and lay one end of each on the charge, and then a little meal-powder, which ram down hard; the looſe ends of the match double up into the top of the fuze, and cover it with a paper cap to keep it dry. When the ſhells are put into the mortars, uncap the fuzes, and pull out the looſe ends of the match, and let them hang on the ſides of the balloons. The uſe of the match is, to receive the fire from the powder in the chamber of the mortar, in order to light the fuze: the ſhell being put in the mortar with the fuze uppermoſt, and exactly in the centre, ſprinkle over it a little meal-powder, and it will be ready to be fired. Fuzes made of wood muſt be longer than thoſe of paper, and not bored quite through, but left ſolid about half an inch at bottom; and when uſed ſaw them off to a proper length, meaſuring the charge from the cup at top.

96 Tourbillons.

To make Tourbillons.—Having filled ſome caſes within about one diameter and a half, drive in a ladleful of clay; then pinch the ends cloſe, and drive them down with a mallet. When done, find the centre of gravity of each caſe; where the nail and ſtick are tied which

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ſhould be half an inch broad at the middle, and run a little narrower to the ends: theſe ſticks muſt have their ends turned upwards, ſo that the caſes may turn horizontally on their centres: at the oppoſite ſides of the caſes, at each end, bore a hole cloſe to the clay with a gimblet, the ſize of the neck of a common caſe of the ſame nature: from theſe holes draw a line round the caſe, and at the under part of the caſe bore a hole with the ſame gimblet, within half a diameter of each line towards the centre; then from one hole to the other draw a right line. Divide this line into three equal parts; and at X and Y (fig. 35.) bore a hole; then from theſe holes to the other two lead a quick-match, over which paſte a thin paper. Fig. 36. repreſents a tourbillon as it ſhould lie to be fired, with a leader from one ſide hole A to the other B. When tourbillons are fired lay them on a ſmooth table, with their ſticks downwards, and burn the leader through the middle with a portfire. They ſhould ſpin three or four ſeconds on the table before they riſe, which is about the time the compoſition will be burning from the ſide holes to thoſe at bottom.

To tourbillons may be fixed reports in this manner: In the centre of the caſe at top make a ſmall hole, and in the middle of the report make another; then place them together, and tie on the report, and with a ſingle paper ſecure it from fire: this done, the tourbillon is completed. By this method you may fix on tourbillons ſmall cones of ſtars, rains, &c. but be careful not to load them too much. One eighth of an inch will be enough for the thickneſs of the ſticks, and their length equal to that of the caſes.

97 Aigrettes.

Mortars to throw aigrettes are generally made of paſteboard, of the ſame thickneſs as balloon mortars, and two diameters and a half long in the inſide from the top of the foot: the foot muſt be made of elm without a chamber, but flat at top, and in the ſame proportion as thoſe for balloon mortars; theſe mortars muſt alſo be bound round with a cord: ſometimes eight or nine of theſe mortars, of about three or four inches diameter, are bound all together, ſo as to appear but one: but when they are made for this purpoſe, the bottom of the foot muſt be of the ſame diameter as the mortars, and only half a diameter high. The mortars being bound well together, fix them on a heavy ſolid block of wood. To load theſe mortars, firſt put on the inſide bottom of each a piece of paper, and on it ſpread one ounce and a half of meal and corn powder mixed; then tie the ſerpents up in parcels with quickmatch, and put them in the mortar with their mouths downwards; but take care the parcels do not fit too tight in the mortars, and that all the ſerpents have been well primed with powder wetted with ſpirit of wine. On the top of the ſerpents in each mortar lay ſome paper or tow; then carry a leader from one mortar to the other all round, and then from all the outſide mortars into that in the middle: theſe leaders muſt be put between the caſes and the ſides of the mortar, down to the powder at bottom: in the centre of the middle mortar fix a fire pump, or brilliant fountain, which muſt be open at bottom, and long enough to project out of the mouth of the mortar; then paſte paper on the tops of all the mortars.

Mortars thus prepared are called a *neſt of ſerpents*, as repreſented by fig. 37. When theſe mortars are to be fired, light the fire-pump C, which when conſumed will communicate to all the mortars at once by means of the leaders. For mortars of 8, 9, or 10 inches diameter, the ſerpents ſhould be made in one and two ounce caſes ſix or ſeven inches long, and fired by a leader brought out of the mouth of the mortar, and turned down the outſide, and the end of it covered with paper, to prevent the ſparks of the other works from ſetting it on fire. For a ſix-inch mortar, let the quantity of powder for firing be two ounces; for an eight-inch, two ounces and three quarters; and for a ten-inch, three ounces and three quarters. Care muſt be taken in theſe, as well as ſmall mortars, not to put the ſerpents in too tight, for fear of burſting the mortars. Theſe mortars may be loaded with ſtars, crackers, &c.

If the mortars, when loaded, are ſent to any diſtance, or liable to be much moved, the firing powder ſhould be ſecured from getting amongſt the ſerpents, which would endanger the mortars, as well as hurt their performance. To prevent this, load the mortars thus: Firſt put in the firing powder, and ſpread it equally about; then cut a round piece of blue touch-paper, equal to the exterior diameter of the mortar, and draw on it a circle equal to the interior diameter of the mortar, and notch it all round as far as that circle: then paſte that part which is notched, and put it down the mortar cloſe to the powder, and ſtick the paſted edge to the mortar: this will keep the powder always ſmooth at bottom, ſo that it may be moved or carried anywhere without receiving damage. The large ſingle mortars are called *pots des aigrettes.*

98 Pots des brins.

Pots des Brins are formed of paſteboard, and muſt be rolled pretty thick. They are uſually made three or four inches diameter, and four diameters long; and pinched with a neck at one end, like common caſes. A number of theſe are placed on a plank thus: Having fixed on a plank two rows of wooden pegs, cut in the bottom of the plank a groove the whole length under each row of pegs; then, through the centre of each peg, bore a hole down to the groove at bottom, and on every peg fix and glue a pot, whoſe mouth muſt fit tight on the peg; through all the holes run a quick match, one end of which muſt go into the pot, and the other into the groove, which muſt have a match laid in it from end to end, and covered with paper, ſo that when lighted at one end it may diſcharge the whole almoſt inſtantaneouſly: in all the pots put about one ounce of meal and corn powder; then in ſome put ſtars, and in others rains, ſnakes, ſerpents, crackers, &c. when they are all loaded, paſte paper over their mouths. Two or three hundred of theſe pots being fired together make a very pretty ſhow, by affording ſo great a variety of fires. Fig. 38. is a range of pots des brins, with a leader A, by which they are fired.

99 Pots des ſauciſſons.

Pots des Sauciſſons are generally fired out of large mortars without chambers, the ſame as thoſe for aigrettes, only ſomewhat ſtronger. Sauciſſons are made of one and two ounce caſes, five or ſix inches long, and choked in the ſame manner as ſerpents. Half the number which the mortar contains muſt be driven one diameter and a half with compoſition, and the other half two diameters, ſo that when fired they may give two volleys of reports. But if the mortars are very ſtrong, and will bear a ſufficient charge to throw the ſauciſſons very high, you may make three volleys of reports, by dividing the number of caſes into three parts, and making a difference

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difference in the height of the charge. After they are filled, pinch and tie them at top of the charge almoſt cloſe; only leaving a ſmall vent to communicate the fire to the upper part of the caſe, which muſt be filled with corn-powder very near the top; then pinch the end quite cloſe, and tie it: after this is done, bind the caſe very tight with waxed packthread, from the choke at top of the compoſition to the end of the caſe; this will make the caſe very ſtrong in that part, and cauſe the report to be very loud. Sauciſſons ſhould be rolled a little thicker of paper than the common proportion. When they are to be put in the mortar, they muſt be primed in their mouths, and fired by a caſe of brilliant fire fixed in their centre.

The charge for theſe mortars ſhould be one-ſixth or one-eighth more than for *pots des aigrettes* of the ſame diameter.

100 Single vertical wheels.

There are different ſorts of vertical wheels; ſome having their fells of a circular form, others of an hexagonal, octagonal, or decagonal form, or of any number of ſides, according to the length of the caſes you deſign for the wheel: the ſpokes being fixed in the nave, nail ſlips of tin, with their edges turned up, ſo as to form grooves for the caſes to lie in, from the end of one ſpoke to that of another; then tie the caſes in the grooves head to tail, in the ſame manner as thoſe on the horizontal water-wheel, ſo that the caſes ſucceſſively taking fire from one another, will keep the wheel in an equal rotation. Two of theſe wheels are very often fired together, one on each ſide of a building; and both lighted at the ſame time, and all the caſes filled alike, to make them keep time together; as they will, if made by the following directions: In all the caſes of both wheels, except the firſt, on each wheel drive two or three ladleſful of ſlow fire, in any part of the caſes; but be careful to ram the ſame quantity in each caſe, and in the end of one of the caſes, on each wheel, you may ram one ladleful of dead-fire compoſition, which muſt be very lightly driven; you may alſo make many changes of fire by this method.

Let the hole in the nave of the wheel be lined with braſs, and made to turn on a ſmooth iron ſpindle. On the end of this ſpindle let there be a nut, to ſcrew off and on; when you have put the wheel on the ſpindle, ſcrew on the nut, which will keep the wheel from flying off. Let the mouth of the firſt caſe be a little raiſed. See fig. 39. Vertical wheels are made from ten inches to three feet diameter, and the ſize of the caſes muſt differ accordingly; four-ounce caſes will do for wheels of 14 or 16 inches diameter, which is the proportion generally uſed. The beſt wood for wheels of all ſorts is a light and dry beech.

101 Horizontal wheels.

Horizontal wheels are beſt when their fells are made circular; in the middle of the top of the nave muſt be a pintle, turned out of the ſame piece as the nave, two inches long, and equal in diameter to the bore of one of the caſes of the wheel: there muſt be a hole bored up the centre of the nave, within half an inch of the top of the pintle. The wheel being made, nail at the end of each ſpoke (of which there ſhould be ſix or eight) a piece of wood, with a groove cut in it to receive the caſe. Fix theſe pieces in ſuch a manner that half the caſes may incline upwards and half downwards, and that, when they are tied on, their heads and tails may come very nearly together; from the tail of one caſe to the mouth of the other carry a leader, which ſhould be ſecured with paſted paper. Beſides theſe pipes, it will be neceſſary to put a little meal-powder within the paſted paper, to blow off the pipe, that there may be no obſtruction to the fire from the caſes. By means of theſe pipes the caſes will ſucceſſively take fire, burning one upwards and the other downwards. On the pintle fix a caſe of the ſame ſort as thoſe on the wheel; this caſe muſt be fired by a leader from the mouth of the laſt caſe on the wheel, which caſe muſt play downwards: inſtead of a common caſe in the middle, you may put a caſe of Chineſe fire, long enough to burn as long as two or three of the caſes on the wheel.

Horizontal wheels are often fired two at a time, and made to keep time like vertical wheels, only they are made without any ſlow or dead fire; 10 or 12 inches will be enough for the diameter of wheels with ſix ſpokes. Fig. 40. repreſents a wheel on fire, with the firſt caſe burning. Plate CCCCLIV. Fig. 40.

102 Spiral wheels.

Spiral wheels, are only double horizontal wheels, and made thus: The nave muſt be about ſix inches long, and rather thicker than the ſingle ſort; inſtead of the pintle at top, make a hole for the caſe to be fixed in, and two ſets of ſpokes, one ſet near the top of the nave, and the other near the bottom. At the end of each ſpoke cut a groove wherein you tie the caſes, there being no fell; the ſpokes ſhould not be more than two inches and a half long from the naves, ſo that the wheel may not be more than eight or nine inches diameter; the caſes are placed in ſuch a manner, that thoſe at top play down, and thoſe at bottom play up, but let the third or fourth caſe play horizontally. The caſe in the middle may begin with any of the others: ſix ſpokes will be enough for each ſet, ſo that the wheel may conſiſt of 12 caſes, beſides that on the top: the caſes ſix inches each.

103 Plural wheels.

Plural wheels are made to turn horizontally, and to conſiſt of three ſets of ſpokes, placed ſix at top, ſix at bottom, and four in the middle, which laſt muſt be a little ſhorter than the reſt: let the diameter of the wheel be 10 inches; the caſes muſt be tied on the ends of the ſpokes in grooves cut on purpoſe, or in pieces of wood nailed on the ends of the ſpokes, with grooves cut in them as uſual: in clothing theſe wheels, make the upper ſet of caſes play obliquely downwards, the bottom ſet obliquely upwards, and the middle ſet horizontally. In placing the leaders, they muſt be managed ſo that the caſes may burn thus, viz. firſt up, then down, then horizontal, and ſo on with the reſt. But another change may be made, by driving in the end of the eighth caſe two or three ladleſful of ſlow fire, to burn till the wheel has ſtopped its courſe; then let the other caſes be fixed the contrary way, which will make the wheel run back again: for the caſe at top you may put a ſmall gerbe; and let the caſes on the ſpokes be ſhort, and filled with a ſtrong brilliant charge.

104 Illuminated ſpiral wheels.

Illuminated ſpiral wheel.—Firſt have a circular horizontal wheel made two feet diameter, with a hole quite through the nave; then take three thin pieces of deal, three feet long each, and three-fourths of an inch broad each: one end of each of theſe pieces nail to the fell of the wheel, at an equal diſtance from one another, and the other end nail to a block with a hole in its bottom, which muſt be perpendicular to that in the block of the wheel, but not ſo large. The wheel being thus made, have

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have a hoop planed down very thin and flat; then nail one end of it into the fell of the wheel, and wind it round the three sticks in a spiral line from the wheel to the block at top: on the top of this block fix a case of Chinese fire; on the wheel you may place any number of cases, which must incline downwards, and burn two at a time. If the wheel should consist of ten cases, you may let the illuminations and Chinese fire begin with the second cases. The spindle for this wheel must be a little longer than the cone, and made very smooth at top, on which the upper block is to turn, and the whole weight of the wheel to rest. See fig. 41.

105 Double spiral wheel.

Double spiral wheel.—For this wheel the block, or nave, must be as long as the height of the worms, or spiral lines, but must be made very thin, and as light as possible. In this block must be fixed several spokes, which must diminish in length, from the wheel to the top, so as not to exceed the surface of a cone of the same height. To the ends of these spokes nail the worms, which must cross each other several times: clothe these worms with illuminations, the same as those on the single wheels; but the horizontal wheel you may clothe as you like. At top of the worm place a case of spur-fire, or an amber light, see fig. 42. This figure is shown without leaders, to prevent a confusion of lines.

106 Balloon wheels.

Balloon wheels are made to turn horizontally: they must be made two feet diameter, without any spokes; and very strong, with any number of sides. On the top of a wheel range and fix in pots, three inches diameter and seven inches high each, as many of these as there are cases on the wheel: near the bottom of each pot make a small vent; into each of these vents carry a leader from the tail of each case; load some of the pots with stars, and some with serpents, crackers, &c. As the wheels turn, the pots will successively be fired, and throw into the air a great variety of fires.

107 Fruiloni wheels.

For fruiloni wheels first have a nave made nine inches long and three in diameter: near the bottom of this nave fix eight spokes, with a hole in the end of each, large enough to receive a two or four ounce case: each of these spokes may be 14 inches long from the block. Near the top of this block fix eight more of the same spokes, exactly over the others, but not so long by two inches. As this wheel is to run horizontally, all the cases in the spokes must play obliquely upwards, and all those in the spokes at bottom obliquely downwards. This being done, have a small horizontal wheel made with eight spokes, each five inches long from the block: on the top of this wheel place a case of brilliant fire: all the cases on this wheel must play in an oblique direction downwards, and burn two at a time, and those on the large wheel four at a time; that is, two of those in the top set of spokes, and two of those in the bottom set of spokes.

The four first cases on the large wheel, and the two first on the small, must be fired at the same time, and the brilliant fire at top at the beginning of the last cases. The cases of the wheels may be filled with a gray charge. When these wheels are completed, you must have a strong iron spindle, made four feet six inches long, and fixed perpendicularly on the top of a stand: on this put the large wheel, whose nave must have a hole quite through from the bottom to the top. This hole must be large enough to turn easily round the bottom of the spindle, at which place there must be a shoulder, to keep the wheel from touching the stand: at the top of the spindle put the small wheel, and join it to a large one with a leader, in order that they may be fired both together.

108 Cascades of fire.

Cascades of fire are made of any size; but one made according to the dimensions of that shown in fig. 43. will be large enough for eight-ounce cases. Let the distance from A to B be three feet; from B to C two feet six inches; and from C to D two feet; and let the cross piece at A be four feet long: then from each end of this piece draw a line to D; then make the other cross pieces so long as to come within those lines. The top piece D may be of any length, so as to hold the cases, at a little distance from each other; all the cross pieces are fixed horizontally, and supported by brackets; the bottom cross piece should be about one foot six inches broad in the middle, the second one foot, the third nine inches, and the top piece four inches: the cases may be made of any length, but must be filled with a brilliant charge. On the edges of the cross pieces must be nailed bits of wood, with a groove cut in each piece, large enough for a case to lie in. These bits of wood are fixed so as to incline downwards, and that the fire from one tier of cases may play over that of the other. All the cases being tied fast on, carry leaders from one to the other; and let there be a pipe hung from the mouth of one of the cases, covered at the end with a single paper, which you burn to fire the cascade.

109 Fire tree.

The Fire Tree.—To make a fire tree, as shown by fig. 44. you must first have a piece of wood six feet long, and three inches square; then at E, nine inches from the top, make a hole in the front, and in each side; or, instead of holes, you may fix short pegs, to fit the inside of the cases. At F, nine inches from E, fix three more pegs; at G, one foot nine inches from F, fix three pegs; at H, nine inches from G, fix three pegs; at I, nine inches from H, fix three pegs, inclining downwards; but all the other pegs must incline upwards, that the cases may have the same inclination as is seen in the figure: then at top place a four-inch mortar, loaded with stars, rains, or crackers. In the middle of this mortar place a case filled with any sort of charge, but let it be fired with the other cases: a brilliant charge will do for all the cases; but the mortar may be made of any diameter, and the tree of any size; and on it any number of cases, provided they are placed in the manner described.

110 Chinese fountains.

Chinese Fountains.—To make a Chinese fountain, you must have a perpendicular piece of wood seven feet long and two inches and a half square. Sixteen inches from the top, fix on the front a cross piece one inch thick, and two and a half broad, with the broad side upwards; below this, fix three more pieces of the same width and thickness, at sixteen inches from each other; let the bottom rail be five feet long, and the others of such a length as to allow the fire-pumps to stand in the middle of the intervals of each other. The pyramid being thus made, fix in the holes made in the bottom rail five fire pumps, at equal distances; on the second rail, place four pumps; on the third, three; on the fourth, two; and on the top of the post, one; but place them all to incline a little forwards, that, when they throw out the stars, they may not strike against the

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the crofs rails. Having fixed your fire-pumps, clothe them with leaders, fo that they may all be fired together. See fig. 45.

111 Illuminated globes with horizontal wheels.

Of illuminated Globes with horizontal Wheels.—The hoops for thefe globes may be made of wood, tin, or iron wire, about two feet in diameter. For a fingle globe, take two hoops, and tie them together, one within the other, at right angles; then have a horizontal wheel made, whofe diameter muft be a little wider than the globe, and its nave fix inches long; on the top of which the globe is fixed, fo as to ftand three or four inches from the wheel: on this wheel you may put any number of cafes, filled with what charge you pleafe; but let two of them burn at a time: they may be placed horizontally, or to incline downwards, juft as you choofe. Now, when the wheel is clothed, fix on the hoops as many illuminations as will ftand within two inches and a half of each other: faften thefe on the hoops with fmall iron binding wire; and when they are all on, put on the pipes of communication, which muft be fo managed as to light them all with the fecond or third cafe on the wheel. The fpindle on which the globe is to run muft go through the block of the wheel, up to the infide of the top of the globe; where muft be fixed a bit of brafs, or iron, with a hole in it to receive the point of the fpindle, on which the whole weight of the wheel is to bear, as in fig. 46. which reprefents a globe on its fpindle. By this method may be made a crown, which is done by having the hoops bent in the form of a crown. Sometimes globes and crowns are managed fo as to ftand ftill, and the wheel only to turn round; but when you would have the globe or crown to ftand ftill, and the wheel to run by itfelf, the block of the wheel muft not be fo long, nor the fpindle any longer than juft to raife the globe a little above the wheels; and the wheel cafes and illumination muft begin together.

112 Dodecahedron.

The Dodecahedron.—So called becaufe it nearly reprefents a twelve-fided figure, is made thus: Firft have a ball turned out of fome hard wood, 14 inches diameter: divide its furface into 14 equal parts, from which bore holes one inch and a half diameter, perpendicular to the centre, fo that they may all meet in the middle: then let there be turned in the infide of each hole a female fcrew; and to all the holes but one muft be made a round fpoke five feet long, with four inches of the fcrew at one end to fit the holes; then in the fcrew-end of all the fpokes bore a hole, five inches up, which muft be bored flanting, fo as to come out at one fide, a little above the fcrew; from which cut a fmall groove along the fpoke, within fix inches of the other end, where make another hole through to the other fide of the fpoke. In this end fix a fpindle, on which put a fmall wheel of three or four fides, each fide fix or feven inches long; thefe fides muft have grooves cut in them, large enough to receive a two or four ounce cafe. When thefe wheels are clothed, put them on the fpindles, and at the end of each fpindle put a nut to keep the wheel from falling off. The wheels being thus fixed, carry a pipe from the mouth of the firft cafe on each wheel, through the hole in the fide of the fpoke, and from thence along the groove, and through the other hole, fo as to hang out at the fcrew-end about an inch. The fpokes being all prepared in this manner, you muft have a poft, on which you intend to fire the work, with an iron fcrew in the top of it, to fit one of the holes in the ball: on the fcrew fix the ball; then in the top hole of the ball put a little meal-powder, and fome loofe quick-match: then fcrew in all the fpokes; and in one fide of the ball bore a hole, in which put a leader, and fecure it at the end; and the work will be ready to be fired. By the leader the powder and match in the centre is fired, which will light the match at the ends of the fpokes all at once, whereby all the wheels will be lighted at once. There may be an addition to this piece, by fixing a fmall globe on each wheel, or one on the top wheel only. A gray charge will be proper for the wheel cafes.

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113 Yew tree of brilliant fire.

The Yew Tree of brilliant Fire is reprefented by fig. 47. as it appears when burning. Firft, let A be an upright piece of wood, four feet long, two inches broad, and one thick: at top of the piece, on the flat fide, fix a hoop 14 inches diameter; and round its edge and front place illuminations, and in the centre a five-pointed ftar; then at E, which is one foot and a half from the edge of the hoop, place two cafes of brilliant fire, one on each fide; thefe cafes fhould be one foot long each: below thefe fix two more cafes of the fame fize, and at fuch a diftance that their mouths may almoft meet them at top: then clofe to the ends of thefe fix two more of the fame cafes; they muft ftand parallel to them at E. The cafes being thus fixed, clothe them with leaders; fo that they, with the illuminations and ftars at top, may all take fire together.

114 Stars with points.

Stars with Points for regulated Pieces, &c.—Thefe ftars are made of different fizes, according to the work for which they are intended; they are made with cafes from one ounce to one pound, but in general with four ounce-cafes, four or five inches long: the cafe muft be rolled with pafte, and twice as thick as that of a rocket of the fame bore. Having rolled a cafe, pinch one end of it quite clofe: then drive in half a diameter of clay; and when the cafe is dry, fill it with compofition two or three inches to the length of the cafes with which it is to burn: at top of the charge drive fome clay; as the ends of thefe cafes are feldom pinched, they would be liable to take fire. Having filled a cafe, divide the circumference of it at the pinched end clofe to the clay into five equal parts; then bore five holes with a gimblet, about the fize of the neck of a common four-ounce cafe, into the compofition: from one hole to the other carry a quick-match, and fecure it with paper: this paper muft be put on in the manner of that on the end of wheel-cafes, fo that the hollow part, which projects from the end of the cafe, may ferve to receive a leader from any other work, to give fire to the points of the ftars. Thefe ftars may be made with any number of points.

115 Fixed fun with a tranfparent face.

Fixed Sun with a tranfparent Face.—To make a fun of the beft kind, there fhould be two rows of cafes, as in fig. 48. which will fhow a double glory, and make the rays ftrong and full. The frame or fun-wheel, muft be made thus: Have a circular flat nave made very ftrong, 12 inches diameter: to this fix fix ftrong flat fpokes, A,B,C,D,E,F. On the front of thefe fix a circular fell, five feet diameter; within which fix another fell, the length of one of the fun-cafes lefs in diameter; within this fix a third fell, whofe diameter muft be lefs than the fecond by the length of one cafe and one-third. The wheel being made, divide the fells into fo many equal

parts

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parts as there are to be caſes (which may be done from 24 to 44): at each diviſion fix a flat iron ſtaple; theſe ſtaples muſt be made to fit the caſes, to hold them faſt on the wheel; let the ſtaples be ſo placed, that one row of caſes may lie in the middle of the intervals of the other.

In the centre of the block of the ſun drive a ſpindle, on which put a ſmall hexagonal wheel, whoſe caſes muſt be filled with the ſame charge as the caſes of the ſun: two caſes of this wheel muſt burn at a time, and begin with them on the fells. Having fixed on all the caſes, carry pipes of communication from one to the other, as you ſee in the figure, and from one ſide of the ſun to the wheel in the middle, and from thence to the other ſide of the ſun. Theſe leaders will hold the wheel ſteady while the ſun is fixing up, and will alſo be a ſure method of lighting both caſes of the wheel together. A ſun thus made is called a *brilliant ſun*, becauſe the wood work is entirely covered with fire from the wheel in the middle, ſo that there appears nothing but ſparks of brilliant fire: but if you would have a tranſparent face in the centre, you muſt have one made of paſteboard of any ſize. The method of making a face is, by cutting out the eyes, noſe, and mouth, for the ſparks of the wheel to appear through; but inſtead of this face, you may have one painted on oiled paper, or Perſian ſilk, ſtrained tight on a hoop; which hoop muſt be ſupported by three or four pieces of wire at ſix inches diſtance from the wheel in the centre, ſo that the light of it may illuminate the face. By this method may be ſhown in the front of a ſun, VIVAT REX, cut in paſteboard, or Apollo painted on ſilk; but, for a ſmall collection, a ſun with a ſingle glory, and a wheel in front, will be moſt ſuitable. Half pound caſes, filled ten inches with compoſition, will be a good ſize for a ſun of five feet diameter; but, if larger, the caſes muſt be greater in proportion.

116 Three vertical wheels illuminated.

Three Vertical Wheels illuminated, which turn on their own Naves upon a horizontal Table.—A plan of this is ſhown by fig. 49. Let D be a fir table three feet in diameter: this table muſt be fixed horizontally on the top of a poſt; on this poſt muſt be a perpendicular iron ſpindle, which muſt come through the centre of the table: then let A, B, C, be three ſpokes joined to a triangular flat piece of wood, in the middle of which make a hole to fit eaſily over the ſpindle: let E, F, G, be pieces of wood, four or five inches long each, and two inches ſquare, fixed on the under ſides of the ſpokes; in theſe pieces make holes lengthwiſe to receive the thin part of the blocks of the wheels, which, when in, are prevented from coming out by a ſmall iron pin being run through the end of each. K, L, M, are three vertical octagonal wheels, 18 inches diameter each: the blocks of theſe wheels muſt be long enough for three or four inches to reſt on the table; round which part drive a number of ſharp points of wire, which muſt not project out of the blocks more than 1-16th of an inch: the uſe of theſe points is, that, when the blocks run round, they will ſtick in the table, and help the wheels forward: if the naves are made of ſtrong wood, one inch will be enough for the diameter of the thin part, which ſhould be made to turn eaſily in the holes of the pieces E, F, G. On the front of the wheels make four or five circles of ſtrong wire, or flat hoops, and tie on them as many illuminations as they will hold at two inches diſtant from each other: inſtead of circles, you may make ſpiral lines, clothed with illuminations, at the ſame diſtance from each other as thoſe on the hoops. When illuminations are fixed on a ſpiral line in the front of a wheel, they muſt be placed a little on the ſlant, the contrary way from that in which the wheel runs; the caſes for theſe wheels may be filled with any coloured charge, but muſt burn only one at a time.

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The wheels being thus prepared, you muſt have a globe, crown, or ſpiral wheel, to put on the ſpindle in the middle of the table: this ſpindle ſhould be juſt long enough to raiſe the wheel of the globe, crown, or ſpiral wheel, ſo high that its fire may play over the three vertical wheels: by this means their fires will not be confuſed, nor will the wheels receive any damage from the fire of each other. In clothing this work, let the leaders be ſo managed, that all the wheels may light together, and the illuminations after two caſes of each wheel are burned.

117 Illuminated chandelier.

Illuminated works are much admired by the Italians, and indeed are a great addition to a collection of works: in a grand exhibition an illuminated piece ſhould be fired after every two or three wheels, or fixed pieces of common and brilliant fires; and likewiſe illuminated works may be made cheap, quick, and eaſy.

To make an illuminated chandelier, you muſt firſt have one made of thin wood (ſee fig. 50.). The chandelier being made, bore in the front of the branches, and in the body, and alſo in the crown at top, as many holes for illuminations as they will contain at three inches diſtance from each other: in theſe holes put illuminations filled with white, blue, or brilliant charge. Having fixed in the port-fires, clothe them with leaders, ſo that the chandelier and crown may light together. The ſmall circles on this figure repreſent the mouths of the illuminations, which muſt project ſtraight from the front.

118 Flaming ſtars with brilliant wheels.

To make a flaming ſtar with brilliant wheels, you muſt firſt have made a circular piece of ſtrong wood about one inch thick and two feet diameter: round this block fix eight points, two feet ſix inches long each; four of theſe points muſt be ſtraight and four flaming; theſe points being joined on very ſtrong, and even with the ſurface of the block, nail tin or paſteboard on their edges, from the block to the end of each, where they muſt be joined: this tin muſt project in front eight inches, and be joined where they meet at the block; round the front of the block fix four pieces of thick iron wire, eight inches long each, equally diſtant from each other: this being done, cut a piece of paſteboard round, two feet diameter, and draw on it a ſtar, as may be ſeen in fig. 51. Cut out this ſtar, and on the back of it paſte oiled paper; then paint each point half red and half yellow, lengthwiſe; but the body of the ſtar muſt be left open, wherein muſt run a brilliant wheel, made thus: Have a light block turned nine inches long: at each end of it fix ſix ſpokes; at the end of each ſpoke put a two ounce caſe of brilliant fire: the length of theſe caſes muſt be in proportion to the wheel, and the diameter of the wheel when the caſes are on muſt be a little leſs than the diameter of the body of the ſmall ſtar: the caſes on the ſpokes in front muſt have their mouths incline outwards, and thoſe on the inſide ſpokes muſt be placed ſo as to form a vertical circle of fire. When you place the leaders, carry the firſt pipe from the tail of one of the

Fig. 51.

caſes

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cases in front to the mouth of one of the inside cases, and from the tail of that to another in front, and so on to all the cases. The wheel being made, put it on a spindle, in the centre of the star; this spindle must have a shoulder at bottom, to keep the wheel at a little distance from the block. The wheel must be kept on the spindle by a nut at the end; having fixed on the wheel, fasten the transparent star to the four pieces of wire: when you fire it, you will only see a common horizontal wheel; but when the first case is burnt out, it will fire one of the vertical cases, which will show the transparent star, and fill the large flames and points with fire; then it will again appear like a common wheel, and so on for 12 charges.

119 Projected regulated piece with mutations.

A regulated piece, if well executed, is as curious as any in fire-works: it consists of fixed and moveable pieces on one spindle, representing various figures, which take fire successively one from another, without any assistance after lighting the first mutation. See fig. 53.

Fig. 53. Plate CCCCLV.

I. Names of the mutations, with the colour of fire and size of the case belonging to each.

First mutation is a hexagon vertical wheel, illuminated in front with small portfires tied on the spokes; this wheel must be clothed with two ounce cases, filled with black charge; the length of these cases is determined by the size of the wheel, but must burn singly.

Second mutation is a fixed piece, called a *golden glory*, by reason of the cases being filled with spur-fire. The cases must stand perpendicular to the block on which they are fixed, so that, when burning, they may represent a glory of fire. This mutation is generally composed of five or seven two ounce cases.

Third mutation is moveable; and is only an octagon vertical wheel, clothed with four ounce cases, filled with brilliant charge: two of these cases must burn at a time. In this wheel you may make changes of fire.

Fourth mutation is a fixed sun of brilliant fire, consisting of 12 four ounce cases; the necks of these cases must be a little larger than those of four ounce wheel-cases. In this mutation may be made a change of fire, by filling the cases half with brilliant charge, and half with grey.

Fifth mutation is a fixed piece, called the *porcupine's quills*. This piece consists of 12 spokes, standing perpendicular to the block in which they are fixed; on each of these spokes, near the end, must be placed a four ounce case of brilliant fire. All these cases must incline either to the right or left, so that they may all play one way.

Sixth mutation is a standing piece, called the *cross-fire*. This mutation consists of eight spokes fixed in a block; near the end of each of those spokes must be tied two four ounce cases of white charge, one across the other, so that the fires from the cases on one spoke may interfect the fire from the cases on the other.

Seventh mutation is a fixed wheel, with two circular fells, on which are placed 16 eight-ounce cases of brilliant fire, in the form of a star. This piece is called a *fixed star of wild-fire*.

Eight mutation.—This is a beautiful piece, called a *brilliant star-piece*. It consists of six spokes, which are strengthened by two fells of a hexagon form, at some distance from each other: at the end of each spoke, in the front, is fixed a brilliant star of five points; and on each side of every star is placed a four-ounce case of black or gray charge; these cases must be placed with their mouths sidewise, so that their fires may cross each other.

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Ninth mutation is a wheel-piece. This is composed of six long spokes, with a hexagon vertical wheel at the end of each: these wheels run on spindles in the front of the spokes; all the wheels are lighted together: two ounce cases will do for these wheels, and may be filled with any coloured charge.

II. Proportions of the mutations, with the method of conveying the fire from one to the other, and the distance at which they stand one from the other on the spindle.

First mutation must be a hexagon vertical wheel, 14 inches diameter; on one side of the block, whose diameter is two inches and a quarter, is fixed a tin barrel A (see fig. 53. N° 1.) This barrel must be a little less in diameter than the nave; let the length of the barrel and block be six inches. Having fixed the cases on the wheel, carry a leader from the tail of the last case into the tin barrel through a hole made on purpose, two inches from the block; at the end of this leader let there be about one inch or two of loose match, but take care to secure well the hole wherein the pipe is put, to prevent any sparks falling in, which would light the second mutation before its time, and confuse the whole.

Second mutation is thus made: Have a nave turned two inches and a half diameter, and three long; then let half an inch of that end which faces the first wheel be turned so as to fit easy into the tin barrel of the first mutation, which must turn round it without touching. On the other end of the block fix a tin barrel B, N° 2. This barrel must be six inches long, and only half an inch of it to fit on the block. Round the nave fix five spokes, one inch and a half long each; the diameter of the spokes must be equal to a two ounce *former*. On these spokes put five seven inch two ounce cases of spur-fire, and carry leaders from the mouth of one to the other, that they may all light together. Then from the mouth of one of the cases carry a leader through a hole bored slantwise in the nave, from between the spokes, to the front of the block near the spindle hole: the end of this leader must project out of the hole into the barrel of the first mutation, so that when the pipe which comes from the end of the last case on the first wheel flashes, it may take fire, and light the second mutation. To communicate the fire to the third mutation, bore a hole near the bottom of one of the five cases to the composition, and from thence carry a leader into a hole made in the middle of the barrel B: this hole must be covered with pasted paper.

Third mutation may be either an octagon or hexagon wheel, 20 inches diameter; let the nave be three inches and a quarter diameter, and three and a half in length; one inch and a half of the front of the nave must be made to fit in the barrel B. On the other end of the block fix a tin barrel C, N° 3. This barrel must be six inches and a half in length, one inch of which must fit over the block. The cases of this wheel must burn two at a time; and from the mouths of the first two cases carry a leader, through holes in the nave, into the barrel of the second mutation, after the usual manner: but besides these leaders let a pipe go across the wheel from the first case to the other; then from the tail of one of the

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the laft cafes carry a pipe into a hole in the middle of the barrel C: at the end of this pipe let there be fome loofe quick-match.

Fourth and fifth mutations.—Thefe may be defcribed under one head, as their naves are made of one piece, which from E to F is 14 inches; E, a block four inches diameter, with 10 or 12 fhort fpokes, on which are fixed 11 inch eight ounce cafes: let the front of this block be made to fit eafily in the barrel C, and clothe the cafes fo that they may all light together; and let a pipe be carried through a hole in the block into the barrel C, in order to receive the fire from the leader brought from the laft cafe on the wheel. G is the nave of the 5th mutation; whofe diameter muft be four inches and a half: in this nave fix 10 or 12 fpokes, one foot and a half in length each; thefe fpokes muft ftand feven inches diftant from the fpokes of the 4th mutation; and at the end of each fpoke tie a four ounce cafe, as N° 5. All thefe cafes are to be lighted together, by a leader brought from the end of one of the cafes on N° 4. Let F and H be of the fame piece of wood as E and G, but as much thinner as poffible, to make the work light.

Sixth and feventh mutations.—The blocks of thefe two mutations are turned out of one piece of wood, whofe length from F to P is 15 inches. L, a block five inches diameter, in which are fixed eight fpokes, each two feet four inches long; at the end of each fpoke tie two four ounce cafes, as in N° 6. All thefe cafes muft be fired at the fame time, by a pipe brought from the end of one of the cafes on the 5th mutation. Let the diftance between the fpokes at L, and thofe in the 5th mutation, be feven inches. M, the nave of the 7th mutation, whofe diameter muft be five inches and a half: in this nave fix eight fpokes, and on the front of them two circular fells, one of four feet eight inches diameter, and one of three feet 11 diameter; on thefe fells tie 16 eight ounce or pound cafes, as in N° 7. and carry leaders from one to the other, fo that they may be all fired together. This mutation muft be fired by a leader brought from the tail of one of the cafes on the 6th mutation.

Eighth and ninth mutations.—The blocks of thefe may be turned out of one piece, whofe length from P to D muft be 12 inches. O, the block of the 8th mutation, which muft be fix inches diameter; and in it muft be fixed fix fpokes, each three feet in length, ftrengthened by a hexagon fell within three or four inches of the ends of the fpokes: clofe to the end of each fpoke, in the front, fix a five-pointed brilliant ftar; then feven inches below each ftar tie two 10 inch eight ounce cafes, fo that the upper ends of the cafes may reft on the fells, and their ends on the fpokes. Each of thefe cafes muft be placed parallel to the oppofite fell (fee N° 8.) NNN, &c. are the cafes, and kkk, &c. the ftars.

The 9th mutation is thus made: Let D be a block feven inches diameter. In this block muft be fcrewed fix fpokes, fix feet long each, with holes and grooves for leaders, as thofe in the dodecaedron; at the end of each fpoke, in the front, fix a fpindle for a hexagon vertical wheel, 10 inches diameter, as in N° 9. When thefe wheels are on, carry a leader from each into the block, fo that they may all meet; then lead a pipe from the end of one of the cafes of the 8th mutation, through a hole bored in the block D, to meet the leaders from the vertical wheels, fo that they may all be fired together.

The fpindles for larger pieces are required to be made very ftrong, and as exact as poffible; for a piece of nine mutations, let the fpindle be at the large end one inch diameter, and continue that thicknefs as far as the 7th mutation; and thence to the 5th, let its diameter be three-fourths of an inch; from the fifth to the fourth, five-eighths of an inch; from the fourth to the fecond half an inch; and from the fecond to the end three eighths of an inch. At the fmall end muft be a nut to keep on the firft wheel, and at the thick end muft be a large nut, as fhown by the figure; fo that the fcrew part of the fpindle being put through a poft, and a nut fcrewed on tight, the fpindle will be held faft and fteady: but you are to obferve, that that part of the fpindle on which the moveable pieces are to run, be made long enough for the wheels to run eafy without fticking; the fixed pieces being made on different blocks, the leaders muft be joined after they are fixed on the fpindle. The beft method of preventing the fixed mutations from moving on the fpindle, is to make that part of the fpindle which goes through them fquare; but as it would be difficult to make fquare holes through fuch long blocks as are fometimes required, it will be beft to make them thus: Bore a hole a little larger than the diameter of the fpindle; and at each end of the block, over the hole, faften a piece of brafs with a fquare hole in it to fit the fpindle.

120 Horizontal changed to a vertical wheel.

To make a horizontal wheel change to a vertical wheel with a fun in front.—The fudden change of this piece is very pleafing; and gives great furprife to thofe who are not acquainted with the contrivance. A wheel for this purpofe fhould be about three feet diameter, and its fell circular; on which tie 16 half pound cafes filled with brilliant charge: two of thefe cafes muft burn at a time; and on each end of the nave muft be a tin barrel of the fame conftruction as thofe on the regulated piece. The wheel being completed, prepare the poft or ftand thus: Firft have a ftand made of any height, about three or four inches fquare; then faw off from the top a piece two feet long; this piece join again at the place where it was cut, with a hinge on one fide, fo that it may lift up and down in the front of the ftand; then fix on the top of the bottom part of the ftand, on each fide, a bracket; and thefe brackets muft project at right angles with the ftand, one foot from the front, for the fhort piece to reft on. Thefe brackets muft be placed a little above the joint of the poft, fo that when the upper ftand falls, it may lie between them at right angles with the bottom ftand; which may be done by fixing a piece of wood, one foot long, between the brackets, and even with the top of the bottom ftand; then, as the brackets rife above the bottom ftand, they will form a channel for the fhort poft to lie in, and keep it fteady without ftraining the hinge. On the fide of the fhort poft, oppofite the hinge, nail a piece of wood, of fuch a length, that, when the poft is perpendicular, it may reach about one foot and a half down the long poft; to which being tied, it will hold the fhort ftand upright. The ftand being thus prepared, in the top of it fix a fpindle 10 inches long: on this fpindle put the wheel: then fix on a brilliant fun with a fingle glory; the diameter of this fun muft be fix inches lefs than that of the wheel. When you fire this piece, light the wheel firft, and let it run horizontally till four cafes are confumed: then from the end of the fourth cafe carry a leader into the tin barrel that turns over the end of the ftand: this leader muft be met by another brought through the top

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of the poft, from a cafe filled with a ftrong port-fire charge, and tied to the bottom poft, with its mouth facing the packthread which holds up the ftand; fo that when this cafe is lighted, it will burn the packthread, and let the wheel fall forward, by which means it will become vertical: then from the laft cafe of the wheel, carry a leader into the barrel next the fun, which will begin as foon as the wheel is burnt out.

121 Grand illuminated volute.

Grand volute illuminated with a projected wheel in front.—Firft have two hoops made of ftrong iron wire, one of fix feet diameter, and one of four feet two inches; thefe hoops muft be joined to fcrolls A, A, A, &c. as in fig. 54. (Fig. 54.) Thefe fcrolls muft be made of the fame fort of wire as the hoops; on thefe fcrolls tie, with iron-binding wire, as many illuminating port-fires as they will hold, at two inches diftance; clothe thefe port-fires with leaders, fo that they may all take fire together.—Then let C be a circular wheel of four fpokes, three feet fix inches diameter; and on its fell tie as many four ounce cafes, head to tail, as will complete the circle, only allowing a fufficient diftance between the cafes, that the fire may pafs free; which may be done by cutting the upper part of the end of each cafe a little fhelving: on each fpoke fix a four ounce cafe, about three inches from the fell of the wheel: thefe cafes are to burn one at a time, and the firft of them to begin with thofe on the fell, of which four are to burn at a time; fo that the wheel will laft no longer than one-fourth of the cafes on the fell, which in number fhould be 16 or 20. On the front of the wheel form a fpiral line with ftrong wire, on which tie port-fires, placing them on a flant, with their mouths to face the fame way as the cafes on the wheel: all thefe port-fires muft be fired with the fecond cafes of the wheel. Let D, D, D, &c. be fpokes of wood, all made to fcrew into a block in the centre; each of thefe fpokes may be in length about four feet fix inches; in the top of each fix a fpindle, and on each fpindle put a fpiral wheel of eight fpokes, fuch as E, E, E, &c. The blocks of thefe wheels muft have a hole at top for the centre cafe, and the fpindle muft have nuts fcrewed on their ends; which nuts fhould fit in the holes at top of the blocks, fo that all the wheels muft be put on before you fix in the centre cafes: as fome of thefe wheels, from their fituation, will not bear on the nut, it will be neceffary to have fmooth fhoulders made on the fpindles for the blocks to run on. The cafes of thefe wheels are to burn double; and the method of firing them, is by carrying a leader from each down the fpokes into the block in the centre, as in the dodecahedron, but the centre cafe of each wheel muft begin with the two laft cafes as ufual. It is to be obferved, that the large circular wheel in front muft have a tin barrel on its block, into which a pipe muft be carried from one of the fecond cafes on the wheel; this pipe being met by another from the large block, in which the eight fpokes are fcrewed, will fire all the fpiral wheels and the illuminating port-fires at the fame time. The cafes of the projected wheel may be filled with a white charge, and thofe of the fpiral wheels with a gray charge.

122 Moon and feven ftars. Fig. 55.

Let fig. 55. be a fmooth circular board fix feet diameter: out of the middle of it cut a circular piece 12 or 14 inches diameter; and over the vacancy put white Perfian filk, on which paint a moon's face: then let I, I, I, &c. be ftars, each four or five inches diameter, cut out with five points, and covered with oiled filk: on the front of the large circular board draw a feven-pointed ftar, as large as the circle will allow; then on the lines which form this ftar, bore holes, wherein fix pointed ftars. When this cafe is to be fired, it muft be fixed upon the front of a poft, on a fpindle, with a wheel of brilliant fire behind the face of the moon; fo that, while the wheel burns, the moon and ftars will appear tranfparent: and when the wheel has burnt out, they will difappear, and the large ftar in front, which is formed of pointed ftars, will begin, being lighted by a pipe of communication from the laft cafe of the vertical wheel, behind the moon; this pipe muft be managed in the fame manner as thofe in regulated pieces.

123 Double cone-wheel illuminated. Fig 56.

Double cone-wheel illuminated.—This piece is reprefented by fig. 56. Let A be a ftrong decagonal or tenfided wheel, two feet fix inches diameter; then on each fide of it fix a cone B and C: thefe cones are to confift of a number of hoops, fupported by three or four pieces of wood, in the manner of the fpiral wheels. Let the height of each cone be three feet fix inches; and on all the hoops tie port-fires horizontally, with their mouths outwards, and clothe the wheel with eight-ounce cafes, all to play horizontally, two at a time: the cones may be fired with the firft or fecond cafes. The fpindle for this piece muft go through both the cones, and rife three feet above the point of the cone at top; fo that its length will be 10 feet four inches from the top of the poft H, in which it is fixed, allowing four inches for the thicknefs of the block of the wheel. The whole weight of the wheel and cones muft bear on a fhoulder in the fpindle, on which the block of the wheel muft turn.—Near the top of the fpindle muft be a hole in the front, into which fcrew a fmall fpindle, after the cones are on: then on this fmall fpindle fix a fun D, compofed of fixteen nine inch four-ounce cafes of brilliant fire; which cafes muft not be placed on a fell, but only ftuck into a block of fix inches diameter: then in the front of this fun muft be a circular vertical wheel, 16 inches diameter; on the front of this wheel form with iron-wire a fpiral line, and clothe it with illuminations after the ufual method. As this wheel is not to be fired till the cones are burnt out, the method of firing it is this: Let the hole in the block, at the top of the uppermoft cone, be a little larger than the fpindle which paffes through it. Then, from the firft cafe of the vertical wheel before the fun, carry a leader down the fide of the fpindle to the top of the block of the horizontal wheel, on which muft be a tin barrel: then this leader being met by another brought from the end of the laft cafe of the horizontal wheel, will give fire to the vertical wheel as foon as the cones are extinguifhed: but the fun D muft not be fired till the vertical wheel is quite burned out.

124 Fire pumps.

Cafes for fire pumps are made as thofe for tourbillons; only they are pafted, inftead of being rolled dry. Having rolled and dried the cafes, fill them: firft put in a little meal-powder, and then a ftar; on which ram lightly a ladleful or two of compofition, then a little meal-powder, and on that a ftar, then again compofition; and fo on till the cafes are filled. Stars for fire pumps fhould not be round; but muft be made either fquare, or flat and circular, with a hole through the middle: the quantity of powder for throwing the ftars muft increafe near the top of the cafe; for, if much powder be put at the bottom, it will burft the cafe. The ftars muft differ in fize in this manner: Let the ftar which is put

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put in firſt be about a quarter leſs than the bore of the caſe; but let the next ſtar be a little larger, and the third ſtar a little larger than the ſecond, and ſo on: let them increaſe in diameter till within two of the top of the caſe, which two muſt fit in tight. As the loading of fire-pumps is rather difficult, it will be neceſſary to make two or three trials before depending on their performance: when you fill a number of pumps, take care not to put in each an equal quantity of charge between the ſtars, ſo that when they are fired, they may not throw up too many ſtars together. Caſes for fire-pumps ſhould be made very ſtrong, and rolled on four or eight ounce formers, 10 or 12 inches long each.

125 Vertical ſcroll wheel. Fig. 57.

A vertical ſcroll wheel may be made of any diameter, but muſt be conſtructed as in fig. 57. to do which proceed thus: Have a block made of a moderate ſize, in which fix four flat ſpokes, and on them fix a flat circular fell of wood; round the front of this fell place port-fires; then on the front of the ſpokes form a ſcroll, either with a hoop or ſtrong iron wire; on this ſcroll tie caſes of brilliant fire, in proportion to the wheel, head to tail, as in the figure. When you fire this wheel, light the firſt caſe near the fell; then, as the caſes fire ſucceſſively, the circle of fire will gradually diminiſh: but whether the illuminations on the fell begin with the ſcroll or not, is immaterial.

N. B. This wheel may be put in the front of a regulated piece, or fired by itſelf, occaſionally.

126 Fire globe.

There are two ſorts of *fire-globes;* one with projected caſes; the other with the caſes concealed. For the latter have a globe made of wood, of any diameter, and divide the ſurface of it into 14 equal parts, and at each diviſion bore a hole perpendicular to the centre: theſe holes muſt be in proportion to the caſes intended to be uſed: in every hole, except one, put a caſe filled with brilliant or any other charge, and let the mouths of the caſes be even with the ſurface of the globe; then cut in the globe a groove, from the mouth of one caſe to the other, for leaders, which muſt be carried from caſe to caſe, ſo that they may all be fired together; this done, cover the globe with a ſingle paper, and paint it. Theſe globes may be uſed to ornament a building.

Fire-globes with projected caſes are made thus: the globe being made with 14 holes bored in it as uſual, fix in every hole except one, a caſe, and let each caſe project from the globe two-thirds of its length; then clothe all the caſes with leaders, ſo that they may all take fire at the ſame time. Fire-globes are ſupported by a pintle, made to fit the hole in which there is no caſe.

127 Method of placing fire-works to be exhibited.

Nothing adds more to the appearance of fire-works than placing them properly; though this chiefly depends on the judgement of the maker. The following are the rules generally obſerved, whether the works are to be fired on a building or on ſtands: if they are a double ſet, place one wheel of a ſort on each ſide of the building; and next to each of them, towards the centre, place a fixed piece, then wheels, and ſo on; leaving a ſufficient diſtance between them for the fire to play from one without burning the other. Having fixed ſome of the works thus in front, place the reſt behind them, in the centre of their intervals: The largeſt piece, which is generally a regulated or tranſparent piece, muſt be placed in the centre of the building, and behind it a ſun, which muſt always ſtand above all the other works. A little before the building, or ſtands, place the large gerbes; and at the back of the works fix marroon batteries, *pots des aigrettes*, *pots des brins*, *pots des sauciſſons*, air-balloons, and flights of rockets; the rocket ſtands may be fixed behind, or anywhere elſe, ſo as not to be in the way of the works.

Single collections are fired on ſtands; which are made in the ſame manner as theodolite ſtands, only the top part muſt be long or ſhort occaſionally: theſe ſtands may be fixed up very ſoon without much trouble.

The following order of Firing will ſerve as a ſpecimen of the Plan to be purſued in an exhibition of Fire-works.

1. Two ſignal }
2. Six ſky } rockets
3. Two honorary }
4. Four caduceus }
5. } Two { vertical } wheels illuminated
6. } Two { ſpiral } wheels illuminated
7. } Two { tranſparent ſtars
8. A line rocket of five changes
9. Four tourbillons
10. } Two { horizontal wheels
11. } Two { air balloons illuminated
12. } Two { Chineſe fountains
13. } Two { regulating pieces of four mutations each
14. } Two { *pots des aigrettes*
15. Three large gerbes
16. A flight of rockets
17. } Two { balloon wheels
18. } Two { caſcades of brilliant fire
19. Twelve ſky-rockets
20. } Two { illuminated yew trees
21. } Two { air-balloons of ſerpents and two compound
22. Four tourbillons
23. } Two { Fruiloni wheels
24. } Two { illuminated globes with horizontal wheels
25. One *pot des ſauciſſons*
26. Two plural wheels
27. Marroon battery
28. Two chandeliers illuminated
29. Range of *pots des brins*
30. Twelve ſky-rockets
31. Two yew-trees of fire
32. Neſt of ſerpents
33. Two double cones illuminated
34. Regulating piece of ſeven mutations, viz.
    1. Vertical wheel illuminated
    2. Golden glory
    3. Octagon vertical wheel
    4. Porcupine's quills
    5. Croſs fires
    6. Star-piece with brilliant rays
    7. Six vertical wheels
35. Brilliant ſun
36. Large flight of rockets.

When water-works are to be exhibited, divide them into ſeveral ſets, and fire one ſet after every fifth or ſixth change of land and air-works. Obſerve this rule in firing a double ſet of works: Always begin with ſky-rockets, then two moveable pieces, then two fixed pieces, and ſo on; ending with a large flight of rockets, or a marroon battery: if a ſingle collection, fire a fixed piece after every wheel or two, and now and then ſome air and water-works.

Fig.

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Fig. 58. repreſents a fountain of 30 rockets. Let A be a perpendicular poſt, 16 feet high from the ground, and four inches ſquare. Let the rail, or croſs piece C,
128 Fountain of ſky-rockets. Fig. 58.
be one foot ſix inches long, three inches broad, and one thick. The rail D, at bottom, muſt be ſix feet long, one foot broad, and one inch thick. F and G are the two ſides which ſerve to ſupply the rails D, E, H, I, C: theſe ſides are one foot broad at bottom, and cut in the front with a regular ſlope, to three inches at top; but their back edges muſt be parallel with the front of the pots A. The breadth of the rails E, H, I, will be determined by the breadth of the ſides: all the rails muſt be fixed at two feet diſtance from each other, and at right angles with the pots. Having placed the rails thus, bore in the bottom rail 10 holes, at equal diſtances, large enough to receive the ſtick of a one-pound rocket: in the back edge of this rail cut a groove from one end to the other, fit to contain a quick-match; then cut a groove in the top of the rail, from the edge of each hole, into the groove in the back: in the ſame manner cut in the ſecond rail, E, eight holes and grooves; in the third rail, H, ſix holes and grooves; in the fourth rail, I, four holes and grooves; and in the top rail, two holes and grooves. B, a rail with holes in it to guide the ends of the rocket ſticks: this rail muſt be fixed ſix feet from the rail D. The fountain frame being thus made, prepare the rockets thus: Tie round the mouth of each a piece of thin paper, large enough to go twice round, and to project about an inch and a half from the mouth of the rocket, which muſt be rubbed with wet meal-powder; in the mouth of each rocket put a leader, which ſecure well with the paper that projects from the mouth of the caſe: theſe leaders muſt be carried into the grooves in the back of the rails, in which lay a quick-match from one end to the other, and cover it with paſted paper: holes muſt be made in the rail D, to receive the ends of the ſticks of the rockets in the rail E, and ſo on to the fourth rail; ſo that the ſticks of the rockets at top may go through all the rails. The rockets being ſo prepared, fix a gerbe, or white flower-pot, on each rail, before the poſt, with its mouth inclining a little forwards: theſe gerbes muſt be lighted all at once. Behind or before each gerbe, fix a caſe of brilliant or ſlow fire: theſe caſes muſt be filled ſo that they may burn out one after the other, to regulate the fountain; which may be done by carrying a leader from the end of each ſlow or brilliant fire, into the groove in the back of each rail. Different fixed rockets may be uſed in theſe fountains: but it will be beſt to fill the heads of the rockets on each rail with different ſorts of things, in this manner; thoſe at top with crackers, the next with rains, the third with ſerpents, the fourth with tailed ſtars, and the laſt flight with common or brilliant ſtars.

129 Palm tree.

The piece called a *palm tree*, though made of common fires, and of a ſimple conſtruction, has a very pleaſing effect; from the fires interſecting ſo often, that
Fig. 59.
they reſemble the branches of trees. Let A (fig. 59.) be a perpendicular poſt, of any thickneſs, ſo that it be ſufficiently ſtrong to hold the caſes; let the diſtance from B to C be two feet ſix inches, and from C to D two feet ſix inches, and let the length of each croſs-piece be two feet; on each end of each fix a five-pointed ſtar: then fix, on pegs made for the purpoſe, twelve-inch half-pound caſes of brilliant fire, as in the figure. All the caſes and ſtars muſt be fired at once. This piece ſhould be fixed high from the ground.

Varieties of Conſtruction.

130 Illuminated pyramid. Fig. 60. Plate CCCCLVI.

An illuminated pyramid, with Archimedian ſcrews, a globe, and vertical ſun, may be of any ſize. One made according to the dimenſions of fig. 60. will be of a good proportion, whoſe height is 21 feet; from C to D, ſix feet; from E to F, nine feet: the ſpace between the rails muſt be ſix inches, and the rails as thin as poſſible: in all the rails ſtick portfires at four inches diſtance. The Archimedian ſcrews, G, K, are nothing more than double ſpiral wheels, with the caſes placed on their wheels horizontally inſtead of obliquely. The vertical ſun, I, need not conſiſt of more than 12 rays, to form a ſingle glory. The globe at top muſt be made in proportion to the pyramid; which being prepared according to the preceding directions, place the leaders ſo that all the illuminating portfires, ſcrews, globe, and ſun, may take fire together. The pyramid muſt be ſupported by the two ſides, and by a ſupport brought from a pole, which muſt be placed two feet from the back of the pyramid, that the wheels may run freely.

131 Roſe piece and ſun. Fig. 61.

A roſe-piece may be uſed for a mutation of a regulated piece, or fired by itſelf: it makes the beſt appearance when made large; if its exterior diameter be ſix feet, it will be of a good ſize. Fig. 61. ſhows the manner in which it appears before it is fired. Let the outer fell be made of wood, and ſupported by four wooden ſpokes: all the other parts, on which the illuminations are fixed, muſt be made of ſtrong iron wire: on the outer fell place as many half-pound caſes of brilliant charge as you think proper, but the more the better; for the nearer the caſes are placed, the ſtronger will be the rays: the illuminations ſhould be placed within three inches of each other: they muſt all be fired together, and burn ſome time before the ſun is lighted; which may be done by carrying a leader from the middle of one of the illuminations, to the mouth of one of the ſun caſes.

132 Tranſparent ſtars with illuminated rays. Fig. 62.

Fig. 62. repreſents an *illuminated ſtar*. Let the diameter from A to B be two feet, and from C to D ſeven feet. Firſt make a ſtrong circular back or body of the ſtar, two feet diameter, to which fix the illuminated rays: in the centre of the front of the body fix a ſpindle, on which put a double triangular wheel, ſix inches diameter, clothed with two ounce caſes of brilliant charge: the caſes on this wheel muſt burn but one at a time. Round the edge of the body nail a hoop made of thin wood or tin: this hoop muſt project in front ſix or ſeven inches: in this hoop cut three or four holes to let out the ſmoke from the wheel. The ſtar and garter may be cut out of ſtrong paſteboard or tin, made in this manner: Cut a round piece of paſteboard or tin, two feet diameter, on which draw a ſtar, and cut it out; then over the vacancy paſte Perſian ſilk; paint the letters yellow; four of the rays yellow, and four red; the croſs in the middle may be painted half red and half yellow, or yellow and blue. This tranſparent ſtar muſt be faſtened to the wooden hoop by a ſcrew, made ſo as to take off and on; the illuminated rays are made of thin wood, with tin ſockets fixed on their ſides within four inches of each other; in theſe ſockets ſtick illuminating portfires; behind the point of each ray fix a half-pound caſe of gray, black, or Chineſe fire.

N. B. The illuminated rays are to be lighted at the ſame

Varieties of Construction. ſame time as the triangular wheel, or after it is burnt out; which may be done by a tin barrel being fixed to the wheel, after the manner of thoſe in the regulated pieces. Into this barrel carry a leader from the illuminated rays, through the back of the ſtar; and this leader muſt be met by another, brought from the tail of the laſt caſe on the wheel.

133 Tranſparent illuminated table ſtar. Fig. 63.

Fig. 63. repreſents a *table ſtar*, whoſe diameter, from E to F, is 12 feet; and from E to I, four feet. This proportion, obſerved on each ſide, will make the centre frame four feet ſquare: in this ſquare fix a tranſparent ſtar, as in the figure. This ſtar may be painted blue, and its rays made as thoſe of the flaming ſtars deſcribed before. The wheel for this ſtar may be compoſed of different coloured fires, with a charge or two of ſlow fire; the wheels *a*, *a*, *a*, *a*, may be clothed with any number of caſes, ſo that the ſtar-wheel conſiſt of the ſame: the illuminating portfires, which muſt be placed very near each other on the frames, muſt be ſo managed as to burn as long as the wheels, and lighted at the ſame time.

134 Regulated illuminated ſpiral piece. Fig. 64.

The regulated illuminated ſpiral piece, with a projected ſtar-wheel illuminated, is repreſented by fig. 64. and is thus made. Have a block made eight inches diameter; in this block ſcrew ſix iron ſpokes, which muſt ſerve for ſpindles for the ſpiral wheels: theſe wheels are made as uſual, each one foot and a half diameter, and three feet in height: the ſpindles muſt be long enough to keep the wheels four or five inches from one another: at the end of each ſpindle muſt be a ſcrew-nut, on which the wheels that hang downwards will run; and on the ſpindles which ſtand upwards muſt be a ſhoulder, for the blocks of the wheels to run on.

The projected ſtar-wheel muſt turn on the ſame ſpindle on which the large block is fixed; this ſpindle muſt be long enough to allow the ſtar-wheel to project a little before the ſpiral wheels: the exterior diameter of the ſtar wheel muſt be three feet five inches. On this wheel fix three circles of iron wire, and on them portfires; on the block place a tranſparent ſtar, or a large five-pointed brilliant ſtar. The caſes on this wheel may burn four at once, as it will contain nearly twice the number of one of the ſpiral wheels: the caſes on the ſpiral wheels muſt be placed parallel to their fells, and burn two at a time.

135 Illuminated figure piece. Fig. 65.

A figure piece illuminated with five-pointed ſtars.—The conſtruction of this piece is very eaſy, as ſhown by fig. 65. whoſe diameter from B to C is eight feet, and from D to F two feet: the vertical wheel in the centre muſt be one foot diameter, and conſiſt of ſix four-ounce caſes of different coloured charge, which caſes muſt burn double: on the frames fix five-pointed brilliant or blue ſtars, rammed four inches with compoſition: let the ſpace between each ſtar be eight inches; at each point fix a gerbe, or caſe of Chineſe fire. When to be fired, let the gerbe, ſtars, and wheel, be lighted at the ſame time.

136 Illuminated ſtar-wheel. Fig. 66.

The ſtar-wheel illuminated, is ſhown by fig. 66. Its exterior fell is made of wood, three feet ſix inches or four feet diameter; within this fell, form with iron wire three circles, one leſs than the other, ſo that the diameter of the leaſt may be about 10 inches: place the portfires on theſe fells with their mouths inclining outwards, and the portfires on the points of the ſtar with their mouths projecting in front: let the exterior fell be clothed with four-ounce caſes of gray charge: theſe caſes muſt burn four at a time, and be lighted at the ſame time as the illuminations. Varieties of Construction.

137 Pyramid of flower-pots. Fig. 67.

Pyramid of flower-pots is repreſented at fig. 67. and made thus. Let the diſtance from A to B be ſix feet; and from one rail to the other, two: on the bottom rail fix five paper mortars, each three inches and a half diameter; theſe mortars load with ſerpents, crackers, ſtars, &c.

In the centre of each mortar fix a caſe of ſpur-fire: on the ſecond rail fix four mortars, ſo as to ſtand exactly in the middle of the intervals of thoſe on the bottom rail; on the third rail place three mortars; on the fourth, two; and on the top of the poſts, 1: the bottom rail muſt be ſix feet long: all the mortars muſt incline a little forwards, that they may be eaſily diſcharged; and the ſpur-fires rammed exactly alike, that the mortars may all be fired at the ſame time. Having prepared the pyramid according to the preceding directions, carry pipes of communication from one ſpur-fire to the other.

138 Illuminated regulating piece. Fig. 68. Plate CCCCLVII.

Fig. 68. repreſents one half of *the illuminated regulating piece.*—A, A, A, A, are flat wooden ſpokes, each five feet long: at the end of each place a vertical wheel, 10 inches diameter, clothed with ſix four-ounce caſes of brilliant fire: theſe caſes muſt burn but one at a time: on two of the ſpokes of each wheel place two portfires, which muſt be lighted with the firſt caſe of the wheel; on each ſpoke A, A, &c. behind the wheels, place ſix caſes of the ſame ſize with thoſe on the wheels: theſe caſes muſt be tied acroſs the ſpokes with their mouths all one way, and be made to take fire ſucceſſively one after the other, ſo that they may aſſiſt the whole piece to turn round.

The diameter of the large wheel muſt be two feet and a half; and its fell made of wood, which muſt be fixed to the large ſpokes: on this wheel place 24 caſes of the ſame ſort with thoſe on the ſmall wheels; theſe caſes muſt burn four at a time: in this wheel make three circles with iron wire, and on them place illuminating portfires, as in the figure: the ſtar-points on the large ſpokes may be made of thin aſh-hoops; the diameter of theſe points cloſe to the centre-wheel muſt be 11 inches: on theſe points place portfires, at three inches and a half diſtance one from the other.

Fig. 69. repreſents the blocks of this piece. The diameters of theſe blocks, at A and B, muſt be eight inches; and C and D, four inches and a half: the length of each of theſe blocks muſt be ſix inches: at the ſmall ends of theſe blocks fix an iron wheel, five inches diameter, and theſe wheels muſt have teeth, to turn the wheel E: this wheel is fixed on a ſmall ſpindle ſcrewed into the large ſpindle, which goes through the two blocks, and on which they run. Fig. 69.

Suppoſing fig. 68. to be on the block A, in fig. 69. and to turn to the right, and another piece of the ſame conſtruction on the block B, with its fires placed ſo as to turn it to the left; you will find them move very true and faſt, by the help of the three iron wheels, which ſerve to regulate their motions, as well as to aſſiſt them in turning: let the iron circles in the front of the great wheels be of different diameters, ſo that when fired there may appear ſix circles. When this piece is fired all the wheels and illuminations muſt be lighted at one time.

Aquatic Fireworks.

Aquatic Fire-works.

139 Works that sport in the water are much esteemed by most admirers of fire-works, particularly water-rockets; and as they seem of a very extraordinary nature to those who are unacquainted with this art, they merit a particular explanation.

140 Water-rockets. *Water rockets*, may be made from four ounces to two pounds. If larger, they are too heavy; so that it will be difficult to make them keep above water without a cork float, which must be tied to the neck of the case; but the rockets will not dive so well with as without floats.

Cases for these are made in the same manner and proportion as sky-rockets, only a little thicker of paper. When you fill those which are driven solid, put in first one ladleful of slow fire, then two of the proper charge, and on that one or two ladles of sinking charge, then the proper charge, then the sinking charge again, and so on, till you have filled the case within three diameters; then drive on the composition one ladleful of clay; through which make a small hole to the charge; then fill the case, within half a diameter, with corn-powder, on which turn down two or three rounds of the case in the inside; then pinch and tie the end very tight; having filled the rockets (according to the above directions), dip their ends in melted rosin or sealing-wax, or else secure them well with grease. When you fire those rockets, throw in six or eight at a time; but, if you would have them all sink, or swim, at the same time, you must fill them with an equal quantity of composition, and fire them all together.

141 Pipes of communication for water. *Pipes of communication, which may be used under water*, must be a little thicker in the paper than those for land. Having rolled a sufficient number of pipes, and kept them till dry, wash them over with drying oil, and set them to dry; but when you oil them, leave about an inch and a half at each end dry, for joints; as if they were oiled all over, when you come to join them, the paste would not stick where the paper is greasy: after the leaders are joined, and the paste dry, oil the joints. These pipes will lie many hours under water, without receiving any damage.

142 Horizontal water-wheels. *To make horizontal wheels for the water*, first get a large wooden bowl without a handle; then have an eight-sided wheel made of a flat board 18 inches diameter, so that the length of each side may be near seven inches: in all the sides cut a groove for the cases to lie in. This wheel being made, nail it on the top of the bowl; then take four eight-ounce cases, filled with a proper charge, each about six inches in length. Now, to clothe the wheel with these cases, get some whitish-brown paper, and cut it into slips four or five inches broad and seven or eight long: these slips being pasted all over on one side, take one of the cases, and roll one of the slips of paper about an inch and a half on its end, so that there will remain about two inches and a half of the paper hollow from the end of the case: tie this case on one of the sides of the wheel, near the corners of which must be holes bored, through which put the pack-thread to tie the cases: having tied on the first case at the neck and end, put a little meal-powder in the hollow paper; then paste a slip of paper on the end of another case, the head of which put into the hollow paper on the first, allowing a sufficient distance from the tail of one to the head of the other for the pasted paper to bend without tearing: tie on the second case as you did the first: and so on with the rest, except the last, which must be closed at the end, unless it is to communicate to any thing on the top of the wheel, such as fire-pumps or brilliant fires, fixed in holes cut in the wheel, and fired by the last or second case, as the fancy directs: six, eight, or any number, may be placed on the top of the wheel, provided they be not too heavy for the bowl.

Before tying on the cases, cut the upper part of all their ends, except the last, a little shelving, that the fire from one may play over the other, without being obstructed by the case. Wheel-cases have no clay drove in their ends, nor pinched, but are always left open, only the last, or those which are not to lead fire, which must be well secured.

For water mines you must have a bowl with a wheel on it, made in the same manner as the water-wheel; only in its middle there must be a hole, of the same diameter as that of the intended mine. These mines are tin pots, with strong bottoms, and a little more than two diameters in length: the mine must be fixed in the hole in the wheel, with its bottom resting on the bowl; then loaded with serpents, crackers, stars, small water-rockets, &c. in the same manner as pots of aigrettes; but in their centre fix a case of Chinese fire, or a small gerbe, which must be lighted at the beginning of the last case on the wheel. These wheels are to be clothed as usual. 143 Water mines.

Bowls for water-globes must be very large, and the wheels on them of ten sides: on each side nail a piece of wood four inches long; and on the outside of each piece cut a groove, wide enough to receive about one-fourth of the thickness of a four-ounce case: these pieces of wood must be nailed in the middle of each face of the wheel, and fixed in an oblique direction, so that the fire from the cases may incline upwards: the wheel being thus prepared, tie in each groove a four-ounce case filled with a gray charge; then carry a leader from the tail of one case to the mouth of the other. 144 Fire-globes for the water.

Globes for these wheels are made of two tin hoops, with their edges outwards, fixed one within the other, at right angles. The diameter of these hoops must be rather less than that of the wheel. Having made the globe, drive in the centre of a wheel an iron spindle, which must stand perpendicular, and its length four or six inches more than the diameter of the globe.

This spindle serves for an axis, on which is fixed the globe, which must stand four or six inches from the wheel: round one side of each hoop must be soldered little bits of tin, two inches and a half distance from each other; which pieces must be two inches in length each, and only fastened at one end, the other ends being left loose, to turn round the small portfires, and hold them on: these portfires must be made of such a length as will last out the cases on the wheel. There need not be any portfires at the bottom of the globe within four inches of the spindle; as they would have no effect, but to burn the wheel: all the portfires must be placed perpendicularly from the centre of the globe, with their mouths outwards; and must be clothed with leaders, so as all to take fire with the second case of the wheel; and the cases must burn two at a time, one opposite the other. When two cases of a wheel begin together, two

will

Aquatic Fireworks.

will end together; therefore the two oppofite end cafes muft have their ends pinched and fecured from fire. The method of firing fuch wheels is, by carrying a leader from the mouth of one of the firft cafes to that of the other; and the leader being burnt through the middle, will give fire to both at the fame time.

145 Odoriferous water-balloons.

Odoriferous water balloons are made in the fame manner as air-balloons, but very thin of paper, and in diameter one inch and three-fourths, with a vent of half an inch diameter. The fhells being made, and quite dry, fill them with any of the following compofitions, which muft be rammed in tight: thefe balloons muft be fired at the vent, and put into a bowl of water. Odoriferous works are generally fired in rooms.

Compofition I. Saltpetre two ounces, flour of fulphur one ounce, camphor half an ounce, yellow amber half an ounce, charcoal-duft three-fourths of an ounce, falt of benjamin half an ounce, all powdered very fine and well mixed.

II. Saltpetre 12 ounces, meal-powder three ounces, frankincenfe one ounce, myrrh half an ounce, camphor half an ounce, charcoal three ounces, all moiftened with the oil of fpike.

III. Saltpetre two ounces, fulphur half an ounce, antimony half an ounce, amber half an ounce, cedar rafpings one-fourth of an ounce, all mixed with the oil of rofes and a few drops of bergamot.

IV. Saltpetre four ounces, fulphur one ounce, faw-duft of juniper half an ounce, faw-duft of cyprefs one ounce, camphor one-fourth of an ounce, myrrh two drams, dried rofemary one-fourth of an ounce, all moiftened a little with the oil of rofes.

N. B. Water-rockets may be made with any of the above compofitions, with a little alteration, to make them weaker or ftronger, according to the fize of the cafes.

146 A fea-fight with fmall fhips and a fire-fhip.

Having procured four or five fmall fhips, of two or three feet in length, make a number of fmall reports, which are to ferve for guns. Of thefe range as many as you pleafe on each fide of the upper decks; then at the head and ftern of each fhip fix a two-ounce cafe, eight inches long, filled with a flow portfire compofition; but take care to place it in fuch a manner that the fire may fall in the water, and not burn the rigging: in thefe cafes bore holes at unequal diftances from one another, but make as many in each cafe as half the number of reports, fo that one cafe may fire the guns on one fide, and the other thofe on the oppofite. The method of firing the guns is, by carrying a leader from the holes in the cafes to the reports on the decks; you muft make thefe leaders very fmall, and be careful in calculating the burning of the flow fire in the regulating cafes, that more than two guns be not fired at a time. When you would have a broadfide given, let a leader be carried to a cracker, placed on the outfide of the fhip; which cracker muft be tied loofe, or the reports will be too flow: in all the fhips put artificial guns at the port-holes (A).

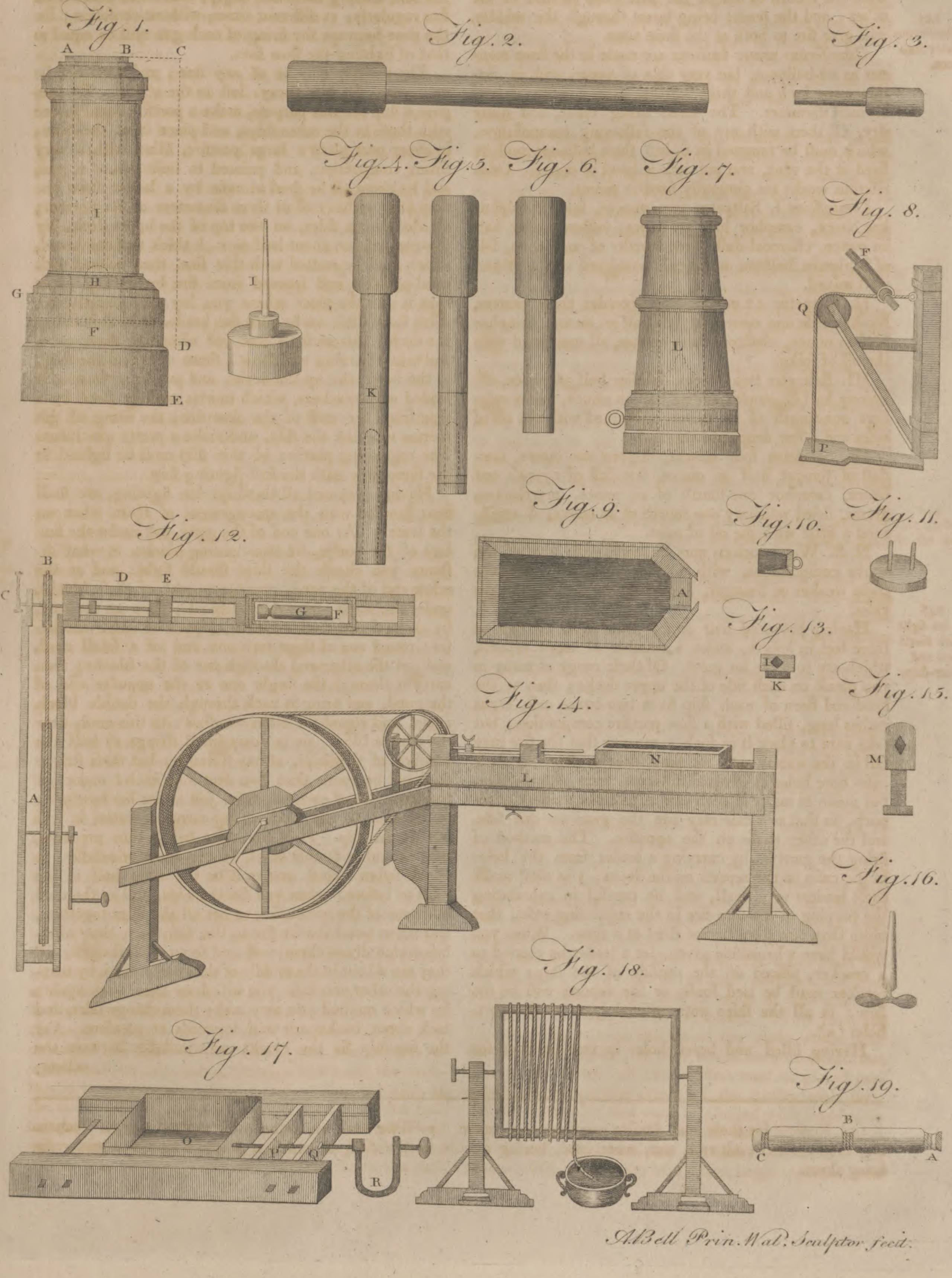
Having filled and bored holes in two portfires for regulating the guns in one fhip, make all the reft exactly the fame; then, when you begin the engagement, light one fhip firft, and fet it a failing, and fo on with the reft, fending them out fingly, which will make them fire regularly, at different times, without confufion; for the time between the firing of each gun will be equal to that of lighting the flow fires.

The fire-fhip may be of any fize; and need not be very good, for it is always loft in the action. To prepare a fhip for this purpofe, make a portfire equal in fize with thofe in the other fhips, and place it at the ftern; in every port place a large portfire, filled with a very ftrong compofition, and painted in imitation of a gun, and let them all be fired at once by a leader from the flow fire, within two or three diameters of its bottom; all along both fides, on the top of the upper deck, lay ftar-compofition about half an inch thick and one broad, which muft be wetted with thin fize, then primed with meal-powder, and fecured from fire by pafting paper over it; in the place where you lay this compofition, drive fome little tacks with flat heads, to hold it faft to the deck: this muft be fired juft after the fham guns, and when burning will fhow a flame all round the fhip: at the head take up the decks, and put in a tin mortar loaded with crackers, which mortar muft be fired by a pipe from the end of the flow fire; the firing of this mortar will fink the fhip, and make a pretty conclufion. The regulating portfire of this fhip muft be lighted at the fame time with the firft fighting fhip.

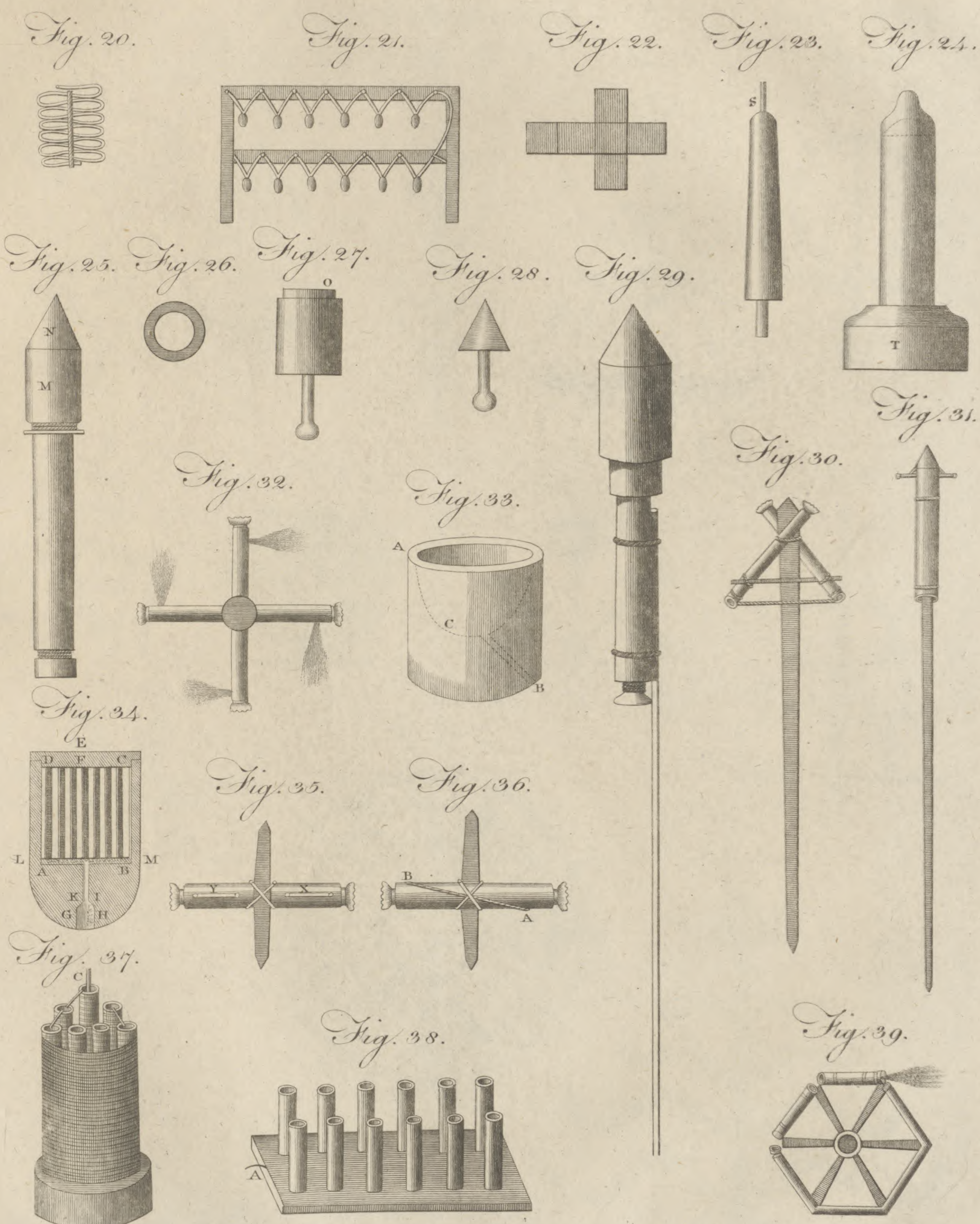
Having prepared all the fhips for fighting, we fhall next proceed with the management of them when on the water. At one end of the pond, juft under the furface of the water, fix two running blocks, at what diftance you choofe the fhips fhould fight; and at the other end of the pond, oppofite to each of thefe blocks, under the water, fix a double block; then on the land, by each of the double blocks, place two fmall windlaffes; round one of them turn one end of a fmall cord, and put the other end through one of the blocks; then carry it through the fingle one at the oppofite end of the pond, and bring it back through the double block again, and round the other windlafs: to this cord, near the double block, tie as many fmall ftrings as half the number of the fhips, at any diftance; but thefe ftrings muft not be more than two feet long each: make faft the loofe end of each to a fhip, juft under her bowfprit; for if tied to the keel, or too near the water, it will overfet the fhip. Half the fhips being thus prepared, near the other double block fix two more windlaffes, to which faften a cord, and to it tie the other half of the fhips as before: when you fire the fhips, pull in the cord with one of the windlaffes, to get all the fhips together; and when you have fet fire to the firft, turn that windlafs which draws them out, and fo on with the reft, till they are all out in the middle of the pond; then, by turning the other windlafs, you will draw them back again; by which method you may make them change fides, and tack about backwards and forwards at pleafure. For the fire-fhip fix the blocks and windlaffes between the others;

(A) Reports for thefe and fimilar occafions are made, by filling fmall cartridges with grained powder; pinching them clofe at each end, and, when ufed, boring a hole in the fide, to which is placed a match or leader for firing them.

PYROTECHNY. Plate CCCCLII.



A. Bell Prin. Wal. Sculptor fecit.



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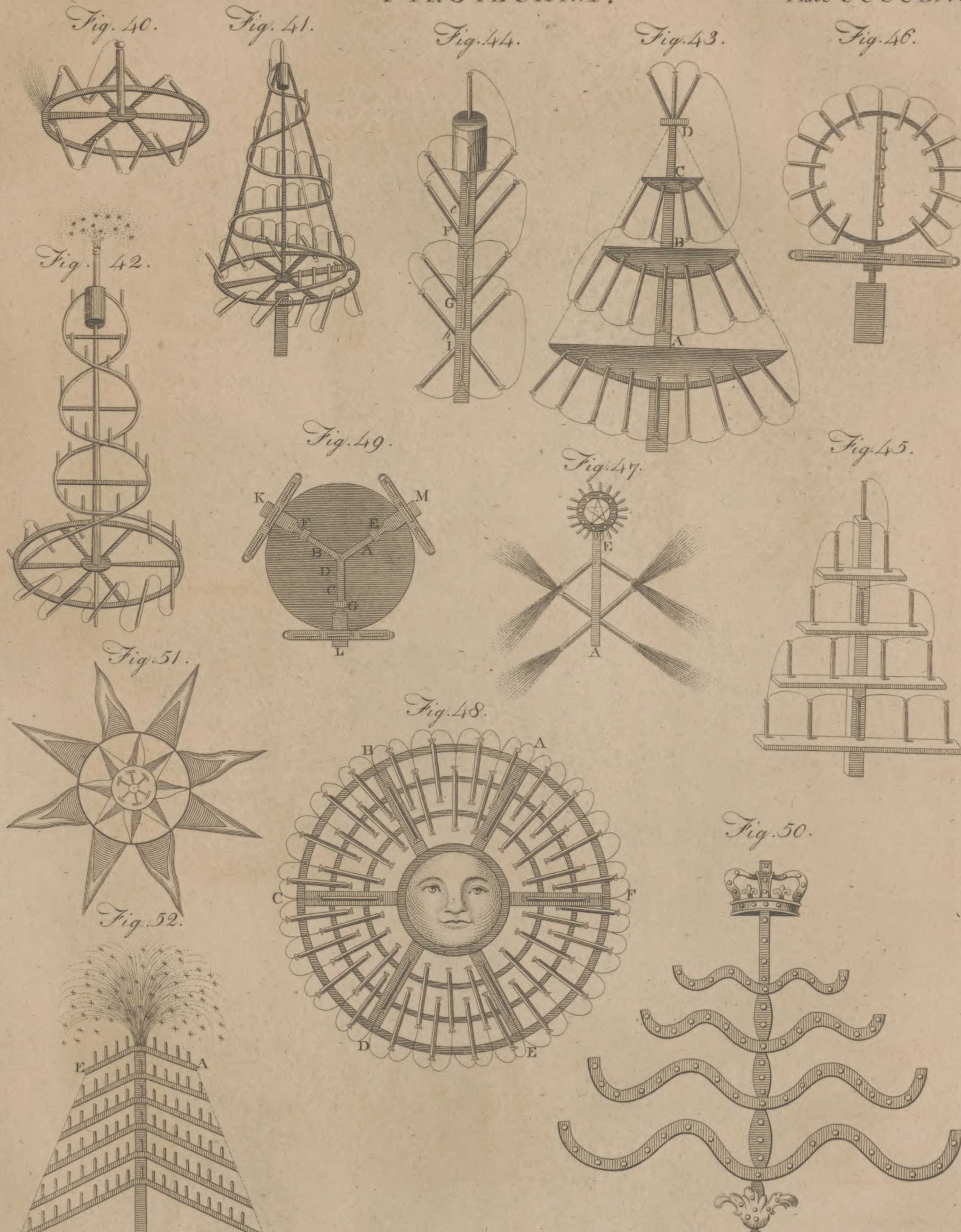
PYROTECHNY. Plate CCCCLIV.



A.Bell Prin. Wal. Sculptor fecit

Fig. 53.

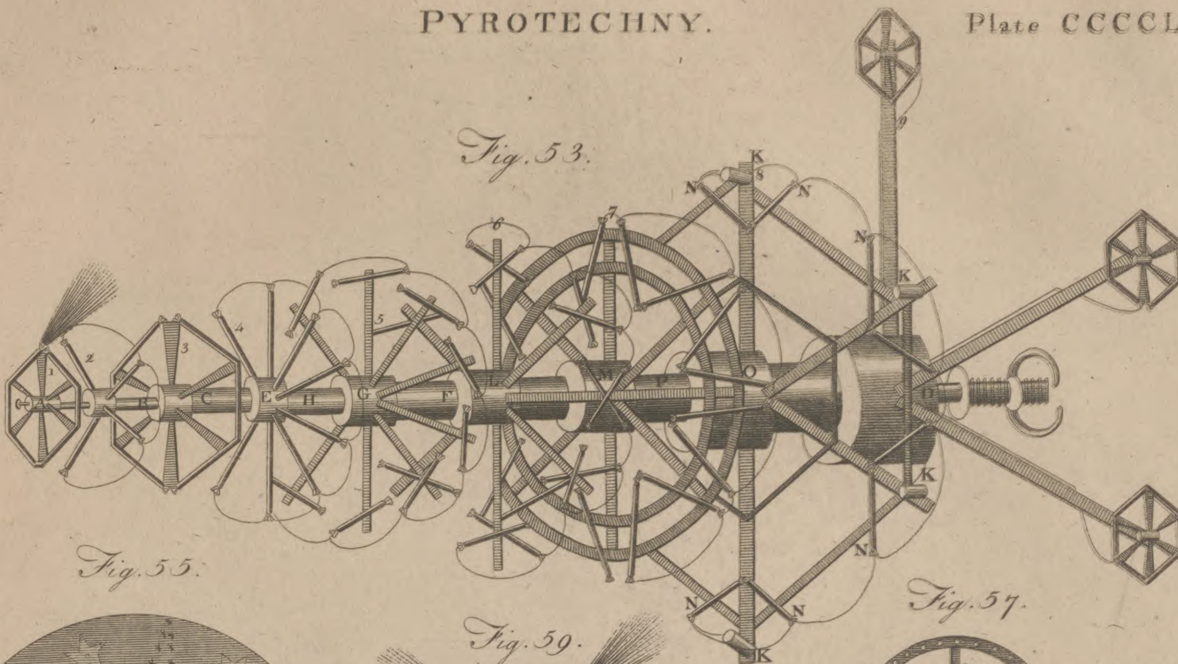


Fig. 55.

Fig. 59.

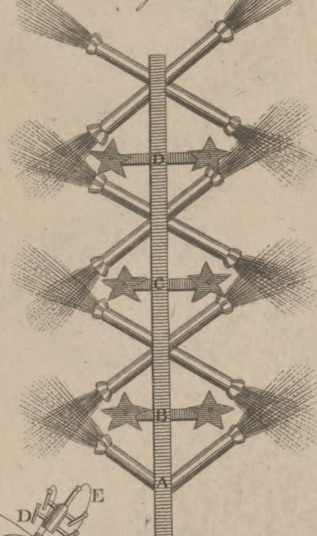


Fig. 57.

Fig. 56.

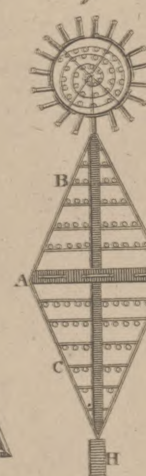


Fig. 58.

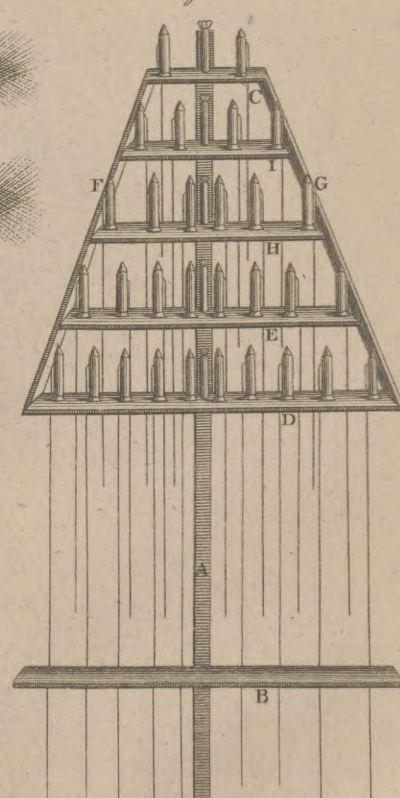


Fig. 54.

A.Bell Prin. Wal. Sculptor fecit.

Fig. 60.

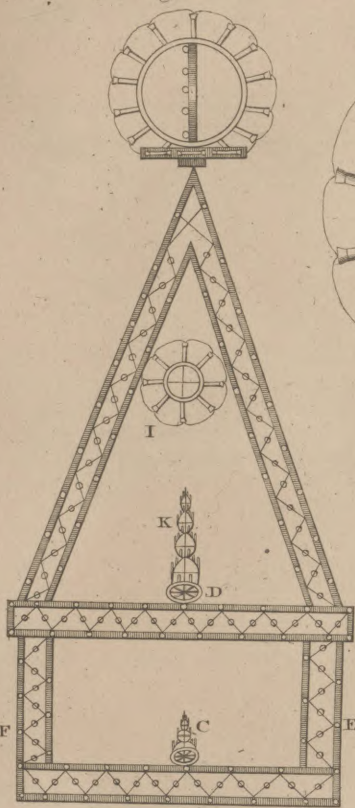


Fig. 61.

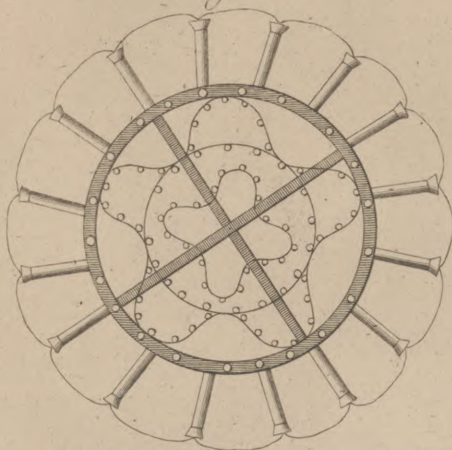


Fig. 62.

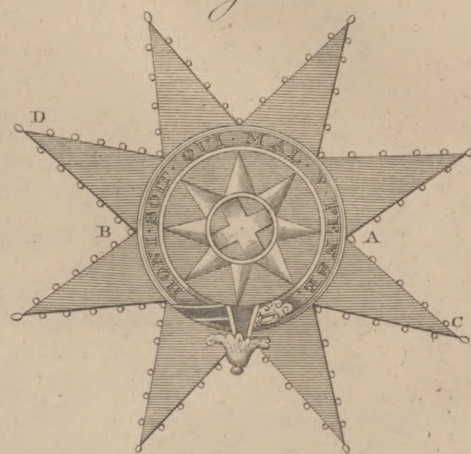


Fig. 63.

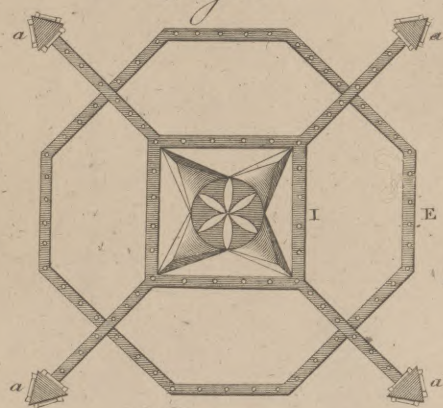


Fig. 64.

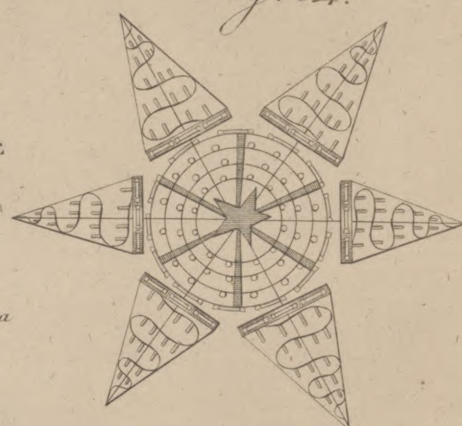


Fig. 65.

Fig. 66.

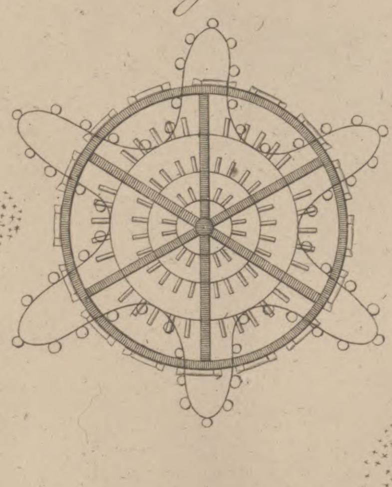
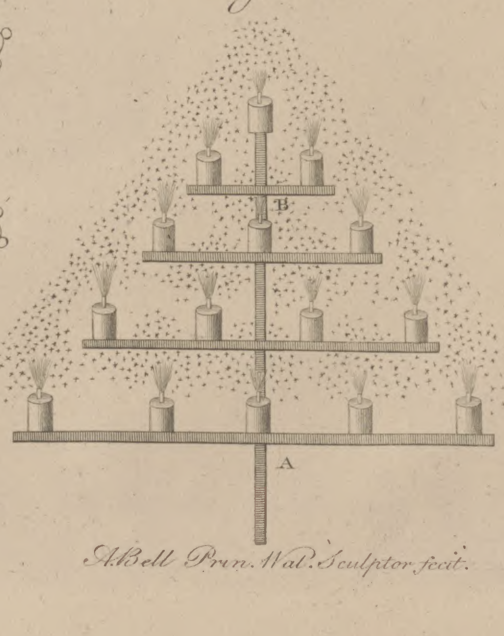


Fig. 67.



A. Bell Prin. Wal. Sculptor fecit.

Fig. 70.

Fig. 69.

Fig. 68.

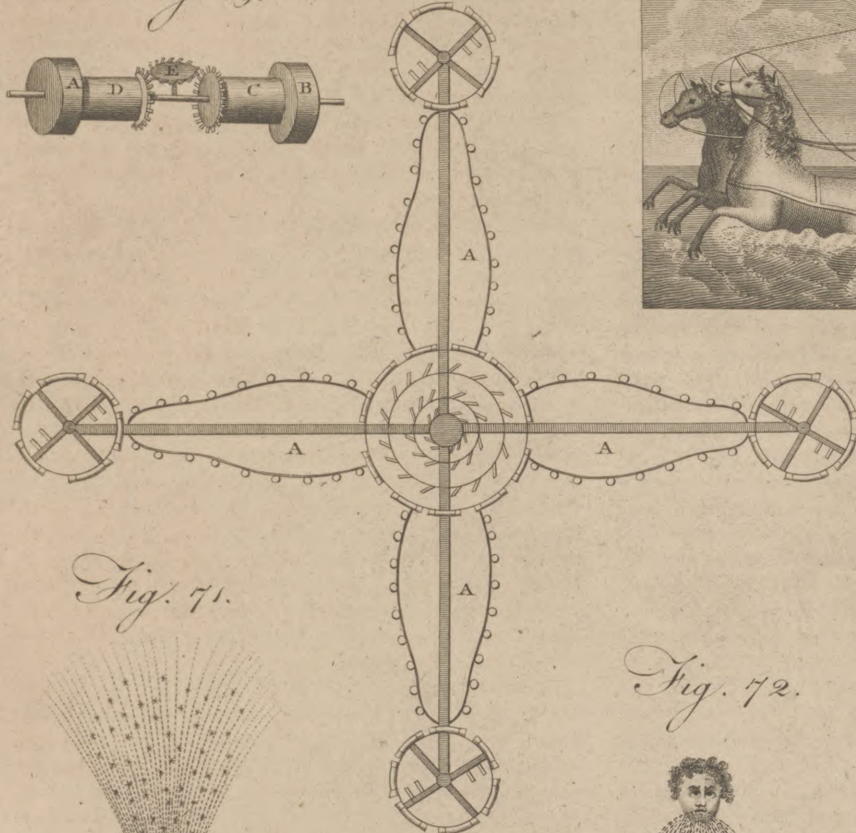


Fig. 73.

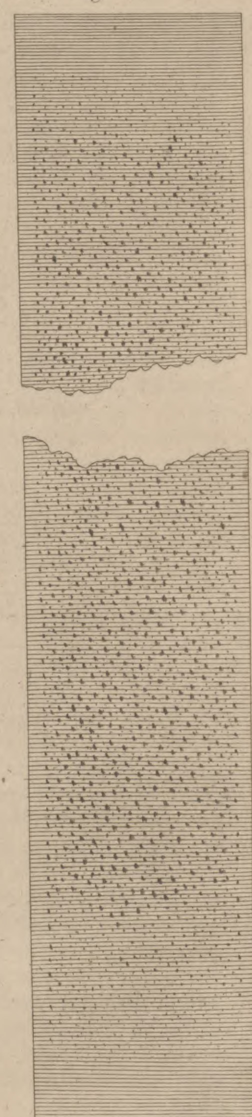


Fig. 71.

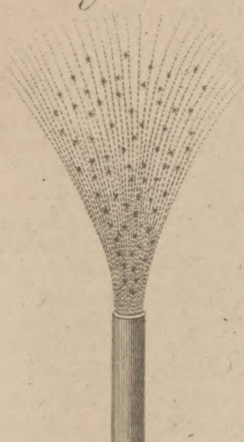
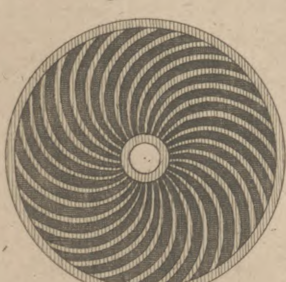


Fig. 72.

Fig. 74.



A.Bell Prin. Wal. Sculptor fecit.

Aquatic Fireworks.

others; ſo that when ſhe ſails out, ſhe will be between the other ſhips: you muſt not let this ſhip advance till the guns at her ports take fire.

147 To fire ſky-rockets under water. *To fire ſky-rockets under water*, you muſt have ſtands made as uſual, only the rails muſt be placed flat inſtead of edgewiſe, and have holes in them for the rocket-ſticks to go through; for if they were hung upon hooks, the motion of the water would throw them off: the ſtands being made, if the pond is deep enough, ſink them at the ſides ſo deep, that, when the rockets are in, their heads may juſt appear above the ſurface of the water; to the mouth of each rocket fix a leader, which put through the hole with the ſtick; then a little above the water muſt be a board, ſupported by the ſtand, and placed along one ſide of the rockets; then the ends of the leaders are turned up through holes made in this board, exactly oppoſite the rockets. By this means you may fire them ſingly or all at once. Rockets may be fired by this method in the middle of a pond, by a Neptune, a ſwan, a water-wheel, or any thing elſe you chooſe.

148 Neptune in his chariot. *To repreſent Neptune in his chariot*, you muſt have a Neptune (made of wood, or baſket work) as big as life, fixed on a float large enough to bear his weight; on which muſt be two horſes heads and necks, ſo as to ſeem ſwimming, as ſhown by fig. 70. For the wheels of the chariot, there muſt be two vertical wheels of black fire, and on Neptune's head a horizontal wheel of brilliant fire, with all its caſes, to play upwards. When this wheel is made, cover it with paper or paſteboard, cut and painted like Neptune's coronet; then let the trident be made without prongs, but inſtead of them, fix three caſes of a weak gray charge, and on each horſe's head put an eight ounce caſe of brilliant fire, and on the mouth of each fix a ſhort caſe, of the ſame diameter, filled with the white-flame compoſition enough to laſt out all the caſes on the wheels: theſe ſhort caſes muſt be open at bottom, that they may light the brilliant fires; for the horſes eyes put ſmall portfires, and in each noſtril put a ſmall caſe half filled with gray change, and the reſt with portfire compoſition.

Fig. 70.

If Neptune is to give fire to any building on the water; at his firſt ſetting out, the wheels of the chariot, and that on his head, with the white flames on the horſes heads, and the portfires in their eyes and noſtrils, muſt all be lighted at once; then from the bottom of the white flames carry a leader to the trident. As Neptune is to advance by the help of a block and cord, you muſt manage it ſo as not to let him turn about, till the brilliant fires on the horſes and the trident begin; for it is by the fire from the horſes (which plays almoſt upright) that the building, or work, is lighted; which muſt be thus prepared. From the mouth of the caſe which is to be firſt fired, hang ſome looſe quick-match to receive the fire from the horſes. When Neptune is only to be ſhown by himſelf, without ſetting fire to any other works, let the white flames on the horſes be very ſhort, and not to laſt longer than one caſe of each wheel, and let two caſes of each wheel burn at a time.

149 Swans and ducks in water. If you would have ſwans or ducks diſcharge rockets into the water, they muſt be made hollow, and of paper, and filled with ſmall water rockets, with ſome blowing powder to throw them out: but if this is not done, they may be made of wood, which will laſt many times. Having made and painted ſome ſwans, fix them on floats: then in the places where their eyes ſhould be, bore holes two inches deep, inclining downwards, and wide enough to receive a ſmall portfire; the portfire caſes for this purpoſe muſt be made of braſs, two inches long, and filled with a ſlow bright charge. In the middle of one of theſe caſes make a little hole; then put the portfire in the eye-hole of the ſwan, leaving about half an inch to project out; and in the other eye put another portfire, with a hole made in it: then in the neck of the ſwan, within two inches of one of the eyes, bore a hole ſlantwiſe, to meet that in the portfire; in this hole put a leader, and carry it to a water-rocket, that muſt be fixed under the tail with its mouth upwards. On the top of the head place two one-ounce caſes, four inches long each, drove with brilliant fire; one of theſe caſes muſt incline forwards, and the other backwards: theſe muſt be lighted at the ſame time as the water-rocket; to do which, bore a hole between them in the top of the ſwan's head, down to the hole in the portfire, to which carry a leader: if the ſwan is filled with rockets, they muſt be fired by a pipe from the end of the water-rocket under the tail. When you ſet the ſwan a ſwimming, light the two eyes.

Optical Imitations of Fireworks.

To make a fire-fountain for the water, firſt have a float made of wood, three feet diameter; then in the middle fix a round perpendicular poſt, four feet high, and two inches diameter; round this poſt fix three circular wheels made of thin wood, without any ſpokes. The largeſt of theſe wheels muſt be placed within two or three inches of the float, and muſt be nearly of the ſame diameter. The ſecond wheel muſt be two feet two inches diameter, and fixed at two feet diſtance from the firſt. The third wheel muſt be one foot four inches diameter, and fixed within ſix inches of the top of the poſt: the wheels being fixed, take 18 four or eight-ounce caſes of brilliant fire, and place them round the firſt wheel with their mouths outwards, and inclining downwards; on the ſecond wheel place 13 caſes of the ſame, and in the ſame manner as thoſe on the firſt; on the third, place eight more of theſe caſes, in the ſame manner as before, and on the top of the poſt fix a gerbe; then clothe all the caſes with leaders, ſo that both they and the gerbe may take fire at the ſame time. Before firing this work, try it in the water to ſee whether the float is properly made, ſo as to keep the fountain upright. 150 Water fire-fountains.

As the artificial fire-works which we have deſcribed, require conſiderable caution in their preparation and management, and are attended with great expence, attempts have been made to imitate ſome of the more ſimple kinds by optical deluſion, and to give to the objects repreſented the appearance of moving fire, though they be really fixed, and no fire be employed. Theſe attempts have been tolerably ſucceſsful; and by means of this invention, a ſpectacle of artificial fire-works may be apparently exhibited at a trifling expence; and if the pieces employed are conſtructed with ingenuity, and with a proper attention to the rules of perſpective, while in viewing them we employ glaſſes which magnify the objects, and prevent them from being too diſtinctly ſeen, a very agreeable illuſion will be produced. 151 Optical imitations of fire-works.

The artificial fire-works imitated with moſt ſucceſs by this invention, are fixed ſuns, gerbes, and jets of fire, caſcades, globes, pyramids, and columns, moveable around their axes. To repreſent a gerbe of fire, take paper

Optical Imitations of Fireworks.

paper blackened on both fides, and very opaque; and having delineated on a piece of white paper the figure of a gerbe of fire, apply it to the black paper, and with the point of a very fharp penknife make feveral flafhes (Plate CCCCLVII. fig. 71.) in it, as 3, 5, or 7, proceeding from the origin of the gerbe: thefe lines muft not be continued, but cut through at unequal intervals. Pierce thefe intervals with unequal holes made with a pinking iron, in order to reprefent the fparks of fuch a gerbe. In fhort, you muft endeavour to paint, by thefe lines and holes, the well known effect of the fire of inflamed gunpowder, when it iffues through a fmall aperture.

Fig. 71.

According to the fame principles, you may delineate the cafcades (fig. 72.) and jets of fire which you are defirous of introducing into this exhibition, which is purely optical; and thofe jets of fire which proceed from the radii of funs, either fixed or moveable. It may eafily be conceived, that in this operation tafte muft be the guide.

If you are defirous of reprefenting globes, pyramids, or revolving columns, draw the outlines of them on paper, and then cut them out in a helical form; that is, cut out fpirals with the point of a penknife, and of a fize proportioned to that of the piece.

It is to be obferved alfo, that as thefe different pieces have different colours, they may be eafily imitated by pafting on the back of the paper, cut as here defcribed, very fine filk paper coloured in the proper manner. As jets, for example, when loaded with Chinefe fire, give a reddifh light, you muft pafte to the back of thefe jets tranfparent paper, flightly tinged with red; and proceed in the fame manner in regard to the other colours by which the different fire-works are diftinguifhed.

When thefe preparations have been made, the next thing is to give motion, or the appearance of motion, to this fire, which may be done two ways, according to circumftances.

If a jet of fire, for example, is to be reprefented, prick unequal holes, and at unequal diftances from each other, in a band of paper, fig. 73. and then move this band, making it afcend between a light and the above jet; the rays of light which efcape through the holes of the moveable paper will exhibit the appearance of fparks rifing into the air. It is to be obferved that one part of the paper muft be whole; that another muft be pierced with holes thinly fcattered; that in another place they muft be very clofe, and then moderately fo: by thefe means it will reprefent thofe fudden jets of fire obferved in fire-works.

To reprefent a cafcade, the paper pierced with holes, inftead of moving upwards, muft be made to defcend.

This motion may be eafily produced by means of two rollers, on one of which the paper is rolled up, while it is unrolled from the other.

Suns are attended with fome more difficulty; becaufe in thefe it is neceffary to reprefent fire, proceeding from the centre to the circumference. The artifice for this purpofe is as follows.

On ftrong paper defcribe a circle, equal in diameter to the fun which you are defirous to exhibit, or even fomewhat larger; then trace out on this circle two fpirals, at the diftance of a line or half a line from each other, and open the interval between them with a penknife, in fuch a manner, that the paper may be cut from the circumference, decreafing in breadth to a certain diftance from the centre, fig. 74.: cut the remainder of the circle into fpirals of the fame kind, open and clofe alternately; then cement the paper circle to a fmall iron hoop, fupported by two pieces of iron, croffing each other in its centre, and adjuft the whole to a fmall machine, which will fuffer it to revolve round its centre. If this moveable paper circle, cut in this manner, be placed before the reprefentation of your fun, with a light behind it, as foon as it is made to move towards that fide to which the convexity of the fpirals is turned, the luminous fpirals, or thofe which afford a paffage to the light, will give, on the image of the radii or jets of fire of your fun, the appearance of fire in continual motion, as if undulating from the centre to the circumference.

The appearance of motion may be given to columns, pyramids, and globes, cut through in the manner above defcribed, by moving in a vertical direction a band of paper cut through into apertures, inclined at an angle rather different from that of the fpirals. By thefe means the fpectators will fuppofe that they fee fire continually circulating and afcending along the fpirals; and thus will be produced an optical illufion, in confequence of which the columns or pyramids will feem to revolve.

We have thus briefly explained the principle on which artificial fire-works may be imitated; and as the tafte of the artift may fuggeft to him many circumftances which may improve the reprefentation, and render the illufion ftronger, we fhall not enlarge further on the fubject, but fhall conclude this article with a few obfervations on illuminated prints and drawings, which are fometimes introduced as accompaniments in thefe imitations of artificial fire-works.

The mode of preparing thefe illuminations is thus defcribed in Hutton's tranflation of Montucla's *Recreations*. Take fome prints reprefenting a caftle, or palace, &c.; and having coloured them properly, cement paper to the back of them, in fuch a manner that they fhall be only femitranfparent; then, with pinking irons of different fizes, prick fmall holes in the places and on the lines where the lamps are generally placed, as along the fides of the windows, on the cornices or baluftrades, &c. But care muft be taken to make thefe holes fmaller and clofer, according to the perfpective diminution of the figure. With other irons of a larger fize, cut out, in other places, fome ftronger lights, fo as to reprefent fire-pots, &c. Cut out alfo the panes in fome of the windows, and cement to the back of them tranfparent paper of a green or red colour, to reprefent curtains drawn before them, and concealing an illuminated apartment.

When the print is cut in this manner, place it in the front of a fort of fmall theatre, ftrongly illuminated from the back part, and look at it through a convex glafs of a pretty long focus, like that ufed in thofe fmall machines called optical boxes. If the rules of perfpective have been properly obferved in the prints, and if the lights and fhades have been diftributed with tafte, this fpectacle will be highly agreeable.

152 Management of burns from fire-works.

Before difmiffing this fubject, it may not be improper to point out the moft effectual means of relieving thofe burns, to which fire-workers are fo much expofed. When the burn is firft received, and before blifters arife, the beft applications are *oil of turpentine, ftrong*

fpirits,

Management of Burns.

spirits, *rectified spirit of wine*, or *camphorated spirit*, with which linen rags must be wetted and kept moist on the part till the pain abates. If no other remedy can be procured, immersing the part for a long time in cold water will often afford great relief. When these means have been neglected, and blisters arise, if these are small, they should not be opened; but if large, the water must be let out, and the sore covered with rags, spread with a mixture of *linseed oil* and *lime water*, in the proportion of one part of the former to three of the latter. We must remark, however, that in all cases of extensive burns, or where some very delicate part is injured, speedy recourse should be had to medical assistance.

PYR

Pyrotics || Pyrrho.

PYROTICS, in *Medicine*, caustics, or remedies either actually or potentially hot; and which accordingly will burn the flesh, and raise an eschar. See CAUSTICITY.

PYRRHICHA, in antiquity, a kind of exercise on horseback, or a feigned combat, for the exercise of the cavalry.

It was thus called from its inventor Pyrrhichus, or Pyrrhus of Cydonia, who first taught the Cretans to march in measure and cadence to battle, and to observe the pace of the Pyrrhic foot.—Others derive the name from Pyrrhus the son of Achilles, who instituted this exercise at the obsequies of his father.—Aristotle says, that it was Achilles himself who invented it.

The Romans also called it *ludus Trojanus*, "the Trojan game;" and Aulus Gellius, *decursus*.—It is doubtless this exercise that we see represented on medals by two cavaliers in front running with lances, and the word *decursio* in the exergum.

PYRRHICHIUS, in the Greek and Latin poetry, a foot consisting of two syllables, both short;—as, *Deus*.—Among the ancients this foot is also called *periambus*; by others *hegemona*.

PYRRHO, a Greek philosopher, born at Elis in Peloponnesus, flourished about 300 B. C. He was the disciple of Anaxarchus, whom he accompanied as far as India, where he conversed with the Brachmans and Gymnosophists. He had made painting his profession before he devoted himself to the study of philosophy. He established a sect whose fundamental principle was, That there is nothing true or false, right or wrong, honest or dishonest, just or unjust; or that there is no standard of any thing beyond law or custom, and that uncertainty and doubt belong to every thing. From this continual seeking after truth and never finding it, the sect obtained the name of *Sceptics* or *Pyrrhonians*. from the founder, who is said to have acted upon his own principles, and to have carried his scepticism to such a ridiculous extreme, that his friends were obliged to accompany him wherever he went, that he might not be run over by carriages, or fall down precipices. If this was true, it was not without reason that he was ranked among those whose intellects were disturbed by intense study. But it is treated by a modern writer as a mere calumny invented by the dogmatists; and we are strongly inclined to be of his opinion, (see SCEPTICS). Pyrrho died about the 90th year of his age, when his memory was honoured with a statue at Athens, and a monument erected to him in his own country.

PYT

Pyrrhus || Pythagoras.

PYRRHUS, the name of two kings of Epirus. See EPIRUS.

PYRUS, the PEAR-TREE. See BOTANY *Index*; and for the culture of this fruit see GARDENING. For an account of the processes followed in making perry, see AGRICULTURE.

PYTHAGORAS, a celebrated philosopher of antiquity, respecting the time and place of whose birth the learned are much divided. Eratosthenes asserts, that in the 48th Olympiad *, when he was very young, he was a victor at the Olympic games. Hence Dr Bentley † determines the date of his birth to be the 4th year of the 43d Olympiad; whilst Lloyd ‡, who denies that the Olympic victor was the same person with the philosopher, places it about the 3d year of the 48th Olympiad. Mr Dodwell § differs from both, and wishes to fix the birth of Pythagoras in the 4th year of the 52d Olympiad. Of the arguments of these learned writers, Le Clerc has given a summary in the *Bibliotheque Choisée*, tom. x. p. 81. &c. and from a review of the whole, it would appear that he was not born earlier than the 4th year of the 43d Olympiad, or later than the 4th year of the 52d; but in what particular year of that period his birth took place, cannot with any degree of certainty be ascertained. It is generally believed that he was born in the island of Samos, and that he flourished about 500 years before Christ, in the time of Tarquin the last king of Rome*. His father Mnesarchus, who is thought by some to have been a lapidary, and by others a merchant of Tyre, appears to have been a man of some distinction, and to have bestowed upon his son the best education.

* An. ante Chr. 588.

† *Dissert. on the Ep. of Phalaris.*

‡ *Chron. of Pythagoras.*

§ *Two Dissertations on the age of Phalereus and Pythagoras.*

* *Tusc. Quest.* lib. iv. cap. 1.

Jamblicus † relates a number of wonderful stories respecting Pythagoras's descent from Jupiter, his birth, and early life; and represents him even in his youth as a prodigy of wisdom and manly seriousness. But most of these idle tales confute themselves, afford nothing of importance to be depended upon, and only prove the credulity, carelessness, and prejudice of their author. Of his childhood and early education we know nothing, except that he was first instructed in his own country by Creophilus, and afterwards in Scyrus by Pherecydes (see PHERECYDES). According to the custom of the times he was made acquainted with poetry and music; eloquence and astronomy became his private studies, and in gymnastic exercises he often bore the palm for strength and dexterity. He first distinguished himself in Greece at the Olympic games, where, beside gaining the prize, he is said to have excited the highest admiration by the elegance and dignity of his person, and the brilliancy of his understanding.

† *Vit. Pythag.* n. 6.

Pythagoras

Soon after his appearance at these games, Pythagoras commenced his travels in quest of knowledge. He first visited Egypt, where, through the interest of Polycrates tyrant of Samos, he obtained the patronage of Amasis king of Egypt, by whose influence, combined with his own assiduity, patience, and perseverance, he at length gained the confidence of the priests; from whom he learned their sacred mysteries, theology, and the whole system of symbolical learning. In Egypt, too, he became acquainted with geometry and the true solar system; and, before he left that country, made himself master of all the learning for which it was so famed among the nations of antiquity.

He afterwards visited Persia and Chaldea, where from the Magi he learnt divination, the interpreting of dreams, and astronomy. He is likewise said to have travelled into India, to have conversed with the Gymnosophists, and to have acquired from them a knowledge of the philosophy and literature of the east; and such was his ardour in the pursuit of science, that in quest of it, we are told by Cicero *, he crossed many seas, and travelled on foot through many barbarous nations.

* *De Finibus*, lib. iv. § 29.

After Pythagoras had spent many years in gathering information on every subject, especially respecting the nature of the gods, the rites of religion, and the immortality of the human soul, he returned to his native island, and attempted to make his knowledge useful by instituting a school for the instruction of his countrymen. Failing of success in this laudable undertaking, he repaired to Delos, where he pretended to receive moral dogmas from the priestess of Apollo, He also visited Crete, where he was initiated into the most sacred mysteries of Greece. He went likewise to Sparta and Elis, and again assisted at the Olympic games; where in the public assembly he was saluted with the title of *sophist* or *wise man*, which he declined for one more humble. See PHILOLOGY, N° 1. and PHILOSOPHY, N° 1.

He returned to Samos enriched with mythological learning and mysterious rites, and again instituted a school. His mysterious symbols and oracular precepts made this attempt more successful than the former had been; but meeting with some opposition, or being detected in some pious frauds, he suddenly left Samos, retired to Magna Grecia, and settled at Crotona.

Here he founded the Italic sect (see PHILOSOPHY, N° 20.); and his mental and personal accomplishments, the fame of his distant travels, and his Olympic crown, soon procured him numerous pupils. His bold and manly eloquence and graceful delivery attracted the most dissolute, and produced a remarkable change in the morals of the people of Crotona. His influence was increased by the regularity of his own example, and its conformity to his precepts. He punctually attended the temples of the gods, and paid his devotions at an early hour; he lived upon the purest and most innocent food, clothed himself like the priests of Egypt, and by his continual purifications and regular offerings appeared to be superior in sanctity to the rest of mankind. He endeavoured to assuage the passions of his scholars with verses and numbers, and made a practice of composing his own mind every morning, by playing on his harp, and singing along with it the pæans of Thales. To avoid the temptations of ease and the seductions of idleness, bodily exercises also made a considerable part of his discipline.

At Crotona he had a public school for the general benefit of the people, in which he taught them their duty, praising virtue and condemning vice; and particularly instructing them in the duties of social life. Beside this, he had a college in his own house, which he denominated κοινοβιον, in which there were two classes of students, viz. εξωτερικοι, who were also called *auscultantes*, and εσωτερικοι. The former of these were probationers, and were kept under a long examen. A silence of five years was imposed upon them; which Apuleius thinks was intended to teach them modesty and attention; but Clemens Alexandrinus thinks it was for the purpose of abstracting their minds from sensible objects, and inuring them to the pure contemplation of the Deity. The latter class of scholars were called *genuini*, *perfecti*, *mathematici*, and, by way of eminence, *Pythagoreans*. They alone were admitted to the knowledge of the arcana and depths of Pythagoric discipline, and were taught the use of ciphers and hieroglyphic writings.

Clemens observes, that these orders corresponded very exactly to those among the Hebrews: for in the schools of the prophets there were two classes, viz. the sons of the prophets, who were the scholars, and the doctors or masters, who were also called *perfecti*; and among the Levites, the novices or tyros, who had their quinquennial exercises, by way of preparation. Lastly, even among the proselytes there were two orders; *exoterici*, or proselytes of the gate; and *intrinseci* or *perfecti*, proselytes of the covenant. He adds, it is highly probable, that Pythagoras himself had been a proselyte of the gate, if not of the covenant. Gale endeavours to prove that Pythagoras borrowed his philosophy from that of the Jews; to this end producing the authorities of many of the fathers and ancient authors, and even pointing out the tracks and footsteps of Moses in several parts of Pythagoras's doctrine. But we believe the learned author was misled by the Christian Platonists.

The authority of Pythagoras among his pupils was so great, that it was even deemed a crime to dispute his word; and their arguments were considered as infallibly convincing, if they could enforce them by adding, that "the master said so;" an expression which afterwards became proverbial in *jurare in verba magistri*. This influence over his school was soon extended to the world, and even his pupils themselves divided the applause and approbation of the people with their master; and the rules and legislators of all the principal towns of Greece, Sicily, and Italy, boasted of being the disciples of Pythagoras. To give more weight to his exhortations, as some writers mention, Pythagoras retired into a subterraneous cave, where his mother sent him intelligence of every thing which happened during his absence. After a certain number of months he again re-appeared on the earth with a grim and ghastly countenance, and declared in the assembly of the people that he was returned from hell. From similar exaggerations it has been asserted that he appeared at the Olympic games with a golden thigh, and that he could write in letters of blood whatever he pleased on a looking-glass; and that by setting it opposite to the moon, when full, all the characters which were on the glass

Pythagoras. became legible on the moon's disc. They also relate, that by some magical words he tamed a bear, stopped the flight of an eagle, and appeared on the same day and at the same instant in the cities of Crotona and Metapontum, &c.

At length his singular doctrines, and perhaps his strenuously asserting the rights of the people against their tyrannical governors, excited a spirit of jealousy, and raised a powerful party against him; which soon became so outrageous as to oblige him to fly for his life. His friends fled to Rhegium; and he himself, after being refused protection by the Locrians, fled to Metapontum, where he was obliged to take refuge in the temple of the muses, and where it is said he died of hunger about 497 years before Christ. Respecting the time, place, and manner of his death, however, there are various opinions, and many think it uncertain when, where, or in what manner, he ended his days. After his death his followers paid the same respect to him as was paid to the immortal gods; they erected statues in honour of him, converted his house at Crotona into a temple of Ceres, appealed to him as a deity, and swore by his name.

Pythagoras married Theano of Crotona, or, according to others, of Crete, by whom he had two sons, Telauges and Mnesarchus, who, after his death, took care of his school. He is said also to have had a daughter called *Damo*.

Whether he left any writings behind him is disputed. It seems probable, however, that he left none, and that such as went under his name were written by some of his followers. The *golden verses* which Hierocles illustrated with a commentary, have been ascribed to Epicharmus or Empedocles, and contain a brief summary of his popular doctrines. From this circumstance, and from the mysterious secrecy with which he taught, our information concerning his doctrine and philosophy is very uncertain, and cannot always be depended on.

The purpose of philosophy, according to the system of Pythagoras, is to free the mind from incumbrances, and to raise it to the contemplation of immutable truth and the knowledge of divine and spiritual objects. To bring the mind to this state of perfection is a work of some difficulty, and requires a variety of intermediate steps. Mathematical science was with him the first step to wisdom, because it inures the mind to contemplation, and takes a middle course between corporeal and incorporeal beings. The whole science he divided into two parts, *numbers* and *magnitude;* and each of these he subdivided into two others, the former into *arithmetic* and *music*, and the latter into *magnitude at rest and in motion;* the former of which comprehends *geometry*, and the latter *astronomy*. Arithmetic he considered as the noblest science, and an acquaintance with numbers as the highest good. He considered numbers as the principles of every thing; and divided them into scientific and intelligible. Scientific number is the production of the powers involved in unity, and its return to the same; number is not infinite, but is the source of that infinite divisibility into equal parts which is the property of all bodies. Intelligible numbers are those which existed in the divine mind before all things. They are the model or archetype of the world, and the cause of the essence of beings. Of the Monad, Duad, Triad, Tetrad, and Decad, various explanations have been given by various authors; but nothing certain or important is known of them. In all probability, numbers were used by Pythagoras as symbolical representations of the first principles and forms of nature, and especially of those eternal and immutable essences which Plato denominated ideas; and in this case the Monad was the simple root from which he conceived numbers to proceed, and as such, analogous to the simple essence of deity; from whence, according to his system, the various properties of nature proceed.

Music followed numbers, and was useful in raising the mind above the dominion of the passions. Pythagoras considered it as a science to be reduced to mathematical principles and proportions, and is said to have discovered the musical chords from the circumstance of several men successively striking with hammers a piece of heated iron upon an anvil. This story Dr Burney * discredits; but allows, from the uniform testimony of writers ancient and modern, that he invented the *harmonical canon* or monochord, (see MONOCHORD). The music of the spheres, of which every one has heard, was a most fanciful doctrine of Pythagoras. It was produced, he imagined, by the planets striking on the ether through which in their motion they passed; and he considered their musical proportions as exact, and their harmony perfect.

* *History of Music*, vol. i. p. 441.

Pythagoras, as we have already seen, learned geometry in Egypt; but by investigating many new theorems, and by digesting its principles, he reduced it to a more regular science. A geometrical point, which he defines to be a monad, or unity with position, he says corresponds to unity in arithmetic, a line to two, a superficies to three, and a solid to four. He discovered several of the propositions of Euclid; and on discovering the 47th of book 1st, he is said to have offered a hecatomb to the gods; but as he was averse to animal sacrifices, this assertion is surely false. His great progress in astronomical science has been mentioned elsewhere. See ASTRONOMY, N° 11, 22. and PHILOSOPHY, N° 15, 16.

Wisdom, according to Pythagoras, is conversant with those objects which are naturally immutable, eternal, and incorruptible; and its end is to assimilate the human mind to the divine, and to qualify us to join the assembly of the gods. Active and moral philosophy prescribes rules and precepts for the conduct of life, and leads us to the practice of public and private virtue.—On these heads many of his precepts were excellent, and some of them were whimsical and useless. Theoretical philosophy treats of nature and its origin, and is, according to Pythagoras, the highest object of study. It included all the profound mysteries which he taught, of which but little is now known. God he considers as the universal mind, diffused through all things, and the self-moving principle of all things (αυτοματισμος τῶν παντῶν), and of whom every human soul is a portion *. It is very probable, that he conceived of the Deity as a subtle fire, eternal, active, and intelligent; which is not inconsistent with the idea of incorporeality, as the ancients understood that term. This Deity was primarily combined with the chaotic mass of passive matter, but he had the power of separating himself, and since the separation he has remained distinct. The learned Cudworth

* *Cicero de Senect.* § 21.

Pythagoras.

worth contends, that Pythagoras maintained a trinity of hypoſtaſes in the divine nature, ſimilar to the Platonic triad (ſee PLATONISM). We cannot ſay that his arguments appear to have much force; but we think the concluſion which he wiſhes to eſtabliſh extremely probable, as Plato certainly drew his doctrine from ſome of the countries which Pythagoras had viſited before him.

Subordinate to the Deity there were in the Pythagorean creed three orders of intelligences, gods, demons, and heroes, of different degrees of excellence and dignity. Theſe, together with the human ſoul, were conſidered as emanations from the Deity, the particles of ſubtle ether aſſuming a groſſer clothing the farther they receded from the fountain. Hierocles defines a hero to be a rational mind united with a luminous body. God himſelf was repreſented under the notion of monad, and the ſubordinate intelligences as numbers derived from and included in unity. Man is conſidered as conſiſting of an elementary nature and a divine or rational ſoul. His ſoul, a ſelf-moving principle, is compoſed of two parts; the rational, ſeated in the brain; and the irrational, including the paſſions, in the heart. In both theſe reſpects he participates with the brutes, whom the temperament of their body, &c. allows not to act rationally. The ſenſitive ſoul periſhes; the other aſſumes an ethereal vehicle, and paſſes to the region of the dead, till ſent back to the earth to inhabit ſome other body, brutal or human. See METEMPSYCHOSIS. It was unqueſtionably this notion which led Pythagoras and his followers to deny themſelves the uſe of fleſh, and to be ſo peculiarly merciful to animals of every deſcription. Some authors, however, ſay, that fleſh and beans, the uſe of which he alſo forbade, were prohibited, becauſe he ſuppoſed them to have been produced from the ſame putrified matter, from which, at the creation of the world, man was formed.

Of the ſymbols of Pythagoras little is known. They have been religiouſly concealed; and though they have awakened much curioſity, and occaſioned many ingenious conjectures, they ſtill appear to us dark and trifling. As a ſpecimen we give the following: "Adore the ſound of the whiſpering wind. Stir not the fire with a ſword. Turn aſide from an edged tool. Paſs not over a balance. Setting out on a journey, turn not back, for the furies will return with you. Breed nothing that hath crooked talons. Receive not a ſwallow into your houſe. Look not in a mirror by the light of a candle. At a ſacrifice pare not your nails. Eat not the heart or brain. Taſte not that which hath fallen from the table. Break not bread. Sleep not at noon. When it thunders touch the earth. Pluck not a crow. Roaſt not that which has been boiled. Sail not on the ground. Plant not a palm. Breed a cock, but do not ſacrifice it, for it is ſacred to the ſun and moon. Plant mallows in thy garden, but eat them not. Abſtain from beans."

The following precepts are more important: "Diſcourſe not of Pythagorean doctrines without light. Above all things govern your tongue. Engrave not the image of God in a ring. Quit not your ſtation without the command of your general. Remember that the paths of virtue and of vice reſemble the letter Y. To this ſymbol Perſius refers *, when he ſays,

* Sat. iii. 56.

Et tibi quæ Samios diduxit litera ramos,
Surgentem dextro monſtravit limite collem.

There has the Samian Y's inſtructive make
Pointed the road thy doubtful foot ſhould take;
There warn'd thy raw and yet unpractis'd youth,
To tread the riſing right-hand path of truth.

Pythagoreans || Python.

The ſcantineſs and uncertainty of our information reſpecting Pythagoras, renders a regular and complete account of his life and doctrines impoſſible. A modern author † of profound erudition, pronounces him to have been *unqueſtionably* the wiſeſt man that ever lived, if his maſters the Egyptian prieſts muſt not be excepted. This is ſaying a great deal too much; but that he was one of the moſt diſtinguiſhed philoſophers of antiquity, or, as Cicero expreſſes it, *vir præſtanti ſapientia*, appears very evident; and his moral character has never been impeached. The myſterious air which he threw over his doctrines, and the apparent inanity of ſome of his ſymbols, have indeed ſubjected him to the charge of impoſture, and perhaps the charge is not wholly groundleſs: but when we conſider the age in which he lived, and the nature of the people with whom he had to deal, who would in all probability have reſiſted more open innovations, even this will not appear ſo blameable as at firſt ſight we are apt to think it; and it is worthy of notice, that the worſt ſtories of this kind have come down to us in a very queſtionable ſhape, and with much probability appear to be falſe.

† *Ancient Metaphyſics.*

PYTHAGOREANS, a ſect of ancient philoſophers, ſo called from being the followers of Pythagoras. See the preceding article.

PYTHIA, the prieſteſs of Apollo at Delphi, by whom he delivered oracles. She was ſo called from Pythius, a name of that god, which is ſaid to have been given him on account of his victory over the ſerpent Python.

The Pythia was at firſt required to be a young girl, but in later times ſhe was a woman of 50 years of age. The firſt and moſt famous Pythia was Phemonöe. Oracles were at firſt delivered by her in hexameter verſe. All the pythias were to be pure virgins, and all of them delivered their oracles with great enthuſiaſm and violent agitations. See ORACLE and DELPHI.

PYTHIAN GAMES, in Grecian antiquity, ſports inſtituted near Delphos in honour of Apollo, on account of his ſlaying the ſerpent Python. See APOLLO.—Theſe games, at their firſt inſtitution, were celebrated only once in nine years; but afterwards every fifth year, from the number of the Parnaſſian nymphs who came to congratulate Apollo, and to make him preſents on his victory. The victor was crowned with garlands.

PYTHON, in fabulous hiſtory, a monſtrous ſerpent, produced by the earth after Deucalion's deluge. Juno being exaſperated at Latona, who was beloved by Jupiter, commanded this ſerpent to deſtroy her; but flying from the purſuit of the monſter, ſhe eſcaped to Delos, where ſhe was delivered of Diana and Apollo; the latter of whom at length deſtroyed Python with his arrows, in memory of which victory the Pythian games were inſtituted. See APOLLO.

Q.

Q, or *q*, the 16th letter and 12th conſonant of our alphabet; but is not to be found either in the Greek, old Latin, or Saxon alphabets; and indeed ſome would entirely exclude it, pretending that *k* ought to be uſed wherever this occurs. However, as it is formed in the voice in a different manner, it is undoubtedly a diſtinct letter: for, in expreſſing this ſound, the cheeks are contracted, and the lips, particularly the under one, are put into a canular form, for the paſſage of the breath.

The q is never ſounded alone, but in conjunction with u, as in *quality*, *queſtion*, *quite*, *quote*, &c. and never ends any Engliſh word.

As a numeral, Q ſtands for 500; and with a daſh over it, thus Q̄ for 500,000.

Uſed as an abbreviature *q* ſignifies *quantity*, or *quantum*. Thus, among phyſicians, *q. pl.* is *quantum placet*, i. e. "as much as you pleaſe" of a thing; and *q. ſ.* is *quantum ſufficit*, i. e. "as much as is neceſſary." Q. E. D. among mathematicians, is *quod erat demonſtrandum*, i. e. "which was to be demonſtrated:" and Q. E. F. is *quod erat faciendum*, i. e. "which was to be done." Q. D. among grammarians is *quaſi dictum*, i. e. "as if it were ſaid;" or, "as who ſhould ſay." In the notes of the ancients, Q ſtands for *Quintus*, or *Quintius*; Q. B. V. for *quod bene vertat*; Q. S. S. S. for *quæ ſupra ſcripta ſunt*; Q. M. for *Quintus Mutius*, or *quomodo*; Quint. for *Quintilius*; and Quæſ. for *quæſtor*.

QUAB, in *Ichthyology*, the name of a Ruſſian fiſh, which is ſaid to be at firſt a tadpole, then a frog, and at laſt a fiſh. Dr Mounſey, who made many inquiries concerning theſe pretended changes, conſiders them all as fabulous. He had opportunity of ſeeing the fiſh itſelf, and found that they ſpawned like other fiſhes, and grew in ſize, without any appearances to juſtify the report. He adds, that they delight in very clear water, in rivers with ſandy or ſtony bottoms, and are never found in ſtanding lakes, or in rivers paſſing through marſhes or moſſy grounds, where frogs chooſe moſt to be.

QUABES, are a free people of Africa, inhabiting the ſouthern banks of the river Seſtos, and between that and Sierra Leona. They are under the protection of the emperor of Manow.

QUACHA, or QUAGGA. See EQUUS, MAMMALIA *Index*.

Marcgrave's Hiſt. Braſil.

QUACHILTO, in *Ornithology*, is the name of a very beautiful Braſilian bird, called alſo *yacazintli* and *porphyrio Americanus*. It is of a fine blackiſh purple colour, variegated with white; its beak is white while young, but becomes red as it grows older, and has a naked ſpace at its baſis, reſembling in ſome ſort the coot; its legs are of a yellowiſh green; it lives about the waters, and feeds on fiſh, yet is a very well taſted bird. It imitates the crowing of a common cock, and makes its muſic early in the morning.

QUACK, among phyſicians, the ſame with empiric. See EMPIRIC.

QUADI, (Tacitus); a people of Germany, ſituated to the ſouth-eaſt of the mountains of Bohemia, on the banks of the Danube, and extending as far as the river Marus, or March, running by Moravia, which country they occupied.

QUADRAGESIMA, a denomination given to lent, from its conſiſting of 40 days. See LENT.

QUADRANGLE, in *Geometry*, the ſame with a quadrilateral figure, or one conſiſting of four ſides and four angles.

QUADRANS, the quarter or fourth part of any thing, particularly the *as*, or pound.

QUADRANS, in Engliſh money, the fourth part of a penny. Before the reign of Edward I. the ſmalleſt coin was a *ſterling*, or penny, marked with a croſs; by the guidance of which a penny might be cut into halves for a halfpenny, or into quarters or four parts for farthings; till, to avoid the fraud of unequal cuttings, that king coined halfpence and farthings in diſtinct round pieces.

QUADRANT, in *Geometry*, the arch of a circle, containing 90°, or the fourth part of the entire periphery.

Sometimes alſo the ſpace or area, included between this arch and two radii drawn from the centre to each extremity thereof, is called a *quadrant*, or, more properly, a *quadrantal ſpace*, as being a quarter of an entire circle.

QUADRANT, alſo denotes a mathematical inſtrument, of great uſe in aſtronomy and navigation, for taking the altitudes of the ſun and ſtars, as alſo for taking angles in ſurveying, &c.

This inſtrument is variouſly contrived, and furniſhed with different apparatus, according to the various uſes it is intended for; but they all have this in common, that they conſiſt of a quarter of a circle, whoſe limb is divided into 90°. Some have a plummet ſuſpended from the centre, and are furniſhed with ſights to look through.

The principal and moſt uſeful quadrants are the common ſurveying quadrant, aſtronomical quadrant, Adams's quadrant, Cole's quadrant, Gunter's quadrant, Hadley's quadrant, horodictical quadrant, Sutton's or Collins's quadrant, and the ſinical quadrant, &c. Of each of which in order.

1. The common ſurveying quadrant, is made of braſs, wood, or any other ſolid ſubſtance; the limb of which is divided into 90°, and each of theſe farther divided into as many equal parts as the ſpace will allow, either diagonally or otherwiſe. On one of the ſemidiameters are fitted two moveable ſights; and to the centre is ſometimes alſo fixed a label, or moveable index, bearing two other ſights; but in lieu of theſe laſt ſights there is ſometimes fitted a teleſcope: alſo from the centre there is hung a thread with a plummet; and on the under ſide or face of the inſtrument is fitted a ball and ſocket, by means of which it may be put into any poſition. The general uſe of it is for taking angles in a vertical plane, comprehended under right lines going

Quadrant.

from the centre of the inftrument, one of which is horizontal, and the other is directed to fome vifible point. But befides the parts already defcribed, there is frequently added on the face, near the centre, a kind of compartment, called the *quadrat*, or *geometrical fquare*. See QUADRAT.

This quadrant may be ufed in different fituations: for obferving heights or depths, its plane muft be difpofed perpendicularly to the horizon; but to take horizontal diftances, its plane is difpofed parallel thereto. Again, heights and diftances may be taken two ways, viz. by means of the fixed fights and plummet, or by the label: As to which, and the manner of meafuring angles, fee GEOMETRY and MENSURATION.

2. The aftronomical quadrant is a large one, ufually made of brafs, or wooden bars faced with iron plates; having its limb nicely divided, either diagonally or otherwife, into degrees, minutes, and feconds; and furnifhed with two telefcopes, one fixed on the fide of the quadrant, and the other moveable about the centre, by means of the fcrew. There are alfo dented wheels which ferve to direct the inftrument to any object or phenomenon.—The ufe of this curious inftrument, in taking obfervations of the fun, planets, and fixed ftars, is obvious; for being turned horizontally upon its axis, by means of the telefcope, till the object is feen through the moveable telefcope, then the degrees, &c. cut by the index give the altitude required. See ASTRONOMY *Index*.

3. Cole's quadrant is a very ufeful inftrument invented by Mr Benjamin Cole. It confifts of fix parts, viz.

Plate CCCCLVIII. Fig. 1.

the ftaff AB (fig. 1.); the quadrantal arch DE; three vanes A, B, C; and the vernier FG. The ftaff is a bar of wood about two feet long, an inch and a quarter broad, and of a fufficient thicknefs to prevent it from bending or warping. The quadrantal arch is alfo of wood; and is divided into degrees, and third-parts of a degree, to a radius of about nine inches; to its extremities are fitted two radii, which meet in the centre of the quadrant by a pin, round which it eafily moves. The fight-vane A is a thin piece of brafs, almoft two inches in height and one broad, placed perpendicularly on the end of the ftaff A, by the help of two fcrews paffing through its foot. Through the middle of this vane is drilled a fmall hole, through which the coincidence or meeting of the horizon and folar fpot is to be viewed. The horizon vane B is about an inch broad, and two inches and a half high, having a flit cut through it of near an inch long and a quarter of an inch broad; this vane is fixed in the centre-pin of the inftrument, in a perpendicular pofition, by the help of two fcrews paffing through its foot, whereby its pofition with refpect to the fight-vane is always the fame, their angles of inclination being equal to 45 degrees. The fhade-vane C is compofed of two brafs plates. The one, which ferves as an arm, is about four inches and a half long, and three quarters of an inch broad, being pinned at one end to the upper limb of the quadrant by a fcrew, about which it has a fmall motion; the other end lies in the arch, and the lower edge of the arm is directed to the middle of the centre-pin; the other plate, which is properly the vane, is about two inches long, being fixed perpendicularly to the other plate, at about half an inch diftance from that end next the arch; this vane may be ufed either by its fhade or by the folar fpot caft by a convex lens placed therein. And, becaufe the wood-work is often apt to warp or twift, therefore this vane may be rectified by the help of a fcrew, fo that the warping of the inftrument may occafion no error in the obfervation, which is performed in the following manner: Set the line G on the vernier againft a degree on the upper limb of the quadrant, and turn the fcrew on the backfide of the limb forward or backward, till the hole in the fight-vane, the centre of the glafs, and the funk fpot in the horizon-vane, lie in a right line.

Quadrant.

To find the fun's altitude by this inftrument: Turn your back to the fun, holding the inftrument by the ftaff with your right hand, fo that it be in a vertical plane paffing through the fun; apply your eye to the fight-vane, looking through that and the horizon-vane till you fee the horizon; with the left hand flide the quadrantal arch upwards, until the folar fpot or fhade, caft by the fhade-vane, fall directly on the fpot or flit in the horizon-vane; then will that part of the quadrantal arch, which is raifed above G or S (according as the obfervation refpected either the folar fpot or fhade) fhow the altitude of the fun at that time. But if the meridian altitude be required, the obfervation muft be continued; and as the fun approaches the meridian, the fea will appear through the horizon-vane, and then is the obfervation finifhed; and the degrees and minutes, counted as before, will give the fun's meridian altitude: or the degrees counted from the lower limb upwards will give the zenith-diftance.

4. Adams's quadrant differs only from Cole's quadrant in having an horizontal vane, with the upper part of the limb lengthened; fo that the glafs, which cafts the folar fpot on the horizon-vane, is at the fame diftance from the horizon-vane as the fight-vane at the end of the index.

5. Gunter's quadrant, fo called from its inventor Edmund Gunter, befides the ufual apparatus of other quadrants, has a ftereographical projection of the fphere on the plane of the equinoctial. It has alfo a kalendar of the months, next to the divifions of the limb.

Ufe of Gunter's quadrant. 1. To find the fun's meridian altitude for any given day, or the day of the month for any given meridian altitude. Lay the thread to the day of the month in the fcale next the limb; and the degree it cuts in the limb is the fun's meridian altitude. Thus the thread, being laid on the 15th of May, cuts 59° 30′, the altitude fought; and, contrarily, the thread, being fet to the meridian altitude, fhows the day of the month. 2. To find the hour of the day. Having put the bead, which flides on the thread, to the fun's place in the ecliptic, obferve the fun's altitude by the quadrant; then, if the thread be laid over the fame in the limb, the bead will fall upon the hour required. Thus fuppofe on the 10th of April, the fun being then in the beginning of Taurus, I obferve the fun's altitude by the quadrant to be 36°; I place the bead to the beginning of Taurus in the ecliptic, and lay the thread over 36° of the limb; and find the bead to fall on the hour-line marked three and nine; accordingly the hour is either nine in the morning or three in the afternoon. Again, laying the bead on the hour given, having firft rectified or put it to the fun's place, the degree cut by the thread on the limb gives the altitude. Note, the bead may be rectified otherwife, by bringing

bringing the thread to the day of the month, and the bead to the hour-line of 12. 3. To find the ſun's declination from his place given, and contrariwiſe. Set the bead to the ſun's place in the ecliptic, move the thread to the line of declination, and the bead will cut the degree of declination required. Contrarily, the bead being adjuſted to a given declination, and the thread moved to the ecliptic, the bead will cut the ſun's place. 4. The ſun's place being given, to find his right aſcenſion, or contrarily. Lay the thread on the ſun's place in the ecliptic, and the degree it cuts on the limb is the right aſcenſion ſought. Contrarily, laying the thread on the right aſcenſion, it cuts the ſun's place in the ecliptic. 5. The ſun's altitude being given, to find his azimuth, and contrariwiſe. Rectify the bead for the time, as in the ſecond article, and obſerve the ſun's altitude: bring the thread to the complement of that altitude; thus the bead will give the azimuth ſought, among the azimuth lines. 6. To find the hour of the night from ſome of the five ſtars laid down on the quadrant. (1.) Put the bead to the ſtar you would obſerve, and find how many hours it is off the meridian, by article 2. (2.) Then, from the right aſcenſion of the ſtar, ſubtract the ſun's right aſcenſion converted into hours, and mark the difference; which difference, added to the obſerved hour of the ſtar from the meridian, ſhows how many hours the ſun is gone from the meridian, which is the hour of the night. Suppoſe on the 15th of May the ſun is in the 4th degree of Gemini, I ſet the bead to Arcturus; and, obſerving his altitude, find him to be in the weſt about 52° high, and the bead to fall on the hour-line of two in the afternoon; then will the hour be 11 hours 50 minutes paſt noon, or 10 minutes ſhort of midnight: for 62°, the ſun's right aſcenſion, converted into time, makes four hours eight minutes; which, ſubtracted from 13 hours 58 minutes, the right aſcenſion of Arcturus, the remainder will be nine hours 50 minutes; which added to two hours, the obſerved diſtance of Arcturus from the meridian, ſhows the hour of the night to be 11 hours 50 minutes.

The mural quadrant has been already deſcribed under the article Astronomy. It is a moſt important inſtrument, and has been much improved by Mr Ramſden, who has diſtinguiſhed himſelf by the accuracy of his diviſions, and by the manner in which he finiſhes the planes by working them in a vertical poſition. He places the plumb-line behind the inſtrument, that there may be no neceſſity for removing it when we take an obſervation near the zenith. His manner of ſuſpending the glaſs, and that of throwing light on the object-glaſs and on the diviſions at the ſame time, are new, and improvements that deſerve to be noticed. Thoſe of eight feet, which he has made for the obſervatories of Padua and Vilna, have been examined by Dr Maſkelyne; and the greateſt error does not exceed two ſeconds and a half. That of the ſame ſize for the obſervatory of Milan is in a very advanced ſtate. The mural quadrant, of ſix feet, at Blenheim, in a moſt admirable inſtrument. It is fixed to four pillars, which turn on two pivots, ſo that it may be put to the north and to the ſouth in one minute. It was for this inſtrument Mr Ramſden invented a method of rectifying the arc of 90 degrees, on which an able aſtronomer had ſtarted ſome difficulties; but by means of an horizontal line and a plumb-line, forming a kind of croſs, without touching the circle, he ſhowed him that there was not an error of a ſingle ſecond in the 90 degrees; and that the difference was occaſioned by a mural quadrant of Bird, in which the arc of 90 degrees was too great by ſeveral ſeconds, and which had never been rectified by ſo nice a method as that of Mr Ramſden.

But the quadrant is not the inſtrument which ſtands higheſt in Mr Ramſden's opinion; it is the complete circle: and he has demonſtrated to M. de la Lande, that the former muſt be laid aſide, if we would arrive at the utmoſt exactneſs of which an obſervation is capable. His principal reaſons are: 1. The leaſt variation in the centre is perceived by the two diametrically oppoſite points. 2. The circle being worked on the turn, the ſurface is always of the greateſt accuracy, which it is impoſſible to obtain in the quadrant. 3. We may always have two meaſures of the ſame arc, which will ſerve for the verification of each other. 4. The firſt point of the diviſion may be verified every day with the utmoſt facility. 5. The dilatation of the metal is uniform, and cannot produce any error. 6. This inſtrument is a meridian glaſs at the ſame time. 7. It alſo becomes a moveable azimuth circle by adding a horizontal circle beneath its axis, and then gives the refractions independent of the menſuration of time.

6. Hadley's quadrant is an inſtrument of vaſt utility both in navigation and practical aſtronomy. It derives its name from Mr Hadley, who firſt publiſhed an account of it, though the firſt thought originated with the celebrated Dr Hooke, and was completed by Sir Iſaac Newton (ſee Astronomy, N° 32. and alſo N° 17. and 22.). The utility of this quadrant ariſes from the accuracy and preciſion with which it enables us to determine the latitude and longitude; and to it is navigation much indebted for the very great and rapid advances it has made of late years. It is eaſy to manage, and of extenſive uſe, requiring no peculiar ſteadineſs of hand, nor any ſuch fixed baſis as is neceſſary to other aſtronomical inſtruments. It is uſed as an inſtrument for taking angles in maritime ſurveying, and with equal facility at the maſt head as upon the deck, by which its ſphere of obſervation is much extended; for ſuppoſing many iſlands to be viſible from the maſt head, and only one from deck, no uſeful obſervation can be made by any other inſtrument. But by this, angles may be taken at the maſt head from the one viſible object with great exactneſs; and further, taking angles from heights, as hills, or a ſhip maſt's head, is almoſt the only way of deſcribing exactly the figure and extent of ſhoals.

It has been objected to the uſe of this inſtrument for ſurveying, that it does not meaſure the horizontal angles, by which alone a plan can be laid down. This objection, however true in theory, may be reduced in practice by a little caution; and Mr Adams has given very good directions for doing ſo.

Notwithſtanding, however, the manifeſt ſuperiority of this inſtrument over thoſe that were in uſe at the time of its publication, it was many years before the ſailors could be perſuaded to adopt it, and lay aſide their imperfect and inaccurate inſtruments; ſo great is the difficulty to remove prejudice, and emancipate the mind from the ſlavery of opinion. No inſtrument has undergone, ſince the original invention, more changes than

Quadrant.

than the quadrant of Hadley; of the various alterations, many had no better foundation than the caprice of the makers, who by these attempts have often rendered the instrument more complicated in construction, and more difficult in use, than it was in its original state.

It is an essential property of this instrument, derived from the laws of reflection, that half degrees on the arc answer to whole ones in the angles measured: hence an octant, or the eighth part of a circle, or 45 degrees on the arch, serves to measure 90 degrees; and sextants will measure an angular distance of 120 degrees, though the arch of the instrument is no more than 60 degrees. It is from this property that foreigners term that instrument an *octant*, which we usually call a *quadrant*, and which in effect it is. This property reduces indeed considerably the bulk of the instrument: but at the same time it calls for the utmost accuracy in the divisions, as every error on the arch is doubled in the observation.

Another essential, and indeed an invaluable, property of this instrument, whereby it is rendered peculiarly advantageous in marine observations, is, that it is not liable to be disturbed by the ship's motion; for provided the mariner can see distinctly the two objects in the field of his instrument, no motion nor vacillation of the ship will injure his observation.

Thirdly, the errors to which it is liable are readily discovered and easily rectified, while the application and use of it is facile and plain.

To find whether the two surfaces of any one of the reflecting glasses be parallel, apply your eye at one end of it, and observe the image of some object reflected very obliquely from it; if that image appear single, and well-defined about the edges, it is a proof that the surfaces are parallel: on the contrary, if the edge of the reflected images appear misted, as if it threw a shadow from it, or separated like two edges, it is a proof that the two surfaces of the glass are inclined to each other: if the image in the speculum, particularly if that image be the sun, be viewed through a small telescope, the examination will be more perfect.

To find whether the surface of a reflecting glass be plane. Choose two distant objects, nearly on a level with each other: hold the instrument in an horizontal position, view the left-hand object directly through the transparent part of the horizon-glass, and move the index till the reflected image of the other is seen below it in the silvered part; make the two images unite just at the line of separation, then turn the instrument round slowly on its own plane, so as to make the united images move along the line of separation of the horizon-glass. If the images continue united without receding from each other, or varying their respective position, the reflecting surface is a good plane.

To find if the two surfaces of a red or darkening glass are parallel and perfectly plane. This must be done by means of the sun when it is near the meridian, in the following manner: hold the sextant vertically, and direct the sight to some object in the horizon, or between you and the sky, under the sun; turn down the red glass and move the index till the reflected image of the sun is in contact with the object seen directly: fix then the index, and turn the red glass round in its square frame; view the sun's image and object immediately, and if the sun's image is neither raised nor depressed, but continues in contact with the object below, as before, then the surfaces of the darkening glass are true.

For a more particular description of Hadley's quadrant, and the mode of using it, see NAVIGATION, Book II. chap. i.

This instrument has undergone several improvements since its first invention, and among these improvers must be ranked Mr Ramsden. He found that the essential parts of the quadrant had not a sufficient degree of solidity; the friction at the centre was too great, and in general the alidada might be moved several minutes without any change in the position of the mirror; the divisions were commonly very inaccurate, and Mr Ramsden found that Abbé de la Caille did not exceed the truth in estimating at five minutes the error to which an observer was liable in taking the distance between the moon and a star; an error capable of producing a mistake of 50 leagues in the longitude. On this account Mr Ramsden changed the principle of construction of the centre, and made the instrument in such a manner as never to give an error of more than half a minute; and he has now brought them to such a degree of perfection as to warrant it not more than six seconds in a quadrant of fifteen inches. Since the time of having improved them, Mr Ramsden has constructed an immense number; and in several which have been carried to the East Indies and America, the deficiency has been found no greater at their return than it had been determined by examinations before their being taken out. Mr Ramsden has made them from 15 inches to an inch and a half, in the latter of which the minutes are easily distinguishable; but he prefers for general use those of 10 inches, as being more easily handled than the greater, and at the same time capable of equal accuracy. See SEXTANT.

A great improvement was also made in the construction of this quadrant by Mr Peter Dollond, famous for his invention of achromatic telescopes. The glasses of the quadrants should be perfect planes, and have their surfaces perfectly parallel to one another. By a practice of several years, Mr Dollond found out methods of grinding them of this form to great exactness; but the advantage which should have arisen from the goodness of the glasses was often defeated by the index-glass being bent by the frame which contains it. To prevent this, Mr Dollond contrived the frame so, that the glass lies on three points, and the part that presses on the front of the glass has also three points opposite to the former. These points are made to confine the glass by three screws at the back, acting directly opposite to the points between which the glass is placed. The principal improvements, however, are in the methods of adjusting the glasses, particularly for the back-observation. The method formerly practised for adjusting that part of the instrument by means of the opposite horizons at sea, was attended with so many difficulties that it was scarcely ever used: for so little dependence could be placed on the observations taken this way, that the best Hadley's sextants made for the purpose of observing the distances of the moon from the sun or fixed stars have been always made without the horizon-glass for the back-observation; for want of which, many valuable observations of the sun and moon have been lost, when their distance exceeded 120 degrees.

grees. To make the adjuſtment of the back-obſervation eaſy and exact, he applied an index to the back horizon-glaſs, by which it may be moved in a parallel poſition to the index-glaſs, in order to give it the two adjuſtments in the ſame manner as the fore-horizon-glaſs is adjuſted. Then, by moving the index to which the back-horizon-glaſs is fixed exactly 90 degrees (which is known by the diviſions made for that purpoſe), the glaſs will thereby be ſet at right angles to the index-glaſs, and will be properly adjuſted for uſe; and the obſervations may be made with the ſame accuracy by this as by the fore-obſervation. To adjuſt the horizon-glaſſes in the perpendicular poſition to the plane of the inſtrument, he contrived to move each of them by a ſingle ſcrew, which goes though the frame of the quadrant, and is turned by means of a milled head at the back; which may be done by the obſerver while he is looking at the object. To theſe improvements alſo he added a method, invented by Dr Maſkelyne, of placing darkening-glaſſes behind the horizon-glaſſes. Theſe, which ſerve for darkening the object ſeen by direct viſion, in adjuſting the inſtrument by the ſun or moon, he placed in ſuch a manner as to be turned behind the fore horizon-glaſs, or behind the back horizon-glaſs: there are three of theſe glaſſes of different degrees of darkneſs.

We have been the more particular in our deſcription and uſe of Hadley's quadrant, as it is undoubtedly the beſt hitherto invented.

7. Horodictical quadrant, a pretty commodious inſtrument, ſo called from its uſe in telling the hour of the day.—Its conſtruction is this: From the centre of

Fig. 3. the quadrant, C, fig. 3. whoſe limb AB is divided into 90°, deſcribe ſeven concentric circles at intervals at pleaſure; and to theſe add the ſigns of the zodiac, in the order repreſented in the figure. Then applying a ruler to the centre C and the limb AB, mark upon the ſeveral parallels the degrees correſponding to the altitude of the ſun when therein, for the given hours; connect the points belonging to the ſame hour with a curve line, to which add the number of the hour. To the radius CA fit a couple of ſights, and to the centre of the quadrant C tie a thread with a plummet, and upon the thread a bead to ſlide. If now the thread be brought to the parallel wherein the ſun is, and the quadrant directed to the ſun, till a viſual ray paſs through the ſights, the bead will ſhow the hour; for the plummet, in this ſituation, cuts all the parallels in the degrees correſponding to the ſun's altitude. Since the bead is in the parallel which the ſun deſcribes, and through the degrees of altitude to which the ſun is elevated every hour there paſs hour lines, the bead muſt ſhow the preſent hour. Some repreſent the hour-lines by arches of circles, or even by ſtraight lines, and that without any ſenſible error.

Fig. 4. 8. Sutton's or Collins's quadrant (fig. 4.) is a ſtereographic projection of one quarter of the ſphere between the tropics, upon the plane of the ecliptic, the eye being in its north pole: it is fitted to the latitude of London. The lines running from the right hand to the left are parallels of altitude; and thoſe croſſing them are azimuths. The leſſer of the two circles, bounding the projection, is one-fourth of the tropic of Capricorn; the greater is one-fourth of that of Cancer. The two ecliptics are drawn from a point on the left edge of the quadrant, with the characters of the ſigns upon them; and the two horizons are drawn from the ſame point. The limb is divided both into degrees and time; and, by having the ſun's altitude, the hour of the day may be found here to a minute. The quadrantal arches next the centre contain the kalendar of months; and under them, in another arch, is the ſun's declination. On the projection are placed ſeveral of the moſt noted fixed ſtars between the tropics; and the next below the projection is the quadrant and line of ſhadows. To find the time of the ſun's riſing or ſetting, his amplitude, his azimuth, hour of the day, &c. by this quadrant: lay the thread over the day and the month, and bring the bead to the proper ecliptic, either of ſummer or winter, according to the ſeaſon, which is called *rectifying;* then, moving the thread, bring the bead to the horizon, in which caſe the thread will cut the limb in the time of the ſun's riſing or ſetting before or after ſix; and at the ſame time the bead will cut the horizon in the degrees of the ſun's amplitude.—Again, obſerving the ſun's altitude with the quadrant, and ſuppoſing it found 45° on the fifth of May, lay the thread over the fifth of May, bring the bead to the ſummer ecliptic, and carry it to the parallel of altitude 45°; in which caſe the thread will cut the limb at 55° 15′, and the hour will be ſeen among the hour-lines to be either 41′ paſt nine in the morning, or 19′ paſt two in the afternoon.—Laſtly, the bead among the azimuths ſhows the ſun's diſtance from the ſouth 50° 41′. But note, that if the ſun's altitude be leſs than what it is at ſix o'clock, the operation muſt be performed among thoſe parallels above the upper horizon, the head being rectified to the winter ecliptic.

9. Sinical quadrant (fig. 5.) conſiſts of ſeveral concentric quadrantal arches, divided into eight equal parts by radii, with parallel right lines croſſing each other at right angles. Now any one of the arches, as BC, may repreſent a quadrant of any great circle of the ſphere, but is chiefly uſed for the horizon or meridian. If then BC be taken for a quadrant of the horizon, either of the ſides, as AB, may repreſent the meridian; and the other ſide, AC, will repreſent a parallel, or line of eaſt and weſt: and all the other lines, parallel to AB, will be alſo meridians; and all thoſe parallel to AC, eaſt and weſt lines, or parallels.—Again, the eight ſpaces into which the arches are divided by the radii, repreſent the eight points of the compaſs in a quarter of the horizon; each containing 11° 15′. The arch BC is likewiſe divided into 90°, and each degree ſubdivided into 12, diagonal-wiſe. To the centre is fixed a thread, which, being laid over any degree of the quadrant, ſerves to divide the horizon. Fig. 5.

If the ſinical quadrant be taken for a fourth part of the meridian, one ſide thereof, AB, may be taken for the common radius of the meridian and equator; and then the other, AC, will be half the axis of the world. The degrees of the circumference, BC, will repreſent degrees of latitude; and the parallels to the ſide AB, aſſumed from every point of latitude to the axis AC, will be radii of the parallels of latitude, as likewiſe the ſine complement of thoſe latitudes.

Suppoſe, then, it be required to find the degrees of longitude contained in 83 of the leſſer leagues in the parallel of 48°; lay the thread over 48° of latitude on the circumference, and count thence the 83 leagues on

Quadrant. AB, beginning at A; this will terminate in H, allowing every ſmall interval four leagues. Then tracing out the parallel HE, from the point H to the thread; the part AE of the thread ſhows that 125 greater or equinoctial leagues make 60° 15′; and therefore that the 83 leſſer leagues AH, which make the difference of longitude of the courſe, and are equal to the radius of the parallel HE, make 60° 15′ of the ſaid parallel.

If the ſhip ſails an oblique courſe, ſuch courſe, beſides the north and ſouth greater leagues, gives leſſer leagues eaſterly and weſterly, to be reduced to degrees of longitude of the equator. But theſe leagues being made neither on the parallel of departure, nor on that of arrival, but in all the intermediate ones, we muſt find a mean proportional parallel between them. To find this, we have on the inſtrument a ſcale of croſs latitudes. Suppoſe then it were required to find a mean parallel between the parallels of 40° and 60°; with your compaſſes take the middle between the 40th and 60th degree on this ſcale: the middle point will terminate againſt the 51ſt degree, which is the mean parallel required.

The principal uſe of the ſinical quadrant is to form triangles upon, ſimilar to thoſe made by a ſhip's way with the meridians and parallels; the ſides of which triangles are meaſured by the equal intervals between the concentric quadrants and the lines N and S, E and W: and every fifth line and arch is made deeper than the reſt. Now, ſuppoſe a ſhip to have ſailed 150 leagues north-eaſt, one fourth north, which is the third point, and makes an angle of 33° 44′ with the north part of the meridian: here are given the courſe and diſtance ſailed, by which a triangle may be formed on the inſtrument ſimilar to that made by the ſhip's courſe; and hence the unknown parts of the triangle may be found. Thus, ſuppoſing the centre A to repreſent the place of departure, count, by means of the concentric circles along the point the ſhip ſailed on, viz. AD, 150 leagues: then in the triangle AED, ſimilar to that of the ſhip's courſe, find AE=difference of latitude, and DE= difference of longitude, which muſt be reduced according to the parallel of latitude come to.

Fig. 6. 10. Gunner's quadrant (fig. 6.), ſometimes called *gunner's ſquare*, is that uſed for elevating and pointing cannon, mortars, &c. and conſiſts of two branches either of braſs or wood, between which is a quadrantal arch divided into 90 degrees, beginning from the ſhorter branch, and furniſhed with a thread and plummet, as repreſented in the figure.—The uſe of the gunner's quadrant is extremely eaſy; for if the longeſt branch be placed in the mouth of the piece, and it be elevated till the plummet cut the degree neceſſary to hit a propoſed object, the thing is done. Sometimes on one of the ſurfaces of the long branch are noted the diviſion of diameters and weights of iron bullets, as alſo the bores of pieces.

QUADRANT of Altitude, is an appendage of the artificial globe, conſiſting of a lamina, or ſlip of braſs, the length of a quadrant of one of the great circles of the globe, and graduated. At the end, where the diviſion terminates, is a nut rivetted on, and furniſhed with a ſcrew, by means whereof the inſtrument is fitted on the meridian, and moveable round upon the rivet to all points of the horizon.—Its uſe is to ſerve as a ſcale in meaſuring altitudes, amplitudes, azimuths, &c. See ASTRONOMY.

Quadrantal ‖ Quadrature.

QUADRANTAL, in *Antiquity*, the name of a veſſel in uſe among the Romans for the meaſuring of liquids. It was at firſt called *amphora*; and afterwards *quadrantal*, from its form, which was ſquare every way like a die. It capacity was 80 libræ, or pounds of water, which made 48 ſextaries, two urnæ, or eight congii.

QUADRAT, a mathematical inſtrument, called alſo a *Geometrical Square*, and *Line of Shadows*: it is frequently an additional member on the face of the common quadrant, as alſo on thoſe of Gunter's and Sutton's quadrants.

QUADRAT, in *Printing*, a piece of metal uſed to fill up the void ſpaces between words, &c. There are quadrats of different ſizes; as m-quadrats, n-quadrats, &c. which are reſpectively of the dimenſions of theſe letters, only lower, that they may not receive the ink.

QUADRATIC EQUATIONS, in *Algebra*, thoſe wherein the unknown quantity is of two dimenſions, or raiſed to the ſecond power. See ALGEBRA.

QUADRATRIX, in *Geometry*, a mechanical line, by means whereof we can find right lines equal to the circumference of circles, or other curves, and their ſeveral parts.

QUADRATURE, in *Geometry*, denotes the ſquaring, or reducing a figure to a ſquare. Thus, the finding of a ſquare, which ſhall contain juſt as much ſurface or area as a circle, an ellipſis, a triangle, &c. is the quadrature of a circle, ellipſis, &c. The quadrature, eſpecially among the ancient mathematicians, was a great poſtulatum. The quadrature of rectilineal figures is eaſily found, for it is merely the finding their areas or ſurfaces, i. e. their ſquares; for the ſquares of equal areas are eaſily found by only extracting the roots of the areas thus found. The quadrature of curvilinear ſpaces is of more difficult inveſtigation; and in this reſpect extremely little was done by the ancients, except the finding the quadrature of the parabola by Archimedes. In 1657, Sir Paul Neil, Lord Brouncker, and Sir Chriſtopher Wren, geometrically demonſtrated the equality of ſome curvilinear ſpaces to rectilinear ſpaces; and ſoon after the like was proved both at home and abroad of other curves, and it was afterwards brought under an analytical calculus; the firſt ſpecimen of which was given to the public in 1688 by Mercator, in a demonſtration of Lord Brouncker's quadrature of the hyperbola, by Dr Wallis's reduction of a fraction into an infinite ſeries by diviſion. Sir Iſaac Newton, however, had before diſcovered a method of attaining the quantity of all quadruple curves analytically by his fluxions before 1668. It is diſputed between Sir Chriſtopher Wren and Mr Huygens which of them firſt diſcovered the quadrature of any determinate cycloidal ſpace. Mr Leibnitz afterwards found that of another ſpace; and in 1669 Bernoulli diſcovered the quadrature of an infinity of cycloidal ſpaces both ſegments and ſectors, &c. See *SQUARING the Circle*.

QUADRATURE, in *Aſtronomy*, that aſpect of the moon when ſhe is 90° diſtant from the ſun; or when ſhe is in a middle point of her orbit, between the points of conjunction and oppoſition, namely, in the firſt and third quarters. See ASTRONOMY *Index*.

QUADRATUS,

QUADRANT.

Fig. 6.
Gunners Quadrant.

Fig. 1.
Coles Quadrant.

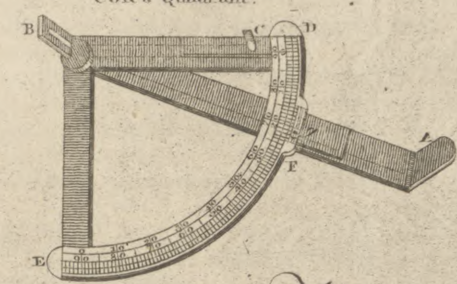


Fig. 4.
Suttons Quadrant.

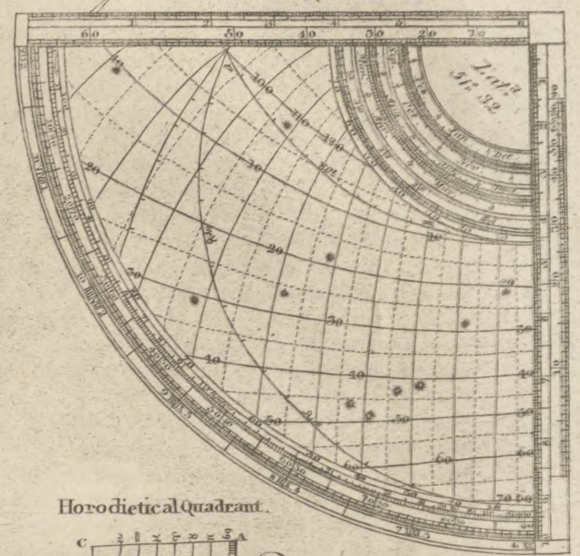


Fig. 5.
Smical Quadrant.

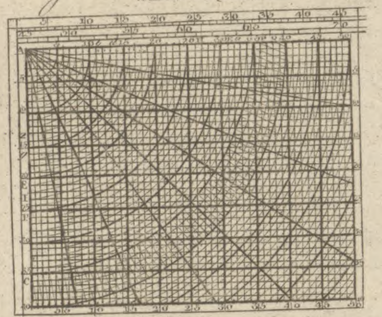
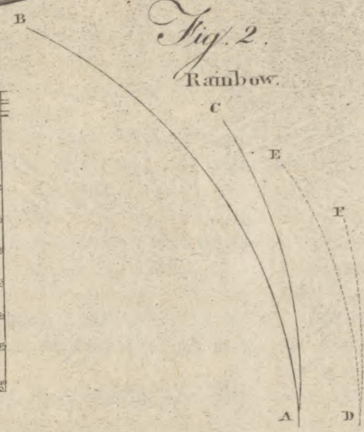


Fig. 2.
Rainbow.



Horodietical Quadrant.

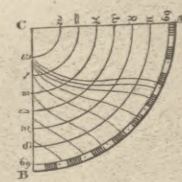


Fig. 3.

QUARTER.

Fig. 7.

Fig. 4.

Fig. 2.

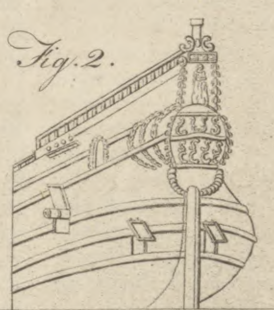


Fig. 1.

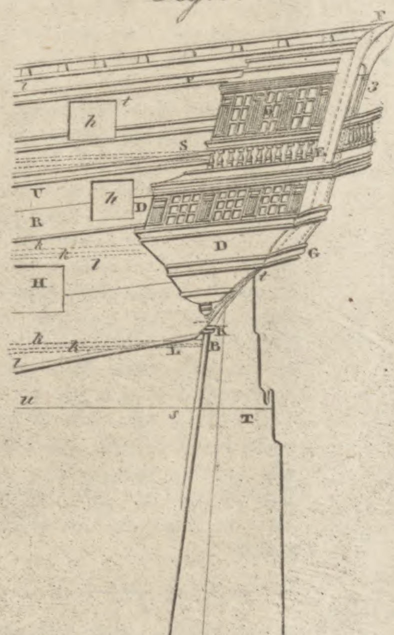


Fig. 3.

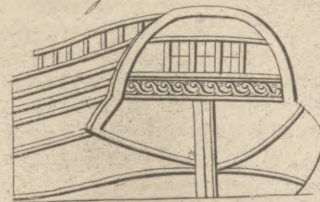


Fig. 5.

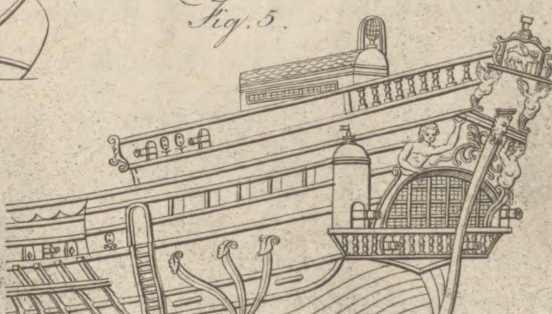
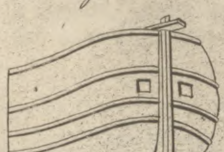


Fig. 6.



A. Bell Prin. Wal. Sculptor fecit.

QUADRATUS, in *Anatomy*, a name given to several muſcles on account of their ſquare figure. See ANATOMY, *Table of the Muſcles.*

QUADREL, in *Building*, a kind of artificial ſtone, ſo called from its being perfectly ſquare. The quadrels are made of a chalky earth, &c. and dried in the ſhade for two years. Theſe were formerly in great requeſt among the Italian architects.

QUADRIGA, in *Antiquity*, a car or chariot drawn by four horſes. On the reverſes of medals, we frequently ſee the emperor or Victory in a quadriga, holding the reins of the horſes; whence theſe coins are, among the curious, called *nummi quadrigati*, and *victoriati*.

QUADRILATERAL, in *Geometry*, a figure whoſe perimeter conſiſts of four ſides and four angles; whence it is alſo called a *quadrangular figure*.

QUADRILLE, a little troop or company of cavaliers, pompouſly dreſſed, and mounted for the performance of carouſals, juſts, tournaments, runnings at the ring, and other gallant divertiſements.

QUADRILLE, a game played by four perſons, with 40 cards; which are the remains of a pack after the four tens, nines, and eights are diſcarded; theſe are dealt three and three, and one round four, to the right hand player; and the trump is made by him that plays with or without calling, by naming ſpades, clubs, diamonds, or hearts, and the ſuit named is trumps. If the perſon who names the trump ſhould miſtake, and ſay ſpades inſtead of clubs, or if he name two ſuits, the firſt named is the trump.

In this game the order of the cards, according to their natural value, is as follows: of hearts and diamonds, *king*, *queen*, *knave*, *ace*, *deuce*, *three*, *four*, *five*, *ſix*, *ſeven*; in all 10: of ſpades and clubs, *king*, *queen*, *knave*, *ſeven*, *ſix*, *five*, *four*, *three*, *deuce*; in all 9. The reaſon why the ace of ſpades and ace of clubs are not mentioned, is, becauſe they are always trumps in whatever ſuit that is played. The ace of ſpades being always the firſt, and the ace of clubs the third trump, for the cards ranked according to their value when *trumps* ſtand in the following order.

Hearts and diamonds, SPADILL, or the *ace of ſpades*; MANILL, the *ſeventh* of the two *red ſuits*; BASTO, the *ace of clubs*; PONTO, the *ace of hearts and diamonds*; *king*, *queen*, *knave*, *deuce*, *three*, *four*, *five*, *ſix*; in all 12. Spades and clubs, SPADILL, the ace of ſpades, MANILL, the *deuce* of ſpades and clubs, BASTO the ace of clubs, *king*, *queen*, *knave*, *ſeven*, *ſix*, *five*, *four*, *three*; in all 11. It is here to be obſerved, that the card which is *manill* and the ſecond trump, is always the loweſt in its ſuit when not trumps; and that the ace of hearts or diamonds, which when trump is above the king, is below the knave when not trump.

There are three matadors; ſpadill, manill, and baſto; the privilege of which is, that when the player has no other trumps but them, and trumps are led, he is not obliged to play them, but may play what card he thinks proper, provided, however, that the trump led is of an inferior rank; but if ſpadill ſhould be led, he that has manill or baſto only is obliged to play it; it is the ſame of manill baſto, with reſpect to the ſuperior matadore always forcing the inferior. Though there are properly but three matadores, nevertheleſs, all thoſe trumps which follow the three firſt without interruption, are likewiſe called matadores; but the three firſt only enjoy the privilege above mentioned.

Each perſon is to play as he judges moſt convenient for his own game. He is not to encourage his friend to play; but each perſon ought to know what to do when it is his turn to play. The ſtakes conſiſt of ſeven equal mils or *contrats*, as they are ſometimes called, compriſing the ten counters and fiſhes, which are given to each player. A mil is equal to ten fiſh, and each fiſh to ten counters: the value of the fiſh is according to the players agreement, as alſo the number of tours, which are generally fixed at ten, and marked by turning the corners of a card.

If the cards ſhould happen not to be deal right, or that there ſhould be two cards of the ſame ſort, as two deuces of ſpades, for example, there muſt be a new deal; provided it is diſcovered before the cards are all played. The cards muſt likewiſe be dealt over again in caſe a card is turned in dealing, as it might be of prejudice to him who ſhould have it; and of courſe if there ſhould be ſeveral cards turned. There is no penalty for dealing wrong, he who does ſo muſt only deal again.

When each player has got his ten cards, he that is on the right hand of the dealer, after examining his game, and finding his hand fit to play, aſks if they play; or if he has not a good hand, he paſſes, and ſo the ſecond, third, and fourth. All the four may paſs; but he that has ſpadill, after having ſhown or named it, is obliged to play by calling a king. Whether the deal is played in this manner, or that one of the players has aſked leave, nobody chooſing to play without calling, the eldeſt hand muſt begin the play, firſt naming the ſuit, and the king which he calls; he who wins the trick plays another card, and ſo of the reſt till the game is finiſhed. The tricks then are counted; and if the ombre, that is, he who ſtands the game, has together with him who is the king called, ſix tricks, they have won and are paid the game, the conſolation, and the matadores, if they have them, and divide what is upon the game, and the beaſts if there are any. But if they make only five tricks, it is a remiſe, and they are beaſted, what goes upon the game, paying to the other players the conſolation and the matadores. If the tricks are equally divided betwixt them, they are likewiſe beaſted; and if they make only four tricks between them, it is a remiſe; if they make leſs they loſe codill (A), and in that caſe they pay to their adverſaries what they ſhould have received if they had won; that is, the game, the conſolation, and the matadores, if they have them, and are beaſted what is upon the game: they who win codill, divide the ſtakes. The beaſt and every thing elſe that is paid, is paid equally betwixt the two loſers; one half by him that calls, and the other half by him that is called, as well in caſe of codill as a remiſe;

(A) Codill is when thoſe who defend the pool make more tricks than they who ſtand the game; which is called *winning the codill*.

Quadrille.

mise; unless the ombre does not make three tricks, in which case he that is called is not only exempted from paying half the beast, but also the game, the consolation, and the matadores if there are any, which the ombre in that case pays alone; and as well in case of a codill as a remise. This is done in order to oblige players not to play games that are unreasonable. There is nevertheless, one case in which if the ombre makes only one trick, he is not beasted alone, and that is, when not having a good hand he passes, and all the other players have passed likewise; he having spadill is obliged to play. Here it would be unjust to oblige him to make three or four tricks; in this case, therefore, he that is called pays one half of the losings. For which reason he that has spadill with a bad hand, should pass, that if he is afterwards obliged to play by calling a king (which is called *forced spadill*), he may not be beasted alone. He that has once passed cannot be admitted to play; and he that has asked leave cannot refuse to play, unless any one should offer to play without calling.

He that has four kings, may call a queen to one of his kings, except that which is trump. He that wants one or more kings, may call one of those kings; but in that case, he must make six tricks alone, and consequently he wins or loses alone. The king of that suit in which he plays cannot be called. No one should play out of his turn, although he is not beasted for so doing. If he who is not the eldest hand has the king called, and plays spadill, manill, or basto, or even the king called in order to show that he is the friend, having other kings that he fears the ombre should trump, he is not to be allowed to go for the vole; he is even beasted, if it appears to be done with that intent. It is not permitted to show a hand though codill may already be won; that it may be seen whether the ombre is beasted alone. If the ombre or his friend shows their cards before they have made six tricks, thinking that they have made them, and there appears a possibility of preventing their making them, the other players can oblige them to play their cards as they think proper.

A player need only name his suit when he plays, without calling a king. He who plays without calling must make six tricks alone to win; for all the other players are united against him, and they are to do what they can to prevent his winning. He who plays without calling, is admitted to play in preference to him who would play with calling; however, if he that has asked leave will play without calling, he has the preference of the other who would force him. These are the two methods of play without calling that are called forced.

As he who plays without calling does not divide the winnings with any person, he consequently, when he loses, pays all by himself: if he loses by remise he is beasted, and pays each of the other players the consolation, the *sans appeller* (which is commonly, but improperly, called the *sans prendre*), and the matadores if there are any; if he loses codill he is likewise beasted and pays to each player what he would have received from each if he had won. They who win codill divide what there is; and if there are any counters remaining, they belong to him of the three who shall have spadill or the highest trump the next deal. It is the same with regard to him who calls one of his own kings; he wins alone or loses alone as in the other case, except the sans appeller, which he does not pay if he loses, or receive if he wins, although he plays alone.

If he plays sans appeller, though he may have a sure game, he is obliged to name his suit; which if he neglects to do, and shows his cards, and says "I play sans appeller;" in that case either of the other players can oblige him to play in what suit he pleases, although he should not have one trump in that suit.

He who has asked leave is not permitted to play sans appeller, unless he is forced; in which case, as was said before, he has the preference of the other that forces him.

A player is not obliged to trump when he has none of the suit led, nor play a higher card in that suit if he has it, being at his option although he is the last player, and the trick should belong to the ombre; but he is obliged to play in the suit led if he can, otherwise he renounces. If he separates a card from his game and shows it, he is obliged to play it, if by not doing it the game may be prejudiced, or if he can give any intelligence to his friend; but especially if it should be a matadore.—He that plays sans appeller, or by calling himself, is not subject to this law. He may turn the tricks made by the other players, and count what has been played as often as it is his turn to play, but not otherwise. If instead of turning a player's tricks, he turns and see his game, or shows it to the other players, he is beasted, together with him whose cards he turned; and each of them must pay one half of the beast.

If any one renounces, he is beasted as often as he has renounced and it is detected; but a renounce is not made till the trick is turned. If the renounce is discovered before the deal is finished, and has been detrimental to the game, the cards must be taken up again, and the game replayed from that trick where the renounce was made; but if the cards are all played, the beast is still made, and the cards must not be replayed; except there should be several renounces in the same deal: then they are to be played again, unless the cards should be mixed. If several beasts are made in the same deal, they all go together, unless it is otherwise agreed at the beginning of the party; and when there are several beasts, the greatest always goes first.

A great advantage accrues from being eldest hand at quadrille, which often renders it very disagreeable to the rest of the players, being obliged to pass with a good hand unless they choose to play alone; and when it happens that the eldest hand having asked leave, the second player has three matadores, several trumps in back, and all small cards, he cannot then even play alone; and having no chance of being called, he must pass with this good hand. On account of which, this method has been thought expedient to remedy this defect of the game; each player having an opportunity of availing himself of the goodness of his game, by adding to the usual method of playing the game that of the mediateur, and the favourite suit.

The first thing to be observed is that of drawing for places, which is done in this manner: One of the players takes four cards; a king, a queen, a knave, and an ace; each player draws one of these cards; and commonly he who comes in last, draws first. The person

son who draws the king sits where he pleases, the queen at his right hand, the knave next the queen, and the ace on the left of the king. The king draws the favourite suit. The number of cards and persons is the same at this game as the other, and is played in the same manner.

The favourite suit is determined by drawing a card out of the pack, and is of the same suit, during the whole party, of the card so drawn.

A king is the mediateur, which is demanded of the others by one of the players, who has a hand he expects to make five tricks of; and through the assistance of this king he can play alone and make six tricks.

In return for the king received, he gives what card he thinks proper with a fish; but must give two fish if it is in the favourite suit. He who asks by calling in the favourite suit, has the preference to him who asks by calling in another; he who asks with the mediateur, has the preference to him who asks by calling in the favourite suit, and by playing alone is obliged to make six tricks to win. He who asks with the mediateur in the favourite suit, has the preference to him who asks with the mediateur in any other suit, and is obliged to play alone, and to make six tricks.

If sans prendre is played in any other suit than the favourite, he who plays it has the preference to him who asks only, or with the mediateur, or even he who plays in the favourite suit with the mediateur; and the sans prendre in the favourite suit has the preference to all other players whatever.

The only difference between this method of playing the game and the other is, that when one of the players demands the mediateur he is obliged to play alone, and to make six tricks, as if he played sans prendre. In this case he should judge from the strength of his hand, whether the aid of the king will enable him to play alone or not.

With the mediateur and without the favourite suit it is played in this manner. The game is marked and played the same as in common, except that a fish extraordinary is given to him who plays the mediateur, and to him who plays sans prendre; that is, he who wins the mediateur receives 13 counters from each; and if he loses by remise he pays 12 to each; and 13 if by codill. The winner of sans prendre receives 17 counters from each; and if by remise he loses, he pays 16 to each, and 17 if by codill.

The vole with the mediateur receives one fish only, as at common quadrille. The beasts are also the same as the common game. The last game is generally played double, and is called *paulans;* but for those who choose to play a higher game, they may play the double colour, which is called the *Turk*, and is double of the favourite suit. There is also a higher game than this, called the *auóde*, which is paying whatever is agreed to him who happens to hold the two aces in his hand.

We have omitted many things respecting the mode of marking the game, and playing the vole, because these are different in different cases, and are to be learned only by practice. The game itself is a very inferior one; but he who wishes to know more of it, may consult Hoyle's games improved by James Beaufort, Esq. from which we have, with very little alteration, taken this article.

QUADRIPARTITION, the dividing by four, or into four equal parts. Hence comes the term *quadripartite*, the fourth part, or something divided into four.

QUADRUPEDS, in *Zoology;* those animals which have four limbs or legs proceeding from the trunk of their body. See MAMMALIA.

QUADRUPLE, four-fold, or something taken four times, or multiplied by four, on which account it is the converse of quadripartition.

QUÆSTOR, see QUESTOR.

QUAGGA, or QUACHA. See EQUUS, MAMMALIA *Index*.

QUAIL. See TETRAO, ORNITHOLOGY *Index*.

Quails are to be taken by means of the call during their whole wooing time, which lasts from April to August. The proper times for using the call are at sunrising, at nine o'clock in the morning, at three in the afternoon, and at sunset; for these are the natural times of the quail's calling. The notes of the cock and hen quail are very different; and the sportsman who expects to succeed in the taking them must be expert in both: for when the cock calls, the answer is to be made in the hen's note; and when the hen calls, the answer is to be made in the cock's. By this means they will come up to the person, so that he may, with great ease, throw the net over them and take them. If a cock-quail be single, on hearing the hen's note he will immediately come; but if he have a hen already with him, he will not forsake her. Sometimes, though only one quail answers to the call, there will three or four come up; and then it is best to have patience, and not run to take up the first, but stay till they are all entangled, as they will soon be.

The quail is a neat cleanly bird, and will not run much into dirty or wet places: in dewy mornings, they will often fly instead of running to the call; and in this case, it is best to let them go over the net, if it so happens that they fly higher than its top; and the sportsman then changing sides, and calling again, the bird will come back, and then will probably be taken in the net.

The calls are to be made of a small leather purse, about two fingers wide, and four fingers long, and made in the shape of a pear; this is to be stuffed half-full of horse-hair, and at the end of it is to be placed a small whistle, made of the bone of a rabbit's leg, or some other such bone: this is to be about two inches long, and the end formed like a flageolet, with a little soft wax. This is to be the end fastened into the purse; the other is to be closed up with the same wax, only that a hole is to be opened with a pin, to make it give a distinct and clear sound. To make this sound, it is to be held full in the palm of the hand, with one of the fingers placed over the top of the wax; then the purse is to be pressed, and the finger is to shake over the middle of it, to modulate the sound it gives into a sort of shake. This is the most useful call; for it imitates the note of the hen quail, and seldom fails to bring a cock to the net if there be one near the place.

The call that imitates the note of the cock, and is used to bring the hen to him, is to be about four inches long, and above an inch thick; it is to be made of a piece of wire turned round and curled, and covered with leather; and one end of it must be closed up with a piece of flat wood, about the middle of which there must

must be a small thread or strap of leather, and at the other end is to be placed the same sort of pipe, made of bone, as is used in the other call. The noise is made by opening and closing the spiral, and gives the same sound that the cock does when he gives the hen a signal that he is near her.

QUAKERS, a religious society, which took its rise in England about the middle of the 17th century, and rapidly found its way into other countries in Europe, and into the English settlements in North America.—The members of this society, we believe, called themselves at first *seekers*, from their *seeking* the truth; but after the society was formed, they assumed the appellation of *friends*. The name of *quakers* was given to them by their enemies; and though an epithet of reproach, seems to be stamped upon them indelibly. Their founder is generally believed to have been George Fox, an illiterate shoemaker (see *George* FOX), but this opinion has been lately controverted. An ingenious writer* having found, or fancied, a similarity of sentiments among the ancient Druids and modern Quakers, seems to think that Fox must have been nothing more than a tool employed by certain deists to pave the way for their system of natural religion, by allegorizing the distinguishing articles of the Christian faith.

* See *Month. Rev.* Sept 1793, art. 5.

It must be confessed, for experience will not allow it to be denied, that extremes in religion are very apt to beget each other; and if the deists alluded to reasoned from this fact, they could not have pitched upon a tool fitter for their purpose than George Fox. From his works still extant, he appears to have been one of the most extravagant and absurd enthusiasts that ever lived, and to have fancied himself, in his apostolic character, something infinitely superior to man. In a book called *News coming out of the North*, (p. 15.) he says of himself, "I am the Door that ever was, the same Christ yesterday, to-day, and for ever:" And in the introduction to his *Battle-door for Teachers and Professors*, he says, "All languages are to me no more than dust, who was before languages were." But one of the most extraordinary and blasphemous things that he ever wrote, is an answer to the Protector, who had required him to promise not to disturb his government as then established. It is as follows:

"I who am of the world called G: F: doth deny the carrying or drawing any carnal sword against any, or against thee O: C: or any man, in the presence of the Lord I declare it, God is my witness, by whom I am moved to give this forth for the truth's sake, from him whom the world calls G: Fox, *who is the son of God*, who is sent to stand a witness against all violence and against the works of darkness, and to turn the people from darkness to light, and to bring them from the occasion of the war and from the occasion of the magistrates sword, which is a terror to the evil doer, which acts contrary to the light of the Lord *Jesus Christ*; which is a praise to them that do well; which is a protection to them that do well, and not the evil; and such soldiers as are put in place no false accusers must be, no violence must do, but be content with their wages: and that magistrate bears not the sword in vain, from under the occasion of that sword do I seek to bring people: my weapons are not carnal but spiritual, and *my kingdom is not of this world;* therefore with carnal weapon I do not fight, but am from those things dead, from him who is not of this world, called of the world by the name of G: F: and this I am ready to seal with my blood; this I am moved to give forth for the truth's sake, who a witness stands against all unrighteousness, and all ungodliness, who a sufferer is for the righteous seed's sake, waiting for the redemption of it, who a crown that is mortal seeks not, for that fadeth away; but in the light dwells which comprehends that crown, which light is the condemnation of all such, in which light I witness the crown that is immortal, which fades not away from him who to all your souls is a friend, for establishing of righteousness, and clearing the land of evil doers, and a witness against all the wicked inventions of man, and murderer's plots, which answer shall be with the light in all your consciences, which makes no covenant with death; to which light in you all I speak, and am clear, G: F: who a new name hath, which the world knows not." (A).

The Quakers, however, did not long entrust the defence of their principles to such senseless enthusiasts as George Fox: They were joined by a number of learned, ingenious, and pious men, who new modelled their creed; and though they did not bring it to what is generally deemed the Christian standard, they so reformed it as that its tenets do not shock common sense, nor the duties prescribed scandalize a man of piety. The chief of these reformers were George Keith, the celebrated Penn, and our countryman Barclay. Keith was indeed excommunicated for the liberties which he took with the great apostle; but we have not a doubt but his writings contributed to the moderation of Penn, and to the elegant and masterly apology of Barclay. From that apology we selected the summary of their opinions which was given in the former edition of this work; but they have lately published such a summary themselves, of which the reader will be pleased with the following abstract:

They tell us, that about the beginning of the 17th century, a number of men, dissatisfied with all the modes of religious worship then known in the world, withdrew from the communion of every visible church to seek the Lord in retirement. Among these was their *honourable elder George Fox*, who being quickened by the immediate touches of divine love, could not satisfy his apprehensions of duty to God without directing the people where to find the like consolation and instruction. In the course of his

(A) We have transcribed this letter from the theological works of Mr Leslie, where it is preserved in its original form. The Quakers, after the death of their apostle, expunged from their edition of it the words which we have printed in Italics; ashamed, as we hope, of the blasphemy imputed to them: but that Mr Leslie's copy is authentic, is thus attested by two of the friends, who saw Fox deliver it to the protector's messenger: "We are witnesses of this testimony, whose names in the flesh are,

Tho. Adam.
Rob. Craven.

Quakers.

his travels, he met with many ſeeking perſons in circumſtances ſimilar to his own, and theſe readily received his teſtimony. They then give us a ſhort account of their ſufferings and different ſettlements; and with a degree of candour which does them infinite credit, they vindicate Charles II. from the character of a perſecutor; acknowledging, that though they ſuffered much during his reign, he gave as little countenance as he could to the ſeverities of the legiſlature. They even tell us, that he exerted his influence to reſcue their friends from the unprovoked and cruel perſecutions of the New England fanatics; and they ſpeak with becoming gratitude of the different acts paſſed in their favour during the reigns of William and Mary, and George I. They then proceed to give us the following account of their doctrine:

"We agree with other profeſſors of the Chriſtian name, in the belief in one eternal God, the Creator and Preſerver of the univerſe; and in Jeſus Chriſt his Son, the Meſſiah, and Mediator of the new covenant (Heb. xii. 24).

"When we ſpeak of the gracious diſplay of the love of God to mankind, in the miraculous conception, birth, life, miracles, death, reſurrection, and aſcenſion of our Saviour, we prefer the uſe of ſuch terms as we find in Scripture; and, contented with that knowledge which divine wiſdom hath ſeen meet to reveal, we attempt not to explain thoſe myſteries which remain under the veil; nevertheleſs, we acknowledge and aſſert the divinity of Chriſt, who is the wiſdom and power of God unto ſalvation (1 Cor. i. 24).

"To Chriſt alone we give the title of the Word of God (John i. 1.) and not to the Scriptures; although we highly eſteem theſe ſacred writings, in ſubordination to the Spirit (2 Pet. i. 21.), from which they were given forth; and we hold, with the apoſtle Paul, that they are able to make wiſe unto ſalvation, through faith which is in Chriſt Jeſus (2 Tim. iii. 15.).

"We reverence thoſe moſt excellent precepts which are recorded in Scripture to have been delivered by our great Lord, and we firmly believe that they are practicable, and binding on every Chriſtian; and that in the life to come every man will be rewarded according to his works (Mat. xvi. 27.). And farther, it is our belief, that, in order to enable mankind to put in practice theſe ſacred precepts, many of which are contradictory to the unregenerate will of man (John i. 9.), every man coming into the world is endued with a meaſure of the light, grace, or good Spirit of Chriſt; by which, as it is attended to, he is enabled to diſtinguiſh good from evil, and to correct the diſorderly paſſions and corrupt propenſities of his nature, which mere reaſon is altogether inſufficient to overcome. For all that belongs to man is fallible, within the reach of temptation; but this divine grace, which comes by Him who hath overcome the world (John xvi. 33.) is, to thoſe who humbly and ſincerely ſeek it, an all-ſufficient and preſent help in time of need. By this the ſnares of the enemy are detected, his allurements avoided, and deliverance is experienced through faith in its effectual operation; whereby the ſoul is tranſlated out of the kingdom of darkneſs, and from under the power of Satan, into the marvellous light and kingdom of the Son of God.

"Being thus perſuaded that man, without the Spirit of Chriſt inwardly revealed, can do nothing to the glory of God, or to effect his own ſalvation; we think this influence eſpecially neceſſary to the performance of the higheſt act of which the human mind is capable, even the worſhip of the Father of lights and of ſpirits, in ſpirit and in truth; therefore we conſider as obſtructions to pure worſhip, all forms which divert the attention of the mind from the ſecret influence of this unction from the Holy One (1 John ii. 20, 27.). Yet, although true worſhip is not confined to time and place, we think it incumbent on Chriſtians to meet often together (Heb. x. 25.) in teſtimony of their dependence on the heavenly Father, and for a renewal of their ſpiritual ſtrength: nevertheleſs, in the performance of worſhip, we dare not depend, for our acceptance with Him, on a formal repetition of the words and experiences of others; but we believe it to be our duty to ceaſe from the activity of the imagination, and to wait in ſilence to have a true ſight of our condition beſtowed upon us: believing even a ſingle ſigh (Rom. viii. 26.) ariſing from ſuch a ſenſe of our infirmities, and of the need we have of divine help, to be more acceptable to God, than any performances, however ſpecious, which originate in the will of man.

"From what has been ſaid reſpecting worſhip, it follows, that the miniſtry we approve muſt have its origin from the ſame ſource: for that which is needful for a man's own direction, and for his acceptance with God (Jer. xxiii. 30, to 32.), muſt be eminently ſo to enable him to be helpful to others. Accordingly, we believe the renewed aſſiſtance of the light and power of Chriſt to be indiſpenſably neceſſary for all true miniſtry; and that this holy influence is not at our command, or to be procured by ſtudy, but is the free gift of God to his choſen and devoted ſervants.—From hence ariſes our teſtimony againſt preaching for hire, and in contradiction to Chriſt's poſitive command, "Freely ye have received, freely give" (Mat. x. 8.); and hence our conſcientious refuſal to ſupport ſuch miniſtry by tithes or other means.

"As we dare not encourage any miniſtry but that which we believe to ſpring from the influence of the Holy Spirit, ſo neither dare we attempt to reſtrain this influence to perſons of any condition in life, or to the male ſex alone; but, as male and female are one in Chriſt, we allow ſuch of the female ſex as we believe to be endued with a right qualification for the miniſtry, to exerciſe their gifts for the general edification of the church: and this liberty we eſteem to be a peculiar mark of the goſpel diſpenſation, as foretold by the prophet Joel (Joel ii. 28, 29.), and noticed by the apoſtle Peter (Acts ii. 16, 17.).

"There are two ceremonies in uſe amongſt moſt profeſſors of the Chriſtian name; Water-baptiſm, and what is termed the Lord's Supper. The firſt of theſe is generally eſteemed the eſſential means of initiation into the church of Chriſt; and the latter of maintaining communion with him. But as we have been convinced, that nothing ſhort of his redeeming power, inwardly revealed, can ſet the ſoul free from the thraldom of ſin, by this power alone we believe ſalvation to be effected. We hold that as there is one Lord and one faith (Eph. iv. 5.), ſo his baptiſm is one in nature and operation; that nothing ſhort of it can make us living members of his myſtical body; and that the baptiſm with water, adminiſtered

nistered by his fore-runner John, belonged, as the latter confessed, to an inferior and decreasing dispensation (John iii. 30.).

"With respect to the other rite, we believe that communion between Christ and his church is not maintained by that nor any other external performance, but only by a real participation of his divine nature (2 Pet. i. 4.) through faith; that this is the supper alluded to in the Revelation (Rev. iii. 20.), "Behold I stand at the door and knock, if any man hear my voice, and open the door, I will come in to him, and will sup with him, and he with me;" and that where the substance is attained, it is unnecessary to attend to the shadow, which doth not confer grace, and concerning which opinions so different, and animosities so violent, have arisen.

"Now, as we thus believe that the grace of God, which comes by Jesus Christ, is alone sufficient for salvation, we can neither admit that it is conferred on a few only, whilst others are left without it; nor, thus, asserting its universality, can we limit its operation to a partial cleansing of the soul from sin, even in this life. We entertain worthier notions both of the power and goodness of our heavenly Father, and believe that he doth vouchsafe to assist the obedient to experience a total surrender of the natural will to the guidance of his pure unerring Spirit; through whose renewed assistance they are enabled to bring forth fruits unto holiness, and to stand perfect in their present rank (Mat. v. 48.; Eph. iv. 13.; Col. iv. 12.).

"There are not many of our tenets more generally known than our testimony against oaths and against war. With respect to the former of these, we abide literally by Christ's positive injunction, delivered in his sermon on the mount, "Swear not at all" (Mat. v. 34.) *. From the same sacred collection of the most excellent precepts of moral and religious duty, from the example of our Lord himself (Mat. ch. v. 39, 44, &c. ch. xxvi. 52, 53.; Luke xxii. 51; John xviii. 11.), and from the correspondent convictions of his Spirit in our hearts, we are confirmed in the belief that wars and fightings are, in their origin and effects, utterly repugnant to the Gospel, which still breathes peace and good-will to men. We also are clearly of the judgment, that if the benevolence of the Gospel were generally prevalent in the minds of men, it would effectually prevent them from oppressing, much more from enslaving, their brethren, (of whatever colour or complexion), for whom, as for themselves, Christ died; and would even influence their conduct in their treatment of the brute creation, which would no longer groan the victims of their avarice, and of their false ideas of pleasure.

* See *Oath*.

"Some of our tenets have in former times, as hath been shown, subjected our friends to much suffering from government, though to the salutary purposes of government our principles are a security. They inculcate submission to the laws in all cases wherein conscience is not violated. But we hold, that as Christ's kingdom is not of this world, it is not the business of the civil magistrate to interfere in matters of religion; but to maintain the external peace and good order of the community. We therefore think persecution, even in the smallest degree, unwarrantable. We are careful in requiring our members not to be concerned in illicit trade, nor in any manner to defraud the revenue.

"It is well known that the society, from its first appearance, has disused those names of the months and days which, having been given in honour of the heroes or false gods of the heathens, originated in their flattery or superstition; and the custom of speaking to a single person in the plural number (B), as having arisen also from motives of adulation. Compliments, superfluity of apparel and furniture, outward shows of rejoicing and mourning, and observation of days and times, we esteem to be incompatible with the simplicity and sincerity of a Christian life; and public diversions, gaming, and other vain amusements of the world, we cannot but condemn. They are a waste of that time which is given us for nobler purposes, and divert the attention of the mind from the sober duties of life, and from the reproofs of instruction, by which we are guided to an everlasting inheritance.

"To conclude, although we have exhibited the several tenets which distinguish our religious society, as objects of our belief, yet we are sensible that a true and living faith is not produced in the mind of man by his own effort; but is the free gift of God (Eph. ii. 8.) in Christ Jesus, nourished and increased by the progressive operation of his spirit in our hearts, and our proportionate obedience (John vii. 17.). Therefore, although, for the preservation of the testimonies given us to bear, and for the peace and good order of the society, we deem it necessary that those who are admitted into membership with us, should be previously convinced of those doctrines which we esteem essential; yet we require no formal subscription to any articles, either as the condition of membership, or to qualify for the service of the church. We prefer the judging of men by their fruits, in a dependence on the aid of Him who, by his prophet, hath promised to be "a spirit of judgment to him that sitteth in judgment" (Isaiah xxviii. 6.). Without this, there is a danger of receiving numbers into outward communion, without any addition to that spiritual sheepfold, whereof our blessed Lord declared himself to be both the door and the shepherd (John x. 7, 11.), that is, such as know his voice, and follow him in the paths of obedience."

Such are the doctrines of this people as we find them stated in a small pamphlet lately presented by themselves to the public; and in the same tract they give the following account of their discipline.

"In the practice of discipline, we think it indispensable that the order recommended by Christ himself be invariably observed: (Matth. xviii. 15. to 17.). 'If thy brother shall trespass against thee, go and tell him his fault between thee and him alone: if he shall hear thee, thou hast gained thy brother; but if he will not hear thee, then take with thee one or two more, that in the mouth of two or three witnesses every word may be

(B) Speaking of this custom, Fox says: "When the Lord sent me into the world, he forbade me to put off my hat to any; and I was required to *thee* and *thou* all men and women." *Journal*, p. 24.

Quakers. be eftablifhed; and if he fhall neglect to hear them, tell it unto the church.'

"To effect the falutary purpofes of difcipline, meetings were appointed, at an early period of the fociety, which, from the times of their being held, were called quarterly meetings. It was afterwards found expedient to divide the diftricts of thofe meetings, and to meet more often; whence arofe monthly meetings, fubordinate to thofe held quarterly. At length, in 1669, a yearly meeting was eftablifhed, to fuperintend, affift, and provide, rules for the whole; previous to which, general meetings had been occafionally held.

"A monthly meeting is ufually compofed of feveral particular congregations, fituated within a convenient diftance of each other. Its bufinefs is to provide for the fubfiftence of their poor, and for the education of their offspring: to judge of the fincerity and fitnefs of perfons appearing to be convinced of the religious principles of the fociety, and defiring to be admitted into memberfhip; to excite due attention to the difcharge of religious and moral duty; and to deal with diforderly members. Monthly meetings alfo grant to fuch of their members as remove into other monthly meetings, certificates of their memberfhip and conduct; without which they cannot gain memberfhip in fuch meetings. Each monthly meeting is required to appoint certain perfons under the name of *overfeers*, who are to take care that the rules of our difcipline be put in practice; and when any cafe of complaint or diforderly conduct comes to their knowledge, to fee that private admonition, agreeable to the gofpel rule before mentioned, be given previoufly to its being laid before the monthly meeting.

"When a cafe is introduced, it is ufual for a fmall committee to be appointed to vifit the offender, to endeavour to convince him of his error, and to induce him to forfake and condemn it. If they fucceed, the perfon is by minute declared to have made fatisfaction for the offence; if not, he is difowned as a member of the fociety.

"In difputes between individuals, it has long been the decided judgment of the fociety that its members fhould not fue each other at law. It therefore enjoins all to end their differences by fpeedy and impartial arbitration, agreeable to rules laid down. If any refufe to adopt this mode, or, having adopted it, to fubmit to the award, it is the direction of the yearly meeting that fuch be difowned.

"To monthly meetings alfo belongs the allowing of marriages; for our fociety hath always fcrupled to acknowledge the exclufive authority of the priefts in the folemnization of marriage. Thofe who intend to marry, appear together and propofe their intention to the monthly meeting; and if not attended by their parents or guardians, produce a written certificate of their confent, figned in the prefence of witneffes. The meeting then appoints a committee to inquire whether they are clear of other engagements refpecting marriage; and if at a fubfequent meeting, to which the parties alfo come and declare the continuance of their intention, no objections are reported, they have the meeting's confent to folemnize their intended marriage. This is done in a public meeting for worfhip; towards the clofe whereof the parties ftand up, and folemnly take each other for hufband and wife. A certificate of the proceedings is then publicly read, and figned by the parties, and afterwards by the relations and others as witneffes. Of fuch certificates the monthly meeting keeps a record; as alfo of the births and burials of its members. A certificate of the date, of the name of the infant, and of its parents, figned by thofe prefent at the birth, is the fubject of one of thefe laft-mentioned records; and an order for the interment, counterfigned by the grave-maker, of the other. The naming of children is without ceremony. Burials are alfo conducted in a fimple manner. The body, followed by the relations and friends, is fometimes, previoufly to interment, carried to a meeting; and at the grave a paufe is generally made; on both which occafions it frequently falls out that one or more friends prefent have fomewhat to exprefs for the edification of thofe who attend; but no religious rite is confidered as an effential part of burial.

"Several monthly meetings compofe a quarterly meeting. At the quarterly meeting are produced written anfwers from the monthly meetings, to certain queries refpecting the conduct of their members, and the meeting's care over them. The accounts thus received are digefted into one, which is fent, alfo in the form of anfwers to queries, by reprefentatives, to the yearly meeting.—Appeals from the judgment of monthly meetings are brought to the quarterly meetings; whofe bufinefs alfo it is to affift in any difficult cafe, or where remiffnefs appears in the care of the monthly-meetings over the individuals who compofe them.

"The yearly meeting has the general fuperintendance of the fociety in the country in which it is eftablifhed (c); and therefore, as the accounts which it receives difcover the ftate of inferior meetings, as particular exigencies require, or as the meeting is impreffed with a fenfe of duty, it gives forth its advice, makes fuch regulations as appear to be requifite, or excites to the obfervance of thofe already made; and fometimes appoints committees to vifit thofe quarterly meetings which appear to be in need of immediate help. Appeals from the judgment of quarterly meetings are here finally determined; and a brotherly correfpondence, by epiftles, is maintained with other yearly meetings.

"In this place it is proper to add, that as we believe women may be rightly called to the work of the miniftry, we alfo think, that to them belongs a fhare in the fupport of our Chriftian difcipline; and that fome parts of it, wherein their own fex is concerned, devolve on them with peculiar propriety. Accordingly they have monthly, quarterly, and yearly meetings of their own fex, held at the fame time and in the fame place with thofe of the men; but feparately, and without the power of

(c) There are feven yearly meetings, viz. 1ft, London, to which come reprefentatives from Ireland; 2d, New-England; 3d, New-York; 4th, Pennfylvania and New-Jerfey; 5th, Maryland; 6th, Virginia; 7th, the Carolinas and Georgia."

Quakers.

of making rules: and it may be remarked, that during the perfecutions, which in the laft century occafioned the imprifonment of fo many of the men, the care of the poor often fell on the women, and was by them fatisfactorily adminiftered.

" In order that thofe who are in the fituation of minifters may have the tender fympathy and counfel of thofe of either fex, who, by their experience in the work of religion, are qualified for that fervice; the monthly meetings are advifed to felect fuch, under the denomination of *elders*. Thefe, and minifters approved by their monthly meetings (D), have meetings peculiar to themfelves, called meetings of minifters and elders; in which they have an opportunity of exciting each other to a difcharge of their feveral duties, and of extending advice to thofe who may appear weak, without any needlefs expofure. Thefe meetings are generally held in the compafs of each monthly, quarterly, and yearly meeting. They are conducted by rules prefcribed by the yearly meeting, and have no authority to make any alteration or addition to them. The members of them unite with their brethren in the meetings for difcipline, and are equally accountable to the latter for their conduct.

" It is to a meeting of this kind held in London, called the fecond-day morning-meeting, that the revifal of manufcripts concerning our principles, previoufly to publication, is intrufted by the yearly meeting held in London; and alfo the granting, in the intervals of the yearly meeting, certificates of approbation to fuch minifters as are concerned to travel in the work of the miniftry in foreign parts. When a vifit of this kind doth not extend beyond Great Britain, a certificate from the monthly meeting of which the minifter is a member is fufficient; if to Ireland, the concurrence of the quarterly meeting is alfo required. Regulations of fimilar tendency obtain in other yearly meetings.

" The yearly meeting held in London, in the year 1675, appointed a meeting to be held in that city, for the purpofe of advifing and affifting in cafes of fuffering for confcience fake, which hath continued with great ufe to the fociety to this day. It is compofed of friends under the name of correfpondents, chofen by the feveral quarterly meetings, and who refide in or near the city. The fame meetings alfo appoint members of their own in the country as correfpondents, who are to join their brethren in London on emergency. The names of all thefe correfpondents, previous to their being recorded as fuch, are fubmitted to the approbation of the yearly meeting. Thofe of the men who are approved minifters are alfo members of this meeting, which is called the *meeting* for *fufferings*; a name arifing from its original purpofe, which is not yet become entirely obfolete.

" The yearly meeting has intrufted the meeting for fufferings with the care of printing and diftributing books, and with the management of its ftock; and confidered as a ftanding committee of the yearly meeting, it hath a general care of whatever may arife, during the intervals of that meeting, affecting the fociety, and requiring immediate attention: particularly of thofe circumftances which may occafion an application to government.

Quakers, Quality.

" There is not in any of the meetings which have been mentioned any prefident, as we believe that Divine Wifdom alone ought to prefide; nor hath any member a right to claim pre-eminence over the reft. The office of clerk, with a few exceptions, is undertaken voluntarily by fome member; as is alfo the keeping of the records. Where thefe are very voluminous, and require a houfe for their depofite (as is the cafe in London, where the general records of the fociety in Great Britain are kept), a clerk is hired to have the care of them; but except a few clerks of this kind, and perfons who have the care of meeting houfes, none receive any ftipend or gratuity for their fervices in our religious fociety."

It is remarkable, that all the fettlements of the Europeans in America, except the Quaker fettlement of Pennfylvania, were made by force of arms, with very little regard to any prior title in the natives. The kings of Spain, Portugal, France, and Britain, together with the States of Holland, then the only maritime powers, gave grants of fuch parts of America as their people could lay hold on, ftudying only to avoid interference with their European neighbours. But Mr Penn, being a Quaker, did not think his power from King Cha. II. a fufficient title to the country fince called *Pennfylvania*: He therefore affembled the fachems or princes then in that country, and purchafed from them the extent of land that he wanted. The government of this province is moftly in the hands of the Quakers, who never have any quarrels with the natives. When they defire to extend their fettlements, they purchafe new lands of the fachems, never taking any thing from them by force. How unlike is this conduct to that of the Spaniards, who murdered millions of the natives of Mexico, Terra Firma, Peru, Chili, &c.

QUALITY is a word which, as ufed in philofophical difquifitions, cannot be explained by any periphrafis. That which is expreffed by it muft be brought into the immediate view of the fenfes or intellect, and the name properly applied, or he who is a ftranger to the word will never be made to comprehend its meaning. Ariftotle, who treated it as a general conception, fecond in order among the ten *predicaments* or *categories* (fee CATEGORY), gives feveral characters of it; but though they are all in fome refpects juft, no man could from them, without other affiftance, learn what *quality* is. Thus he tells us *, Ὑπαρχει δε εναντιοτης κατα το ποιον; Επιδεχεται δε το μαλλον και το ἡττον τα ποια. And again, Ὁμοια δε ἡ ανομοια κατα μονας τας ποιοτητας λεγεται· ὁμοιον γαρ ἑτερον ἑτερω ουκ εστι κατ' αλλο. ουδεν, ἡ καθ' ὁ ποιον εστιν.

1 Quality characterized by Ariftotle.

* *Præd.* ed. Sylb. p. 44. 45.

When

(D) " Thofe who believe themfelves required to fpeak in meetings for worfhip, are not immediately acknowledged as minifters by their monthly meetings; but time is taken for judgment, that the meeting may be fatisfied of their call and qualification. It will alfo fometimes happen, that fuch as are not approved, will obtrude themfelves as minifters, to the grief of their brethren; but much forbearance is ufed towards thefe, before the difapprobation of the meeting is publicly teftified."

Quality.

When a man comprehends, by means of his ſenſes and intellect, what it is which the word *quality* denotes, he will indeed perceive that the firſt of theſe characters is applicable to ſome qualities and not to others; that the ſecond is more applicable to *quantity* than to quality; and that it is only the third which can with propriety be conſidered as the general characteriſtic of this predicament. Thus when we have learned by our ſenſe of ſight that *whiteneſs* is a quality of ſnow, and *blackneſs* of coal; and by means of obſervation and reflection, that *wiſdom* is a quality of one man and *folly* of another—we muſt admit that the ſenſible quality of the ſnow is *contrary* to that of the coal, and the intellectual quality of wiſdom contrary to that of folly. There is, however, no contrariety between *wiſdom* and *whiteneſs* or *blackneſs*, nor between *hardneſs* or *ſoftneſs* and *any particular colour;* for ſenſible and intellectual qualities can never be compared; and it is not eaſy, if poſſible, to make a compariſon between qualities perceptible only by different ſenſes: Nay, among qualities perceptible by the ſame ſenſe, we often meet with a difference where there is no contrariety; for though the *figure* of a *cube* is *different* from that of a *ſphere*, and the figure of a *ſquare* from that of a *circle*, the ſphere is not *contrary* to the cube, nor the circle to the ſquare.

His ſecond characteriſtic of this genus is ſtill leſs proper than the firſt. It is indeed true that ſome qualities admit of *intenſion* and *remiſſion;* for ſnow is whiter than paper, and one woman is handſomer than another; but of the ſpecies of quality called *figure* we cannot predicate either *more* or *leſs*. A crown-piece may have as much of the *circular quality* in it as the plane of the equator, and a muſket-bullet as much of the *ſpherical quality* as the orb of the ſun. It is indeed a property of all *quantity* to admit of *intenſion* and *remiſſion;* and therefore this ought to have been given as the character not of the ſecond but of the third category. See QUANTITY.

2 Nothing known but qualities.

That it is only from a *compariſon of their qualities that things are denominated like or unlike*, or that *one thing cannot reſemble another but in ſome quality*, is indeed a juſt obſervation. We know nothing directly but qualities ſenſible and intellectual (ſee METAPHYSICS, N° 149, 150, 151, and 227); and as theſe have no reſemblance to each other, we conclude that body or matter, the ſubject of the former, is a being unlike mind, the ſubject of the latter. Even of bodies themſelves we can ſay, that one is like or unlike another only by virtue of their qualities. A ball of ivory reſembles a ball of ſnow in its *figure* and *colour*, but not in its *coldneſs* or *hardneſs;* a ball of lead may reſemble a ball of ſnow in its *figure* and *coldneſs*, but not in its *colour;* and a cube of ivory reſembles not a ball of lead either in *figure*, *colour*, or *coldneſs*. The mind of a brute reſembles that of a man in its powers of *ſenſation* and *perception*, but does not reſemble it in the powers of *volition* and *reaſoning;* or at leaſt the reſemblance, in this latter inſtance, is very ſlight. All bodies reſemble one another in being ſolid and extended, and all minds in being more or leſs active. *Likeneſs* or *unlikeneſs* therefore is the univerſal characteriſtic of the category *quality*.

3 Important diſtinctions of quality,

Ariſtotle has other ſpeculations reſpecting quality, which are worthy of notice. He diſtinguiſhes between qualities which are *eſſential* and thoſe which are *accidental;* between qualities which are *natural* and thoſe which are *acquired;* and he ſpeaks of the qualities of *capacity* and thoſe of *completion*. *Extenſion* and *figure* in *general* are qualities eſſential to all bodies: but a *particular* extenſion, ſuch as an *inch* or an *ell*, and a *particular* figure, ſuch as a *cube* or a *ſphere*, are qualities accidental to bodies. Among the *natural* qualities of glaſs it is one to tranſmit objects of viſion; but to enlarge theſe objects is an *adventitious* or *acquired* quality. The ſame quality may be *natural* in one ſubſtance, as attraction in the magnet; and *acquired* in another, as the ſame attraction in the magnetic bar. *Docility* may be called a quality *natural* to the mind of man, ſcience an *acquired* one. To underſtand what he means by qualities of *capacity* and *completion*, it may be ſufficient to obſerve that every piece of iron has the qualities of a razor in *capacity*, becauſe it may be converted into ſteel, and formed into a razor: when it is ſo formed, it has, in the language of this ſage, the quality of a razor in *completion*. Among the qualities of *capacity* and *completion*, the moſt important, and what may lead to intereſting ſpeculations, is the reaſoning faculty of man. A *capacity* of reaſoning is eſſential to the human mind; but the *completion* of this capacity or *actual reaſoning* is not, otherwiſe *infants* and perſons *aſleep* would be excluded from the human ſpecies.

4 overlooked by Locke.

Mr Locke has puzzled his readers, and perhaps himſelf, with a queſtion reſpecting the ſpecies of an idiot or changeling, whom he pronounces to be ſomething between a man and a brute *. It is not often that we feel ourſelves inclined to regret Locke's ignorance of Ariſtotle's diſtinctions; but we cannot help thinking, that had the Britiſh philoſopher attended to the Stagyrite's account of qualities in *capacity* and qualities in *completion*, this perplexing queſtion would never have been ſtarted. It is juſtly obſerved in the Eſſay on Human Underſtanding, that of *real eſſences* we know nothing: but that every man ſelects a certain number of qualities which he has always perceived united in certain beings; and forming theſe into one complex conception, gives to this conception a *ſpecific* name, which he applies to every being in which he finds thoſe qualities united. This is undoubtedly the proceſs of the mind in forming genera and ſpecies; and as the excellent author refuſes the name of *man* to the changeling, it is obvious that the complex conception, to which he gives that name, muſt imply *rationality* or the *actual exerciſe* of reaſon. But this limitation will exclude many beings from the ſpecies *man*, whom Mr Locke certainly conſidered as men and women. Not to mention infants and perſons in ſound ſleep, how ſhall we claſs thoſe who, after having lived 30 or 40 years in the full exerciſe of reaſon, have been ſuddenly or by degrees deprived of it by ſome diſorder in the brain?

* Book iv. ch. 4. § 13. &c.

5 Strange conſequence of this overſight.

From Marlb'rough's eyes the ſtreams of dotage flow;
And Swift expires a driveller and a ſhow. JOHNSON.

But were the hero and the wit in thoſe deplorable circumſtances excluded from the human ſpecies, and claſſed between men and brutes? No ſurely; they were both acknowledged to be men, becauſe they were known to have the quality of reaſon in what Ariſtotle would have called *capacity*. Their dotage and drivelling originated from ſome diſorder in their bodies, probably in the region of the brain; and Locke himſelf contends that no defect in body is ſufficient to degrade a perſon from the rank

rank of manhood. Again, lunatics have the exerciſe of reaſon, except at new and full moon. Are theſe unhappy beings ſometimes men and ſometimes a ſpecies by themſelves between men and brutes?

6 Fallacy of his doctrine reſpecting the human ſpecies.

It appears, therefore, that *not* the *actual exerciſe* of reaſon, but reaſon in *capacity*, ought to be included in the complex conception to which we give the ſpecific name of *man*, as ſome of the greateſt men that ever lived have been during parts of their lives deprived of the power of *actual reaſoning*. This, however, it will be ſaid, does not remove the difficulty; for the occaſional exerciſe of reaſon in lunatics, and the great exertions of it in ſuch men as Swift and Marlborough, ſhow that they had it in *capacity* at all times; whereas we have no evidence that changelings have even a *capacity* of reaſoning at any time, ſince they never do a rational action, nor ever utter a ſentence to the purpoſe. That we have no *direct* and *poſitive* evidence of the minds of changelings being capable of reaſoning, were they ſupplied with proper organs, muſt be granted; but the probabilities of their being ſo are many and great. We know by experience that the actual exerciſe of reaſon may be interrupted by an occaſional and accidental preſſure on the brain: and therefore we cannot doubt but that if this preſſure were rendered permanent by any wrong configuration of the ſkull given to it in the womb, or in the act of being born into the world, an infant, with a mind capable of reaſoning by means of proper organs, would by this accident be rendered, through the whole of life, an idiot or changeling. That idiotiſm is cauſed by ſuch accidents, and is not the quality of an inferior mind occaſionally given to a human body, will at leaſt ſeem probable from the following conſiderations.

7 True doctrine.

It does not appear that an animal body can live and move but while it is actuated by ſome mind. Whence then does the unborn infant derive its mind? It muſt be either immediately from God, or *ex traduce* from its parents; but if the mind of man be immaterial, it cannot be *ex traduce*. Now, as idiots are very few in number when compared with the rational part of the human ſpecies, and as God in the government of this world acts not by partial but by general laws; we muſt conclude that the law which he has eſtabliſhed reſpecting the union of mind and matter, is, that human bodies ſhall be animated with minds endowed with a capacity of reaſoning, and that thoſe who never exert this capacity are prevented by ſome ſuch accident as we have aſſigned.

For a further account of qualities, why they are ſuppoſed to inhere in ſome ſubject, together with the uſual diſtinction between the primary and ſecondary qualities of matter, ſee METAPHYSICS, Part II. chap. i.

Chemical QUALITIES, thoſe qualities principally introduced by means of chemical experiments, as fumigation, amalgamation, cupellation, volatilization, precipitation, &c.

QUALITY, is alſo uſed for a kind of title given to certain perſons, in regard of their territories, ſigniories, or other pretenſions.

QUANGA. See CAPRA.

QUANG-PING-FOU, a city in China, is ſituated in the northern part of the province of Pe-tcheli, between the provinces of Chang-tong and Ho-nan, and has nine cities of the third claſs dependent on it; all its plains are well watered by rivers. Among its temples, there is one dedicated to thoſe men who, as the Chineſe pretend, diſcovered the ſecret of rendering themſelves immortal.

QUANGSI, a province of China, bounded on the north by Kee-Tcheau and Hu-Quang; on the eaſt, by Yunan and Quantong; on the ſouth, by the ſame and Tonquin; and on the weſt, by Yun-nan. It produces great plenty of rice, being watered by ſeveral large rivers; and containing 10,000,000 of inhabitants. The ſouthern part is a flat country, and well cultivated; but the northern is full of mountains covered with trees. It contains mines of all ſorts; and there is a gold-mine lately opened. The capital town is Quie-ling.

A very ſingular tree, ſays Groſier, grows in this province; inſtead of pith, it contains a ſoft pulp, which yields a kind of flour: the bread made of it is ſaid to be exceedingly good. Beſides paroquets, hedgehogs, porcupines, and rhinoceroſes, a prodigious number of wild animals, curious birds, and uncommon inſects, are found here.

This province contains 12 villages of the firſt claſs, and 80 of the ſecond and third.

QUANG-TONG, a province of China, bounded on the eaſt by Kiang-ſi and Fokien; on the ſouth, by the ocean; and on the weſt, by Tonquin. This province is diverſified by valleys and mountains; and yields two crops of corn in a year. It abounds in gold, jewels, ſilk, pearls, tin, quickſilver, ſugar, braſs, iron, ſteel, ſaltpetre, ebony, and ſeveral ſorts of odoriferous wood; beſides fruits of all ſorts proper to the climate. They have a prodigious number of ducks, whoſe eggs they hatch in ovens; and a tree, whoſe wood is remarkably hard and heavy, and thence called *iron-wood*. The mountains are covered with a ſort of oſiers which creep along the ground, and of which they make baſkets, hurdles, matts, and ropes.

Although the climate of this province is warm, the air is pure, and the people are robuſt and healthy. They are very induſtrious; and it muſt be allowed that they poſſeſs in an eminent degree the talents of imitation: if they are only ſhown any of our European works, they execute others like them with the moſt ſurpriſing exactneſs. This province ſuffered much during the civil wars; but at preſent it is one of the moſt flouriſhing in the empire; and, as it is at a great diſtance from court, its government is one of the moſt important. This province is divided into ten diſtricts, which contain ten cities of the firſt claſs, and 84 of the ſecond and third. Canton is the capital town.

QUANTITY, as explained by the great Engliſh lexicographer, is that property of any thing which may be increaſed or diminiſhed. This interpretation of the *word* is certainly juſt, and for the purpoſes of common converſation it is ſufficiently determinate; but the man of ſcience may expect to find in a work like ours a definition of the *thing* ſignified. This, however, cannot be given him. A logical definition conſiſts of the *genus* under which the thing defined is ranked, and the *ſpecific* difference (ſee LOGIC, N° 20, &c.); but quantity is ranked under no genus. In that ſchool where ſuch definitions were moſt valued, it was conſidered as one of the ten *categories*, or general conceptions, under which all the objects of human apprehenſion were muſtered, like ſoldiers in an army (ſee CATEGORY and PHILOSOPHY, N° 22.). On this account, even Ariſtotle himſelf, 1 Quantity.

himself, who delighted in definitions, and was not easily deterred from a favourite pursuit, coold not consistently with his own rules attempt to define *quantity*. He characterizes it, however, in several parts of his works: and particularly in the 15th chapter of the 4th book of his metaphysics, where he gives the following account of the three first *categories*: Ταυ̃τα μεν γαρ, ων μια ἡ ουσια. ὁμοια δ' ων ἡ ποιοτης μια ισα δε, ων το ποσον εν. "Things are the *same* of which the SUBSTANCE is one; *similar*, of which the QUALITY is one; *equal*, of which the QUANTITY is one. Again, he tells us*, that the chief characteristic of quantity is, that it may be denominated *equal* and *unequal*.

2
characterized by Aristotle.

* *Præd.* p. 34. edit. Sylb.

That any man can become wiser by reading such descriptions as these, none but an idolater of Aristotle will suppose. There is, indeed, no periphrasis by which we can explain what is meant by quantity to those who have not previously formed such a notion.—All that can be done by making the attempt is only to settle language, by stating exactly the cases in which we use this word in the greatest conformity to general custom; for there is a laxness or carelessness of expression in the language of most men, and our notions are frequently communicated by speech in a way by no means precise; so that it is often a great chance that the notions excited in the mind of the hearer are not exact counterparts of those in the mind of the speaker.

The understandings of men differ in nothing more remarkably than in their power of abstraction, and of rapidly forming conceptions so general and simple as not to by clogged with distinguishing circumstances, which may be different in different minds while uttering and hearing the same words: and it is of great consequence to a man of scientific habits, either to cultivate, if possible, this talent, or to supersede its use, by studiously forming to himself notions of the most important *universals* in his own course of contemplation, by careful abstraction of every thing extraneous. His language by this means becomes doubly instructive by its extreme precision; and he will even judge with greater certainty of notions intended to be communicated by the more slovenly language of another person.

We cannot say that there is much ambiguity in the general use of the term *quantity*: But here, as in all other cases, a love of refinement, of novelty, and frequently of vanity, and the wish of appearing ingenious and original, have made men take advantage of even the small latitude with which the careless use of the word will furnish them, to amuse themselves and the public by giving the appearance of science to empty sounds.

3
The subject of mathematical reasoning.

Mathematics is undoubtedly employed in discovering and stating many relations of quantity; and it is in this category alone that any thing is contemplated by the mathematician, whether in geometry, arithmetic, or algebra. Hence mathematics has been called the science of quantity. The simplicity of the object of the mathematician's contemplation, and the unparalleled distinctness with which he can perceive its modifications, have enabled him to erect a body of science, eminent not only for its certainty, but also for the great length to which he can carry his reasonings without danger of error; and the intimate connection which this science has with the arts of life, and the important services which it has performed, have procured it a most respectable place in the circle of the sciences. Ingenious men have availed themselves of this pre-eminence of mathematics, and have endeavoured to procure respect for their disquisitions on other subjects, by presenting them to the public as branches of mathematical science, and therefore susceptible of that accuracy and certainty which are its peculiar boast. Our moral affections, our sensations, our intellectual powers, are all susceptible of augmentation and diminution, are conceivable as greater and less when stated together, and are familiarly spoken of as admitting of degrees of comparison. We are perfectly well understood when we say that one pain, heat, grief, kindness, is greater than another; and as this is the distinguishing characteristic of quantity, and as quantity is the subject of mathematical discussion, we suppose that these subjects may be treated mathematically. Accordingly, a very celebrated and excellent philosopher* has said, among many things of the same kind, that the greatness of a favour is in the direct compound ratio of the service performed and the dignity of the performer, and in the inverse ratio of the merit and rank of the receiver; that the value of a character is in the compound ratio of the talents and virtue, &c.; and he has delivered a number of formal propositions on the most interesting questions in morals, couched in this mathematical language, and even expressed by algebraic formulæ. But this is mere play, and conveys no instruction. We understand the words; they contain no absurdity; and in as far as they have a sense, we believe the propositions to be true. But they give no greater precision to our sentiments than the more usual expressions would do. If we attend closely to the meaning of any one of such propositions, we shall find that it only expresses some vague and indistinct notions of degrees of those emotions, sentiments, or qualities, which would be just as well conceived by means of the expressions of ordinary language; and that it is only by a sort of analogy or resemblance that this mathematical language conveys any notions whatever of the subjects.

* *Dr Francis Hutchinson.*

4
Which is improperly introduced into other subjects.

The object of contemplation to the mathematician is not whatever is susceptible of greater and less, but what is measurable; and mathematics is not the science of magnitude, in its most abstracted and general acceptation, but of magnitude which can be measured. It is, indeed the SCIENCE OF MEASURE, and whatever is treated in the way of mensuration is treated mathematically. Now, in the discourse of ordinary life and ordinary men, many things are called quantities which we cannot or *do not* measure. This is the case in the instances already given of the affections of the mind, pleasure, pain, beauty, wisdom, honour, &c. We do not say that they are incapable of measure; but we have not yet been able to measure them, nor do we think of measuring them when we speak rationally and usefully about them. We therefore do not consider them mathematically; nor can we introduce mathematical precision into our discussions of these subjects till we can, and actually do, measure them. Persons who are precise in their expression will even avoid such phrases on these subjects as suppose, or strictly express, such measurement. We should be much embarrassed how to answer the question, How much pain does the toothache give you just now; and how much is it easier since yesterday?

5
The mathematician contemplates only quantities that are measurable.

Quantity.

yesterday? Yet the answer (if we had a measure) would be as easy as to the question, How many guineas did you win at cards? or how much land have you bought? Nay, though we say familiarly, "I know well how much such a misfortune would affect you," and are understood when we say it, it would be aukward language to say, "I know well the quantity of your grief." It is in vain, therefore, to expect mathematical precision in our discourse or conceptions of quantities in the most abstracted sense. Such precision is confined to quantity which may be and is measured (A). It is only trifling with the imagination when we employ mathematical language on subjects which have not this property.

It will therefore be of some service in science to discriminate quantities in this view; to point out what are susceptible of measure, and what are not.

6 Measuring explained.

What is measuring? It is one of these two things: It is either finding out some known magnitude of the thing measured, which we can demonstrate to be equal to it; or to find a known magnitude of it, which being taken so many times shall be equal to it. The geometer measures the contents of a parabolic space when he exhibits a parallelogram of known dimensions, and demonstrates that this parallelogram is equal to the parabolic space. In like manner, he measures the solid contents of an infinitely extended hyperbolic spindle, when he exhibits a cone of known dimensions, and demonstrates that three of these cones are equal to the spindle.

In this process it will be found that he actually subdivides the quantity to be measured into parts of which it consists, and states these parts as actually making up the quantity, specifying each, and assigning its boundaries. He goes on with it, piece by piece, demonstrating the respective equalities as he goes along, till he has exhausted the figure, or considered all its parts.—When he measures by means of a submultiple, as when he shows the surface of a sphere to be equal to four of its great circles, he stops, after having demonstrated the equality of one of these circles to one part of the surface: then he demonstrates that there are other three parts, each of which is precisely equal to the one he has minutely considered. In this part of the process he expressly assigns the whole surface into its distinct portions, of which he demonstrates the equality.

But there is another kind of geometrical measurement which proceeds on a very different principle. The geometer conceives a certain individual portion of his figure, whether line, angle, surface, or solid, as known in respect to its dimensions. He conceives this to be lifted from its place, and again laid down on the *adjoining* part of the figure, and that it is equal to the part which it now covers; and therefore that this part together with the first is double of the first: he lifts it again, and lays it down on the next adjoining part, and affirms that this, added to the two former, make up a quantity triple of the first. He goes on in this way, making similar inferences, till he can demonstrate that he has in this manner covered the whole figure by twenty applications, and that his moveable figure will cover no more; and he affirms that the figure is twenty times the part employed.

This mode is precisely similar to the manner of practical measurement in common life: we apply a foot-rule successively to two lines, and find that 30 applications exhaust the one, while it requires 35 to exhaust the other. We say therefore, that the one line is 30 and the other 35 feet long; and that these two lines are to each other in the ratio of 30 to 35. Having measured two shorter lines by a similar application of a stick of an inch long 30 times to the one and 35 times to the other, we say that the ratio of the two first lines is the same with that of the two last. Euclid has taken this method of demonstrating the fourth proposition of the first book of his celebrated elements.

7 Euclid's fourth proposition.

But all this process is a fiction of the mind, and it is the fiction of an impossibility. It is even *inconceivable*, that is, we cannot in imagination make this application of one figure to another; and we presume to say, that, if the elements of geometry cannot be demonstrated in some other way, the science has not that title to pure, abstract, and infallible knowledge, which is usually allowed it. We cannot *suppose* one of the triangles lifted and laid on the other, without supposing it something different from a triangle *in abstracto*. The *individuality* of such a triangle consists solely in its being in the precise place where it is, and in occupying *that* portion of space. If we could distinctly conceive otherwise, we should perceive that, when we have lifted the triangle from its place, and applied it to the other, it is gone from its former place, and that there is no longer a triangle *there*. This is inconceivable, and space has always been acknowledged to be immoveable. There is therefore some logical defect in Euclid's demonstration. We apprehend that he is labouring to demonstrate, or rather illustrate, a simple apprehension. This indeed is the utmost that can be done in any demonstration (see METAPHYSICS, N° 82.): but the mode by which he guides the mind to the apprehension of the truth of his fourth proposition is not consistent either with pure mathematics or with the laws of corporeal nature. The real process, as laid down by him, seems to be this. We suppose something different from the abstract triangle; some *thing* that, in conjunction with other properties, has the property of being triangular, with certain dimensions of two of its sides and the included angle. It has avowedly another property, not essential to, and not contained in, the abstract notion of a triangle, viz. mobility. We also suppose it permanent in shape and dimensions, or that although, *during* its motion, it does not occupy *the same space*, it continues, and all its parts, to occupy *an equal space*. In short, our conception is very mixed, and does not perceptibly differ from our conception of a triangular piece of matter, where the

(A) To talk intelligibly of the quantity of a pain, we should have some standard by which to measure it; some known degree of it so well ascertained, that all men, when talking of it, should mean the same thing.—And we should be able to compare other degrees of pain with this, so as to perceive distinctly, not only whether they exceed or fall short of it, but also how much, or in what proportion; whether by an half, or a fifth, or a tenth. *Reid.*

the triangle is not the ſubject, but an adjunct, a quality. And when we ſuppoſe the application made, we are not in fact ſuppoſing two abſtract triangles to coincide. This we cannot do with any thing like diſtinctneſs; for our diſtinct conception now is, not that of two triangles coinciding, but of one triangle being now exactly occupied by that moveable thing which formerly occupied the other. In ſhort, it is a vulgar meaſurement, reſtricted by ſuppoſitions which are inadmiſſible in all *actual* meaſurements in the preſent univerſe, in which no moveable material thing is *known* to be permanent, either in ſhape or magnitude.

This is an undeniable conſequence of the principle of univerſal gravitation, and the compreſſibility of every kind of tangible matter with which we are acquainted. Remove the braſs rule but one inch from its place; its gravitation to the earth and to the reſt of the univerſe is immediately changed, and its dimenſions change of conſequence. A change of temperature will produce a ſimilar effect; and this is attended to and conſidered in all nice menſurations. We do the beſt we can to aſſure ourſelves that our rule always occupies a ſenſibly equal ſpace; and we muſt be contented with chances of error which we can neither perceive nor remove.

We might (were this a proper place) take notice of ſome other logical defects in the reaſoning of this celebrated propoſition: but they are beſide our preſent purpoſe of explaining the different modes of mathematical meaſurement, with the view of diſcovering that circumſtance in which they all agree, and which (if the only one) muſt therefore be the characteriſtic of menſuration.

8
The characteriſtic notion of menſuration.

We think that the only circumſtance in which all modes of menſuration agree, or the only notion that is found in them all, is, that the quantity is conceived as conſiſting of parts, diſtinguiſhable from each other, and ſeparated by aſſignable boundaries; ſo that they are at once conceived ſeparately and jointly. We venture to aſſert that no quantity is directly meaſured which we cannot conceive in this way, and that ſuch quantities only are the immediate objects of mathematical contemplation, and ſhould be diſtinguiſhed by a generic name. Let them be called MATHEMATICAL QUANTITIES. EXTENSION, DURATION, NUMBER, and PROPORTION, have this characteriſtic, and they are the only quantities which have it. Any perſon will be convinced of the firſt aſſertion by attending to his own thoughts when contemplating theſe notions. He will find that he conceives every one of them as made up of its own parts, which are diſtinguiſhable from each other, and have aſſignable boundaries, and that it is only in conſequence of involving this conception that they can be added to or ſubtracted from each other; that they can be multiplied, divided, and conceived in any proportion to each other.

He may perhaps find conſiderable difficulty in acquiring perfectly diſtinct notions of the menſurability, and the accuracy of the modes of menſuration. He will find that the way in which he meaſures duration is very ſimilar to that in which he meaſures ſpace or extenſion. He does not know, or does not attend to, any thing which hinders the braſs foot-rule in his hand from continuing to occupy equal ſpaces during his uſe of it, in meaſuring the diſtance of two bodies. In like manner he ſelects an event which nature or art can repeat continually, and in which the circumſtances which contribute to its accompliſhment are invariably the ſame, or their variations and their effects are inſenſible. He concludes that it will always occupy an equal portion of time for its accompliſhment, or always laſt an equal time. Then, obſerving that, during the event whoſe duration he wiſhes to meaſure, this ſtandard event is accompliſhed $29\frac{1}{2}$ times, and that it is repeated $365\frac{1}{4}$ times during the accompliſhment of another event, he affirms that the durations of theſe are in the ratio of $29\frac{1}{2}$ to $365\frac{1}{4}$. It is thus (and with the ſame logical defect as in the meaſuring a line by a braſs rod) that the aſtronomer meaſures the celeſtial revolutions by means of the rotation of the earth round its axis, or by the vibrations of a pendulum.

We are indebted for moſt of the preceding obſervations to Dr Reid, the celebrated author of the Inquiry into the Human Mind on the Principles of Common Senſe, and of the Eſſays on the Intellectual and Active Powers of Man. He has publiſhed a diſſertation on this ſubject in the 45th volume of the Philoſophical Tranſactions, N° 489, which we recommend to our philoſophical readers as a performance eminent for preciſion and acuteneſs. If we preſume to differ from him in any trivial circumſtance, it is with that deference and reſpect which is due to his talents and his worth.

9
Characters of mathematical quantity.

Dr Reid juſtly obſerves, that as nothing has proportion which has not either extenſion, duration, or number, the characters of mathematical quantity may be reſtricted to theſe three. He calls them PROPER quantities, and all others he calls IMPROPER. We believe that, in the utmoſt preciſion of the Engliſh language, this denomination is very appoſite, and that the word *quantity*, derived from *quantum*, always ſuppoſes meaſurement: But the word is frequently uſed in caſes where its original is not kept in view, and we uſe other words as ſynonymous with it, when all menſuration, whether poſſible or not, is out of our thoughts. According to practice, therefore, the *jus et norma loquendi*, there ſeems to be no impropriety in giving this name, in our language at leaſt, to whatever can be conceived as great or little. There is no impropriety in ſaying that the pain occaſioned by the ſtone is greater than that of the toothache; and when we ſearch for the category to which the aſſertion may be referred, we cannot find any other than quantity. We may be allowed therefore to ſay, with almoſt all our ſcientific countrymen, that every thing is conceivable in reſpect of quantity which we can think or ſpeak of as greater and leſs; and that this notion is the characteriſtic of quantity as a genus, while meaſurableneſs is the characteriſtic of mathematical quantity as a ſpecies.

10
Other quantities that cannot be conſidered mathematically.

But do we not meaſure many quantities, and conſider them mathematically, which have not this characteriſtic of being made up of their own diſtinguiſhable parts? What elſe is the employment of the mechanician, when ſpeaking of velocities, forces, attractions, repulſions, magnetic influence, chemical affinity, &c. &c.? Are not theſe mathematical ſciences? And if the preciſion and certainty of mathematics ariſe from the nature of their ſpecific object, are not all the claims of the mechanician and phyſical aſtronomer ill-founded pretenſions? Theſe queſtions require and deſerve a ſerious anſwer.

It is moſt certain that we conſider the notions which are expreſſed by theſe terms velocity, force, denſity, and the

the like, as ſuſceptible of meaſure, and we conſider them mathematically.

11 Velocity, force, denſity, how meaſured.

Some of theſe terms are nothing but names for relations of meaſurable quantity, and only require a little reflection to ſhow themſelves ſuch. VELOCITY is one of theſe. It is only a name expreſſing a relation between the ſpace deſcribed by a moving body and the time which elapſes during its deſcription. Certain moderate rates of motion are familiar to us. What greatly exceeds this, ſuch as the flight of a bird when compared with our walking, excites our attention, and this exceſs gets a name. A motion not ſo rapid as we are familiar with, or as we wiſh, alſo gets a name; becauſe in this the exceſs or defect may intereſt us. We wiſh for the flight of the hawk; we chide the tardy pace of our meſſenger: but it is ſcientific curioſity which firſt conſiders this relation as a *ſeparate* object of contemplation, and the philoſopher muſt have a name for it. He has not formed a new one, but makes uſe of a word of common language, whoſe natural meaning is the combination of a great ſpace with a ſhort time. Having once appropriated it, in his ſcientific vocabulary, to this very general uſe, it loſes with him its true ſignification. Tardity would have done juſt as well, though its true meaning is diametrically oppoſite; and there is no greater impropriety in ſaying the tardity of a cannon bullet than in ſaying the velocity of the hour-hand of a watch. Velocity is a quality or affection of motion, the notion of which includes the notions of ſpace and duration (two mathematical quantities), and no other. It does not therefore expreſs a mathematical quantity itſelf, but a relation, a combination of two mathematical quantities of different kinds; and as it is meaſurable in the quantities ſo combined, its meaſure muſt be a unit of its own kind, that is, an unit of ſpace *as combined* with an unit of time.

DENSITY is another word of the ſame kind, expreſſing a combination of ſpace with number. *Denſæ arbores* means trees ſtanding at a ſmall diſtance from each other; and the word is uſed in the ſame ſenſe when we ſay that quickſilver is denſer than water. The expreſſion always ſuggeſts to the reflecting mind the notions of particles and their diſtances. We are indeed ſo habituated to complicated views of things, that we can ſee remote connections with aſtoniſhing rapidity; and a very few circumſtances are ſufficient for leading forward the mind in a train of inveſtigation. Common diſcourſe is a moſt wonderful inſtance of this. It is in this way that we ſay, that we found by weighing them that inflammable air had not the ſixth part of the denſity of common air. Suppoſing all matter to conſiſt of equal atoms equally heavy, and knowing that the weight of a bladder of air is the ſum of the weights of all the atoms, and alſo knowing that the *vicinity* of the atoms is in a certain proportion of the *number* contained in a given bulk, we affirm that common air is more than ſix times denſer than inflammable air; but this rapid deciſion is entirely the effect of habit, which makes us familiar with certain groups of conceptions, and we inſtantaneouſly diſtinguiſh them from others, and thus think and diſcourſe rationally. The Latin language employs the word *frequens* to expreſs both the combination of ſpace and number, and that of time and number.

There are perhaps a few more words which expreſs combinations of mathematical quantities of different kinds; and the correſponding ideas or notions are therefore proper and immediate ſubjects of mathematical diſcuſſion: But there are many words which are expreſſive of things, or at leaſt of notions, to which this way of conſidering them will not apply. All thoſe affections or qualities of external bodies, by which they are conceived to act on each other, are of this kind: IMPULSIVE FORCE, WEIGHT, CENTRIPETAL AND CENTRIFUGAL FORCE, MAGNETICAL, ELECTRICAL, CHEMICAL ATTRACTIONS AND REPULSIONS; in ſhort, all that we conſider as the immediate cauſes of natural phenomena. Theſe we familiarly meaſure, and conſider mathematically.

12 Forces meaſured in the phenomena.

What was ſaid on this ſubject in the article PHYSICS will give us clear conceptions of this proceſs of the mind. Theſe forces or cauſes are not immediate objects of contemplation, and are known only *by* and *in* the phenomena which we conſider as their effects. The phenomenon is not only the indication of the agency of any cauſe, and the characteriſtic of its kind, but the meaſure of its degree. The neceſſary circumſtances in this *train of human thought* are, 1ſt, The notion of the force as ſomething ſuſceptible of augmentation and diminution. 2d, The notion of an inſeparable connection of the force with the effect produced, and of every degree of the one with a correſponding degree of the other. From theſe is formed the notion that the phenomenon or effect is the proper meaſure of the force or cauſe. All this is ſtrictly logical.

But when we are conſidering theſe ſubjects mathematically, the immediate objects of our contemplation are not the forces which we are thus treating. It is not their relations which we perceive, and which we combine with ſuch complication of circumſtances and certainty of inference as are known in all other ſciences: by no means; they are the phenomena only, which are ſubjects of purely mathematical diſcuſſion. They are motions, which involve only the notions of ſpace and time; and when we have finiſhed an accurate mathematical inveſtigation, and make our affirmation concerning the forces, we are certain of its truth, becauſe we *ſuppoſe* the forces to have the proportions and relations, and no other, which we obſerve in the phenomena. Thus, after having demonſtrated, by the geometrical compariſon of the lines and angles and ſurfaces of an ellipſe, that the momentary deflection of the moon from the tangent of her orbit is the 3600th part of the ſimultaneous deflection of a ſtone from the tangent of its parabolic path; Newton affirms, that the force by which a particle of the moon is retained in her orbit is the 3600th part of the weight of a particle of the ſtone; and having farther ſhown, from fact and obſervation, that theſe momentary deflections are inverſely as the ſquares of the diſtances from the centre of the earth, he affirms, that all this is produced by a force which varies its intenſity in this manner.

Now all this inveſtigation proceeds on the two ſuppoſitions mentioned above, and the meaſures of the forces are in fact the meaſures of the phenomena. The whole of phyſical aſtronomy, and indeed the whole of mechanical philoſophy, might be taught and underſtood, without ever introducing the word force, or the notion which it is ſuppoſed to expreſs: for our mathematical reaſonings are really about the phenomena, which are ſubjects purely mathematical.

The preciſion, therefore, that we preſume to affirm to attend theſe inveſtigations, ariſes entirely from the

meaſurable

Quantity. meaſureable nature of the quantities which are the real objects of our contemplation, and the ſuitableneſs and propriety of the meaſures which we adopt in our compariſons.

Since, then, the phenomena are the *immediate* ſubjects of our diſcuſſion, and the operating powers are only inferences from the phenomena conſidered as effects, the quantity aſcribed to them muſt alſo be an inference from the quantity of the effect, or of ſome circumſtance in the effect. The meaſure, therefore, of the cauſe, or natural power or force, cannot be one of its own parts; for the whole and the part are equally unperceived by us. Our meaſure, therefore, muſt be a meaſure of ſome intereſting part, or of the only intereſting part of the phenomenon. It is therefore in a manner arbitrary, and depends chiefly on the intereſt we take in the phenomenon. It muſt, however, be ſettled with preciſion, ſo that all men in uſing it may mean the ſame thing. It muſt be ſettled, therefore, by the deſcription of that part or circumſtance of the phenomenon which is characteriſtic of of the natural power. This deſcription is the *definition* of the meaſure.

13 Meaſures of centripetal force.

Thus Newton aſſumes as his meaſure of the centripetal force, the momentary deviation from uniform rectilineal motion. Others, and ſometimes Newton himſelf, aſſumes the momentary change of velocity, which again is meaſured by *twice this deviation*. Theſe meaſures, being thus ſelected, are always proper in a mathematical ſenſe; and if ſtrictly adhered to, can never lead us into any paralogiſm. They may, however, be phyſically wrong: there may not be that indiſſoluble connection between the phenomenon and the ſuppoſed cauſe. But this is no mathematical error, nor does it invalidate any of our mathematical inferences: it only makes them uſeleſs for explaining the phenomenon by the principle which we adopted; but it prepares a modification of the phenomenon for ſome more fortunate application of phyſical principles.

14 Requiſites of ſuch meaſures.

All that can be deſired in the definitions or deſcriptions of theſe meaſures is, that they may not deviate from the ordinary uſe of the terms, becauſe this would always create confuſion, and occaſion miſtakes. Dr Reid has given an example of an impropriety of this kind, which has been the ſubject of much debate among the writers on natural philoſophy. We mean the meaſure of the force inherent in a body in motion. Deſcartes, and all the writers of his time, aſſumed the velocity produced in a body as the meaſure of the force which produces it; and obſerving that a body, in conſequence of its being in motion, produces changes in the ſtate or motion of other bodies, and that theſe changes are in the proportion of the velocity of the changing body, they aſſerted that there is in a moving body a VIS INSITA, an INHERENT FORCE, and that this is proportional to its velocity; ſaying that its force is twice or thrice as great, when it moves twice or thrice as faſt at one time as at another. But Leibnitz obſerved, that a body which moves twice as faſt, riſes four times as high, againſt the uniform action of gravity; that it penetrates four times as deep into a piece of uniform clay; that it bends four times as many ſprings, or a ſpring four times as ſtrong, to the ſame degree; and produces a great many effects which are four times greater than thoſe produced by a body which has half the initial velocity. If the velocity be triple, quadruple, &c. the effects are nine times, 16 times, &c. greater; and, in ſhort, are proportional, not to the velocity, but to its ſquare. This obſervation had been made before by Dr Hooke, who has enumerated a prodigious variety of important caſes in which this proportion of effect is obſerved. Leibnitz, therefore, affirmed, that the force inherent in a moving body is proportional to the ſquare of the velocity.

15 Controverſy between the Carteſians and Leibnitzians on this ſubject.

It is evident that a body, moving with the ſame velocity, has the ſame inherent force, whether this be employed to move another body, to bend ſprings, to riſe in oppoſition to gravity, or to penetrate a maſs of ſoft matter. Therefore theſe meaſures, which are ſo widely different, while each is agreeable to a numerous claſs of facts, are not meaſures of this ſomething inherent in the moving body which we call its force, but are the meaſures of its exertions when modified according to the circumſtances of the caſe; or, to ſpeak ſtill more cautiouſly and ſecurely, they are the meaſures of certain claſſes of phenomena conſequent on the action of a moving body. It is in vain, therefore, to attempt to ſupport either of them by a demonſtration. The meaſure itſelf is nothing but a definition. The Carteſian calls that a double force which produces a double velocity in the body on which it acts. The Leibnitzian calls that a quadruple force which makes a quadruple penetration. The reaſonings of both in the demonſtration of a propoſition in dynamics may be the ſame, as alſo the reſult, though expreſſed in different numbers.

But the two meaſures are far from being equally proper: for the Leibnitzian meaſure obliges us to do continual violence to the common uſe of words. When two bodies moving in oppoſite directions meet, ſtrike each other, and ſtop, all men will ſay that their forces are equal, becauſe they have the beſt teſt of equality which we can deviſe. Or when two bodies in motion ſtrike the parts of a machine, ſuch as the oppoſite arms of a lever, and are thus brought completely to reſt, we and all men will pronounce their mutual energies by the intervention of the machine to be equal. Now, in all theſe caſes, it is well known that a perfect equality is found in the products of the quantities of matter and velocity. Thus a ball of two pounds, moving with the velocity of four feet in a ſecond, will ſtop a ball of eight pounds moving with the velocity of one foot per ſecond. But the followers of Leibnitz ſay, that the force of the firſt ball is four times that of the ſecond.

All parties are agreed in calling gravity a uniform or invariable accelerating force; and the definition which they give of ſuch a force is, that it always produces the ſame acceleration, that is, equal accelerations in equal times, and *therefore* produces augmentations of velocity proportionable to the times in which they are produced. The only effect aſcribed to this force, and conſequently the only thing which indicates, characteriſes, and meaſures it, is the augmentation of velocity. What is this velocity, conſidered not merely as a mathematical term, but as a phenomenon, as an event, a production by the operation of a natural cauſe? It cannot be conceived any other way than as a *determination* to move on for ever at a certain rate, if nothing ſhall change it. We cannot conceive this very clearly. We feel ourſelves forced to animate, as it were, the body, and give it not only a will and intention to move in this manner, but a real exertion of ſome faculty in

Quantity. consequence of this determination of mind. We are conscious of such a train of operations in ourselves; and the last step of this train is the exertion or energy of some natural *faculty*, which we, in the utmost propriety of language, call force. By such analogical conception, we suppose a something, an energy, inherent in the moving body; and its only office is the production and continuation of this motion, as in our own case. Scientific curiosity was among our latest wants, and language was formed long before its appearance: as we formed analogical conceptions, we contented ourselves with the words already familiar to us, and to this something we gave the name FORCE, which expressed that energy in ourselves which bears some resemblance (in office at least) to the determination of a body to move on at a certain rate. This sort of allegory pervades the whole of our conceptions of natural operations, and we can hardly think or speak of any operation without a language, which supposes the animation of matter. And, in the present case, there are so many points of resemblance between the effects of our exertions and the operations of nature, that the language is most expressive, and has the strongest appearance of propriety. By exerting our force, we not only move and keep in motion, but we move other bodies. Just so a ball not only moves, but puts other bodies in motion, or penetrates them, &c.—This is the origin of that conception which so forcibly obtrudes itself into our thoughts, that there is inherent in a moving body a force by which it produces changes in other bodies. No such thing appears in the same body if it be not in motion. We therefore conclude, that it is the production of the moving force, whatever that has been. If so, it must be conceived as proportional to its producing cause. Now this force, thus produced or exerted in the moving body, is only another way of conceiving that determination which we call velocity, when it is conceived as a natural event. We can form no other notion of it. The *vis insita*, the determination to move at a certain rate, and the velocity, are one and the same thing, considered in different relations.

16 Vis insita.

Therefore the *vis insita corpori moventi*, the determination to move at a certain rate, and the velocity, should have one and the same measure, or any one of them may be taken for the measure of the other. The velocity being an object of perception, is therefore a proper measure of the inherent force; and the propriety is more evident by the perfect agreement of this use of the words with common language. For we conceive and express the action of gravity as uniform, when we think and say that its effects are proportional to the times of its action. Now all agree, that the velocity produced by gravity is proportional to the time of its action. And thus the measure of force, in reference to its producing cause, perfectly agrees with its measure, independent of this consideration.

But this agreement is totally lost in the Leibnitzian doctrine; for the body which has fallen four times as far, and has sustained the action of gravity twice as long, is said to have four times the force.

The quaintness and continued paradox of expression which this measure of inherent force leads us into, would have quickly exploded it, had it not been that its chief abettors were leagued in a keen and acrimonious warfare with the British mathematicians who supported the claim of Sir Isaac Newton to the invention of fluxions. They rejoiced to find in the elegant writings of Huyghens a physical principle of great extent, such as this is, which could be set in comparison with some of the wonderful discoveries in Newton's Principia. The fact, that in the mutual action of bodies on each other the product of the masses and the squares of the velocities remain always the same (which they call the *conservatio virium vivarum*) is of almost universal extent; and the knowledge of it enabled them to give ready and elegant solutions of the most abstruse and intricate problems, by which they acquired a great and deserved celebrity. Dr Robert Hooke, whose observation hardly any thing escaped, was the first (long before Huyghens) who remarked *, that in all the cases of the gradual production and extinction of motion, the sensible phenomenon is proportional to the square of the produced or extinguished velocity.

17 Conservatio virium vivarum.

* *Micographia, vis restitutiva*, &c. in his Posthumous Works.

John Bernoulli brought all these facts together, and systematized them according to the principle advanced by Huyghens in his treatise on the centre of oscillation. He and Daniel Bernoulli gave most beautiful specimens of the prodigious use of this principle for the solution of difficult physical problems in their dissertations on the motion and impulse of fluids, and on the communication of motion. It was however very early objected to them (we think by Marquis Poleni), that in the collision of bodies perfectly hard there was no such *conservatio virium vivarum*; and that, in this case, the forces must be acknowledged to be proportional to the velocities. The objections were unanswerable.—But John Bernoulli evaded their force, by affirming that there were and could be no bodies perfectly hard. This was the origin of another celebrated doctrine, on which Leibnitz greatly plumed himself, THE LAW OF CONTINUITY, viz. that nothing is observed to change abruptly, or *per saltum*. But no one will pretend to say that a perfectly hard body is an inconceivable thing; on the contrary, all will allow that softness and compressibility are adjunct ideas, and not in the least necessary to the conception of a particle of matter, nay totally incompatible with our notion of an ultimate atom.

18 Law of continuity.

Sir Isaac Newton never could be provoked to engage in this dispute. He always considered it as a wilful abuse of words, and unworthy of his attention. He guarded against all possibility of cavil, by giving the most precise and perspicuous definitions of those measures of forces, and all other quantities which he had occasion to consider, and by carefully adhering to them. And in one proposition of about 20 lines, viz. the 39th of the 1st book of the Principia, he explained every phenomenon adduced in support of the Leibnitzian doctrine, showing them to be immediate consequences of the action of a force measured by the velocity which it produces or extinguishes. There it appears that the heights to which bodies will rise in opposition to the uniform action of gravity are as the squares of the initial velocities: So are the depths to which they will penetrate uniformly resisting matter: So is the number of equal springs which they will bend to the same degree, &c. &c. &c. We have had frequent occasion to mention this proposition as the most extensively useful of all Newton's discoveries. It is this which gives the immediate application of mechanical principles to the explanation of natural phenomena. It is incessantly employed in

19 Great superiority of Newton.

in every problem by the very perſons who hold by the other meaſure of forces, although ſuch conduct is virtually giving up that meaſure. They all adopt, in every inveſtigation the two theorems $ft=\dot{v}$, and $f\dot{s}=v\dot{v}$; both of which ſuppoſe an accelerating force f proportional to the velocity v which it produces by its uniform action during the time t, and the theorem $\int f\dot{s}=v^2$ is the 39th 1. Princip. and is the *conſervatio virium vivarum*.

This famous diſpute (the only one in the circle of mathematical ſcience) has led us ſomewhat aſide. But we have little more to remark with reſpect to meaſurable quantity. We cannot ſay what varieties of quantity are ſuſceptible of ſtrict meaſure, or that it is impoſſible to give accurate meaſures of every thing ſuſceptible of augmentation and diminution. We affirm, however, with confidence, that pain, pleaſure, joy, &c. are not made up of their own parts, which can be contemplated ſeparately: but they may chance to be aſſociated by nature with ſomething that is meaſurable; and we may one day be able to aſſign their degrees with as much preciſion as we now aſcertain the degrees of warmth by the expanſion of the fluid in the thermometer. There is one ſenſe in which they may all be meaſured, viz numerically, as Newton meaſures denſity, *vis motrix*, &c. We can conceive the pain of each of a dozen men to be the ſame. Then it is evident that the pain of eight of theſe men is to that of the remaining four as two to one; but from ſuch menſuration we do not foreſee any benefit likely to ariſe.

Quantity, in *Grammar*, an affection of a ſyllable, whereby its meaſure, or the time wherein it is pronounced, is aſcertained; or that which determines the ſyllable to be long or ſhort.

Quantity is alſo the object of proſody, and diſtinguiſhes verſe from proſe; and the economy and arrangement of quantities, that is, the diſtribution of long and ſhort ſyllables, makes what we call the *number*. See Poetry, Part III.

The quantities are uſed to be diſtinguiſhed, among grammarians, by the characters ˘, ſhort, as pĕr; and ¯, long, as rōs. There is alſo a common, variable, or dubious quantity; that is, ſyllables that are at one time taken for ſhort ones, and at another time for long ones; as the firſt ſyllable in *Atlas*, *patres*, &c.

QUARANTINE, is a trial which ſhips muſt undergo when ſuſpected of a peſtilential infection. It may be ordered by the king, with advice of the privy-council, at ſuch times, and under ſuch regulations, as he judges proper. Ships ordered on quarantine muſt repair to the place appointed, and muſt continue there during the time preſcribed (generally ſix weeks); and muſt have no intercourſe with the ſhore, except for neceſſary proviſions, which are conveyed with every poſſible precaution. When the time is expired, and the goods opened and expoſed to the air as directed, if there be no appearance of infection, they are admitted to port.

Ships infected with the peſtilence muſt proceed to St Helen's Pool, in the Scilly iſlands, and give notice of their ſituation to the cuſtomhouſe officers, and wait till the king's pleaſure be known.

Perſons giving falſe information to avoid performing quarantine, or refuſing to go to the place appointed, or eſcaping, alſo officers appointed to ſee quarantine performed, deſerting their office, neglecting their duty, or giving a falſe certificate, ſuffer death as felons.

Goods from Turkey, or the Levant, may not be landed without licenſe from the king, or certificate that they have been landed and aired at ſome foreign port. See Plague.

QUARLES, Francis, the ſon of James Quarles clerk to the board of green cloth, and purveyor to Queen Eliſabeth, was born in 1592. He was educated at Cambridge; became a member of Lincoln's Inn; and was for ſome time cup-bearer to the queen of Bohemia, and chronologer to the city of London. It was probably on the ruin of her affairs that he went to Ireland as ſecretary to Archbiſhop Uſher; but the troubles in that kingdom forcing him to return, and not finding affairs more at peace in England, ſome diſquiets he met with were thought to have haſtened his death, which happened in 1644. His works both in proſe and verſe are numerous, and were formerly in great eſteem, particularly his Divine Emblems: but the obſolete quaintneſs of his ſtyle has cauſed them to fall into neglect, excepting among particular claſſes of readers. "The memory of Quarles, ſays a late author, has been branded with more than common abuſe, and he ſeems to have been cenſured merely from the want of being read. If his poetry failed to gain him friends and readers, his piety ſhould at leaſt have ſecured him peace and goodwill. He too often, no doubt, miſtook the enthuſiaſm of devotion for the inſpiration of fancy; to mix the waters of Jordan and Helicon in the ſame cup, was reſerved for the hand of Milton; and for him, and him only, to find the bays of Mount Olivet equally verdant with thoſe of Parnaſſus. Yet, as the effuſions of a real poetical mind, however thwarted by untowardneſs of ſubject, will be ſeldom rendered totally abortive, we find in Quarles original imagery, ſtriking ſentiment, fertility of expreſſion, and happy combinations; together with a compreſſion of ſtyle that merits the obſervation of the writers of verſe. Groſs deficiencies of judgement, and the infelicity of his ſubjects, concurred in ruining him. Perhaps no circumſtance whatever can give a more complete idea of Quarles's degradation than a late edition of his Emblems; the following paſſage is extracted from the preface: 'Mr Francis Quarles, the author of the Emblems that go under his name, was a man of the moſt exemplary piety, and had a deep inſight into the myſteries of our holy religion. But, for all that, the book itſelf is written in ſo old a language, that many parts of it are ſcarce intelligible in the preſent age; many of his phraſes are ſo affected, that no perſon, who has any taſte for reading, can peruſe them with the leaſt degree of pleaſure; many of his expreſſions are harſh, and ſometimes whole lines are included in a parentheſis, by which the mind of the reader is diverted from the principal object. His Latin mottoes under each cut can be of no ſervice to an ordinary reader, becauſe he cannot underſtand them. In order, therefore, to accommodate the public with an edition of Quarles's Emblems properly moderniſed, this work was undertaken.' Such an exhibition of Quarles is chaining Columbus to an oar, or making John Duke of Marlborough a train-band corporal."

Headley's ſelect Beauties of Ancient Engliſh Poetry.

QUARRIES, a name commonly given to an extraordinary cavern under the city of Paris, the exiſt-

ence

Quarries. ence of which is known to few even of the inhabitants, and many of those who have heard of it consider the whole as an idle story. Mr White visited this cavern in 1784, having, with many others, obtained leave (which is very cautiously granted) to inspect it, accompanied by guides with torches. He gives the following account of it in the second volume of the Manchester Transactions. "At the entrance by the *Observatoire Royal*, the path is narrow for a considerable way; but soon we entered large and spacious streets, all marked with names, the same as in the city; different advertisements and bills were found, as we proceeded, pasted on the walls, so that it had every appearance of a large town swallowed up in the earth.

"The general height of the roof is about nine or ten feet; but in some parts not less than 30 and even 40. In many places there is a liquor continually dropping from it, which congeals immediately, and forms a species of transparent stone, but not so fine and clear as rock crystal. As we continued our peregrination, we thought ourselves in no small danger from the roof, which we found but indifferently propped in some places with wood much decayed. Under the houses, and many of the streets, however, it seemed to be tolerably secured by immense stones set in mortar; in other parts, where there are only fields or gardens above it, it was totally unsupported for a considerable space, the roof being perfectly level, or a plane piece of rock. After traversing about two miles, we again descended about 20 steps, and here found some workmen in a very cold and damp place, propping up a most dangerous part, which they were fearful would give way every moment. The path here is not more than three feet in width, and the roof so low, that we were obliged to stoop considerably.

"On walking some little distance farther, we entered into a kind of saloon cut out of the rock, and said to be exactly under the *Eglise de St Jacques*. This was illuminated with great taste, occasioned an agreeable surprise, and made us all ample amends for the danger and difficulty we had just before gone through. At one end was a representation in miniature of some of the principal forts in the Indies, with the fortifications, draw-bridges, &c. Cannons were planted with a couple of soldiers to each ready to fire. Centinels were placed in different parts of the garrison, particularly before the governor's house; and a regiment of armed men was drawn up in another place with their general in the front. The whole was made up of a kind of clay which the place affords, was ingeniously contrived, and the light that was thrown upon it gave it a very pretty effect.

"On the other side of this hall was a long table set out with cold tongues, bread, and butter, and some of the best Burgundy I ever drank. Now every thing was hilarity and mirth; our fears were entirely dispelled, and the danger we dreaded the moment before was now no longer thought of. In short, we were all in good spirits again, and proceeded on our journey about two miles farther, when our guides judged it prudent for us to ascend, as we were then got to the steps which lead up to the town. We here found ourselves safe at the *Val de Grace*, near to the English Benedictine convent, without the least accident having happened to any one of the party. We imagined we had walked about two French leagues, and were absent from the surface of the earth betwixt four and five hours.

"There were formerly several openings into the quarries, but the two I have mentioned, viz. the *Observatory* and the *Val de Grace*, are, I believe, the only ones left; and these the inspectors keep constantly locked, and rarely open them, except to strangers particularly introduced, and to workmen who are always employed in some part by the king. The police thought it a necessary precaution to secure all the entrances into this cavern, from its having been formerly inhabited by a famous gang of robbers, who infested the country for many miles round the city of Paris.

"As to the origin of this quarry, I could not, on the strictest inquiry, learn any thing satisfactory; and the only account I know published is the following contained in the *Tableaux de Paris, nouvelle edition, tome premier, chapitre 5me, page 12me.*

"For the first building of Paris it was necessary to get the stone in the environs; and the consumption of it was very considerable. As Paris was enlarged, the suburbs were insensibly built on the ancient quarries, so that all that you see without is essentially wanting in the earth for the foundation of the city: hence proceed the frightful cavities which are at this time found under the houses in several quarters. They stand upon abysses. It would not require a very violent shock to throw back the stones to the place from whence they have been raised with so much difficulty. Eight men being swallowed up in a gulf of 150 feet deep, and some other less known accidents, excited at length the vigilance of the police and the government, and, in fact, the buildings of several quarters have been privately propped up; and by this means a support given to these obscure subterraneous places which they before wanted.

"All the suburbs of St James's, Harp-street, and even the street of Tournon, stand upon the ancient quarries; and pillars have been erected to support the weight of the houses. What a subject for reflections, in considering this great city formed and supported by means absolutely contrary! These towers, these steeples, the arched roofs of these temples, are so many signs to tell the eye that what we now see in the air is wanting under our feet."

Quarry. QUARRY, a place under ground, out of which are got marble, freestone, slate, limestone, or other matters proper for building. See STRATA.

Some limestone quarries in Fife are highly worthy the attention of the curious, on account of an amazing mixture of organized marine productions found in them. One of this kind was opened about the year 1759, at a farm called *Enderteel*, in the neighbourhood of Kirkaldy, belonging to General St Clair.

The flakes of the stone, which are of unequal thickness, most of them from eight to ten inches, lie horizontally, dipping towards the sea. Each of these flakes, when broken, presents to our view an amazing collection of petrified sea bodies, as the bones of fishes, stalks of sea-weed, vast quantities of shells, such as are commonly found on those coasts, besides several others of very uncommon figures. In some places the shells are so numerous, that little else is to be seen but prodigious clusters or concretions of them. In the uppermost stratum the shells are so entire, that the outer crust or plate may be scraped off with the finger; and the stalks of the sea-weed have a darkish colour, not that glossy whiteness which they have in the heart of

Quarry. ‖ Quartation

of the quarry. The ſmalleſt rays or veins of the ſhells are deeply indented on the ſtone, like the impreſſion of a ſeal upon wax. In ſhort, no ſpot at the bottom of the ocean could exhibit a greater quantity of ſea-bodies than are to be found in this ſolid rock; for we have the ſkeletons of ſeveral fiſhes, the *antennæ* or feelers of lobſters, the roots and ſtalks of ſea-weeds, with the very *capſulæ* which contain the ſeed. The place where all theſe curioſities are found is on an eminence about an Engliſh mile from the ſea; and as the ground is pretty ſteep the whole way, it may be 200 feet higher at leaſt.

There are two or three things to be remarked here. 1. That among all the bodies we have mentioned, there are none but what are ſpecifically heavier than water. This holds ſo conſtantly true, that the ſea-weed, which floats in water when the plant is entire, has been ſtripped of the broad leaves, which make it buoyant, before it has been lodged here. 2. The ſhells have been all empty; for the double ones, as thoſe of the flat kind, are always found ſingle, or with one ſide only. 3. The rock ſeems to have been gradually deſerted by the ſea, and for a long time, waſhed with the tides; for the upper ſurface is all eaten, and hollowed in many places like an honey-comb, juſt as we obſerve in flat rocks expoſed every tide to the acceſs and receſs of the waters. See the article SEA.

QUARRY, or *Quarrel*, among glaziers, a pane of glaſs cut in a diamond form.

Quarries are of two kinds, ſquare and long; each of which are of different ſizes, expreſſed by the number of the pieces that make a foot of glaſs, viz. eighths, tenths, eighteenths, and twentieths: but all the ſizes are cut to the ſame angles, the acute angle in the ſquare quarrels being $77^{\circ}\ 19'$, and $67^{\circ}\ 21'$ in the long ones.

QUARRY, among hunters, is ſometimes uſed for a part of the entrails of the beaſt taken, given by way of reward to the hounds.

QUARRY, in falconry, is the game which the hawk is in purſuit of, or has killed.

QUART, a meaſure of capacity, being the fourth part of ſome other meaſure. The Engliſh quart is the fourth part of the gallon, and contains two pints. The quart of the Romans was the fourth part of their congius. The French have various quarts, beſides their quart or pot conſiſting of two pints, and are diſtinguiſhed by the whole of which they are quarters; as *quart de muid*, and *quart de boiſſeau*.

QUARTAN, a meaſure containing the fourth part of ſome other meaſure.

QUARTAN, a ſpecies of intermitting fever. See MEDICINE *Index*.

QUARTATION, is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus when gold alloyed with ſilver is to be parted, we are obliged to facilitate the action of the aquafortis, by reducing the quantity of the former of theſe metals to one fourth part of the whole maſs; which is done by ſufficiently increaſing the quantity of the ſilver, if it be neceſſary. This operation is called *quartation*, and is preparatory to the parting; and even many authors extend this name to the operation of parting. See ORES, *Analyſis of*.

Quarter.

QUARTER, the fourth part of any thing, the fractional expreſſion for which is $\frac{1}{4}$.

QUARTER, in weights, is generally uſed for the fourth part of an hundred weight avoirdupois, or 28 lb.

Uſed as the name of a dry meaſure, *quarter* is the fourth part of a ton in weight, or eight buſhels.

QUARTER, a term in the manege. To work from quarter to quarter, is to ride a horſe three times in upon the firſt of the four lines of a ſquare; then changing your hand, to ride him three times upon the ſecond: and ſo to the third and fourth; always changing hands, and obſerving the ſame order.

QUARTERS, with reſpect to the parts of a horſe, is uſed in various ſenſes: thus the ſhoulders and fore-legs are called the *fore-quarters*, and the hips and hinder-legs the *hind quarters*. The *quarters* of a horſe's foot are the ſides of the coffin, comprehending between the toe and the heel: the *inner* quarters are thoſe oppoſite to one another, facing from one foot to the other; and theſe are always weaker than the *outſide* quarters, which lie on the external ſides of the coffin. *Falſe quarters*, are a cleft in the horn of a horſe's hoof, extending from the coronet to the ſhoe. A horſe is ſaid to be *quarter-caſt* when for any diſorder in the coffin we are obliged to cut one of the quarters of the hoof.

QUARTER, in *Aſtronomy*, the fourth part of the moon's period: thus, from the new moon to the quadrature is the firſt quarter; from this to full moon, the ſecond quarter, &c.

QUARTER, in *Heraldry*, is applied to the parts or members of the firſt diviſion of a coat that is quartered, or divided into four quarters.

Franc QUARTER, in *Heraldry*, is a quarter ſingle or alone; which is to poſſeſs one fourth part of the field. It makes one of the honourable ordinaries of a coat.

QUARTER of a Ship, that part of a ſhip's ſide which lies towards the ſtern; or which is comprehended between the aftmoſt end of the main chains and the ſides of the ſtern, where it is terminated by the quarter-pieces.

Although the lines by which the quarter and bow of a ſhip, with reſpect to her length, are only imaginary, yet experience appears ſufficiently to have aſcertained their limits: ſo that if we were to divide the ſhip's ſides into five equal portions, the names of each ſpace would be readily enough expreſſed. Thus the firſt, from the ſtern, would be the quarter; the ſecond, abaft the midſhips; the third, the midſhips; the fourth, before the midſhips; and the fifth, the bow. Whether theſe diviſions, which in reality are ſomewhat arbitrary, are altogether improper, may be readily diſcovered by referring to the mutual ſituation or approach of two adjacent veſſels. The enemy boarded us on the larboard ſide! Whereabouts? Abaſt the midſhips, before the midſhips, &c.

Fig. 1. repreſents a geometrical elevation of a quarter of a 74 gun ſhip. A the keel, with *a* the falſe keel beneath it. B the ſtern-poſt. DD the quarter-gallery, with its balluſtrades and windows. EE the quarter-pieces, which limit and form the outlines of the ſtern. F the taffarel, or upper pieces of the ſtern. FG the profile of the ſtern, with its galleries. H the gun-ports (Plate CCCCLVIII. Fig. 1.)

of

Quarter. of the lower deck; *h* the gun-ports of the upper and quarter-deck. I the after-part of the mizen channel. K the wing tranſom. KG the lower counter. LB the ſtation of the deck tranſom. LQ the after-part of the main-wale. DR the after-part of the channel-wale, parallel to the main-wale. SU the ſheer-rail, parallel to both wales. T *t* the rudder. A *t* F the rake of the ſtern. P *i i* the drift-rails. TU the after-part of the load *water line; k k l* the curve of the ſeveral decks correſponding to thoſe repreſented in the head. See the article HEAD.

As the marks, by which veſſels of different conſtructions are diſtinguiſhed from each other, are generally more conſpicuous on the ſtern or quarter than any other part, we have repreſented ſome of the quarters, which aſſume the moſt different ſhapes, and form the greateſt contraſt with each other. Fig. 2. ſhows the ſtern and quarter of a Dutch flight. Fig. 3. the ſtern and quarter of a cat. Fig. 4. is the ſtern and quarter of a common galley. Fig 5. exhibits the quarter of a firſt-rate galley, otherwiſe called a *galleaſſe*. Fig. 6. the quarter of a Dutch dogger, or galliot. Fig. 7. repreſents the ſtern and quarter of a ſloop of war. (Fig. 2. 3. 4. 5. 6. 7.)

The quarters of all other ſhips have a near affinity to thoſe above exhibited. Thus all ſhips of the line, and Eaſt-Indiamen, are formed with a quarter little differing from the principal figure in this plate. Xebecs have quarters nearly reſembling thoſe of galeaſſes, only ſomewhat higher. Hagboats and pinks approach the figure of *cats*, the former being a little broader in the ſtern, and the latter a little narrower; and the ſterns and quarters of cats ſeem to be derived from thoſe of fly-boats. The ſterns of Dutch doggers and galliots are indeed ſingular, and like thoſe of no other modern veſſel: they have nevertheleſs a great reſemblance to the ſhips of the ancient Grecians, as repreſented in medals and other monuments of antiquity.

On the QUARTER, may be defined an arch of the horizon, contained betwen the line prolonged from the ſhip's ſtern and any diſtant object, as land, ſhips, &c. Thus if the ſhip's keel lies on an eaſt and weſt line, the ſtern being weſtward, any diſtant object perceived on the north-weſt or ſouth weſt, is ſaid to be on the larboard or ſtarboard quarter.

QUARTER-Bill, a roll, or liſt, containing the different ſtations, to which all the officers and crew of the ſhip are quartered in the time of battle, and the names of all the perſons appointed to thoſe ſtations. See QUARTERS.

QUARTER-Maſter, an officer, generally a lieutenant, whoſe principal buſineſs is to look after the quarters of the ſoldiers, their clothing, bread, ammunition, firing, &c. Every regiment of foot and artillery has a quarter-maſter, and every troop of horſe one, who are only warrant-officers, except in the Blues.

QUARTER-Maſter-General, is a conſiderable officer in the army; and ſhould be a man of great judgment and experience, and well ſkilled in geography. His duty is to mark the marches and encampments of an army: he ſhould know the country perfectly well, with its rivers, plains, marſhes, woods, mountains, defiles, paſſages, &c. even to the ſmalleſt brook. Prior to a march, he receives the order and route from the commanding general, and appoints a place for the quarter-maſters of the army to meet him next morning, with whom he marches to the next camp; where being come, and having viewed the ground, he marks out to the regimental quarter-maſters the ground allowed each regiment for their camp: he chooſes the head-quarters, and appoints the villages for the generals of the army's quarters: he appoints a proper place for the encampment of the train of artillery: he conducts foraging parties, as likewiſe the troops to cover them againſt aſſaults, and has a ſhare in regulating the winter-quarters and cantonments.

QUARTER Netting, a ſort of net-work, extended along the rails on the upper part of a ſhip's quarter. In a ſhip of war theſe are always double, being ſupported by iron cranes, placed at proper diſtances. The interval is ſometimes filled with cork, or old ſails; but chiefly with the hammocks of the ſailors, ſo as to form a parapet to prevent the execution of the enemy's ſmall arms in battle.

QUARTER-Seſſions, a general court held quarterly by the juſtices of peace of each county. This court is appointed by ſtat. 2 Hen. V. c. 4. to be in the firſt week after Michaelmas-day; the firſt week after the Epiphany; the firſt week after the cloſe of Eaſter; and in the week after the tranſlation of Saint Thomas à Becket, or the 7th of July. The court is held before two or more juſtices of the peace, one of whom muſt be of the *quorum*. The juriſdiction of this court by 34 Ed. III. c. 1. extends to the trying and determining of all felonies and treſpaſſes whatſoever, though they ſeldom, if ever, try any greater offence than ſmall felonies within the benefit of clergy, their commiſſion providing, that if any caſe of difficulty ariſes, they ſhall not proceed to judgment, but in the preſence of one of the juſtices of the courts of king's bench or common pleas, or one of the judges of aſſize. And therefore murderers and other capital felons are uſually remitted for a more ſolemn trial to the aſſizes. They cannot alſo try any new created offence, without expreſs power given them by the ſtatute which creates it. But there are many offences, and particular matters, which by particular ſtatutes belong properly to this juriſdiction, and ought to be proſecuted in this court; as, the ſmaller miſdemeanors againſt the public or commonwealth, not amounting to felony, and eſpecially offences relating to the game, highways, alehouſes, baſtard children, the ſettlement and proviſion for the poor, vagrants, ſervants wages, apprentices, and popiſh recuſants. Some of theſe are proceeded upon by indictment, and others in a ſummary way by motion and order thereupon; which order may, for the moſt part, unleſs guarded againſt by particular ſtatutes, be removed into the court of king's bench, by writ of *certiorari facias*, and be there either quaſhed or confirmed. The records or rolls of the ſeſſions are committed to the cuſtody of a ſpecial officer, denominated the *cuſtos rotulorum*. In moſt corporation towns there are quarter-ſeſſions kept before juſtices of their own, within their reſpective limits, which have exactly the ſame authority as the general quarter-ſeſſions of the county, except in very few inſtances: one of the moſt conſiderable of which is the matter of appeals from orders of removal of the poor, which, though they be from the orders of corporation juſtices, muſt be to the ſeſſions of the county, by 8 and 9 Will. III. c. 30. In both corporations

(Blackſt. Comment. vol. iv. p. 271.)

rations and counties at large, there is ſometimes kept a ſpecial or petty ſeſſion, by a few juſtices, for diſpatching ſmaller buſineſs in the neighbourhood between the times of the general ſeſſions, as for licenſing alehouſes, paſſing the accounts of pariſh-officers, and the like.

QUARTER-Staff, a long ſtaff borne by foreſters, park-keepers, &c. as a badge of their office, and occaſionally uſed as a weapon.

QUARTERS, a name given at ſea to the ſeveral ſtations where the officers and crew of a ſhip of war are poſted in action. See *Naval TACTICS*.

The number of men appointed to manage the artillery is always in proportion to the nature of the guns, and the number and condition of the ſhip's crew. They are, in general, as follow, when the ſhip is well manned, ſo as to fight both ſides at once occaſionally:

Pounder.		No. of men.	Pounder.		No. of men.
To a 42	-	15	To a 9	-	6
32	-	13	6	-	5
24	-	11	4	-	4
18	-	9	3	-	3
12	-	7			

This number, to which is often added a boy to bring powder to every gun, may be occaſionally reduced, and the guns nevertheleſs well managed. The number of men appointed to the ſmall arms, on board his Majeſty's ſhips and ſloops of war, by order of the admiralty, are,

Rate of the ſhip.	No. of men to the ſmall arms.
1ſt	150
2d	120
3d of 80 guns	100
—of 70 guns	80
4th of 60 guns	70
4th of 50 guns	60
5th	50
6th	40
Sloops of war	30

The lieutenants are uſually ſtationed to command the different batteries, and direct their efforts againſt the enemy. The maſter ſuperintends the movements of the ſhip, and whatever relates to the ſails. The boatſwain, and a ſufficient number of men, are ſtationed to repair the damaged rigging; and the gunner and carpenter, wherever neceſſary, according to their reſpective offices.

The marines are generally quartered on the poop and forecaſtle, or gang-way, under the direction of their officers; although, on ſome occaſions, they aſſiſt at the great guns, particularly in diſtant cannonading.

QUARTERS, at a ſiege, the encampment upon one of the principal paſſages round a place beſieged, to prevent relief and convoys.

Head QUARTERS of an Army, the place where the commander in chief has his quarters. The quarters of generals of horſe are, if poſſible, in villages behind the right and left wings, and the generals of foot are often in the ſame place: but the commander in chief ſhould be near the centre of the army.

QUARTERS of Refreſhment, the place or places where troops that have been much haraſſed are put to recover themſelves during ſome part of the campaign.

Intrenched QUARTERS, a place fortified with a ditch and parapet to ſecure a body of troops.

Winter QUARTERS, ſometimes means the ſpace of time included between leaving the camp and taking the field; but more properly the places where the troops are quartered during the winter.

The firſt buſineſs, after the army is in winter-quarters, is to form the chain of troops to cover the quarters well: which is done either behind a river, under cover of a range of ſtrong poſts, or under the protection of fortified towns. Huſſars are very uſeful on this ſervice.

It ſhould be obſerved, as an invariable maxim, in winter-quarters, that your regiments be diſpoſed in brigades, to be always under the eye of a general officer; and, if poſſible, let the regiments be ſo diſtributed, as to be each under the command of its own chief.

QUARTILE, an aſpect of the planets when they are at the diſtance of 90° from each other, and it is denoted by the character □.

QUARTERING, in heraldry, is dividing a coat into four or more quarters, or quarterings, by parting, couping, &c. that is, by perpendicular and horizontal lines, &c.

QUARTO-DECIMANS, an ancient ſect in the Chriſtian church, who taught that Eaſter ſhould always be celebrated according to the cuſtom of the Jews, on the fourteenth day of the moon in the month of March, whenſoever that day fell out. And hence they derived their name *quarto-decimani*, q. d. Fourteenthers. The Aſiatics were mightily attached to this opinion, pretending that it was built on the authority of St John, who was their apoſtle; and Pope Victor could never bring them to obedience in this article, though he was upon the point of excommunicating them: but it is more probable he contented himſelf with menaces. See EASTER.

QUARTZ, a mineral compoſed chiefly of ſiliceous earths. See MINERALOGY *Index*.

QUASHING, in *Law*, the overthrowing and annulling a thing.

QUASI-CONTRACT, in the civil law, an act without the ſtrict form of a contract, but yet having the force thereof. In a contract there muſt be the mutual conſent of both parties, but in a *quaſi-contract* one party may be bound or obligated to the other, without having given his conſent to the act whereby he is obliged. For example: I have done your buſineſs, in your abſence, without your procuration, and it has ſucceeded to your advantage. I have then an action againſt you for the recovery of what I have diſburſed, and you an action againſt me to make me give an account of my adminiſtration, which amounts to a *quaſi-contract*.

QUASI-Crime, or *Quaſi-delict*, in the civil law, the action of a perſon who does damage, or evil, involuntarily. The reparation of *quaſi-crimes* conſiſts in making good the damages, with intereſt.

QUASS, a fermented liquor drunk in Ruſſia. See PEASANT.

QUASSIA, a genus of plants, belonging to the decandria claſs; and in the natural method ranking under the 14th order, *Gruinales*. See BOTANY *Index*.

QUATUORVIR, in antiquity, formerly written IIII. VIR, a Roman magistrate, who had three colleagues joined with him in the same administration, and had the care of conducting and settling the colonies sent into the provinces. There were also quatuorviri appointed to inspect and take care of repairs, &c.

QUAVER, in *Music*, a measure of time equal to half a crotchet, or an eighth part of a semibreve.

QUAY. See KEY.

QUEBEC, a handsome and large town of North America, and capital of Canada. The first place taken notice of upon landing here is a square of an irregular figure, with well-built houses on each side; on the back of which is a rock; on the left it is bounded by a small church; and on the right are two rows of houses, parallel to each other. There is another between the church and the harbour; as also another long row on the side of the bay. This may be looked upon as a kind of suburb; and between this and the great street is a very steep ascent, in which they have made steps for the foot passengers to go up. This may be called the *Upper Town*, wherein is the bishop's palace; and between two large squares is a fort where the governor lodges. The Recolets have handsome houses over-against it, and on the right is the cathedral church: over-against this is the Jesuits college, and between them are well built houses; from the fort runs two streets, which are crossed by a third, and between these is a church and a convent. In the second square are two descents to the river of St Charles. The Hotel Dieu is in the midway; and from thence are small houses, which reach to the house of the intendant. On the other side of the Jesuits college, where the church stands, is a pretty long street in which is a nunnery. Almost all the houses are built of stone, and there are about 7000 inhabitants; the fort is a handsome building, but not quite finished. Quebec is not regularly fortified: but it cannot be easily taken; for the harbour is flanked with two bastions, which at high tides are almost level with the water. A little above one of the bastions is a demi-bastion, partly taken out of the rock; and above it, on the side of the gallery of the fort, is a battery of 25 pieces of cannon: still above this is a square fort called the *citadel;* and the ways from one fortification to another are difficult to pass. To the left of the harbour, on the side of the road, there are large batteries of cannon, and some mortars; besides these, there are several other fortifications not very easy to be described. In 1711 the British fitted out a fleet with a design to conquer Canada, which failed on account of the rashness of the admiral; who, contrary to the advice of his pilot, went too near the Seven isles, and so lost his largest ships, and 3000 of his best soldiers. It is about 300 miles north-west of Boston in New-England. On October, 18. 1759, it was taken by the British under the command of General Wolfe, who lost his life in the battle, after he had the satisfaction to know that our troops were victorious. Admiral Saunders commanded a squadron of men of war, and did immense service in reducing this place; there being not a man in the navy but what was active on this occasion, not excepting the sailors belonging to the transport vessels. After this valuable acquisition, all Canada came under the jurisdiction of the crown of Great Britain. W. Long. 69. 48. N. Lat. 46. 55.

QUEDA, a kingdom of Asia, in the peninsula beyond the Ganges, and near the straits of Malacca. The king is tributary to Siam. The principal town is of the same name, and said to contain about 8000 inhabitants. It has a harbour, and is 300 miles north of Malacca. E. Long. 100. 5. N. Lat. 7. 5.

QUEDLINGBURG, a town of Germany, in the circle of Upper Saxony, and on the confines of the duchy of Brunswick. Here is a famous abbey, whose abbess is a princess of the empire, and who sends deputies to the diets. Her contingent is one horseman and ten footmen. The inhabitants of the town live by brewing, husbandry, and feeding of cattle. It is 10 miles south-east of Halberstadt, and 32 west of Bernberg. E. Long. 11. 34. N. Lat. 52. 1.

QUEEN, a woman who holds a crown singly.

The title of *queen* is also given by way of courtesy to her that is married to a king, who is called by way of distinction *queen-consort;* the former being termed *queen-regent.* The widow of a king is also called *queen*, but with the addition of *dowager.* See *ROYAL Family.*

QUEEN Charlotte's Sound is situated at the northern extremity of the southern island of New Zealand, near Cook's Strait, lying in 41. 6. of south latitude, and 174. 19. of east longitude. The climate of this sound is much more mild than at Dusky Bay; and though there is not such plenty of wild fowl and fish, the defect is sufficiently compensated by the abundance of excellent vegetables. The hills about the sound consist mostly of an argillaceous stone of a greenish grey, or bluish or yellowish brown colour. A green talkous or nephritic (by the jewellers called *jade)* is likewise very common, together with horn-stone, shingle, several sorts of flinty stones and pebbles, some loose pieces of basaltes, strata of a compact mica or glimmer, with particles of quartz. Hence, Mr Forrester thinks, there is reason to believe that this part of New Zealand contains iron-ore, and perhaps several other metallic substances. The country is not so steep as at Dusky Bay, and the hills near the sea are generally inferior in height, but covered with forests equally intricate and impenetrable. Captain Cook sowed the seeds of many vegetables in this place, that have useful and nutritive roots. He sowed also corn of several sorts, beans, kidney-beans, and pease. The dogs here are of the long-haired sort, with pricked ears, and resemble the common shepherd's cur, but they are very stupid animals. They are fed with fish, and even dogs flesh, and perhaps human flesh, which the natives also eat. Captains Cook and Furneaux left on these islands a boar and two sows, with a pair of goats, male and female, with some geese, in order to benefit the natives and future generations of navigators. They left likewise among them a number of brass medals gilt, on one side of which was the head of his present Majesty, with the inscription "George III. King of Great Britain, France, and Ireland", &c. On the reverse, a representation of two men of war, with the names Resolution and Adventure over them; and on the exergue, "Sailed from England March MDCCLXXII."

QUEEN-Gold, is a royal duty or revenue belonging to

Queen's-County || Queensferry.

to every queen of England during her marriage to the king, payable by persons in this kingdom and Ireland, on divers grants of the king by way of fine or oblation, &c. being one full tenth part above the entire fines, on pardons, contracts, or agreements, which becomes a real debt to the queen, by the name of *aurum reginæ*, upon the party's bare agreement with the king for his fine, and recording the same.

QUEEN's-County, a division of the province of Leinster in Ireland; so called from the popish Queen Mary, in whose reign it was first made a county by the earl of Suffex, then lord-deputy. It is bounded on the south by Kilkenny and Catherlogh: by King's county on the north and west; part of Kildare and Catherlogh on the east; and part of Tipperary on the west. Its greatest length from north to south is 35 miles, and its breadth near as much; but it is unequal both ways. This county was anciently full of bogs and woods, though now pretty well inclosed, cultivated, and inhabited. The baronies contained in it are seven; and it formerly sent eight members to parliament.

QUEEN-Bee. See *BEE*, N° 3, &c.

QUEENBOROUGH, a town of the isle of Sheppey in Kent, which sends two members to parliament, though consisting only of about 100 low brick houses, and scarce 350 inhabitants. The chief employment of the people here is oyster dredging; oysters being very plentiful, and of a fine flavour. E. Long. 0. 50. N. Lat. 51. 25.

QUEENSFERRY, which is sometimes denominated South Queensferry, is a royal borough in the shire of Linlithgow, on the coast of the frith of Forth, about 9 miles to the westward of Edinburgh. It obtained the name from Margaret, queen of Malcolm Canmore, who was in the habit of frequenting the passage of the frith at this place, and was the principal patroness of the town. It is a small place, consisting of no more than one irregular street, the houses of which are small, and chiefly inhabited by people who lead a seafaring life. The principal manufacture is that of soap, begun in the year 1770, which from 1783 to 1789 was a trade of considerable extent, the works being then four in number, and paying about 10,000l. annually of excise duty.

The shipping of the port has considerably declined; and at present the chief consequence of the place may be regarded as arising from the ferry over the frith of Forth, which is very much frequented. The river here is about 2 miles broad, and on each side has convenient landing places. The passage is both safe and expeditious, and with the exception of a very few cases, may be had at all times. It is one of five boroughs that send a member to the British or Imperial parliament, the other four being Stirling, Dunfermline, Inverkeithing and Culross. The parish is of very small extent, being confined to the borough. It is an erection in the parish of Dalmeny, which took place in the year 1636. The inhabitants were 505 in the year 1792.

QUEENSFERRY, NORTH, a village in Fifeshire, situated on the Forth, directly opposite to the borough of Queensferry, between which there are regular passage boats. It lies in the parish of Dunfermline, but is annexed, *quoad sacra*, to the parish of Inverkeithing. The inhabitants in 1793, were 312.

Quei-ling-fou || Quercus.

QUEI-LING-FOU, the capital of the province of Quangsi in China, has its name from a flower called *quei*, which grows on a tree resembling a laurel; it exhales so sweet and agreeable an odour, that the whole country around is perfumed with it. It is situated on the banks of a river, which throws itself into the Taho; but it flows with such rapidity, and amidst so narrow valleys, that it is neither navigable nor of any utility to commerce. This city is large, and the whole of it is built almost after the model of our ancient fortresses; but it is much inferior to the greater part of the capitals of the other provinces. A great number of birds are found in the territories belonging to it, the colours of which are so bright and variegated, that the artists of this country, in order to add to the lustre of their silks, interweave with them some of their feathers, which have a splendor and beauty that cannot be imitated. Quei-ling has under its jurisdiction two cities of the second class and seven of the third.

Grosier's General Description of China.

QUEI, in *Natural History*, is a name given by the Chinese to a peculiar earth found in many parts of the east. It is of the nature of an indurated clay, and in some degree approaches to the talks, as our steatites and the galactites do. It is very white and abstersive, used by the women of China to take off spots from the skin, and render it soft and smooth, as the Italian ladies use talk of Venice. They sometimes use the fine powder of this stone dry, rubbing it on the hands and face after washing; sometimes they mix it in pomatum.

QUELPAERT, an island in the mouth of the channel of Japan, subject to the king of Corea. Before the last voyage of the unfortunate La Perouse, this island was only known to the Europeans by the wreck of the Dutch ship Sparrow-hawk, in the year 1635. Some of the crew of this ship were kept prisoners for about 18 years, during which period they were often severely treated; but having found means to escape to Japan, and from thence to Batavia, they at last arrived in safety at Amsterdam. La Perouse discovered the island on the 21st of May 1787, the south point of which is in N. Lat. 33° 14′, and E. Long. 124° 15′ from Paris. The land has a gradual slope towards the sea, which makes the habitations assume the appearance of an amphitheatre. The soil appeared to be highly cultivated, and the divisions of fields were perceived by the assistance of glasses, which afforded a convincing proof of an extensive population. It is unfortunately inhabited by a people who are prohibited from all intercourse with strangers, and who make slaves of all those who have the misfortune to suffer shipwreck on their coasts.

QUERCI, a province of Guienne in France; bounded on the north by Limosin, on the east by Rouergue and Auvergne, on the south by Upper Languedoc, and on the west by Agenois and Perigord. It is divided into Upper and Lower; and is fertile in corn, wine, and fruits. Cahors is the capital town.

QUERCUS, a genus of plants belonging to the monoecia class; and in the natural method ranking under the 50th order, *Amentaceæ*. See BOTANY *Index*.

The robur, or common English oak, grows from about 60 or 70 to 100 feet high, with a prodigious large trunk, and monstrous spreading head; oblong leaves, broadest towards the top, the edges acutely sinuated, having the angles obtuse. There is a variety, having the leaves finely striped with white. This species grows in in great abundance all over England, in woods, forests, and hedge-rows; is naturally of an amazing large growth, there being accounts of some above 100 feet stature, with wonderful large trunks and spreading heads; and is supposed to continue its growth many centuries.

The suber, or cork-tree, grows 30 or 40 feet high, having a thick, rough, fungous, cleft bark, and oblong-oval undivided serrated leaves, downy underneath. This species furnishes that useful material cork; it being the bark of the tree, which becoming of a thick fungous nature, under which, at the same time, is formed a new bark, and the old being detached for use, the tree still lives, and the succeeding young bark becomes also of the same thick spongy nature in six or seven years, fit for barking, having likewise another fresh bark forming under it, becoming cork like the others in the like period of time; and in this manner these trees wonderfully furnish the cork for our use, and of which is made the corks for bottles, bungs for barrels, and numerous other useful articles. The tree grows in great plenty in Spain and Portugal, and from these countries we receive the cork. The Spaniards burn it, to make that kind of light black we call Spanish black, used by painters. Cups made of cork are said to be good for hectical persons to drink out of. The Egyptians made coffins of cork; which being lined with a resinous composition, preserved dead bodies uncorrupted. The Spaniards line stone-walls with it, which not only renders them very warm, but corrects the moisture of the air.

Oak-trees, of all the above sorts, may be employed in gardening to diversify large ornamental plantations in out-grounds, and in forming clumps in spacious lawns, parks, and other extensive opens; the evergreen kinds in particular have great merit for all ornamental purposes in gardens. But all the larger growing kinds, both deciduous and evergreens, demand esteem principally as first-rate forest-trees for their timber. The English oak, however, claims precedence as a timber-tree, for its prodigious height and bulk, and superior worth of its wood. Every possessor of considerable estates ought therefore to be particularly assiduous in raising woods of them, which is effected by sowing the acorns either in a nursery and the plants transplanted where they are to remain, or sowed at once in the places where they are always to stand. All the sorts will prosper in any middling soil and open situation, though in a loamy soil they are generally more prosperous: however, there are but few soils in which oaks will not grow; they will even thrive tolerably in gravelly, sandy, and clayey land, as may be observed in many parts of this country of the common oak.

The oak is of the utmost importance to Britain, and its cultivation deserves the utmost attention. Much, therefore to the honour of the members of the *London Society for encouraging Arts, Manufactures, and Commerce*, they have excited particular attention to it; and many excellent observations, drawn from practice, will be found in their Transactions.

The propagation of the striped-leaved varieties of the common oak, and any particular variety of the other species, must be effected by grafting, as they will not continue the same from seed: the grafting may be performed upon any kind of oakling stocks raised from the acorns, and train them for standards like the others.

The oak is remarkable for its slowness of growth, bulk, and longevity. It has been remarked that the trunk has attained to the size only of 14 inches in diameter, and of some to 20, in the space of fourscore years. As to bulk, we have an account of an oak belonging to Lord Powis, growing in Broomfield wood, near Ludlow in Shropshire, in the year 1764, the trunk of which measured 68 feet in girth, 23 in length, and which, reckoning 90 feet for the larger branches, contained in the whole 1455 feet of timber, round measure, or 29 loads and five feet, at 50 feet to a load.

The Greendale oak, &c. we have already mentioned (see Oak). In the opinion of many, the Cowthorp oak near Wetherby in Yorkshire is the father of the forest. Dr Hunter, in his edition of Evelyn, has given an engraving of it. Within three feet of the surface he says it measures 16 yards, and close to the ground 26. In 1776, though in a ruinous condition, it was 85 feet high, and its principal limb extended 16 yards from the bole. The foliage was very thin. If this measurement were taken as the dimension of the *real stem*, the size of this tree would be enormous; but, like most very large trees, its stem is short, spreading wide at the base, the roots rising above the ground like buttresses to the trunk, which is similar not to a cylinder but to the frustum of a cone. Mr Marsham says, "I found it in 1768, at four feet, 40 feet six inches; at five feet, 36 feet six inches; and at six feet, 32 feet one inch." In the principal dimensions then, *the size of the stem*, it is exceeded by the Bentley oak; of which the same writer gives the following account: "In 1759 the oak in Holt-Forest, near Bentley, was at seven feet 34 feet. There is a large excrescence at five and six feet that would render the measure unfair. In 1778, this tree was increased half an inch in 19 years. It does not appear to be hollow, but by the trifling increase I conclude it not sound." These dimensions, however, are exceeded by those of the Boddington oak. It grows in a piece of rich grass land, called the *Old Orchard Ground*, belonging to Boddington-Manor Farm, lying near the turnpike-road between Cheltenham and Tewksbury, in the Vale of Gloucester. The stem is remarkably collected at the root, the sides of its trunk being much more upright than those of large trees in general; and yet its circumference at the ground is about 20 paces: measuring with a two-foot rule, it is more than 18 yards. At three feet high it is 43 feet, and where smallest, *i. e.* from five to six feet high, it is 36 feet. At six feet it swells out larger, and forms an enormous head, which has been furnished with huge, and probably extensive, arms. But time and the fury of the wind have robbed it of much of its grandeur; and the greatest extent of arm in 1783 was eight yards from the stem.

In the Gentleman's Magazine for May 1794 we have an account of an oak tree growing in Penshurst park in Kent, together with an engraving. It is called the *Bear* or *Bare oak*, from being supposed to resemble that which Camden thought gave name to the county of Berkshire. The tradition at Penshurst is that it is the very tree planted on the day that the celebrated Sir Philip Sydney was born. "Some late writers (says Mr

Mr Rawlet) have queſtioned this, and think that to have been a different tree, which was cut down ſome years ago, and was indeed much larger than this. I remember being once in the hollow of the preſent oak with the late Sir John Cullum; and his opinion then was, that its antiquity was greater than the period aſſigned. But, I aſſure you, the tradition of this place is conſtant for this tree; and, in confirmation of it, an old lady of 94 years of age, now living, has told me, that all the tenants uſed to furniſh themſelves with boughs from this tree, to ſtick in their hats, whenever they went to meet the earls of Leiceſter, as was always the cuſtom to do at the end of the park when they came to reſide at their ſeat here. This fine old oak ſtands upon a plain about 500 yards from their venerable manſion, near a large piece of water called *Lancut-well*. Ben Jonſon and Waller have particularly noticed it; and from the diſtinguiſhed owners of this place, it may be truly ſaid to ſtand on claſſic ground. Within the hollow of it there is a ſeat, and it is capable of containing five or ſix perſons with eaſe. The bark round the entrance was ſo much grown up, that it has lately been cut away to facilitate the acceſs. The dimenſions of the tree are theſe:

	Feet.	Inches.
Girth cloſe to the ground - -	35	6
Ditto one foot from ditto - -	27	6
Ditto five feet from ditto - -	24	0
Height taken by ſhadow - -	73	0
Girth of loweſt, but not largeſt, limb	6	9

With reſpect to longevity, Linnæus gives account of an oak 260 years old: but we have had traditions of ſome in England (how far to be depended upon we know not) that have attained to more than double that age. Mr Marſham, in a letter to Thomas Beevor, Eſq. Bath Papers, vol. i. p. 79, makes ſome very ingenious calculations on the age of trees, and concludes from the increaſe of the Bentley oak, &c. that the Fortworth cheſnut is 1100 years old.

Beſides the grand purpoſes to which the timber is applied in navigation and architecture, and the bark in tanning of leather, there are other uſes of leſs conſequence, to which the different parts of this tree have been referred. The Highlanders uſe the bark to dye their yarn of a brown colour, or, mixed with copperas, of a black colour. They call the oak *the king of all the trees in the foreſt*; and the herdſman would think himſelf and his flock unfortunate if he had not a ſtaff of it. The acorns are a good food to fatten ſwine and turkeys; and, after the ſevere winter of the year 1709, the poor people in France were miſerably conſtrained to eat them themſelves. There are, however, acorns produced from another ſpecies of oak, which are eaten to this day in Spain and Greece, with as much pleaſure as cheſnuts, without the dreadful compulſion of hunger.

Quercus Marina, the *Sea Oak*, in *Botany*, the name of a broad-leaved dichotomous ſea-fucus. It is not agreed, among the late botaniſts, what was the ſea-oak of Theophraſtus; and the moſt ancient botaniſts, Cluſius and Cæſalpinus, ſuppoſe it to have been a ſpecies of the ſhrubby coralline; but that ſeems by no means to have been the caſe, ſince Theophraſtus ſays his ſea-oak had a long, thick, and fleſhy leaf; whence we may much more naturally conclude it to have been of the fucus claſs.

QUERIA, a genus of plants, belonging to the triandria claſs; and in the natural method ranking under the 22d order, *Caryophillei*. See Botany *Index*.

QUESNE, Abraham du, marquis of Queſne, admiral of the naval forces of France, and one of the greateſt men of the 17th century, was born in Normandy in 1610. He contributed to the defeating of the naval power of Spain before Gattari; was dangerouſly wounded before Barcelona in 1642, and on other occaſions: he went into the ſervice of the Swedes, and became vice-admiral; gave the Danes an entire defeat, killed their admiral, and took his ſhip. He was recalled into France in 1647, and commanded the ſquadron ſent to Naples. The ſea-affairs of France being much fallen, he fitted out divers ſhips for the relief of the royal army that blocked up Bourdeaux; which was the principal cauſe of the ſurrender of the town. He was very fortunate in the laſt wars of Sicily, where he beat the Dutch thrice, and De Ruyter was killed. He alſo obliged the Algerines to ſue for peace from France in a very humble manner. In ſhort, Aſia, Africa, and Europe, felt the effects of his valour. He was a Proteſtant; yet the king beſtowed on him the land of Bouchet, and to immortalize his memory gave it the name of that great man. He died in 1688.

QUESTION, in *Logic*, a propoſition ſtated by way of interrogation.

Question, or *Torture*. See Rack.

QUESTOR, or Quæstor, in Roman antiquity, an officer who had the management of the public treaſure.

The queſtorſhip was the firſt office any perſon could bear in the commonwealth, and have a right to ſit in the ſenate.

At firſt there were only two; but afterwards two others were created, to take care of the payment of the armies abroad, of ſelling the plunder, booty, &c. for which purpoſe they generally accompanied the conſuls in their expeditions; on which account they were called *peregrini*, as the firſt and principal two were called *urbani*.

The number of queſtors was afterwards greatly increaſed. They had the keeping of the decrees of the ſenate: and hence came the two officers of *queſtor principis*, or *auguſti*, ſometimes called *candidatus principis*, whoſe office reſembled in moſt reſpects that of our ſecretaries of ſtate, and the *queſtor palatii*, anſwering in a great meaſure to our lord-chancellor.

QUEUE, in *Heraldry*, ſignifies the tail of a beaſt; thus, if a lion be borne with a forked tail, he is blazoned double-queued.

Queue d'Aronde, or *Swallows Tail*, in *Fortification*, a detached or outwork, the ſides of which open towards the champaign, or draw cloſer towards the gorge. Single or double tenailles are of this kind, and ſome hornworks, the ſides of which are not parallel, but narrow at the gorge, and open at the head, reſembling a ſwallow's tail. When the ſides are leſs than the gorge, the work is called *centre queue d'aronde*.

Queue d'Aronde, in carpentry, a method of jointing alſo called *dove-tailing*.

QUEVEDO de Villegas, Francisco, a celebrated Spaniſh poet, born at Madrid in 1570. He was deſcended

Quevedo, Quick.

descended from a noble family, and was made a knight of St James; but was thrown into prison by order of Count Olivarez, whose administration he satirized in his verses, and was not set at liberty till after that minister's disgrace. Quevedo wrote some heroic, lyric, and facetious poems. He also composed several treatises on religious subjects, and has translated some authors into Spanish. He died in 1644. The most known of his works are, 1. The Spanish Parnassus. 2. The Adventurer Buscon. 2. Visions of Hell Reformed, &c. Quevedo was one of the greatest scholars and most eminent poets of his time. His youth was spent in the service of his country in Italy, where he distinguished himself with the utmost sagacity and prudence. His moral discourses prove his sound doctrine and religious sentiments, while his literary pieces display his infinite judgement and refined taste. His great knowledge of Hebrew is apparent from the report of the historian Mariana to the king, requesting that Quevedo might revise the new edition of the Bible of Arias Montanus. His translations of Epictetus and Phocylides, with his imitations of Anacreon, and other Greek authors, show how well he was versed in that language: that he was a Latin scholar, his constant correspondence, from the age of twenty, with Lipsius, Chifflet, and Scioppius, will sufficiently illustrate. As a poet, he excelled both in the serious and burlesque style, and was singularly happy in that particular turn we have since admired in Butler and Swift. His library, which consisted of about five thousand volumes, was reduced at his death to about two thousand, and is preserved in the convent of St Martin at Madrid.

QUICK or *QUICKSET Hedge*, among gardeners, denotes all live hedges, of whatever sort of plants they are composed, to distinguish them from dead hedges; but in a more strict sense of the word, it is restrained to those planted with the hawthorn, under which name those young plants or sets are sold by the nursery-gardeners who raise them for sale.

The following method of propagating the common white thorn for hedges is recommended by Mr Taylor of Moston near Manchester, in a letter addressed to the Society for the Encouragement of Arts, &c. After premising that we have successfully repeated the experiment, we shall give the account of the process in his own words.

"Every one of you, I think, will allow that fences are material objects to be attended to in agriculture; you must also be convinced that there is no plant in this kingdom of which they can so properly be made as the *cratægus oxyacantha Linnæi*, or common white thorn. In consequence of my being convinced of this, I have been induced to make a few experiments to effect the better propagation of that valuable plant; the result of which, along with specimens of my success, I beg leave to submit to your inspection.

"In the year 1801, I had occasion to purchase a quantity of thorns, and finding them very dear, I was determined to try some experiments, in order if possible to raise them at a less expence. I tried to propagate them from cuttings of the branches, but with little or no success. I likewise tried if pieces of the root would grow; and I cut from the thorns which I had purchased about a dozen of such roots as pleased me, and planted them in a border along with those I had bought. To my great astonishment, not one of them died; and in two years they became as good thorns as the average of those I had purchased. The thorns I purchased were three years old when I got them. In April 1802, I had occasion to move a fence, from which I procured as many roots of thorns as made me upwards of two thousand cuttings, of which I did not lose five in the hundred.

Quick.

"In the spring of 1803, I likewise planted as many cuttings of thorn roots as I could get. In 1804, I did the same; and this year I shall plant many thousands.

"I have sent for your inspection specimens of the produce of 1802, 1803, and 1804, raised after my method, with the best I could get of those raised from haws in the common way, which generally lie one year in the ground before they vegetate. They are exactly one, two, and three years old, from the day they were planted.—I was so pleased with my success in raising so valuable an article to the farming interest of this kingdom, at so trifling an expence, (for it is merely that of cutting the roots into lengths and planting them), that I was determined to make it known to the world, and could think of no better method than communicating it to your society; and should you so far approve of this method of raising thorns, as to think me entitled to any honorary reward, I shall receive it with gratitude, but shall feel myself amply repaid for any trouble I have been at, should you think it worthy a place in the next volume of your Transactions.

"The method of raising the thorns from roots of the plant, is as follows.

"I would advise every farmer to purchase a hundred or a thousand thorns, according to the size of his farm, and plant them in his orchard or garden, and when they have attained the thickness of my three-year-old specimens, which is the size I always prefer for planting in fences, let him take them and prune the roots in the manner I have pruned the specimen sent you, from which he will upon an average get ten or twelve cuttings from each plant, which is as good as thorns of the same thickness; so that you will easily perceive that in three years he will have a succession of plants fit for use, which he may if he pleases increase tenfold every time he takes them up.

"The spring (say in all April) is the best time to plant the cuttings, which must be done in rows half a yard asunder, and about four inches from each other in the row; they ought to be about four inches long, and planted with the top one-fourth of an inch out of the ground, and well fastened; otherwise they will not succeed so well.

"The reason why I prefer spring to autumn for planting the roots, is, that were they to be planted in autumn, they would not have got sufficient hold of the ground before the frost set in, which would raise them all from the ground; and, if not entirely destroy the plants, would oblige the farmer to plant them afresh.

"I have attached the produce of my three-year-old specimen to the plants it came from, cut in the way I always practise; on the thick end of the root I make two, and on the other end one cut, by which means the proper end to be planted uppermost, which is the thick one, may easily be known.

"Although I recommend the roots to be planted in April,

April, yet the farmer may, where he pleafes, take up the thorns he may want, and put the roots he has pruned off into fand or mould, where they will keep until he has leifure to cut them into proper lengths for planting; he will likewife keep them in the fame way until planted.

"The great advantage of my plan is: firft, that in cafe any one has raifed from haws a thorn with remarkably large prickles, of vigorous growth, or poffeffing any other qualification requifite to make a good fence, he may propagate it far better and fooner, from roots, than any other way. Secondly, in three years he may raife from roots a better plant than can in fix years be raifed from haws, and with double the quantity of roots; my three-year-old fpecimen would have been half as big again, had I not been obliged to move all my cuttings the fecond year after they were planted.

"It would not be a bad way, in order to get roots, to plant a hedge in any convenient place, and on each fide trench the ground two yards wide, and two grafts deep; from which, every two or three years, a large quantity of roots might be obtained, by trenching the ground over again, and cutting away what roots were found, which would all be young and of a proper thicknefs."

QUICKLIME, a general name for all calcarous fubftances when deprived of their fixed air; fuch as chalk, limeftone, oyfter-fhells, &c. calcined. See LIME, CHEMISTRY, for an account of the properties and combinations of lime.

QUICKSILVER, or MERCURY, one of the metals, and fo fufible that it cannot be reduced to a folid ftate but at a degree of cold, equal to 40 below 0 of Fahrenheit's thermometer. For the method of extracting quickfilver from its ore, &c. fee *ORES*, *Reduction of*. For the various preparations, &c. fee CHEMISTRY and MATERIA MEDICA *Index*; and for the natural hiftory of the ores of quickfilver or mercury, fee MINERALOGY *Index*.

Mines of quickfilver are very rare, infomuch that, according to the calculations of Hoffman, there is 50 times more gold got every year out of the mines than mercury and its ores. But Dr Lewis, in his notes upon Newmann, fays, that Cramer fufpects that Hoffman only meant five times inftead of 50; but neither the Latin nor the Englifh edition of this author expreffes any fuch thought; on the contrary, he adopts the fame opinion; and only adds, that mercury is much more frequently met with than is commonly believed; but being fo volatile in the fire, it often flies off in the roafting of ores, and efcapes the attention of metallurgifts.

According to Newmann, the mines of Idria have produced at the rate of 231,778 pounds weight of mercury per annum; but thofe of Almaden in Spain produce much more. The chemifts of Dijon inform us, that their annual produce is five or fix thoufand quintals, or between five and fix hundred thoufand pounds weight. In the year 1717 there were upwards of 2,500,000 pounds of quickfilver fent from them to Mexico, for the amalgamation of the gold and filver ores of that country.

At Guançavelica in Brafil the annual produce of the mines, according to Bomare, amounts to one million of pounds, which are carried overland to Lima, thence to Arica, and laftly to Potofi for the fame purpofe.

Befides thefe mines there are others in Brafil near Villa Rica, where fuch a quantity of cinnabar, and native running mercury are found near the furface of the earth, that the black flaves often collect it in good quantities, and fell it for a trifling price to the apothecaries; but none of thefe mines have ever been worked or taken notice of by the owners. Gold naturally amalgamated with mercury is likewife met with in the neighbourhood of that place; and it is faid that almoft all the gold mines of that country are worked out by fimply wafhing them out with running water, after reducing into powder the hard ores, which are fometimes imbedded in quartzofe and rocky matrices.

In the duchy of Deux Ponts and in the Lower Auftria the quickfilver flows from a fchiftofe or ftony matrice, and is probably, fays Mr Kirwan, mixed with fome other metal, as its globules are not perfectly fpherical. The mines of Friuli are all in fimilar beds or ftrata. The metal is likewife found vifibly diffufed through maffes of clay or very heavy ftone, of a white, red, or blue colour; of which laft kind are the mines of Spain, fome of Idria, and of Sicily. Mafcagni found fluid quickfilver, as well as native cinnabar and mineral ethiops, near the lake of Travale in the duchy of Sienna; but the quantity was fo fmall as not to be worth the expence of working. On the other hand, the following mines afford profits to the owners after clearing all expences, viz. thofe at Kremnitz in Hungary; at Horowitz in Bohemia; Zorge in Saxony; Wolfteim, Stahlberg, and Moefchfeld in the Palatinate. Mercury is alfo brought from Japan in the Eaft Indies; but the greateft part of what is fold in Europe as Japan cinnabar is faid to be manufactured in Holland.

Lemery, Pomet, and others, lay down fome external marks by which thofe places are diftinguifhed where there are mines of quickfilver, viz. thick vapours like clouds arifing in the months of April and May; the plants being much larger and greener than in other places: the trees feldom bearing flowers or fruit, and putting forth their leaves more flowly than in other places; but, according to Neumann, thefe marks are far from being certain. They are not met with in all places where there is quickfilver, and are obferved in places where there is none. Abundance of thefe cloudy exhalations are met with in the Hartz foreft in Germany, though no mercury has ever been found there; to which we may add, that though vaft quantities of mercurial ores are found at Almaden in Spain, none of the above-mentioned indications are there to be met with.

Native mercury was formerly fought from the mines of Idria with great avidity by the alchemifts for the purpofe of making gold; and others have fhowed as ridiculous an attachment to the Hungarian cinnabar, fuppofing it to be impregnated with gold; nay, we are informed by Newmann, that not only the cinnabar, antimony, and copper of Hungary, but even the vine trees of that country were thought to be impregnated with the precious metal. Not many years ago a French chemift advertifed that he had obtained a confiderable quantity of gold from the afhes of vine twigs and ftems, as well as of the garden foil where they grew: but the falfehood of thefe affertions was demonftrated by the count de Lauragais to the fatisfaction of the Royal Academy of Sciences.

The reduction of mercury into a folid ftate, fo that it it might be employed like filver, was another favourite alchemical purfuit. But all proceffes and operations of this kind, fays Newmann, if they have mercury in them, are no other than hard amalgams. When melted lead or tin are juft becoming confiftent after fufion, if a ftick be thruft into the metal, and the hole filled with quickfilver, as foon as the whole is cold, the mercury is found folid. Macquer informs us, that mercury becomes equally folid by being expofed to the fumes of lead. Maurice Hoffman, as quoted by Newmann, even gives a procefs for reducing mercury, thus coagulated, to a ftate of malleability, viz. by repeatedly melting and quenching it in linfeed oil. Thus, he tells us, we obtain a metal which can be formed into rings and other utenfils. But here the mercury is entirely diffipated by the repeated fufions, and nothing but the original lead is left. Wallerius, after mentioning ftrong foap-leys, or cauftic lixivium, and fome other liquors proper for fixing quickfilver, tells us, that by means of a certain gradatory water, the compofition of which he learned from Creuling *de Aureo Vellere*, he could make a coagulum of mercury whenever he pleafed, of fuch confiftency that great part of it would refift cupellation; but what this gradatory water was, he has not thought proper to lay before the public.

QUICK-MATCH, among artillery men, a kind of combuftible preparation formed of three cotton ftrands drawn into length, and dipped in a boiling compofition of white-wine vinegar, faltpetre, and mealed powder. After this immerfion it is taken out hot, and laid in a trough where fome mealed powder, moiftened with fpirits of wine, is thoroughly incorporated into the twifts of the cotton, by rolling it about therein. Thus prepared, they are taken out feparately, and drawn through mealed powder; then hung upon a line and dried, by which they are fit for immediate fervice.

QUID PRO QUO, in *Law*, q. d. "what for what," denotes the giving one thing of value for another; or the mutual confideration and performance of both parties to a contract.

QUID *pro quo*, or QUI *pro quo*, is alfo ufed in phyfic to exprefs a miftake in the phyfician's bill, where *quid* is wrote for *quo*, i. e. one thing for another; or of the apothecary in reading *quid* for *quo*, and giving the patient the wrong medicine. Hence the term is in the general extended to all blunders or miftakes committed in medicine, either in the prefcription, the preparation, or application of remedies.

QUIDDITY, QUIDDITAS, a barbarous term ufed in the fchools for *effence*. The name is derived hence, that it is by the effence of a thing that it is a *tale quid*, fuch a *quid*, or thing, and not another. Hence what is effential to a thing is faid to be *quiddative*.

QUIETISTS, a religious fect, famous towards the clofe of the laft century. They were fo called from a kind of abfolute reft and inaction, which they fuppofed the foul to be in when arrived at that ftate of perfection which they called the *unitive life*; in which ftate they imagined the foul wholly employed in contemplating its God, to whofe influence it was entirely fubmiffive; fo that he could turn and drive it where and how he would. In this ftate, the foul no longer needs prayers, hymns, &c. being laid, as it were, in the bofom and between the arms of its God, in whom it is in a manner fwallowed up.

Molinos, a Spanifh prieft, is the reputed author of Quietifm; though the Illuminati in Spain had certainly taught fomething like it before. The fentiments of Molinos were contained in a book which he publifhed at Rome in the year 1681, under the title of the *Spiritual Guide;* for which he was caft into prifon in 1685, and where he publicly renounced the errors of which he was accufed. This folemn recantation, however, was followed by a fentence of perpetual imprifonment, and he died in prifon in the year 1696. Molinos had numerous difciples in Italy, Spain, France, and the Netherlands. One of the principal patrons and propagators of Quietifm in France was Marie Bouvieres de la Mothe Guyon, a woman of fafhion, remarkable for goodnefs of heart and regularity of manners; but of an unfettled temper, and fubject to be drawn away by the feduction of a warm and unbridled fancy. She derived all ideas of religion from the feelings of her own heart, and defcribed its nature to others as fhe felt it herfelf. Accordingly her religious fentiments made a great noife in the year 1687; and they were declared unfound, after accurate inveftigation, by feveral men of eminent piety and learning, and profeffedly confuted, in the year 1697, by the celebrated Boffuet. Hence arofe a controverfy of greater moment between the prelate laft mentioned and Fenelon archbifhop of Cambray, who feemed difpofed to favour the fyftem of Guyon, and who in 1697 publifhed a book containing feveral of her tenets. Fenelon's book, by means of Boffuet, was condemned in the year 1699, by Innocent XII. and the fentence of condemnation was read by Fenelon himfelf at Cambray, who exhorted the people to refpect and obey the papal decree. Notwithftanding this feeming acquiefcence, the archbifhop perfifted to the end of his days in the fentiments, which, in obedience to the order of the pope, he retracted and condemned in a public manner.

A fect fimilar to this had appeared at Mount Athos in Theffaly, near the end of the 14th century, called *Hefychafts*, meaning the fame with Quietifts. They were a branch of the myftics, or thofe more perfect monks, who, by long and intenfe contemplation, endeavoured to arrive at a tranquillity of mind free from every degree of tumult and perturbation. In conformity to an ancient opinion of their principal doctors (who thought there was a celeftial light concealed in the deepeft retirements of the mind), they ufed to fit every day, during a certain fpace of time, in a folitary corner, with their eyes eagerly and immoveably fixed upon the middle regions of the belly, or navel; and boafted, that while they remained in this pofture, they found, in effect, a divine light beaming forth from their foul, which diffufed through their hearts inexpreffible fenfations of pleafure and delight. To fuch as inquired what kind of light this was, they replied, by way of illuftration, that it was the glory of God, the fame celeftial radiance that furrounded Chrift during his transfiguration on the Mount. Barlaam, a monk of Calabria, from whom the Barlaamites derived their denomination, ftyled the monks who adhered to this inftitution *Maffalians* and *Euchites;* and he gave them alfo the new name of *Umbilicani*. Gregory Palamas, archbifhop of Theffalonica, defended their caufe againft Barlaam, who was condemned in a council held at Conftantinople in the year 1341.—See *Fenelon's Max. des Saints*.

The Mahometans seem to be no strangers to quietism. They expound a passage in the 17th chapter of the Koran, viz. "O thou soul which art at rest, return unto thy Lord, &c." of a soul which, having, by pursuing the concatenation of natural causes, raised itself to the knowledge of that being which produced them and exists of necessity, rests fully contented, and acquiesces in the knowledge, &c. of him, and in the contemplation of his perfection.

QUILLET, Claude, an eminent Latin poet of the 17th century, was born at Chinon, in Touraine, and practised physic there with reputation: but having declared against the pretended possession of the nuns of Loudun, in a manuscript treatise, the original of which was deposited in the library of the Sorbonne, he was obliged to retire into Italy, where he became secretary to the marshal d'Estrees, the French ambassador at Rome. In 1655 Quillet having published in Holland a Latin poem, entitled *Callipædia*, under the name of *Galvidius Lætus*, he there inserted some verses against the cardinal Mazarine and his family; but that cardinal making him some gentle reproaches, he retrenched what related to the cardinal in another edition, and dedicated it to him, Mazarine having, before it was printed, given him an abbey. He died in 1661, aged 59, after having given Menage all his writings, and 500 crowns to pay the expence of printing them; but the abbé took the money and papers, and published none of them. His *Callipædia*, or the art of getting beautiful children, has been translated into English verse.

QUILLS, the large feathers taken out of the end of the wing of a goose, crow, &c. They are denominated from the order in which they are fixed in the wing; the second and third quills being the best for writing, as they have the largest and roundest barrels. Crow-quills are chiefly used for drawing. In order to harden a quill that is soft, thrust the barrel into hot ashes, stirring it till it is soft, and then taking it out, press it almost flat upon your knee with the back of a penknife, and afterwards reduce it to a roundness with your fingers. If you have a number to harden, set water and alum over the fire, and while it is boiling put in a handful of quills, the barrels only, for a minute, and then lay them by.

QUIN, James, a celebrated performer on the English stage, was born at London in 1693. He was intended for the bar; but preferring Shakespeare to the statutes at large, he on the death of his father, when it was necessary for him to do something for himself, appeared on the stage at Drury-lane. In 1720, he first displayed his comic powers in the character of Falstaff, and soon after appeared to as great advantage in Sir John Brute; but it was upon Booth's quitting the stage that Quin appeared to full advantage, in the part of Cato He continued a favourite performer until the year 1748, when, on some disgust between him and Mr Rich the manager, he retired to Bath, and only came up annually to act for the benefit of his friend Ryan; until the loss of two front teeth spoiled his utterance for the stage. While Mr Quin continued upon the stage, he constantly kept company with the greatest geniuses of the age. He was well known to Pope and Swift; and the earl of Chesterfield frequently invited him to his table: but there was none for whom he entertained a higher esteem than for the poet Thomson, the author of the Seasons, to whom he made himself known by an act of generosity that does the greatest honour to his character; and for an account of which see our life of Thomson. Mr Quin's judgement in the English language recommended him to his royal highness Frederick prince of Wales, who appointed him to instruct his children in speaking and reading with a graceful propriety; and Quin being informed of the elegant manner in which his present Majesty delivered his first gracious speech from the throne, he cried out in a kind of ecstasy, "Ay—I taught the boy to speak!" Nor did his majesty forget his old tutor; for, soon after his accession to the throne, he gave orders, without any application being made to him, that a genteel pension should be paid to Mr Quin during his life. Mr Quin, indeed, was not in absolute need of this royal benefaction; for, as he was never married, and had none but distant relations, he sunk 2000l. which was half his fortune, in an annuity, for which he obtained 200l. a-year; and with about 2000l. more in the funds, lived in a decent manner during the latter part of his life at Bath, from whence he carried on a regular correspondence with Mr Garrick, and generally paid a visit to his friends in the metropolis once a-year, when he constantly passed a week or two at Mr Garrick's villa at Hampton. He died of a fever in 1766.

QUINARIUS, was a small Roman coin equal to half the denarius, and consequently worth about threepence three farthings of our money. See Money. It was called *quinarius*, because it contained the value of five asses, in the same manner as the denarius was named from its containing ten.

QUINAUT, Philip, a celebrated French poet, born of a good family at Paris in 1635. He cultivated poetry from his infancy, and 16 dramatic pieces of his were acted between the years 1653 and 1666. In the mean time, Quinaut was not so much devoted to poetry but that he applied himself to the study of the law; and made his fortune by marrying the widow of a rich merchant to whom he had been useful in his profession. Quinaut afterwards turned his attention to the composing of operas, which were set to music by the famous Lully; and Lully was charmed with a poet whose verses were not too nervous to yield to the capricious airs of music. He died in 1688, after having for many years enjoyed a handsome pension from Louis XIV.: and we are told he was extremely penitent in his last illness for all those of his compositions which tended to inspire love and pleasure.

QUINCE, in *Botany*. See Cydonia.

QUINCUNX, in Roman antiquity, denotes any thing that consists of five-twelfths of another; but particularly of the *as*.

Quincunx *Order*, in gardening, is a plantation of trees, disposed originally in a square consisting of five trees, one at each corner, and a fifth in the middle; which disposition, repeated again and again, forms a regular grove, wood, or wilderness.

QUINDECAGON, in *Geometry*, a plain figure with 15 sides and 15 angles.

QUINDECEMVIRI, in Roman antiquity, a college of 15 magistrates, whose business it was to preside over

over the sacrifices. They were also the interpreters of the Sybil's books; which, however, they never consulted but by an express order of the senate.

QUINQUAGENARIUS, in Roman antiquity, an officer who had the command of 50 men.

QUINQUAGESIMA SUNDAY, Shrove Sunday, so called as being about the 50th day before Easter.

QUINQUATRIA, or QUINQUATRUS, was a festival kept at Rome in honour of Minerva, which began on the 18th of March, or, as others will have it, on the 19th, and lasted five days. On the first day they offered sacrifices and oblations without the effusion of blood; the second, third, and fourth, were spent in shows of gladiators; and on the fifth day they went in procession through the city. Scholars had a vacation during the solemnity, and presented their masters at this time with a gift or fee, called *Minerval*. Boys and girls used now to pray to the goddess Minerva for wisdom and learning, of which she had the patronage. Plays were acted, and disputations held, at this feast, on subjects of polite literature. The quinquatria were so called, because they lasted for five days. There seems to be a strong resemblance betwixt this festival and the panathenæa of the Greeks.

QUINQUENNALIS, in Roman antiquity, a magistrate in the colonies and municipal cities of that empire, who had much the same office as the ædile at Rome.

QUINQUEREMIS, in the naval architecture of the ancients, a name given to a galley which had five rows of oars. They divided their vessels in general into *monocrota* and *polycrota**. The former had only one tire of rowers: the latter had several tires of them, from two or three up to 20, 30, or even 40; for such a vessel we have an account of in the time of Philopater, which required no less than 4000 men to row it.

* See *Polycrota*.

Meibom has taken off from the imaginary improbability of there ever having been such a vessel, by reducing the enormous height supposed necessary for such a number of rows of oars and men to work them, by finding a better way of placing the men than others had thought of. The quinqueremes of the ancients had 420 men in each; 300 of which were rowers, and the rest soldiers. The Roman fleet at Messina consisted of 330 of these ships; and the Carthaginian, at Lilybœum, of 350 of the same size. Each vessel was 150 feet long. Thus 130,000 men were contained in the one, and 150,000 in the other, with the apparatus and provisions necessary for such expeditions as they were intended for. This gives so grand an idea of the ancient naval armaments, that some have questioned the truth of the history: but we find it related by Polybius, an historian too authentic to be questioned, and who expresses his wonder at it while he relates it.

QUINQUEVIRI, in Roman antiquity, an order of five priests, peculiarly appointed for the sacrifices to the dead, or celebrating the rites of Erebus.

QUINQUINA. See CINCHONA, BOTANY and MATERIA MEDICA *Index*.

QUINSY, or QUINZY. See MEDICINE, n° 177—183.

QUINTEN, a town of France, in Bretagne, with a handsome castle. It is seated in a valley near the river Guy, and near a large forest of the same name, eight miles south of St Brieux, and 200 west of Paris. It had formerly the title of a duchy. W. Long. 2. 40. N. Lat. 48. 26.

QUINTESSENCE, in *Chemistry*, a preparation consisting of the essential oil of some vegetable substance, mixed and incorporated with spirit of wine.

QUINTESSENCE, in *Alchemy*, is a mysterious term, signifying the fifth or last and highest essence of power in a natural body.—Or when divested of its alchemistical signification, and employed to express something that is intelligible, the word denotes merely the highest state of purification in which any body can be exhibited.

QUINTAL, the weight of 100 lbs. in most countries, but in England it is the cwt. or 112 lbs. Quintal was formerly used for a weight of lead, iron, or other common metal, usually equal to 100 lbs. at six scores to the hundred.

QUINTILE, in *Astronomy*, an aspect of the planets when they are 72 degrees distant from one another, or a fifth part of the zodiac.

QUINTILIANUS, MARCUS FABIUS, a celebrated Latin orator, and the most judicious critic of his time, was a native of Calagurris, or Calahorra, in Spain; and was the disciple of Domitius Afer, who died in the year 59. He taught rhetoric at Rome for 20 years with great applause: and not only laid down rules for speaking, but exhibited his eloquence at the bar. Some authors imagine, but with little foundation, that he arrived at the consulship; but it is more certain that he was preceptor to the grandsons of the emperor Domitian's sister. There is still extant his excellent work, intitled, *Institutiones Oratoriæ*, which is a treatise of rhetoric in 12 books; where his precepts, judgment, and taste, are justly admired. These institutions were found entire by Poggius, in an old tower of the abbey of St Gal, and not in a grocer's shop in Germany as some authors have asserted. There is also attributed to Quintilian a dialogue *De causis corruptæ eloquentiæ*; but it is more commonly ascribed to Tacitus. The best editions of Quintilian's works are those of Mr Obreight, published at Strasburg in 2 vols 4to, in 1698, and of M. Capperonier, in folio. There is an English translation by Mr Guthrie.

Quintilian had a son of the same name, on whom he bestows great praises. This son ought not to be confounded with Quintilian the father, or rather the grandfather, of him who is the subject of this article, and who wrote 145 declamations. Ugolin of Parma published the first 136 in the 15th century; the nine others were published in 1563 by Peter Ayrault, and afterwards by Peter Pithou in 1580. There have also been 19 other declamations printed under the name of Quintilian the Orator; but, in the opinion of Vossius, they were written neither by that orator nor his grandfather.

QUINTILIANS, a sect of antient heretics, thus called from their prophetess Quintilia. In this sect the women were admitted to perform the sacerdotal and episcopal functions. They attributed extraordinary gifts to Eve for having first eaten of the tree of knowledge; told great things of Mary the sister of Moses, as having been a prophetess, &c. They added, that Philip the deacon had four daughters, who were all prophetesses, and were of their sect. In these assemblies it was usual to see the virgins entering in white robes, personating prophetesses.

QUINTIN MATSYS, also called the *Farrier of Antwerp*, famous for being transformed, by the force of love, from a blacksmith to a painter. He had followed the trade of a blacksmith and farrier for near twenty years; when falling in love with a painter's daughter who was very handsome, and disliked nothing but his trade, he quitted it, and betook himself to painting, in which he made very great progress. He was a diligent and careful imitator of ordinary life, and succeeded better in representing the defects than the beauties of nature. Some historical performances of this master deserve commendation, particularly a Descent from the Cross, in the cathedral at Antwerp: but his best known picture is that of the two Misers in the gallery at Windsor. He died in 1529.

QUINTINIE, JOHN DE LA, a celebrated French gardener, born at Poictiers in 1626. He was brought up to the law; and acquitted himself so well at the bar as to acquire the esteem of the chief magistrate. M. Tamboneau, president of the chamber of accounts, engaged him to undertake the preceptorship of his only son, which Quintinie executed entirely to his satisfaction; applying his leisure hours to the study of writers on agriculture, ancient and modern, to which he had a strong inclination. He gained new lights by attending his pupil at Italy; for all the gardens about Rome being open to him, he failed not to add practice to his theory. On his return to Paris, M. Tamboneau gave up the management of his garden entirely to him; and Quintinie applied so closely to it, that he became famous all over France. Louis XIV. erected a new office purposely for him, that of director of the royal fruit and kitchen gardens; and these gardens, while he lived, were the admiration of the curious. He lived to a good old age; we have not learned the time of his death; his Directions for the management of Fruit and Kitchen Gardens have been much esteemed.

QUINTUS CALABER, a Greek poet, who wrote a large Supplement to Homer's Iliad, in 14 books, in which a relation is given of the Trojan war from the death of Hector to the destruction of Troy. It is conjectured, from his style and manner, that he lived in the fifth century. Nothing certain can be collected either concerning his person or country. His poem was first made known by Cardinal Bessarion, who discovered it in St Nicolas's church, near Otranto in Calabria; from whence the author was named *Quintus Calaber*. It was first published at Venice by Aldus, but it is not said in what year.

QUINTUS CURTIUS. See CURTIUS.

QUINZY, QUINSEY, or *Angina Pectoris*. See MEDICINE, N° 403.

QUIRE OF PAPER, the quantity of 24 sheets.

QUIRINALIA, in antiquity, a feast celebrated among the Romans in honour of Romulus.

QUIRITES, in Roman antiquity. In consequence of the agreement entered into by Romulus and Tatius king of the Sabines, Rome was to retain its name, taken from Romulus, and the people were to be called *Quirites*, from Cures, the principal town of the Sabines, a name used in all public addresses to the Roman people. ——Dion. Hal. says, that each particular citizen was to be called *Romanus*, and the collective body of them *Quirites*; yet it appears by this ancient form of words used at funerals, *Ollus Quiris letho datus est*, that each private citizen was also called *Quiris*.

The origin of the word *Quirites*, which was at first peculiar to the Sabines, and became, in Romulus's time, the general name of the inhabitants of Rome, has been much sought for; and the most probable account antiquity gives us of it, is this: The word *Quiris*, according to Plutarch and some others, signified, in the Sabine language, both "a dart," and "a warlike deity armed with a dart." It it uncertain whether the god gave name to the dart, or the dart to the god. But be that as it will, this *Quiris*, or *Quirinus*, was either Mars or some other god of war; and the worship of *Quiris* continued in Rome all Romulus's reign: but after his death he was honoured with the name *Quirinus*, and took the place of the god *Quiris*.

QUIRK, in a general sense, denotes a subtilty or artful distinction.

QUIRK, in building, a piece of ground taken out of any regular ground-plot, or floor: thus, if the ground-plot were oblong or square, a piece taken out of a corner to make a court or yard, &c. is called a *quirk*.

QUISQUALIS, a genus of plants belonging to the decandria class, and in the natural method ranking under the 31st order, *Veprecula*. See BOTANY *Index*.

QUITO, a town of South America, in Peru (see PERU), seated between two chains of high mountains called *Cordillera de los Andes*, on much higher ground than the rest of habitable Peru. It is 300 yards higher than the level of the sea according to the exactest observations. The town is 1600 yards long and 1200 broad, and is the seat of a bishop. It contains about 35,000 inhabitants, one-third of whom are originally Spaniards. Among the inhabitants are some persons of high rank and distinction, descended either from the original conquerors, or persons who at different times came from Spain invested with some lucrative post. The number of these, however, is but small. The commonalty, besides Spaniards, consist of Mestizos, Indians, and Negroes; but the last are not proportionally numerous. Merchandises and commodities of all sorts are extremely dear, partly on account of the difficulty of bringing them.

There are several religious communities at Quito, and two colleges or universities governed by Jesuits and Dominicans.

The principal courts held at Quito are that of the royal audience, which consists of the president, who is governor of the province with regard to law affairs; four auditors, who are at the same time civil and criminal judges; a royal fiscal, who, besides the causes brought before the audience, takes cognizance of every thing relating to the revenue; and an officer styled the *protector of the Indians*, who solicits for them, and when they are injured pleads in their defence. The next is the treasury, the chief officers of which are an accountant, a treasurer, and a royal fiscal. The tribunal of the Croisade, which has a commissary, who is generally some dignitary of the church, and a treasurer. There is also a treasury for the effects of persons deceased: an institution established all over the Indies, for receiving the goods of those whose lawful heirs are in Spain, in order to secure them from those accidents to which they might be liable in private hands. There is likewise a commissary of the inquisition, with an alguazil-major and familiars, appointed by the inquisition of Lima. The corporation consists of a corregidor, two ordinary alcaldes, chosen annually, and regidores. The latter superintend the election of the alcaldes, which is attended with no small disturbance, the people being divided into two parties, the Creoles and Europeans.

QUITTER-BONE. See FARRIERY, N° 347.

QUIT-RENT (*quietus redditus*, i. e. "quiet rent,") is a certain small rent payable by the tenants of manors, in token of subjection, and by which the tenant goes quiet and free. In ancient records it is called *white rent* because paid in silver money, to distinguish it from rent-corn, &c.

QUOIN, or COIN, on board a ship, a wedge fastened on the deck close to the breech of the carriage of a gun, to keep it firm up to the ship's side. Cantic quoins are short three-legged quoins put between casks to keep them steady.

QUOINS, in *Architecture*, denote the corners of brick or stone walls. The word is particularly used for the stones in the corners of brick buildings. When these stand out beyond the brick-work, their edges being chamfred off, they are called *rustic quoins*.

QUOTIDIAN, any thing which happens every day. Hence, when the paroxysms of an ague recur every day, it is called a *quotidian ague*. See MEDICINE, N° 161—164.

QUOTIDIANA DECEPTIVA. See MEDICINE, N° 150.

QUOAD HOC, is a term used in the pleadings and arguments of lawyers; being as much as to say, As to this thing the law is so and so.

QUORUM, a word frequently mentioned in our statutes, and in commissions both of justices of the peace and others. It is thus called from the words of the commission, *quorum* A. B. *unum esse volumus*. For an example, where a commission is directed to seven persons, or to any three of them, whereof A. B. and C. D. are to be two; in this case, they are said to be of the quorum, because the rest cannot proceed without them: so a justice of the peace and quorum is one without whom the rest of the justices in some cases cannot proceed.

QUOTIENT, in *Arithmetic*, the number resulting from the division of a greater number by a smaller, and which shows how often the smaller is contained in the greater, or how often the divisor is contained in the dividend. The word is formed from the Latin *quoties*; *q. d.* How often is such a number contained in such another?

In division, as the divisor is to the dividend, so is unity to the quotient.—Thus the quotient of 12 divided by 3 is 4; which is thus disposed, 3) 12 (4 quotient. See ARITHMETIC.

R.

R, or *r*, a liquid consonant, being the 17th letter of our alphabet. Its sound is formed by a guttural extrusion of the breath vibrated through the mouth, with a sort of quivering motion of the tongue drawn from the teeth, and canulated with the tip a little elevated towards the palate. In Greek words it is frequently aspirated with an *h* after it, as in *rhapsody*, *rhetoric*, &c. otherwise it is always followed by a vowel at the beginning of words and syllables.

In the notes of the ancients, R. or RO. signifies *Roma*; R. C. *Romana civitas*; R. G. C. *rei gerendæ causa*; R. F. E. D. *recte factum et dictum*; R. G. F. *regis filius*; R. P. *res publica*, or *Romani principes*; and R. R. R. F. F. F. *res Romana ruet ferro, fame, flamma*.

Used as a numeral, R anciently stood for 80; and with a dash over it thus $\bar{R}$, for 80,000; but the Greek *r*, ῥ, with a small mark over it, signified 100; with the same mark under it, it denoted 1000 × 10; thus ϱ͵ signified 100,000. In the Hebrew numeration ר denoted 200: and with two horizontal points over it 1000 × 200; thus ר̈ = 200,000.

In the prescriptions of physicians, R or ℞ stands for *recipe*, i. e. "take."

RAAB, a town of Lower Hungary, capital of Javern, with a castle and a bishop's see. It is a strong frontier bulwark against the Turks, and has two bridges, one over a double ditch, and another that leads towards Alba Regalis. The surrounding country is plain, and there is nothing that seems to command it but a small hill at some distance, which is undermined and may be blown up. It was taken by Amurath III. with the loss of 20,000 men; but was surprised soon after by Count Palfi, who killed all the Turks that were found therein. It is seated at the confluence of the rivers Rab and Rabnitz, not far from the Danube, 32 miles west of Gran, and 55 south-east of Vienna. E. Long. 17. 25. N. Lat. 47. 48.

RABAC, a small port on the Arabian coast of the Red sea, in N. Lat. 22° 35′ 40″, by Mr Bruce's account. The entry to the harbour is from the E. N. E. and is about a quarter of a mile broad. The port extends about two miles in length to the eastward. The mountains are about three leagues to the north, and the town about four miles north by east from the entrance to the harbour. The water is good, and all ships may be supplied here from the wells which are in the neighbourhood of the town. The country is bare and uncultivated; but from the appearance of it, and the freshness of the water, Mr Bruce supposes that it sometimes rains among the mountains here, which is the more probable as it is considerably within the tropic.

RABAT, a large and handsome sea-port town of Africa,

Africa, in the kingdom of Fez and province of Tremesen. It has fine mosques and handsome palaces, and is seated at the mouth of the river Burrigrig, almost in the mid-way between Fez and Tangier. W. Long. 5. 28. N. Lat. 34. 40.

Raba, together with Sallee, which is opposite to it, was formerly famous for fitting out piratical vessels; but the late emperor Sidi Mahomet subdued them both, and annexed them to the empire; since which time the harbour of Rabat has been so filled with the sand washed in by the sea as to render it unfit to carry on such piracies in future.

The town of Rabat, whose walls inclose a large space of ground, is defended on the sea-side by three forts tolerably well finished, which were erected some little time ago by an English renegado, and furnished with guns from Gibraltar. The houses in general are good, and many of the inhabitants are wealthy. The Jews, who are very numerous in this place, are generally in better circumstances than those of Larache or Tangier, and their women are extremely beautiful.

The castle, which is very extensive, contains a strong building, formerly used by the late emperor as his principal treasury, and a noble terrace, which commands an extensive prospect of the town of Sallee, the ocean, and all the neighbouring country. There are also the ruins of another castle, which is said to have been built by Jacob Almanzor, one of their former emperors, and of which at present very little remains but its walls, containing within them some very strong magazines for powder and naval stores. On the outside of these walls is a very high and square tower, handsomely built of cut stone, and called the tower of *Hassen*. From the workmanship of this tower, contrasted with the other buildings, a very accurate idea may be formed how greatly the Moors have degenerated from their former splendour and taste for architecture.

RABBETTING, in *Carpentry*, the planing or cutting of channels or grooves in boards, &c.

In ship-carpentry, it signifies the letting in of the planks of the ship into the keel; which, in the rake and run of a ship, is hollowed away, that the planks may join the closer.

RABBI, or RABBINS, a title which the Pharisees and doctors of the law among the Jews assumed, and literally signifies *masters* or *excellents*.

There were several gradations before they arrived at the dignity of a rabbi; which was not conferred till they had acquired the profoundest knowledge of the law and the traditions. It does not, however, appear that there was any fixed age or previous examination necessary; but when a man had distinguished himself by his skill in the written and oral law, and passed through the subordinate degrees, he was saluted a rabbin by the public voice.

Among the modern Jews, for near 700 years past, the learned men retain no other title than that of *rabbi*, or *rabbins*; they have great respect paid them, have the first places or seats in their synagogues, determine all matters of controversy, and frequently pronounce upon civil affairs; they have even power to excommunicate the disobedient.

RABBINISTS, among the modern Jews, an appellation given to the doctrine of the rabbins concerning traditions, in opposition to the Caraites; who reject all traditions. See CARAITE.

RABELAIS, FRANCIS, a French writer famous for his facetiousness, was born at Chinon in Touraine about the year 1483. He was first a Franciscan friar; but quitting his religious habit studied physic at Montpelier, where he took his doctor's degree. It is said, that the chancellor du Pratt having abolished the privileges of the faculty of physic at Montpelier by a decree of the parliament, Rabelais had the address to make him revoke what he had done; and that those who were made doctors of that university wore Rabelais's robe, which is there held in great veneration. Some time after, he came to Rome, in quality of physician in ordinary to Cardinal John du Bellay archbishop of Paris. Rabelais is said to have used the freedom to jeer Pope Paul III. to his face. He had quitted his religious connections for the sake of leading a life more agreeable to his taste; but renewed them on a second journey to Rome, when he obtained, in 1536, a brief to qualify him for holding ecclesiastical benefices; and, by the interest of his friend Cardinal John du Bellay, he was received as a secular canon in the abbey of St Maur near Paris. His profound knowledge in physic rendered him doubly useful; he being as ready, and at least as well qualified, to prescribe for the body as for the soul: but as he was a man of wit and humour, many ridiculous things are laid to his charge, of which he was quite innocent. He published several things; but his chief performance is a strange incoherent romance, called the *History of Gargantua and Pantagruel*, being a satire upon priests, popes, fools, and knaves of all kinds. This work contains a wild, irregular profusion of wit, learning, obscenity, low conceits, and arrant nonsense; hence the shrewdness of his satire, in some places where he is to be understood, gains him credit for those where no meaning is discoverable. Some allusions may undoubtedly have been so temporary and local as to be now quite lost: but it is too much to conclude thus in favour of every unintelligible rhapsody; for we are not without English writers of great talents, whose sportive geniuses have betrayed them into puerlities, no less incoherent at the times of writing than those of Rabelais appear above two centuries after. He died about 1553.

RABBIT, in *Zoology*. See LEPUS, MAMMALIA *Index*.

The buck rabbits, like our boar cats, will kill the young ones if they can get at them; and the does in the warrens prevent this, by covering their stocks, or nests, with gravel or earth, which they close so artificially up with the hinder part of their bodies, that it is hard to find them out. They never suckle their young ones at any other time than early in the morning and late at night; and always, for eight or ten days, close up the hole at the mouth of the nest, in this careful manner, when they go out. After this they begin to leave a small opening, which they increase by degrees; till at length, when they are about three weeks old, the mouth of the hole is left wholly open that they may go out; for they are at that time grown big enough to take care of themselves, and to feed on grass.

People who keep rabbits tame for profit, breed them in hutches; but these must be kept very neat and clean, else they will be always subject to diseases. Care must be taken also to keep the bucks and does apart till the latter

Rabbit.

latter have juſt kindled; then they are to be turned to the bucks again, and to remain with them till they ſhun and run from them.

The general direction for the chooſing of tame rabbits is, to pick the largeſt and faireſt; but the breeder ſhould remember that the ſkins of the ſilver-haired ones ſell better than any other. The food of the tame rabbits may be colewort and cabbage-leaves, carrots, parſneps, apple-rinds, green corn, and vetches, in the time of the year; alſo vine-leaves, graſs, fruits, oats, and oatmeal, milk-thiſtles, ſow-thiſtles, and the like: but with theſe moiſt foods they muſt always have a proportionable quantity of the dry foods, as hay, bread, oats, bran, and the like, otherwiſe they will grow pot-bellied, and die. Bran and grains mixed together have been alſo found to be very good food. In winter they will eat hay, oats, and chaff, and theſe may be given them three times a-day; but when they eat green things, it muſt be obſerved that they are not to drink at all, for it would throw them into a dropſy. At all other times a very little drink ſerves their turn, but that muſt always be freſh. When any green herbs or graſs are cut for their food, care muſt be taken that there be no hemlock among it; for though they will eat this greedily among other things when offered to them, yet it is ſudden poiſon to them.

Rabbits are ſubject to two principal infirmities. Firſt, the rot, which is cauſed by giving them too large a quantity of greens, or from giving them freſh gathered with the dew or rain hanging in drops upon them. Exceſs of moiſture always cauſes this diſeaſe. The greens therefore are always to be given dry; and a ſufficient quantity of hay, or other dry food, intermixed with them, to take up the abundant moiſture of their juices. On this account the very beſt food that can be given them, is the ſhorteſt and ſweeteſt hay that can be got, of which one load will ſerve 200 couples a year; and out of this ſtock of 200, 200 may be eaten in the family, 200 ſold in the markets, and a ſufficient number kept in caſe of accidents.

The other general diſeaſe of theſe creatures is a ſort of madneſs: this may be known by their wallowing and tumbling about with their heels upwards, and hopping in an odd manner into their boxes. This diſtemper is ſuppoſed to be owing to the rankneſs of their feeding; and the general cure is the keeping them low, and giving them the prickly herb called *tare thiſtle* to eat.

The general computation of males and females is, that one buck-rabbit will ſerve for nine does: ſome allow 10 to one buck; but thoſe who go beyond this always ſuffer for it in their breed.

Wild rabbits are either to be taken by ſmall cur-dogs, or by ſpaniels bred up to the ſport; and the places of hunting thoſe who ſtraggle from their burrows, is under cloſe hedges or buſhes, or among corn-fields and freſh paſtures. The owners uſe to courſe them with ſmall greyhounds; and though they are ſeldom killed this way, yet they are driven back to their burrows, and are prevented from being a prey to others. The common method is by nets called *purſe-nets*, and ferrets. The ferret is ſent into the hole to fetch them out; and the purſe-net being ſpread over the hole, takes them as they come out. The ferrets mouths muſt be muffled, and then the rabbit gets no harm. For the more certain taking of them, it may not be improper to pitch up a hay-net or two, at a ſmall diſtance from the burrows that are intended to be hunted: thus very few of the number that are attempted will eſcape.

Rabbit.

Some who have no ferrets ſmoke the rabbits out of their holes with burning brimſtone and orpiment. This certainly brings them out into the nets; but then it is a very troubleſome and offenſive method, and is very detrimental to the place, as no rabbit will for a long time afterwards come near the burrows which have been fumed with ſuch ingredients.

The following obſervations on the breeding and management of rabbits and ſome other animals appear to us to be of ſuch importance, that we ſhall give them a place in the words of the author.

"In my travels through America," ſays the author, "I have often been ſurpriſed that no attempt has been made to introduce, for the purpoſe of propagation, that uſeful little animal, the warren rabbit, of ſuch vaſt importance to the hat manufactory of England. It is chiefly owing to the fur of this animal that the Engliſh hats are ſo much eſteemed abroad. It is a fact well known amongſt the hatters, that a hat compoſed of one half of coney wool, one-ſixth old coat beaver, one-ſixth pelt beaver, and one-ſixth Vigonia wool, will wear far preferable to one made all of beaver, as it will keep its ſhape better, feel more firm, and wear bright and black much longer.

"The value of the coney wool, the produce of the united kingdom only, is not leſs, I will venture to ſay, than 250,000l. per annum; but the quantity is much diminiſhed, owing to the baniſhment and perſecution they meet with on every ſide, and ſo many ſmall warrens taken in for grain land; in conſequence of which it is time that ſome protection ſhould be afforded, if poſſible, to that important branch of Britiſh manufactory (in which coney wool is uſed) from ſuffering any inconvenience in the want of ſo eſſential an article, and the accompliſhment of this grand object I conceive perfectly eaſy.

"*General Obſervations.*—When I ſpeak of the warren rabbit, I have to obſerve, that there are in England, as well as in moſt parts of Europe, three other kinds, viz. the tame rabbit, of various colours, the fur of which is of little value, except the white; the ſhock rabbit, which has a long ſhaggy fur of little value; the buſh rabbit, like thoſe of America, which commonly ſits as a hare, and the fur of which is of a rotten inferior quality.

"To return to the warren rabbit.—There are two ſorts in reſpect to colour, that is, the common gray, and the ſilver gray, but little or no difference in reſpect to the ſtrength and felting qualities of the fur. The nature of this animal is to burrow deep in ſandy ground, and there live in families, nor will they ſuffer one from a neighbouring family to come amongſt them without a ſevere conteſt, in which the intruders are generally glad to retire with the loſs of part of their coat, unleſs when purſued by an enemy, when they find protection.

"It is ſcarcely worth while for me to mention a thing ſo generally known, viz. that rabbits, particularly thoſe of the warren, are the moſt prolific of all other four-footed animals in the world; nor do I apprehend any difficulty would attend the exporting this little quadruped with ſafety to any diſtance, provided it was

was kept dry, and regularly supplied with clean sweet food, and a due regard to the cleanliness of the boxes or places of confinement.

"Twelve or fifteen pair of these valuable animals taken to Upper Canada, and there enclosed within a small space of ground suitable to their nature, but furnished with a few artificial burrows at the first by way of a nursery, spread over those now useless plains, islands, and peninsulas, so well calculated to their nature, would, I will make bold to say, the eighth year after their introduction, furnish the British market with a valuable raw material, amounting to a large sum, increasing every year with astonishing rapidity, so as to become, in a few years, one amongst the first of national objects.

"It may be supposed by some, that the above project is magnified beyond possibility, or even probability; but the serious attention I have paid to the subject, these many years past, as to all points for and against, leaves no room to accuse myself of being too sanguine; for, if properly managed a few years at the first, I cannot find a single thing likely to interrupt their progress.

"Some idea of the astonishing increase of the rabbit may be had from the following facts:

"An old doe rabbit will bring forth young nine times in one year, and from four to ten each time; but to allow for casualities, state the number at five each litter.

In nine months - - - - - -	45
The females of the first litter will bring forth five times, the proportion of which is 2½ females produce - - - - - - -	62
Those of the second litter four times produce	50
Ditto of ditto third ditto three ditto ditto -	37
Ditto of ditto second ditto two ditto ditto -	25
Total in one year from one pair -	219

"The third female race of the old dam, and the second of the first litter, seldom breed the first year, but are early breeders in the spring following, when we might expect an increase of the whole in proportion to the first pair, if properly attended to and protected.

"It is generally allowed, that hares are not more than one-fourth as prolific as rabbits, notwithstanding, agreeable to an experiment tried by Lord Ribblesdale, who enclosed a pair of hares for one year, the offspring was (as I have been credibly informed) 68: these animals could they be exported to Upper Canada with safety, and there protected within enclosures for a few years, would soon after spread over a large extent of country: the fur is nearly as valuable as that of the rabbit.

"In that part of Upper Canada within the 45 degrees of north latitude, and the southern and western boundaries, the climate is nearly the same as that of England, a little hotter a few days in summer, and a little colder a few days in winter, agreeable to Fahrenheit's thermometer, which I have paid great attention to for some years, comparing the same with the observations of the English.

"The increase of most animals appears much greater in proportion in America than in England, mankind not excepted: that of sheep is very apparent to those that pay attention to their breeding stock, which gives me hopes, that in a few years we shall be able to pay for our woollen cloths in wool. Finding the effect of soil and climate so salutary to sheep, &c., it may be reasonably supposed, that rabbits will answer the most sanguine expectations, as I understand the wool of the sheep retains all its nature the same as in England, particularly its strength, and felting qualities among the hatters, which assures me that rabbit wool from those bred in Upper Canada will do the same; and there are some millions of acres within the latitude and boundaries which I have before described, suited to the nature of the warren rabbit; nor do I apprehend that the wolves, foxes, &c., of Upper Canada will be half so destructive as the poachers in England.

"The *guanaco*, or camel sheep of South America, no doubt will be a national object at some future period. This is a tame, domestic animal, very hardy, and used with much cruelty by the natives in travelling over the mountains with their burthens; it shears a fleece of wool of from 2lb. to 3lb., which is of dusky red on the back; on the sides inclined to white, and under the belly quite white; its texture is very fine, yet strong; its felting qualities very powerful, and is worth, when ready for use, from five to fifteen shillings per pound. This animal would no doubt thrive, and do well in England, Upper Canada, and in particular I should suppose in New Holland.

"The *beaver* might be propagated to great advantage in Scotland, Ireland, and northern parts of England. It is an animal, when tamed, very familiar, and will eat bread and milk, willow sticks, elm bark, &c., and no doubt might be imported with safety; but as these two last-mentioned animals are not likely to be attended to immediately, I shall say no more respecting them for the present*."

* *Transf. of Soc. for encouragement of Arts*, &c. for 1807.

RABIRIUS, C. a Roman knight, who lent an immense sum of money to Ptolemy Auletes king of Egypt. The monarch afterwards not only refused to repay him, but even confined him, and endangered his life. Rabirius escaped from Egypt with difficulty; but at his return to Rome he was accused by the senate of having lent money to an African prince for unlawful purposes. He was ably defended by Cicero, and acquitted with difficulty.—There was a Latin poet of the same name in the age of Augustus. He wrote a poem on the victory which the emperor had gained over Antony at Actium. Seneca has compared him to Virgil for elegance and majesty; but Quintilian is not so favourable to his poetry.—And there was an architect in the reign of Domitian called *Rabirius*. He built a celebrated palace for the emperor, of which the ruins are still seen at Rome.

RACCOON. See URSUS, MAMMALIA *Index*.

RACE, in general, signifies running with others in order to obtain a prize, either on foot, or by riding on horseback, in chariots, &c.

The race was one of the exercises among the ancient Grecian games, which was performed in a course containing 125 paces; and those who contended in these foot-races were frequently clothed in armour. Chariot and horse-races also made a part of the ancient games.

Races were known in England in very early times. Fitz-Stephen, who wrote in the days of Henry II. mentions the great delight that the citizens of London took

took in the diverfion. But by his words, it appears not to have been defigned for the purpofes of gaming, but merely to have fprung from a generous emulation of fhowing a fuperior fkill in horfemanfhip.

Races appear to have been in vogue in the reign of Queen Elizabeth, and to have been carried to fuch excefs as to injure the fortunes of the nobility. The famous George earl of Cumberland is recorded to have wafted more of his eftate than any of his anceftors, and chiefly by his extreme love to horfe-races, tiltings, and other expenfive diverfions. It is probable that the parfimonious queen did not approve of it; for races are not among the diverfions exhibited at Kennelworth by her favourite Leicefter. In the following reign, places were allotted for the fport. Croyden in the fouth, and Garterly in Yorkfhire, were celebrated courfes. Camden alfo fays, that in 1607 there were races near York, and the prize was a little golden bell. See Racing.

Race, in genealogy, a lineage or extraction continued from father to fon. See Descent.

RACINE, John, a celebrated French poet, member of the French academy, treafurer of France in the generality of Moulins, and fecretary to his majefty, was born at Ferre Milon in 1639. He had a fine genius for the *belles lettres*, and became one of the firft poets of the age. He produced his *Thebaide* when but very young, and afterward other pieces, which met with great fuccefs, though they appeared when Corneille was in his higheft reputation. In his career, however, he did not fail to meet with all that oppofition which envy and cabal are ever ready to fet up againft a fuperior genius. It was partly owing to a chagrin from this circumftance that he took a refolution to quit the theatre for ever; although his genius was ftill in full vigour, being not more than 38 years of age. But he had alfo imbibed in his infancy a deep fenfe of religion; and this, though it had been fmothered for a while by his connections with the theatre, and particularly with the famous actrefs Champmelle, whom he greatly loved, and by whom he had a fon, now at length broke out, and bore down all before it. In the firft place, he refolved not only to write no more plays, but to do a rigorous penance for thofe he had written; and he actually formed a defign of becoming a Carthufian friar. His religious director, however, a good deal wifer than he, advifed him to think more moderately, and to take meafures more fuitable to his character. He put him upon marrying, and fettling in the world: with which propofal this humble and tractable penitent complied; and immediately took to wife the daughter of a treafurer of France for Amiens, by whom he had feven children.

He had been admitted a member of the French academy in 1673, in the room of La Mothe le Vayer deceafed; but fpoiled the fpeech he made upon that occafion by pronouncing it with too much timidity. In 1677, he was nominated with Boileau, with whom he was ever in ftrict friendfhip, to write the hiftory of Louis XIV.; and the public expected great things from two writers of their diftinction, but were difappointed. Boileau and Racine, after having for fome time laboured at this work, perceived that it was entirely oppofite to their genius.

He fpent the latter years of his life in compofing a hiftory of the houfe of Port-Royal, the place of his education, which, however, though finely drawn up, as many have afferted, has not been publifhed. Too great fenfibility, fay his friends, but more properly an impotence of fpirit, fhortened the days of this poet.—Though he had converfed much with the court, he had not learned the wifdom, which is ufually learned there, of difguifing his real fentiments. Having drawn up a well-reafoned and well-written memorial upon the miferies of the people, and the means of relieving them, he one day lent it to Madame de Maintenon to read; when the king coming in, and demanding what and whofe it was, commended the zeal of Racine, but difapproved of his meddling with things that did not concern him, and faid with an angry tone, "Becaufe he knows how to make good verfes, does he think he knows every thing? And would he be a minifter of ftate, becaufe he is a great poet?" Thefe words hurt Racine greatly: he conceived dreadful ideas of the king's difpleafure; and his chagrin and fears brought on a fever, of which he died the 22d of April 1699.

The king, who was fenfible of his great merit, and always loved him, fent often to him in his illnefs; and finding after his death that he had more glory than riches, fettled a handfome penfion upon his family.—There is nothing in the French language written with more wit and elegance than his pieces in profe. Befides his plays, feveral of his letters have been publifhed; he alfo wrote fpiritual fongs, epigrams, &c. Racine's works were printed at Amfterdam in 1722, in 2 vols 12mo, and the next year a pompous edition was printed in 2 vols quarto.

RACING, the riding heats for a plate, or other premium. See Plate. The amufement of horfe-racing, which is now fo common, was not unknown among the great nations of antiquity, nor wholly unpractifed by our anceftors in Britain, as we have already mentioned in the article Race. In 1599, private matches between gentlemen, who were their own jockies and riders, were very common; and in the reign of James I. public races were eftablifhed at various places, when the difcipline, and mode of preparing the horfes for running, &c. were much the fame as they are now. The moft celebrated races of that time were called bell-courfes, the prize of the conqueror being a bell: hence, perhaps, the phrafe *bearing the bell*, when applied to excellence, is derived. In the latter end of Charles I.'s reign, races were performed in Hyde-Park. Newmarket was alfo a place for the fame purpofe, though it was firft ufed for hunting. Racing was revived foon after the Reftoration, and much encouraged by Charles II. who appointed races for his own amufement at Dachet Mead, when he refided at Windfor. Newmarket, however, now became the principal place. The king attended in perfon, eftablifhed a houfe for his own accommodation, and kept and entered horfes in his own name. Inftead of bells, he gave a filver bowl or cup value 100 guineas; on which prize the exploits and pedigree of the fuccefsful horfe were generally engraved. Inftead of the cup or bowl, the royal gift is now a hundred guineas. William III. not only added to the plates, but even founded an academy for riding; and Queen Anne continued the bounty of her anceftors, adding feveral plates herfelf. George I. towards the end of his reign, difcontinued the plates, and gave in their room a hundred guineas. An act was paffed in the 13th year of the reign of George II. for fuppreffing races by poneys and other fmall and weak horfes, horses, &c. by which all matches for any prize under the value of 50l. are prohibited, under a penalty of 200l. to be paid by the owner of each horse running, and 100l. by such as advertise the plate; and by which each horse entered to run, if five years old, is obliged to carry ten stones; if six, eleven; and if seven, twelve. It is also ordained, that no person shall run any horse at a course unless it be his own, nor enter more than one horse for the same plate, upon pain of forfeiting the horses; and also every horse-race must be begun and ended in the same day. Horses may run for the value of 50l. with any weight, and at any place, 13 Geo. II. cap. 19. 18 Geo. II. cap. 34. Pennant's British Zoology, vol. i. p. 6, &c. Berrenger's History and Art of Horsemanship, vol. i. p. 185, &c. At Newmarket there are two courses, the long and the round: the first is exactly four miles and about 380 yards, i. e. 7420 yards. The second is 6640 yards. Childers, the swiftest horse ever known, has run the first course in seven minutes and a half, and the second in six minutes forty seconds; which is at the rate of more than forty-nine feet in a second. But all other horses take up at least seven minutes and fifty seconds in completing the first and longest course, and seven minutes only in the shortest, which is at the rate of more than forty-seven feet in a second. And it is commonly supposed that these coursers cover, at every bound, a space of ground in length about twenty-four English feet. Race-horses have for some time been an object of taxation.

RACHITIS, the Rickets. See Medicine *Index*.

RACK, Edmund, a person well known in the literary world by his attachment to, and promotion of, agricultural knowledge: he was a native of Norfolk, a Quaker. His education was common, and he was apprenticed originally to a shopkeeper: his society was select in this situation, and by improving himself in learning, his conversation was enjoyed by a respectable acquaintance. He wrote many essays, poems, and letters, and some few controversial tracts. At length he settled, about his 40th year, at Bath in 1775, and was soon introduced to the most eminent literati of that place, among whom Dr Wilson and Mrs Macaulay highly esteemed him for his integrity and abilities. In 1777 he published Mentor's Letters, a moral work, which has run through many editions. But this year he gained great celebrity by his plan of an agricultural society, which was soon adopted by four counties. He still further advanced his fame by his papers in the Farmer's Magazine, and his communications in the Bath Society's papers; a work remarkable for its ingenuity and spirit. His last engagement was in the History of Somersetshire, where the topographical parochial surveys were his. This work, in 3 vols 4to, was published in 1791, by his colleague the Reverend Mr Collinson.—Mr Rack died of an asthma in February 1787, aged 52.

Rack, an engine of torture, furnished with pulleys, cords, &c. for extorting confession from criminals.—The trial by rack is utterly unknown to the law of England: though once, when the dukes of Exeter and Suffolk, and other ministers of Henry VI. had laid a design to introduce the civil law into this kingdom as the rule of government; for a beginning thereof they erected a rack for torture, which was called in derision the duke of Exeter's daughter, and still remains in the Tower of London, where it was occasionally used as an engine of state, not of law, more than once in the reign of Queen Elizabeth. But when, upon the assassination of Villiers duke of Buckingham, by Felton, it was proposed in the privy council to put the assassin to the rack in order to discover his accomplices; the judges, being consulted, declared unanimously, to their own honour and the honour of the English law, that no such proceeding was allowable by the laws of England. It seems astonishing that this usage of administering the torture should be said to arise from a tenderness to the lives of men; and yet this is the reason given for its introduction in the civil law, and its subsequent adoption by the French and other foreign nations, viz. because the laws cannot endure that any man should die upon the evidence of a false or even a single witness, and therefore contrived this method that innocence should manifest itself by a stout denial, or guilt by a plain confession; thus rating a man's virtue by the hardiness of his constitution, and his guilt by the sensibility of his nerves. The Marquis Beccaria, in an exquisite piece of raillery, has proposed this problem, with a gravity and precision that are truly mathematical: "The force of the muscles and the sensibility of the nerves of an innocent person being given; it is required to find the degree of pain necessary to make him confess himself guilty of a given crime". See *Act of Faith*, Inquisition, and Torture.

Rack, a spirituous liquor made by the Tartars of Tongusia. This kind of rack is made of mare's milk, which is left to be sour, and afterwards distilled twice or thrice between two earthen pots closely stopped; whence the liquor runs through a small wooden pipe. This liquor is more intoxicating than brandy distilled from wine.

Rack, or *Arack*. See Arack.

To Rack Wines, &c. To draw them off from their lees, after having stood long enough to ebb and settle. Hence rack-vintage is frequently used for the second voyage our wine-merchants used to make into France for racked wines.

RACKOON, a species of ursus. See Ursus, Mammalia *Index*.

RACONI, a populous town of Italy, in Piedmont, seated in a pleasant plain, on the road from Savillan to Turin, on the rivers Grana and Macra. It belongs to the prince of Carignan, who has a handsome castle here. It is six miles from Savillan, and six from Carignan. E. Long. 7. 46. N. Lat. 44. 39.

RADCLIFFE, Dr John, an English physician of great eminence in his time, born at Wakefield in Yorkshire in 1650. He was educated at Oxford, and enrolled himself upon the physical line; but it was remarkable that he recommended himself more by his ready wit and vivacity, than by any extraordinary acquisitions in learning. He began to practise at Oxford in 1675; but never paid any regard to established rules, which he censured whenever he thought fit, with great freedom and acrimony; and as this drew all the old practitioners upon him, he lived in a continual state of hostility with them. Nevertheless, his reputation increased with his experience; so that, before he had been two years in business, his practice was very extensive among persons of high rank. In 1684 he removed to London,

London, and settled in Bow-street, Covent Garden, where in less than a year he got into great employment. In 1687 the princess Anne of Denmark made him her physician: yet when her husband and she joined the prince of Orange, Radcliffe, either not choosing to declare himself, or unwilling to favour the measures then in agitation, excused himself from attending them, on the plea of the multitude of his patients. Nevertheless, he was often sent for to King William and other great personages, though he did not incline to be a courtier. He incurred some censure for his treatment of Queen Mary, who died of the smallpox; and soon after lost his place about the princess Anne, by his attachment to his bottle. He also totally lost the favour of King William by his uncourtly freedom; for, in 1699, when the king showed him his swollen ankles, while the rest of his body was emaciated, and asked him what he thought of them? "Why truly I would not have your majesty's two legs for your three kingdoms," replied Radcliffe. He continued increasing in business and insolence as long as he lived, continually at war with his brethren the physicians; who considered him in no other light than that of an active ingenious empiric, whom constant practice had at length brought to some degree of skill in his profession. He died in 1714; and if he never attempted to write any thing himself, has perpetuated his memory by founding a fine library at Oxford, to preserve the writings of other men.

RADIALIS, the name of two muscles in the arm. See ANATOMY, *Table of the Muscles*.

RADIANT, in *Optics*, is any point of a visible object from whence rays proceed.

RADIATED FLOWERS, in *Botany*, are such as have several semiflofcules set round a disk, in form of a radiant star; those which have no such rays are called *discous flowers*.

RADIATION, the act of a body emitting or diffusing rays of light all round as from a centre.

RADICAL, in general, something that serves as a basis or foundation. Hence physicians talk much of a radical moisture. In grammar, we give the appellation *radical* to primitives, in contradistinction to compounds and derivatives. Algebraists also speak of the radical sign of quantities, which is the character expressing their roots.

RADICLE, that part of the seeds of all plants which upon vegetating becomes their root, and is discoverable by the microscope. See PLANT.

RADISH. See RAPHANUS, BOTANY *Index*; and for the mode of culture see GARDENING *Index*.

RADIUS, in *Geometry*, the semidiameter of a circle, or a right line drawn from the centre to the circumference.

In *Trigonometry*, the radius is termed the whole sine, or sine of 90°. See SINE.

RADIUS, in *Anatomy*, the exterior bone of the arm, descending along with the ulna from the elbow to the wrist.

RADNOR, the county-town of Radnorshire, in South Wales. It is a small town, distant from London about 150 miles. It is situated near the springhead of the river Somergil, in a fruitful valley at the bottom of a hill, where there are sheep grazing in abundance. It is a very ancient borough-town, whose jurisdiction extends near 12 miles round about: the government of it is vested in a bailiff and 25 burgesses. Though it is the county-town, the assizes are held at Presteign: it has one privilege, however, that is very extraordinary, besides that of sending one member to parliament; and that is, it keeps a court of pleas for all actions, without being limited to any particular sum. It was formerly fenced with a wall and strong castle; but both were in a great measure demolished by Owen Glendower, when he assumed the title of Prince of Wales, upon the deposition of King Richard II. W. Long. 2. 45. N. Lat. 52. 10.

RADNORSHIRE, a county of South Wales, is bounded on the north by Montgomeryshire; on the east by Shropshire and Herefordshire; on the south and south-west by Brecknockshire; and on the west by Cardiganshire; extending 30 miles in length and 25 in breadth. This county is divided into six hundreds, in which are contained three market-towns, 52 parishes, about 3160 houses, and 19,050 inhabitants. It is seated in the diocese of Hereford, and sends two members to parliament, one for the county and one for the town of Radnor. The air of this county is in winter cold and piercing. The soil in general is but indifferent; yet some places produce corn, particularly the eastern and southern parts; but in the northern and western, which are mountainous, the land is chiefly stocked with horned cattle, sheep, and goats.

RADIX. See ROOT.

RAFT, a sort of float, formed by an assemblage of various planks or pieces of timber, fastened together side by side, so as to be conveyed more commodiously to any short distance in a harbour or road than if they were separate. The timber and plank with which merchant-ships are laden, in the different parts of the Baltic sea, are attached together in this manner, in order to float them off to the shipping.

RAFTERS, in building, are pieces of timber which, standing by pairs on the reason or railing piece, meet in an angle at the top, and form the roof of a building. See ARCHITECTURE.

ROWLEY RAGG, a variety of whinstone or greenstone of a dusky or dark gray colour, with many small shining crystals, having a granular texture, and acquiring an ochry crust by exposure to the air.

RAGMAN's ROLL, Rectius Ragimund's roll, so called from one Ragimund a legate in Scotland, who calling before him all the beneficed clergymen in that kingdom, caused them on oath to give in *the true value* of their benefices; according to which they were afterwards taxed by the court of Rome; and this roll, among other records, being taken from the Scots by Edward I. was redelivered to them in the beginning of the reign of Edward III.

RAGOUT, or RAGOO, a sauce, or seasoning, intended to rouse the appetite when lost or languishing.

This term is also used for any high-seasoned dish prepared of flesh, fish, greens, or the like: by stewing them with bacon, salt, pepper, cloves, and the like ingredients. We have ragouts of celery, of endive, asparagus, cock's combs, giblets, craw fish, &c.

The ancients had a ragout called *garum*, made of the putrified guts of a certain fish kept till it dissolved into a mere sanies, which was thought such a dainty, that, according to Pliny, its price equalled that of the richest perfumes.

RAGSTONE,

RAGSTONE, a coarſe kind of ſandſtone which is uſed as a whetſtone for coarſe cutting tools. It is found in the hills about Newcaſtle, and many other parts of England, where there are large rocks of it.

RAGULED, or RAGGED, in *Heraldry*, jagged or knotted. This term is applied to a croſs formed of the trunks of two trees without their branches, of which they ſhow only the ſtumps. *Raguled* differs from *indented*, in that the latter is regular, the former not.

RAGUSA, an ancient town of Sicily, in the Val di-Noto, near the river Maulo, 12 miles north of Modica E. Long. 14. 59. N. Lat. 37. 0.

RAGUSA, a city of Dalmatia, and capital of Raguſen. It is about two miles in circumference, is pretty well built, and ſtrong by ſituation, having an inacceſſible mountain on the land-ſide, and on the ſide of the ſea a ſtrong fort. It has an archbiſhop's ſee and a republic, and has a doge like that of Venice, but he continues a month only in his office. It carries on a conſiderable trade with the Turks, and is 60 miles north-weſt of Scutari, and 110 north of Brindiſi. E. Long. 18. 10. N. Lat. 42. 50.

RAGUSEN, a territory of Europe in Dalmatia, lying along the coaſt of the gulf of Venice, about 55 miles in length, and 20 in breadth. It was formerly a republic under the protection of the Turks and Venetians, but has fallen under the dominion of the French. Raguſa is the capital town.

RAJA, or RAJAH, the title of the Indian black princes, the remains of thoſe who ruled there before the Moguls. Some of the rajas are ſaid to preſerve their independency, eſpecially in the mountainous parts; but moſt of them pay an annual tribute to the Mogul. The Indians call them *rai;* the Perſians, *raian*, in the plural; and our travellers *rajas*, or *ragias*.

RAJA, the *Ray-Fiſh*, in *Ichthyology*, a genus of fiſhes belonging to the cartilaginous order.

RAIANIA, a genus of plants belonging to the diœcia claſs; and in the natural method ranking under the 11th order, *Sarmentaceæ*. See BOTANY *Index*.

RAIETEA, one of the South ſea iſlands, named alſo ULIETEA.

RAIL. See RALLUS, ORNITHOLOGY *Index*.

RAILLERY, according to Dr Johnſon, means ſlight ſatire, or ſatirical merriment; and a beautiful writer of the laſt century compares it to a light which dazzles, and which does not burn. It is ſometimes innocent and pleaſant, and it ſhould always be ſo, but it is moſt frequently offenſive. Raillery is of various kinds; there is a ſerious, ſevere, and good-humoured raillery; and there is a kind which perplexes, a kind which offends, and a kind which pleaſes.

To rally well, it is abſolutely neceſſary that kindneſs run through all you ſay; and you muſt ever preſerve the character of a friend to ſupport your pretenſions to be free with a man. Alluſions to paſt follies, hints to revive what a man has a mind to forget for ever, ſhould never be introduced as the ſubjects of raillery. This is not to thruſt with the ſkill of fencers, but to cut with the barbarity of butchers. But it is below the character of men of humanity and good-breeding to be capable of mirth, while there is any in the company in pain and diſorder.

RAIN, the deſcent of water from the atmoſphere in the form of drops of a conſiderable ſize. By this circumſtance it is diſtinguiſhed from dew and fog: in the former of which the drops are ſo ſmall that they are quite inviſible; and in the latter, though their ſize be larger, they ſeem to have very little more ſpecific gravity than the atmoſphere itſelf, and may therefore be reckoned hollow ſpherules rather than drops. Some of the more general facts relative to the phenomena of rain have been already given under METEOROLOGY. We ſhall here add ſome account of the ſpeculations of philoſophers on the ſame ſubject, in attempting to account for thoſe phenomena.

It is univerſally agreed, that rain is produced by the water previouſly abſorbed by the heat of the ſun, or otherwiſe, from the terraqueous globe, into the atmoſphere; but very great difficulties occur when we begin to explain why the water, once ſo cloſely united with the atmoſphere, begins to ſeparate from it. We cannot aſcribe this ſeparation to cold, ſince rain often takes place in very warm weather; and though we ſhould ſuppoſe the condenſation owing to the ſuperior cold of the higher regions, yet there is a remarkable fact which will not allow us to have recourſe to this ſuppoſition. It is certain that the drops of rain increaſe in ſize conſiderably as they deſcend. On the top of a hill, for inſtance, they will be ſmall and inconſiderable, forming only a drizzling ſhower; but at the bottom of the ſame hill the drops will be exceſſively large, deſcending in an impetuous rain; which ſhows that the atmoſphere is diſpoſed to condenſe the vapours, and actually does ſo, as well where it is warm as where it is cold.

For ſome time the ſuppoſitions concerning the cauſe of rain were exceedingly inſufficient and unſatisfactory. It was imagined, that when various congeries of clouds were driven together by the agitation of the winds, they mixed, and run into one body, by which means they were condenſed into water. The coldneſs of the upper parts of the air alſo was thought to be a great means of collecting and condenſing the clouds into water; which, being heavier than the air, muſt neceſſarily fall down through it in the form of rain. The reaſon why it falls in drops, and not in large quantities, was ſaid to be the reſiſtance of the air; whereby being broken, and divided into ſmaller and ſmaller parts, it at laſt arrives to us in ſmall drops. But this hypotheſis is entirely contrary to almoſt all the phenomena: for the weather, when coldeſt,' that is, in the time of ſevere froſt, is generally the moſt ſerene; the moſt violent rains alſo happen where there is little or no cold to condenſe the clouds; and the drops of rain, inſtead of being divided into ſmaller and ſmaller ones as they approach the earth, are plainly increaſed in ſize as they deſcend.

Dr Derham accounted for the precipitation of the drops of rain from the veſiculæ being full of air, and meeting with an air colder than they contained, the air they contained was of conſequence contracted into a ſmaller ſpace; and conſequently the watery ſhell rendered thicker, and thus ſpecifically heavier, than the common atmoſphere. But it has been ſhown, that the veſiculæ, if ſuch they are, of vapour, are not filled with air, but with fire, or heat; and conſequently, till they part with this latent heat, the vapour cannot be condenſed. Now, cold is not always ſufficient to effect this, ſince in the moſt ſevere froſts the air is very often ſerene, and parts with little or none of its vapour

 for

Rain.

for a very confiderable time. Neither can we admit the winds to have any confiderable agency in this matter, fince we find that blowing upon vapour is fo far from condenfing it, that it unites it more clofely with the air, and wind is found to be a great promoter of evaporation.

According to Rohault, the great caufe of rain is the heat of the air; which, after continuing for fome time near the earth, is raifed on high by a wind, and there thawing the fnowy villi or flocks of half-frozen veficulæ, reduces them to drops; which, coalefcing, defcend. Here, however, we ought to be informed by what means thefe veficulæ are fufpended in their half-frozen ftate; fince the thawing of them can make but little difference in their fpecific gravity, and it is certain that they afcended through the air not in a frozen but in an aqueous ftate.

Dr Clarke and others afcribe this defcent of the rain rather to an alteration of the atmofphere than of the veficulæ; and fuppofe it to arife from a diminution of the elaftic force of the air. This elafticity, which, they fay, depends chiefly or wholly upon terrene exhalations, being weakened, the atmofphere finks under its burden, and the clouds fall. Now, the little veficles being once upon the defcent, will continue therein, notwithftanding the increafe of refiftance they every moment meet with. For, as they all tend to the centre of the earth, the farther they fall, the more coalitions they will make; and the more coalitions, the more matter will there be under the fame furface; the furface increafing only as the fquares, but the folidity as the cubes; and the more matter under the fame furface, the lefs refiftance will there be to the fame matter. Thus, if the cold, wind, &c. act early enough to precipitate the afcending veficles before they are arrived at any confiderable height, the coalitions being but few, the drops will be proportionably fmall; and thus is formed a dew. If the vapours be more copious, and rife a little higher, we have a mift or fog. A little higher ftill, and they produce a fmall rain; if they neither meet with cold nor wind, they form a heavy thick dark fky. This hypothefis is equally unfatisfactory with the others; for, granting that the defcent and condenfation of the vapours are owing to a diminution of the atmofphere's elafticity, by what is this diminution occafioned? To fay that it is owing to terrene exhalations, is only folving one difficulty by another; fince we are totally unacquainted both with the nature and operation of thefe exhalations. Befides, let us fuppofe the caufe to be what it will, if it acts equally and at once upon all the vapour in the air, then all that vapour muft be precipitated at once; and thus, inftead of gentle fhowers continuing for a confiderable length of time, we fhould have the moft violent water-fpouts, continuing only for a few minutes, or perhaps feconds, which, inftead of refrefhing the earth, would drown and lay wafte every thing before them.

Since philofophers have admitted the electric fluid to fuch a large fhare in the operations of nature, almoft all the natural phenomena have been accounted for by the action of that fluid; and rain, among others, has been reckoned an effect of electricity. But this word, unlefs it is explained, makes us no wifer than we were before; the phenomena of artificial electricity having been explained on principles which could fcarce apply in any degree to the electricity of nature: and therefore all the folution we can obtain of the natural appearances of which we fpeak, comes to this, that rain is occafioned by a moderate electrification, hail and fnow by one more violent, and thunder by the moft violent of all; but in what manner this electrification is occafioned, has not yet been explained. The principles of electricity neceffary to be attended to in the folution of the phenomena under confideration are the following:

1. The electric fluid and folar light are the fame fubftances in two different modifications.

2. Electricity is the motion of the fluid when running, or attempting to run, in a continued ftream from one place to another: heat is when the fluid has no tendency but to vibrate outwards and inwards to and from a centre; or at leaft when its ftreams converge to a point or focus.

3. The fluid acting as electricity, like water, or any other fluid, always tends to the place where there is leaft refiftance.

On thefe three principles may the phenomena of atmofpherical electricity, and the defcent of rain by its means, be explained as follows:

1. The light or heat of the fun, acting in that peculiar manner which we call *heat*, unites itfelf with the moifture of the earth, and forms it into vapour, which thus becomes fpecifically lighter than air, and of confequence afcends in the atmofphere to a certain height.

2. Befides the quantity of light which is thus united to the water, and forms it into vapour, a very confiderable quantity enters the earth, where it affumes the nature of electric fluid.

3. As the earth is always full of that fluid, every quantity which enters muft difplace an equal quantity which is already there.

4. This quantity which is difplaced muft efcape either at a diftance from the place where the other enters, or very near it.

5. At whatever place a quantity of electric matter efcapes, it muft electrify the air above that place where it has efcaped; and as a confiderable quantity of light muft always be reflected from the earth into the atmofphere, where it does not combine with the aqueous vapour, we have thence another fource of electricity to the air; as this quantity muft undoubtedly affume the action of electric fluid, efpecially after the action of the fun has ceafed. Hence the reafon why in ferene weather the atmofpherical electricity is always ftrongeft, and rather more fo in the night than in the day.

6. From thefe confiderations, we fee an evident reafon why there muft commonly be a difference between the electricity of the earth and that of the atmofphere, excepting when an earthquake is about to enfue. The confequence of this muft be, that as the action of the folar light continues to bring down the electric matter, and the earth continues to difcharge an equal quantity of it into the atmofphere, fome part of the atmofphere muft at laft become overloaded with it, and attempt to throw it back into the earth. This attempt will be vain, until a vent is found for the electricity at fome other place; and as foon as this happens, the electrified atmofphere begins to throw off its fuperfluous electricity, and the earth to receive it. As the atmofphere itfelf is

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is a bad conductor, and the more ſo the drier it is, the electric matter attacks the ſmall aqueous particles which are detained in it by means of the latent heat. Theſe being unable to bear the impetus of the fluid, throw out their latent heat, which eaſily eſcapes, and thus makes a kind of vacuum in the electrified part of the atmoſphere. The conſequences of this are, that the aqueous particles being driven together in large quantity, at laſt become viſible, and the ſky is covered with clouds; at the ſame time a wind blows againſt theſe clouds, and, if there is no reſiſtance in the atmoſphere, will drive them away.

7. But if the atmoſphere all round the cloud is exceedingly electrified, and the earth is in no condition to receive the ſuperfluous fluid excepting in that place which is directly under the cloud, then the whole electricity of the atmoſphere for a vaſt way round will tend to that part only, and the cloud will be electrified to an extreme degree. A wind will now blow againſt the cloud from all quarters, more and more of the vapour will be extricated from the air by the electric matter, and the cloud will become darker and thicker, at the ſame time that it is in a manner ſtationary, as being acted upon by oppoſite winds; though its ſize is enlarged with great rapidity by the continual ſupplies of vapour brought by the winds.

8. The vapours which were formerly ſuſpended inviſibly by means of the latent heat are now ſuſpended viſibly by the electric fluid, which will not let them fall to the earth, until it is in a condition to receive the electric matter deſcending with the rain.—It is eaſy to ſee, however, that thus every thing is prepared for a violent ſtorm of thunder and lightning as well as rain. The ſurface of the earth becomes electrified from the atmoſphere: but when this has continued for ſome time, a zone of earth conſiderably below the ſurface acquires an electricity oppoſite to that of the clouds and atmoſphere; of conſequence the electricity in the cloud being violently preſſed on all ſides, will at laſt burſt out towards that zone where the reſiſtance is leaſt, as explained under the article LIGHTNING.—The vapours now having loſt that which ſupported them, will fall down in rain, if there is not a ſufficient quantity of electric matter to keep them in the ſame ſtate in which they were before: but if this happens to be the caſe, the cloud will inſtantly be charged again, while little or no rain will fall; and hence very violent thunder ſometimes takes place without any rain at all, or ſuch as is quite inconſiderable in quantity.

9. When the electricity is leſs violent, the rain will deſcend in vaſt quantity, eſpecially after every flaſh of lightning; and great quantities of electric matter will thus be conveyed to the earth, inſomuch that ſometimes the drops have been obſerved to ſhine as if they were on fire, which has given occaſion to the reports of fiery rain having fallen on certain occaſions. If the quantity of electric matter is ſmaller, ſo that the rain can convey it all gradually to the ground, there will be rain without any thunder; and the greater the quantity of electricity the more violent will be the rain.

From this account of the cauſes of rain, we may ſee the reaſon why in warm climates the rains are exceſſive, and for the moſt part accompanied with thunder; for there the electricity of the atmoſphere is immenſely greater than it is with us. We may alſo ſee why in certain places, according to the ſituation of mountains, ſeas, &c. the rains will be greater than in others, and likewiſe why ſome parts of the world are exempted from rain altogether; but as a particular diſcuſſion of theſe would neceſſarily include an explanation of the cauſes and phenomena of THUNDER, we ſhall for this reaſon refer the whole to be treated of under that article.

Whether this theory be juſt, however, it would be too aſſuming in us to ſay. It may admit of diſpute, for we muſt grant that in the very beſt ſyſtems, though an occurrence ſo frequent, the theory of rain is but very imperfectly underſtood. Dr Hutton, whoſe ſpeculations are always ingenious, though generally extraordinary, and much out of the common way, has given a new theory of rain in the firſt volume of the Tranſactions of the Royal Society of Edinburgh. It is well known that atmoſpheric air is capable of diſſolving, with a certain degree of heat, a given quantity of water. The Doctor aſcertains the ratio of the diſſolving power of air, in relation to water, in different degrees of heat; and ſhows, that by mixing a portion of tranſparent humid warm air with a portion of cold air, the mixture becomes opake, and part of the water will be precipitated; or, in other words, the vapour will be condenſed into rain. The ratio which he ſtates, however, does not appear to us to be ſupported by experience. Whether the electricity of the air changes in conſequence of its depoſiting the water diſſolved in it, or the change is a cauſe of this depoſition, muſt remain uncertain; but, in either view, there muſt be an agent different from heat and cold, ſince the changes in theſe reſpects do not in other operations change the ſtate of electricity. Dr Hutton ſuppoſes that heat and ſolution do not increaſe by equal increments; but that, in reality, if heat be ſuppoſed to increaſe by equal increments along a ſtraight line, ſolution will be expreſſed by ordinates to a curve whoſe convex ſide is turned towards that line. That the power of ſolution is not increaſed in the ſame ratio with heat, is, however, hypothetical, except when we riſe pretty high in the ſcale, when its proportional increaſe is a little doubtful; and it is not, in this paper, ſupported by experiment. The condenſation of the breath in air is not an obſervation in point, except in air already ſaturated with vapour. It can amount, in any view, to no more than this, that to render it viſible, the heat muſt be diminiſhed in a greater proportion than can be compenſated by the power of ſolution in the body of air, in which the portion expired is at firſt immerſed. To explain rain from this cauſe, we muſt always ſuppoſe a conſtant diminution of heat to take place at the moment of the condenſation of the vapour; but we actually find that the change from a ſtate of vapour to the fluid ſtate is attended with heat; ſo that rain muſt at once oppoſe its own cauſe, and continued rains would be impoſſible, without calling in the aid of other cauſes. From his own ſyſtem, Dr Hutton endeavours to explain the regular and irregular ſeaſons of rain, either reſpecting the generality of its appearance, or the regularity of its return. And to obviate the apparent exceptions of the theory, from the generality of rain, he explains the proportional quantities of rain, and adds a comparative eſtimate of climates, in relation to rain, with the meteorological obſervations made in our own climate.

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climate. As his principle is at leaſt inſufficient, and we think erroneous, it would be uſeleſs, even were this a proper place for it, to purſue theſe various branches, which muſt partake of the errors of the ſyſtem. In theſe branches we ought to obſerve, that there are ſeveral juſt obſervations, mixed with errors, becauſe evaporation and condenſation muſt at laſt be the great baſis of every theory: the miſtakes ariſe from not being aware of all the cauſes, and miſrepreſenting the operation of thoſe which do exiſt.

In a work entitled Thoughts on Meteorology, vol. ii. M. de Luc conſiders very particularly the grand phenomenon of rain, and the numerous circumſtances connected with it. He examines the ſeveral hypotheſes with conſiderable care; but thinks them, even if admiſſible, utterly inſufficient to account for the formation of rain. The grand queſtion in this inquiry is, what becomes of the water that riſes in vapour into the atmoſphere; or what ſtate it ſubſiſts in there, between the time of its evaporation and its falling down again in rain. If it continues in the ſtate of watery vapour, or ſuch as is the immediate product of evaporation, it muſt poſſeſs the diſtinctive characters eſſential to that fluid: it muſt make the hygrometer move towards humidity, in proportion as the vapour is more or leſs abundant in the air: on a diminution of heat, the humidity, as ſhown by the hygrometer, muſt increaſe; and on an increaſe of the heat the humidity muſt diminiſh; and the introduction of other hygroſcopic ſubſtances, drier than the air, muſt have the ſame effect as an augmentation of heat. Theſe are the properties of watery vapour, on every hypotheſis of evaporation; and therefore all the water that exiſts in the atmoſphere without poſſeſſing theſe properties, is no longer vapour, but muſt have changed its nature. M. de Luc ſhows, that the water which forms rain, though it has ever been conſidered and reaſoned upon as producing humidity, does not poſſeſs theſe properties, and muſt therefore have paſſed into another ſtate. As he thinks that the vapour paſſes into an inviſible ſtate in the interval between evaporation and its falling again in rain, and that in that ſtate it is not ſenſible to the hygrometer, he conſiders the laws of hygrology as inſufficient for explaining the formation of rain; but he does not pretend to have diſcovered the immediate cauſe of the formation of clouds and rain. If it is not in the immediate product of evaporation that rain has its ſource; if the vapours change their nature in the atmoſphere, ſo as no longer to be ſenſible to the hygrometer, or to the eye; if they do not become vapour again till clouds appear; and if, when the clouds are formed, no alteration is perceived in the quality of the air—we muſt acknowledge it to be very probable, that the intermediate ſtate of vapour is no other than air—and that the clouds do not proceed from any diſtinct fluid contained in the atmoſphere, but from a decompoſition of a part of the air itſelf, perfectly ſimilar to the reſt.

It appears, to us at leaſt, that M. de Luc's mode of reaſoning on this ſubject agrees better with the phenomena than Dr Hutton's. The Doctor, however, thinks differently, and publiſhed anſwers to the objections of M. de Luc with regard to his theory of rain; to which M. de Luc replied in a letter which was printed in the Appendix to the 81ſt volume of the Monthly Review: but it would extend our article beyond its due bounds, to give a view of this controverſy.

As to the general quantity of rain that falls, and its proportion in ſeveral places at the ſame time, and in the ſame place at ſeveral times, we have many obſervations, journals, &c. in the Memoirs of the French Academy, the Philoſophical Tranſactions, &c. Upon meaſuring, then, the rain falling yearly, its depth, at a medium, and its proportion in ſeveral places, is found as in the following table:

	Inches.
At Townley, in Lancaſhire, obſerved by Mr Townley - - - -	42½
Upminſter, in Eſſex, by Dr Derham -	19½
Zurich, in Swiſſerland, by Dr Scheuchzer	32¼
Piſa, in Italy, by Dr Mich. Ang. Tilli -	43¼
Paris, in France, by M. de la Hire -	19
Liſle, in Flanders, by M. de Vauban -	24

At Upminſter.			At Paris.	
1700	19 Inch.	.03	21 Inch.	.37
1701	18	.69	27	.77
1702	20	.38	17	.45
1703	23	.99	18	.51
1704	15	.80	21	.20
1705	16	.93	14	.82

From the Meteorological Journal of the Royal Society, kept by order of the preſident and council, it appears that the whole quantity of rain at London, in each of the years ſpecified below, was as follows, viz.

			Inches.	
1774	-	-	26	.328
1775	-	-	24	.083
1776	-	-	20	.354
1777	-	-	25	.371
1778	-	-	20	.772
1779	-	-	26	.785
1780	-	-	17	.313

The quantity of rain in the four following years at London was

			Inches.	
In 1789	-	-	21	.976
1790	-	-	16	.052
1791	-	-	15	.310
1792	-	-	19	.489

Proportion of the Rain of the ſeveral Seaſons to one another.

1708	Depth at Piſa. Inch.	Depth at Upminſ. Inch.	Depth at Zurich. Inch.	1708	Depth at Piſa. Inch.	Depth at Upminſ. Inch.	Depth at Zurich. Inch.
Jan.	6 .41	2 .88	1 .64	July	0 .20	1 .11	3 .50
Feb.	3 .28	0 .46	1 .65	Aug.	2 .27	2 .94	3 .15
Mar.	2 .65	2 0.3	1 .51	Sept.	7 .21	1 .46	3 .02
April	1 .25	0 .96	4 .69	Oct.	5 .33	0 .23	2 .44
May	3 .33	2 .02	1 .91	Nov.	0 .13	0 .86	0 .62
June	4 .90	2 .32	5 .91	Dec.	0 .00	1 .97	2 .62
Half Year	21 .82	10 .67	17 .31	Half Year	14 .94	8 .57	15 .35

See Philoſophical Tranſactions abridged, vol. iv. part ii. p. 81, &c. and alſo Meteorological Journal of the Royal Society, publiſhed annually in the Philoſophical Tranſactions.

As to the uſe of rain, we may obſerve, that it moiſtens

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ſtens and ſoftens the earth, and thus fits it for affording nouriſhment to plants; by falling on high mountains, it carries down with it many particles of looſe earth, which ſerve to fertilize the ſurrounding valleys, and purifies the air from noxious exhalations, which tend in their return to the earth to meliorate the ſoil; it moderates the heat of the air; and is one means of ſupplying fountains and rivers. However, vehement rains in many countries are found to be attended with barrenneſs and poorneſs of the lands, and miſcarriage of the crops in the ſucceeding year: and the reaſon is plain; for theſe exceſſive ſtorms waſh away the fine mould into the rivers, which carry it into the ſea, and it is a long time before the land recovers itſelf again. The remedy to the famine, which ſome countries are ſubject to from this ſort of miſchief, is the planting large orchards and groves of ſuch trees as bear eſculent fruit; for it is an old obſervation, that in years, when grain ſucceeds worſt, theſe trees produce moſt fruit of all. It may partly be owing to the thorough moiſtening of the earth, as deep as their roots go by theſe rains, and partly to their trunks ſtopping part of the light mould carried down by the rains, and by this means furniſhing themſelves with a coat of new earth.

Preternatural RAINS. We have numerous accounts, in the hiſtorians of our own as well as other countries, of preternatural rains; ſuch as the raining of ſtones, of duſt, of blood, nay, and of living animals, as young frogs, and the like. We are not to doubt the truth of what thoſe who are authors of veracity and credit relate to us of this kind, ſo far as to ſuppoſe that the falling of ſtones and duſt never happened; the whole miſtake is, the ſuppoſing them to have fallen from the clouds: but as to the blood and frogs, it is very certain that they never fell at all, but the opinion has been a mere deception of the eyes. Men are extremely fond of the marvellous in their relations; but the judicious reader is to examine ſtrictly whatever is reported of this kind, and is not to ſuffer himſelf to be deceived.

There are two natural methods by which quantities of ſtones and duſt may fall in certain places, without their having been generated in the clouds or fallen as rain. The one is by means of hurricanes: the wind which we frequently ſee tearing off the tiles of houſes, and carrying them to conſiderable diſtances, being equally able to take up a quantity of ſtones, and drop them again at ſome other place. But the other, which is much the moſt powerful, and probably the moſt uſual way, is for the eruptions of volcanoes and burning mountains to toſs up, as they frequently do, a vaſt quantity of ſtones, aſhes, and cinders, to an immenſe height in the air: and theſe, being hurried away by the hurricanes and impetuous winds which uſually accompany thoſe eruptions, and being in themſelves much lighter than common ſtones, as being half calcined, may eaſily be thus carried to vaſt diſtances; and there falling in places where the inhabitants know nothing of the occaſion, they cannot but be ſuppoſed by the vulgar to fall on them from the clouds. It is well known, that, in the great eruptions of Ætna and Veſuvius, ſhowers of aſhes, duſt, and ſmall cinders, have been ſeen to obſcure the air, and overſpread the ſurface of the ſea for a great way, and cover the decks of ſhips; and this at ſuch a diſtance, as it ſhould appear ſcarce conceivable that they ſhould have been carried to: and probably, if the accounts of all the ſhowers of theſe ſubſtances mentioned by authors be collected, they will all be found to have fallen within ſuch diſtances of volcanoes; and if compared as to the time of their falling, will be found to correſpond in that alſo with the eruptions of thoſe mountains. We have known inſtances of the aſhes from Veſuvius having been carried thirty, nay, forty leagues, and peculiar accidents may have carried them yet farther. It is not to be ſuppoſed that theſe ſhowers of ſtones and duſt fall for a continuance in the manner of ſhowers of rain, or that the fragments or pieces are as frequent as drops of water; it is ſufficient that a number of ſtones, or a quantity of duſt, fall at once on a place, where the inhabitants can have no knowledge of the part from whence they came, and the vulgar will not doubt their dropping from the clouds. Nay, in the canton of Berne in Swiſſerland, the inhabitants accounted it a miracle that it rained earth and ſulphur upon them at a time that a ſmall volcano terrified them; and even while the wind was ſo boiſterous, and hurricanes ſo frequent, that they ſaw almoſt every moment the duſt, ſand, and little ſtones torn up from the ſurface of the earth in whirlwinds, and carried to a conſiderable height in the air, they never conſidered that both the ſulphur thrown up by the volcano, and the duſt, &c. carried from their feet muſt fall ſoon after ſomewhere. It is very certain that in ſome of the terrible ſtorms of large hail, where the hailſtones have been of many inches round, on breaking them there have been found what people have called *ſtones in their middle*; but theſe obſervers needed only to have waited the diſſolving of one of theſe hailſtones, to have ſeen the ſtone in its centre diſunite alſo, it being only formed of the particles of looſe earthy matter, which the water, exhaled by the ſun's heat, had taken up in extremely ſmall moleculæ with it; and this only having ſerved to give an opaque hue to the inner part of the congelation, to which the freezing of the water alone gave the apparent hardneſs of ſtone.

The raining of *blood* has been ever accounted a more terrible ſight and a more fatal omen than the other preternatural rains already mentioned. It is very certain that nature forms blood nowhere but in the veſſels of animals; and therefore ſhowers of it from the clouds are by no means to be credited. Thoſe who ſuppoſe that what has been taken for blood has been actually ſeen falling through the air, have had recourſe to flying inſects for its origin, and ſuppoſe it the eggs or dung of certain butterflies diſcharged from them as they were high up in the air. But it ſeems a very wild conjecture, as we know of no butterfly whoſe excrements or eggs are of ſuch a colour, or whoſe abode is ſo high, or their flocks ſo numerous, as to be the occaſion of this.

It is moſt probable that theſe bloody waters were never ſeen falling; but that people ſeeing the ſtanding waters blood-coloured, were aſſured, from their not knowing how it ſhould elſe happen, that it had rained blood into them. A very memorable inſtance of this took place at the Hague in the year 1670. Swammerdam, who relates it, tells us, that one morning the whole town was in an uproar on finding their lakes and ditches full of blood, as they thought; and having been certainly full of water the night before, they agreed it muſt have rained blood in the night: but a certain phy-

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ſician went down to one of the canals, and taking home a quantity of this blood-coloured water, he examined it by the microſcope, and found that the water was water ſtill, and had not at all changed its colour; but that it was full of prodigious ſwarms of ſmall red animals, all alive, and very nimble in their motions, whoſe colour and prodigious number gave a red tinge to the whole body of the water they lived in, on a leſs accurate inſpection. The certainty that this was the caſe, did not however perſuade the Hollanders to part with the miracle: they prudently concluded, that the ſudden appearance of ſuch a number of animals was as great a prodigy as the raining of blood would have been; and are aſſured to this day, that this portent foretold the ſcene of war and deſtruction which Louis XIV. afterwards brought into that country, which had before enjoyed 40 years of uninterrupted peace.

The animals which thus colour the water of lakes and ponds are the *pulices arboreſcentes* of Swammerdam, or the water-fleas with branched horns. Theſe creatures are of a reddiſh-yellow or flame colour: they live about the ſides of ditches, under weeds, and among the mud; and are therefore the leſs viſible, except at a certain time, which is in the end or beginning of June: it is at this time that theſe little animals leave their receſſes to float looſe about the water, to meet for the propagation of their ſpecies, and by that means become viſible in the colour they give the water. This is viſible, more or leſs, in one part or other of almoſt all ſtanding waters at this ſeaſon; and it is always at this ſeaſon that the bloody waters have alarmed the ignorant.

The raining of *frogs* is a thing not leſs wonderful in the accounts of authors who love the marvellous, than thoſe of blood or ſtones; and this is ſuppoſed to happen ſo often, that there are multitudes who pretend to have been eye-witneſſes of it. Theſe rains of frogs always happen after very dry ſeaſons, and are much more frequent in the hotter countries than in the cold ones. In Italy they are very frequent; and it is not uncommon to ſee the ſtreets of Rome ſwarming both with young frogs and toads in an inſtant in a ſhower of rain; they hopping everywhere between the people's legs as they walk, though there was not the leaſt appearance of them before. Nay, they have been ſeen to fall through the air down upon the pavements. This ſeems a ſtrong circumſtance in favour of their being rained down from the clouds; but, when ſtrictly examined, it comes to nothing: for theſe frogs that are ſeen to fall, are always found dead, lamed, or bruiſed by the fall, and never hop about as the reſt; and they are never ſeen to fall, except cloſe under the walls of houſes, from the roofs and gutters of which they have accidentally ſlipped down. Some people, who love to add to ſtrange things yet ſtranger, affirm that they have had the young frogs fall into their hats in the midſt of an open field; but this is idle, and wholly falſe.

Others, who cannot agree to their falling from the clouds, have tried to ſolve the difficulty of their ſudden appearance, by ſuppoſing them hatched out of the egg, or ſpawn, by theſe rains. Nay, ſome have ſuppoſed them made immediately out of the duſt: but there are unanſwerable arguments againſt all theſe ſuppoſitions. Equivocal generation, or the ſpontaneous production of animals out of duſt, is now wholly exploded. The fall from the clouds muſt deſtroy and kill theſe tender and ſoft-bodied animals: and they cannot be at this time hatched immediately out of eggs; becauſe the young frog does not make its appearance from the egg in form, but has its hinder legs enveloped in a ſkin, and is what we call a *tadpole;* and the young frogs are at leaſt 100 times larger at the time of their appearance, than the egg from which they ſhould be hatched.

It is beyond a doubt, that the frogs which make their appearance at this time, were hatched and in being long before: but that the dry ſeaſons had injured them, and kept them ſluggiſhly in holes or coverts; and that all the rain does, is the enlivening them, giving them new ſpirits, and calling them forth to ſeek new habitations, and enjoy the element they were deſtined in great part to live in. Theophraſtus, the greateſt of all the naturaliſts of antiquity, has affirmed the ſame thing. We find that the error of ſuppoſing theſe creatures to fall from the clouds was as early as that author's time; and alſo that the truth, in regard to their appearance, was as early known; though, in the ages ſince, authors have taken care to conceal the truth, and to hand down to us the error. We find this venerable ſage, in a fragment of his on the generation of animals which appear on a ſudden, bantering the opinion, and aſſerting that they were hatched and living long before. The world owes, however, to the accurate Signior Redi the great proof of this truth, which Theophraſtus only has affirmed: for this gentleman, diſſecting ſome of theſe new-appearing frogs, found in their ſtomachs herbs and other half-digeſted food; and, openly ſhowing this to his credulous countrymen, aſked them whether they thought that nature, which engendered, according to their opinion, theſe animals in the clouds, had alſo been ſo provident as to engender graſs there for their food and nouriſhment?

To the raining of frogs we ought to add the raining of *graſshoppers* and *locuſts*, which have ſometimes appeared in prodigious numbers, and devoured the fruits of the earth. There has not been the leaſt pretence for the ſuppoſing that theſe animals deſcended from the clouds, but that they appeared on a ſudden in prodigious numbers. The naturaliſt, who knows the many accidents attending the eggs of theſe and other the like animals, cannot but know that ſome ſeaſons will prove particularly favourable to the hatching them, and the prodigious number of eggs that many inſects lay could not but every year bring us ſuch abundance of the young, were they not liable to many accidents, and had not provident nature taken care, as in many plants, to continue the ſpecies by a very numerous ſtock of ſeeds, of which perhaps not one in 500 need take root in order to continue an equal number of plants. As it is thus alſo in regard to inſects, it cannot but happen, that if a favourable ſeaſon encourage the hatching of all thoſe eggs, a very ſmall number of which alone was neceſſary to continue the ſpecies, we muſt, in ſuch ſeaſons, have a proportionate abundance of them. There appeared about 50 years ago, in London, ſuch a prodigious ſwarm of the little beetle called the *lady-cow*, that the very poſts in the ſtreets were everywhere covered with them. But thanks to the progreſs of philoſophy among us, we had nobody to aſſert that it rained cow-ladies, but contented ourſelves with ſaying that it had been a favourable ſeaſon for their eggs. The prodigious number of a ſort of grub which did vaſt miſchief about the ſame period

Rain.

period among the corn and grafs by eating off their roots, might alfo have been fuppofed to proceed from its having rained grubs by people fond of making every thing a prodigy; but our knowledge in natural hiftory affured us, that thefe were only the hexapode worms of the common hedge-beetle called the *cockchafer*.

The raining of *fifhes* has been a prodigy alfo much talked of in France, where the ftreets of a town at fome diftance from Paris, after a terrible hurricane in the night, which tore up trees, blew down houfes, &c. were found in a manner covered with fifhes of various fizes. Nobody here made any doubt of thefe having fallen from the clouds; nor did the abfurdity of fifh, of five or fix inches long, being generated in the air, at all ftartle the people, or fhake their belief in the miracle, till they found, upon inquiry, that a very well-ftocked fifh-pond, which ftood on an eminence in the neighbourhood, had been blown dry by the hurricane, and only the great fifh left at the bottom of it, all the fmaller fry having been toffed into their ftreets.

Upon the whole, all the fuppofed marvellous rains have been owing to fubftances naturally produced on the earth, and either never having been in the air at all, or only carried thither by accident.

In Silefia, after a great dearth of wheat in that country, there happened a violent ftorm of wind and rain, and the earth was afterwards covered, in many places, with fmall round feeds. The vulgar cried out that Providence had fent them food, and that it had rained *millet*: but thefe were, in reality, only the feeds of a fpecies of veronica, or fpeedwell, very common in that country; and whofe feeds being juft ripe at that time, the wind had diflodged them from their capfules, and fcattered them about. In our own country, we have hiftories of rains of this marvellous kind, but all fabulous. It was once faid to rain *wheat* in Wiltfhire; and the people were all alarmed at it as a miracle, till Mr Cole fhowed them, that what they took for wheat was only the feeds or kernels of the berries of ivy, which being then fully ripe, the wind had diflodged from the fides of houfes, and trunks of trees, on which the ivy that produced them crept.

And we even once had a raining of fifhes near the coaft of Kent in a terrible hurricane, with thunder and lightning. The people who faw fmall fprats ftrewed all about afterwards, would have it that they had fallen from the clouds; but thofe who confidered how far the high winds have been known to carry the fea-water, did not wonder that they fhould be able to carry fmall fifh with it fo fmall a part of the way.

In the Philofophical Tranfactions for 1782 we have the following account of a preternatural kind of rain by Count de Gioeni: "The morning of the 24th inftant there appeared here a moft fingular phenomenon. Every place expofed to the air was found wet with a coloured cretaceous gray water, which, after evaporating and filtrating away, left every place covered with it to the height of two or three lines; and all the ironwork that was touched by it became rufty.

"The public, inclined to the marvellous, fancied various caufes of this rain, and began to fear for the animals and vegetables.

"In places where rain-water was ufed, they abftained from it: fome fufpecting vitriolic principles to be mixed with it, and others predicting fome epidemical diforder.

"Thofe who had obferved the explofions of Etna 20 days and more before, were inclined to believe it originated from one of them.

"The fhower extended from N. $\frac{1}{4}$ N. E. to S. $\frac{1}{4}$ S. W. over the fields, about 70 miles in a right line from the vertex of Etna.

"There is nothing new in volcanoes having thrown up fand, and alfo ftones, by the violent expanfive force generated within them, which fand has been carried by the wind to diftant regions.

"But the colour and fubtilty of the matter occafioned doubts concerning its origin; which increafed from the remarkable circumftance of the water in which it came incorporated; for which reafons fome other principle or origin was fufpected.

"It became, therefore, neceffary by all means to afcertain the nature of this matter, in order to be convinced of its origin, and of the effects it might produce. This could not be done without the help of a chemical analyfis. To do this then with certainty, I endeavoured to collect this rain from places where it was moft probable no heterogeneous matter would be mixed with it. I therefore chofe the plant called *braffica capitata*, which having large and turned-up leaves, they contained enough of this coloured water: many of thefe I emptied into a veffel, and left the contents to fettle till the water became clear.

"This being feparated into another veffel, I tried it with vegetable alkaline liquors and mineral acids; but could obferve no decompofition by either. I then evaporated the water in order to reunite the fubftances that might be in folution; and touching it again with the aforefaid liquors, it fhowed a flight effervefcence with the acids. When tried with the fyrup of violets, this became a pale green; fo that I was perfuaded it contained a calcareous falt. With the decoction of galls no precipitation was produced.

"The matter being afterwards dried in the fhade, it appeared a very fubtile fine earth, of a cretaceous colour, but inert, from having been diluted by the rain.

"I next thought of calcining it with a flow fire, and it affumed the colour of a brick. A portion of this being put into a crucible, I applied to it a ftronger heat; by which it loft almoft all its acquired colour. Again, I expofed a portion of this for a longer time to a very violent heat (from which a vitrification might be expected); it remained, however, quite foft, and was eafily bruifed, but returned to its original dufky colour.

"From the moft accurate obfervations of the fmoke from the three calcinations, I could not difcover either colour or fmell that indicated any arfenical or fulphureous mixture.

"Having therefore calcined this matter in three portions, with three different degrees of fire, I prefented a good magnet to each: it did not act either on the firft or fecond; a flight attraction was vifible in many places on the third: this perfuaded me, that this earth contains a martial principle in a metallic form, and not in a vitriolic fubftance.

"The nature of thefe fubftances then being difcovered, their volcanic origin appears; for iron, the more it is is expoſed to violent calcination, the more it is divided by the loſs of its phlogiſtic principle; which cannot naturally happen but in the great chimney of a volcano. Calcareous ſalt, being a marine ſalt combined with a calcareous ſubſtance by means of violent heat, cannot be otherwiſe compoſed than in a volcano.

"As to their dreaded effects on animals and vegetables, every one knows the advantageous uſe, in medicine, both of the one and the other, and this in the ſame form as they are thus prepared in the great laboratory of nature.

"Vegetables, even in flower, do not appear in the leaſt macerated, which has formerly happened from only ſhowers of ſand.

"How this volcanic production came to be mixed with water may be conceived in various ways.

"Ætna, about its middle regions, is generally ſurrounded with clouds that do not always riſe above its ſummit, which is 2900 paces above the level of the ſea. This matter being thrown out, and deſcending upon the clouds below it, may happen to mix and fall in rain with them in the uſual way. It may alſo be conjectured, that the thick ſmoke which the volcanic matter contained might, by its rarefaction, be carried in the atmoſphere by the winds over that tract of country; and then cooling ſo as to condenſe and become ſpecifically heavier than the air, might deſcend in that coloured rain.

"I muſt, however, leave to philoſophers (to whom the knowledge of natural agents belongs) the examination and explanation of ſuch phenomena, confining myſelf to obſervation and chemical experiments."

Rain, a well built and fortified town of Bavaria, one of the keys of this electorate, on the Lech, 20 miles weſt of Ingolſtadt. N. Lat. 48. 51. E. Long. 11. 12.

Rain-Bird. See Cuculus, Ornithology *Index*.

RAINBOW. See Optics.

In the Philoſophical Tranſactions for 1793, we have the following account of two rainbows ſeen by the Rev. Mr Sturges.

"On the evening of the 9th of July 1792, between ſeven and eight o'clock, at Alverſtroke, near Goſport, on the ſea-coaſt of Hampſhire, there came up, in the ſouth-eaſt, a cloud with a thunder ſhower; while the ſun ſhone bright, low in the horizon to the north-weſt.

Plate CCCLVIII. Fig. 2. "In this ſhower two primary rainbows appeared, AB and AC, not concentric, but touching each other at A, in the ſouth part of the horizon; with a ſecondary bow to each, DE and DF (the laſt very faint, but diſcernible), which touched likewiſe at D. Both the primary were very vivid for a conſiderable time, and at different times nearly equally ſo; but the bow AB was moſt permanent, was a larger ſegment of a circle, and at laſt, after the other had vaniſhed, became almoſt a ſemicircle; the ſun being near ſetting. It was a perfect calm, and the ſea was as ſmooth as glaſs.

"If I might venture to offer a ſolution of this appearance, it would be as follows. I conſider the bow AB as the true one, produced by the ſun itſelf; and the other, AC, as produced by the reflection of the ſun from the ſea, which, in its perfectly ſmooth ſtate, acted as a ſpeculum. The direction of the ſea, between the Iſle of Wight and the land, was to the north-weſt in a line with the ſun, as it was then ſituated. The image reflected from the water, having its rays iſſuing from a point lower than the real ſun, and in a line coming from beneath the horizon, would conſequently form a bow higher than the true one AB. And the ſhores, by which that narrow part of the ſea is bounded, would before the ſun's actual ſetting intercept its rays from the ſurface of the water, and cauſe the bow AC, which I ſuppoſe to be produced by the reflection, to diſappear before the other."

The marine or ſea bow is a phenomenon which may be frequently obſerved in a much agitated ſea, and is occaſioned by the wind ſweeping part of the waves, and carrying them aloft; which when they fall down are refracted by the ſun's rays, which paint the colours of the bow juſt as in a common ſhower. Theſe bows are often ſeen when a veſſel is ſailing with conſiderable force, and daſhing the waves around her, which are raiſed partly by the action of the ſhip and partly by the force of the wind, and, falling down, they form a rainbow; and they are alſo often occaſioned by the daſhing of the waves againſt the rocks on ſhore.

In the Philoſophical Tranſactions, it is obſerved by F. Bourzes, that the colours of the marine rainbow are leſs lively, leſs diſtinct, and of ſhorter continuance, than thoſe of the common bow; that there are ſcarcely above two colours diſtinguiſhable, a dark yellow on the ſide next the ſun, and a pale green on the oppoſite ſide. But they are more numerous, there being ſometimes 20 or 30 ſeen together.

To this claſs of bows may be referred a kind of white or colourleſs rainbows, which Mentzelius and others affirm to have ſeen at noon-day. M. Marlotte, in his fourth *Eſſai de Phyſique*, ſays, theſe bows are formed in miſts, as the others are in ſhowers; and adds, that he has ſeen ſeveral both after ſunriſing and in the night. The want of colours he attributes to the ſmallneſs of the vapours which compoſe the miſt; but perhaps it is rather from the exceeding tenuity of the little veſiculæ of the vapour, which being only little watery pellicles bloated with air, the rays of light undergo but little refraction in paſſing out of air into them; too little to ſeparate the differently coloured rays, &c. Hence the rays are reflected from them, compounded as they came, that is, white. Rohault mentions * coloured rainbows on the graſs; formed by the refractions of the ſun's rays in the morning dew. Rainbows have been alſo produced by the reflection of the ſun from a river; and in the Philoſophical Tranſactions, vol. l. p. 294. we have an account of a rainbow, which muſt have been formed by the exhalations from the city of London, when the ſun had been ſet 20 minutes, and conſequently the centre of the bow was above the horizon. The colours were the ſame as in the common rainbow, but fainter.

* *Traite de Phyſique.*

It has often been made a ſubject of inquiry among the curious how there came to be no rainbow before the flood, which is thought by ſome to have been the caſe from its being made a ſign of the covenant which the Deity was pleaſed to make with man after that event. Mr Whitehurſt, in his *Inquiry into the Original State and Formation of the Earth*, p. 173, &c. endeavours to eſtabliſh it as a matter of great probability at leaſt, that the antediluvian atmoſphere was ſo uniformly temperate as never to be ſubject to ſtorms, tempeſts, or rain, and of courſe it could never exhibit a rainbow. For our own part, we cannot ſee how the earth at that period could

Rainbow.

do without rain any more than at preſent; and it appears to us from Scripture equally probable that the rainbow was ſeen before the flood as after it. It was then, however, made a token of a certain covenant; and it would unqueſtionably do equally well for that purpoſe if it had exiſted before as if it had not.

Lunar RAINBOW. The moon ſometimes alſo exhibits the phenomenon of an iris or rainbow by the refraction of her rays in drops of rain in the night time. This phenomenon is very rare. In the Philoſophical Tranſactions for 1783, however, we have an account of three ſeen in one year, and all in the ſame place, communicated in two letters by Marmaduke Tunſtall, Eſq. The firſt was ſeen 27th February 1782, at Greta Bridge, Yorkſhire, between ſeven and eight at night, and appeared "in tolerably diſtinct colours, ſimilar to a ſolar one, but more faint: the orange colour ſeemed to predominate. It happened at full moon; at which time alone they are ſaid to have been always ſeen. Though Ariſtotle is ſaid to have obſerved two, and ſome others have been ſeen by Snellius, &c. I can only find two deſcribed with any accuracy; viz. one by Plot, in his Hiſtory of Oxfordſhire, ſeen by him in 1675, though without colours; the other ſeen by a Derbyſhire gentleman at Glapwell, near Cheſterfield, deſcribed by Thoreſby, and inſerted in N° 331. of the Philoſophical Tranſactions: this was about Chriſtmas, 1710, and ſaid to have had all the colours of the Iris Solaris. The night was windy; and though there was then a drizzling rain and dark cloud, in which the rainbow was reflected, it proved afterwards a light froſt."

Two others were afterwards ſeen by Mr Tunſtall; one on July the 30th, about 11 o'clock, which laſted about a quarter of an hour, without colours. The other, which appeared on Friday October 18. was "perhaps the moſt extraordinary one of the kind ever ſeen. It was firſt viſible about nine o'clock, and continued, though with very different degrees of brilliancy, till paſt two. At firſt, though a ſtrongly marked bow, it was without colours; but afterwards they were very conſpicuous and vivid in the ſame form as in the ſolar, though fainter; the red, green, and purple, were moſt diſtinguiſhable. About twelve it was the moſt ſplendid in appearance; its arc was conſiderably a ſmaller ſegment of a circle than a ſolar; its ſouth-eaſt limb firſt began to fail, and a conſiderable time before its final extinction: the wind was very high, nearly due weſt, moſt part of the time, accompanied with a drizzling rain. It is a ſingular circumſtance, that three of theſe phenomena ſhould have been ſeen in ſo ſhort a time in one place, as they have been eſteemed ever ſince the time of Ariſtotle, who is ſaid to have been the firſt obſerver of them, and ſaw only two in 50 years, and ſince by Plot and Thoreſby, almoſt the only two Engliſh authors who have ſpoke of them, to be exceeding rare. They ſeem evidently to be occaſioned by a refraction in a cloud or turbid atmoſphere, and in general are indications of ſtormy and rainy weather: ſo bad a ſeaſon as the late ſummer having, I believe, ſeldom occurred in England. Thoreſby, indeed, ſays, the one he obſerved was ſucceeded by ſeveral days of fine ſerene weather. One particular, rather ſingular, in the ſecond, viz. of July the 30th, was its being ſix days after the full of the moon; and the laſt, though of ſo long a duration, was three days before the full: that of the 27th of February was exactly at the full, which uſed to be judged the only time they could be ſeen, though in the Encyclopedia there is an account that Weidler obſerved one in 1719, in the firſt quarter of the moon, with faint colours, and in very calm weather. No lunar iris, I ever heard or read of, laſted near ſo long as that on the 18th inſtant, either with or without colours."

Rainbows, Raiſins.

In the Gentleman's Magazine for Auguſt 1788 we have an account of a lunar rainbow by a correſpondent who ſaw it. "On Sunday evening the 17th of Auguſt (ſays he), after two days, on both of which, particularly the former, there had been a great deal of rain, together with lightning and thunder, juſt as the clocks were ſtriking nine, 23 hours after full moon, looking through my window, I was ſtruck with the appearance of ſomething in the ſky, which ſeemed like a rainbow. Having never ſeen a rainbow by night, I thought it a very extraordinary phenomenon, and haſtened to a place where there were no buildings to obſtruct my view of the hemiſphere: here I found that the phenomenon was no other than a lunar rainbow; the moon was truly 'walking in brightneſs,' brilliant as ſhe could be; not a cloud was to be ſeen near her; and over againſt her, toward the north-weſt, or perhaps rather more to the north, was a rainbow, a vaſt arch, perfect in all its parts, not interrupted or broken as rainbows frequently are, but unremittedly viſible from one horizon to the other. In order to give ſome idea of its extent, it is neceſſary to ſay, that as I ſtood toward the weſtern extremity of the pariſh of Stoke Newington, it ſeemed to take its riſe from the weſt of Hampſtead, and to end, perhaps, in the river Lea, the eaſtern boundary of Tottenham; its colour was white, cloudy, or greyiſh, but a part of its weſtern leg ſeemed to exhibit tints of a faint ſickly green. I continued viewing it for ſome time, till it began to rain; and at length the rain increaſing, and the ſky growing more hazy, I returned home about a quarter or 20 minutes paſt nine, and in ten minutes came out again; but by that time all was over, the moon was darkened by clouds, and the rainbow of courſe vaniſhed."

Marine RAINBOW, or *Sea-bow*. See the article RAINBOW.

RAINBOW *Stone*. See MOON-*Stone*.

RAISINS, grapes prepared by ſuffering them to remain on the vine till they are perfectly ripe, and then drying them in the ſun, or by the heat of an oven. The difference between raiſins dried in the ſun and thoſe dried in ovens, is very obvious: the former are ſweet and pleaſant, but the latter have a latent acidity with the ſweetneſs that renders them much leſs agreeable.

The common way of drying grapes for raiſins, is to tie two or three bunches of them together while yet on the vine, and dip them into a hot lixivium of wood-aſhes, with a little of the oil of olives in it. This diſpoſes them to ſhrink and wrinkle; and after this they are left on the vine three or four days ſeparated on ſticks in an horizontal ſituation, and then dried in the ſun at leiſure, after being cut from the tree. The fineſt and beſt raiſins are thoſe called in ſome places *Damaſcus* and *Jube raiſins*; which are diſtinguiſhed from the others by their ſize and figure: they are flat and wrinkled on on the surface, soft and juicy within, and near an inch long; and, when fresh and growing on the bunch, are of the size and shape of a large olive.

The raisins of the sun, and jar-raisins, are all dried by the heat of the sun; and these are the sorts used in medicine. However, all the kinds have much the same virtues: they are all nutritive and balsamic; they are allowed to be attenuant, are said to be good in nephritic complaints, and are an ingredient in pectoral decoctions: in which cases, as also in all others where astringency is not required of them, they should have the stones carefully taken out.

RAISIN-Wine. See WINE.

RAKKATH, in *Ancient Geography*, a town of Upper Galilee, thought to be Tiberias, (Talmud): but this is denied by Reland, who says that Rakkath was a town of the tribe of Naphthali.

RAKE is a well known instrument with teeth, by which the ground is divided. See AGRICULTURE, *Instruments.*

RAKE also means a loose, disorderly, vicious, and thoughtless fellow.

RAKE of a Ship, is all that part of her hull which hangs over both ends of her keel. That which is before is called the *fore rake*, or *rake forward*, and that part which is at the setting on of the stern-post is called the *rake-aft* or *afterward.*

RALEIGH, SIR WALTER, fourth son of Walter Raleigh, Esq. of Fardel, in the parish of Cornwood in Devonshire, was born in 1552 at Hayes, in the parish of Budley, a farm belonging to his father. About the year 1568, he was sent to Oriel college in Oxford, where he continued but a short time; for in the following year he embarked for France, being one of the hundred volunteers, commanded by Henry Champernon, who, with other English troops, were sent by Queen Elizabeth to assist the queen of Navarre in defending the Protestants. In this service he continued for five or six years; after which he returned to London, and probably resided in the Middle Temple. But his enterprising genius would not suffer him to remain long in a state of inactivity. In 1577 or 1578, he embarked for the Low Countries with the troops sent by the queen to assist the Dutch against the Spaniards, and probably shared the glory of the decisive victory over Don John of Austria in 1578. On his return to England, a new enterprise engaged his attention. His half brother, Sir Humphrey Gilbert, having obtained a patent to plant and inhabit some parts of North America, Mr Raleigh embarked in this adventure; but, meeting with a Spanish fleet, after a smart engagement they returned, without success, in 1579.

The following year, the king of Spain, in conjunction with the pope, having projected a total conquest of the English dominions, sent troops to Ireland to assist the Desmonds in the Munster rebellion. Raleigh obtained a captain's commission under Lord Grey of Wilton, then deputy of Ireland, and embarked for that kingdom; where, by his conduct and resolution, he was principally instrumental in putting an end to the rebellious attempt. He returned to England; and attracted the notice of Queen Elizabeth, owing, as we are told in Naunton's *Fragmenta Regalia*, to the following accidental of piece of gallantry. The queen, as she was one day taking a walk, being stopped by a *splashy* place in the road, our gallant young soldier took off his new plush mantle, and spread it on the ground. Her majesty trod gently over the fair foot-cloth, surprised and pleased with the adventure. He was a handsome man, and remarkable for his gentility of address.

The queen admitted him to her court, and employed him first as an attendant on the French ambassador Simier on his return home, and afterwards to escort the duke of Anjou to Antwerp. During this excursion he became personally known to the prince of Orange; from whom, at his return, he brought special acknowledgments to the queen, who now frequently conversed with him. But the inactive life of a courtier did not suit the enterprising spirit of Mr Raleigh. In the year 1583, he embarked with his brother, Sir Humphrey Gilbert, on a second expedition to Newfoundland, in a ship called the *Raleigh*, which he built at his own expence; but was obliged to return on account of an infectious distemper on board. He was, however, so little affected by this disappointment, that he now laid before the queen and council a proposal for exploring the continent of North America; and in 1584 obtained a patent empowering him to possess such countries as he should discover in that part of the globe. Accordingly Mr Raleigh fitted out two ships at his own expence, which sailed in the month of April, and returned to England about the middle of September, reporting that they had discovered and taken possession of a fine country called *Windangocoa*, to which the queen gave the name of *Virginia.* About this time he was elected knight of the shire for the county of Devon, and soon after received the honour of knighthood; and to enable him to carry on his designs abroad, the queen granted him a patent for licensing the venders of wine throughout the kingdom. In 1585 he sent a fleet of seven ships to Virginia, commanded by his relation Sir Richard Greenville, who left a colony at Roanah of 107 persons, under the government of Mr Lane; and by the establishment of this colony he first imported tobacco into England. See NICOTIANA. In the same year Sir Walter Raleigh obtained a grant of 12,000 acres of the forfeited lands in the county of Corke in Ireland.—About the same time he was made seneschal of the duchy of Cornwall, and warden of the stanneries; and grew into such favour with the queen, that even Leicester was jealous of his influence.

In 1587, he sent another colony of 150 men to Virginia, with a governor, Mr John White, and 12 assistants. About this time we find our knight distinguished by the titles of *Captain of the queen's guards*, and *Lieutenant general of Cornwall.* From this period to the year 1594, he was continually engaged in projecting new expeditions, sending succours to the colonies abroad, defending the kingdom from the insults of the Spaniards, and transacting parliamentary business, with equal ability and resolution. Whilst thus employed, he was publicly charged, in a libel written by the infamous Jesuit Parsons, with being an Atheist; a groundless and ridiculous imputation. In 1594, he obtained from the queen a grant of the manor of Sherborne in Dorsetshire, where he built a magnificent house: but Sir Walter fell under the queen's displeasure on account of an intrigue with the daughter of Sir Nicholas Throgmorton, one of the maids of honour; however, he married the lady, and lived with her in great conjugal harmony.

mony. During his disgrace at court, he projected the conquest of Guiana in South America, and in 1595 sailed for that country; of which having taken possession, after defeating the Spaniards who were settled there, he returned to England the same year, and soon after published an account of his expedition. In the following year he was one of the admirals in the successful expedition against Cadiz, under the command of Howard and the earl of Essex; and in 1597 he sailed with the same commanders against the Azores. Soon after these expeditions, we find him assiduously engaged in parliamentary business, and a distinguished personage in jousts and tournaments. In 1600 he was sent on a joint embassy with Lord Cobham to Flanders, and at his return made governor of Jersey.

Queen Elizabeth died in the beginning of the year 1603; and with her Raleigh's glory and felicity sunk, never to rise again. Upon the accession of James, Sir Walter lost his interest at court, was stripped of his preferments, and accused of a plot against the king. He was arraigned at Winchester, and, on his trial, insulted with the most shocking brutality by the famous Coke, attorney-general, whose sophistical vociferation influenced the jury to convict him without the least proof of guilt. After a month's imprisonment, however, in daily expectation of his execution, he was reprieved, and sent to the Tower; and his estates were given to Car, earl of Somerset, the king's favourite. During this confinement, he wrote many of his most valuable pieces, particularly his History of the World. In March, 1615, after 16 years imprisonment, he obtained his liberty, and immediately began to prepare for another voyage to Guiana. In August 1616, the king granted him a very ample commission for that purpose; and in July the year following, he sailed from Plymouth: but, strange as it may appear, it is most certain that the whole scheme was revealed to the Spaniards by the king himself, and thus necessarily rendered abortive.

He returned to England in 1618, where he was soon after seized, imprisoned, and beheaded; not for any pretended misdemeanor on the late expedition, but in consequence of his former attainder. The truth of the matter is, he was sacrificed by the pusillanimous monarch to appease the Spaniards; who, whilst Raleigh lived, thought every part of their dominions in danger. He was executed in Old Palace Yard, and buried in St Margaret's adjoining, in the 66th year of his age. His behaviour on the scaffold was manly, unaffected, cheerful, and easy. Being asked by the executioner which way he would lay his head, he answered, "So the heart be right, it is no matter which way the head lies." He was a man of admirable parts, extensive knowledge, undaunted resolution, and strict honour and honesty. He was the author of a great many works, some of which have not been printed.

RALLUS, the Rail, a genus of birds belonging to the order of grallæ. See Ornithology *Index*.

RALPH, James, an ingenious historical and political writer, of whose birth and country nothing is exactly known. He was first known as a schoolmaster in Philadelphia in North America. He came to England about the beginning of the reign of George I. and wrote some things in the dramatic way, which were not received with great applause; but though he did not succeed as a poet, he was a very ingenious prose-writer. He wrote A History of England, commencing with the the Stuarts, which is much esteemed; as were his political essays and pamphlets, some of which were looked upon as master-pieces. His last publication, The Case of Authors by Profession, is an excellent and entertaining performance. He died in 1762.

RAM. See Ovis, Mammalia *Index*.

Battering RAM, in antiquity, a military engine used to batter down the walls of besieged places. See *Battering Ram*.

RAM's Head, in a ship, is a great block belonging to the fore and main haulyards. It has three shivers in it, in which the haulyards are put; and in a hole at the end are reeved the ties.

RAMADAN, a solemn season of fasting among the Mahometans. See Mahometanism.

RAMAH, in *Ancient Geography*, a town of Benjamin, near Gibea, (Judges); called *Rama of Saul* (1 Sam. xxii.), six miles from Jerusalem to the north; memorable for the story of the Levite and his concubine: Taken and fortified by Baasa king of Israel, in order to annoy the kingdom of Judah. This Rama is mentioned Isa. x. Jer. xxxi. and Math. ii. and is to be distinguished from *Rama of Samuel*, 1. Sam. xix. called also *Ramatha*, 1 Sam. i. 19. and *Ramathaim Zophim*, ibid. i. 1. which lay a great way to the west, towards Joppa, near Lydda, 1 Maccab. ii. the birth-place of Samuel; adjoining to the mountains of Ephraim, and the place of his residence, 1 Sam. xv. &c. (Joseph.). Called *Ramula* in the lower age, (Gul. Tyrius). There is here a convent of the Fathers of the Holy Land, inhabited only by Portuguese, Spaniards, and Italians.

RAMATH-mizpe, (Joshua xiii.); *Ramoth-Masphe*, (Septuagint, Vulgate); *Ramoth in Gilead*, or *Remmoth Galaad*, (Seventy); a town in that tract of Gilead called *Maspha*, or *Mizpe*, one of the cities of refuge.

RAMAZZINI, Bernardin, an Italian physician, born at Carpi near Modena in 1633. He was professor of physic in the university of Modena for 18 years; and in 1700 accepted an invitation from Padua, where he was made rector of the college; and died in 1714. His works were collected and published in London, 1716; of which, his treatise *De Morbis Artificum*, "Of the peculiar maladies of artificers," will always be esteemed useful and curious.

RAMEKINS, a fortress of the United Netherlands, on the south coast of the island of Walcherin, in the province of Zealand. One of the cautionary towns given to Queen Elizabeth for the repayment of the charges she had been at for the defence of this republic in its infancy. Four miles east of Flushing; in N. Lat. 51. 34. E. Long. 4. 24.

RAMESSE, in *Ancient Geography*, a town built by the Israelites during their bondage in Egypt, and from which the Exodus took place, and which must have been towards and not far from the Arabian gulf, seeing in the third station the Israelites arrived on its shore.

Rameses, king of the Lower Egypt when Jacob went thither with his family, in the 1706th year before the Christian era. Ancient authors mention several other kings of Egypt of the same name; and it is thought that one of those princes erected in the temple of the sun at Thebes, the magnificent obelisk which the emperor Constantine caused to be removed to Alexandria

dria in the year 334; and that prince dying, his son Constantius had the obelisk transported from Alexandria to Rome in 352, where it was erected in the grand Circus. Its height was 132 feet. When the Goths sacked the city of Rome in 409, they overthrew this obelisk, which continued buried in the sand till the time of Sixtus V. in 1587, when it was found broken in three pieces; which being joined together, it was set up in the square of St John de Lateran. On the four sides of this wonderful obelisk are a number of figures and hieroglyphical characters, which, according to the explication of Ammianus Marcellinus, contain the praises of Rameses.

RAMIFICATION, the production of boughs or branches, or of figures resembling branches.

RAMILLIES, a small village of Brabant, in the Austrian Low Countries, 12 miles north of Namur, and 22 south-east of Brussels. Lat. 50. 51. Long. 4. 48. Famous for the battle fought by the allies commanded by the duke of Marlborough and M. d'Auverquirque, against that of the two crowns, commanded by the duke of Bavaria and Marshal Villeroy, the 22d of May 1706. See BRITAIN, N° 357.

The troops destined to compose the army of the allies being joined at the camp of Borchloon the 20th of May, halted the 21st. On the 22d the army marched from Borchloon in four columns, and posted itself the same day, with the right towards the mill of Quorem, extending with the left towards Blehen: from this camp was discovered the army of the two crowns, which was encamped with the left at Over-Espen, and the right towards the wood of Chapiaraux, Heylissem in their front, and Tirlemont in their rear. It was resolved the same day to march the next morning towards the plain of Meerdorp or Mierdau, to view the posture of the enemies, and determine what would be the most proper means of attacking them according to the movement they should make. To this end, an advanced guard of 600 horse and all the quarter-masters of the army were sent forward on the 23d at break of day.

The same morning about four, the army marched in eight columns toward the aforesaid plain. The advanced guard and the quarter-masters arrived about eight at the height of Meerdorp or Mierdau; from whence the army of the enemy was seen in motion: a little after it was perceived that the enemy was marching through the plain of Mount St Andrew in four columns, of which information was given to the duke of Marlborough and M. d'Auverquirque, who immediately repaired to the said height; and by the time these generals were arrived there, the head of the enemy's army already appeared at the tomb of Ottomont upon the causeway, near the Mehaigne: whereupon the duke of Marlborough and M. d'Auverquirque made the army advance with all expedition.

The enemy, as fast as they advanced, ranged in order of battle, with their right towards the tomb of Ottomont upon the Mehaigne, extending with their left to Autr'Eglise; having Tranquiers in front of the right, into which they had thrown several battalions of infantry and 14 squadrons of dragoons, who had dismounted their horses to support them. They had placed many of their infantry and a considerable part of their artillery in the village of Ramillies, which fronted the right of their main body, as well as into the village of Offuz,

which fronted the left of their infantry, and into the village of Autr'Eglise, quite on their left. The front between the village of Ramillies and Autr'Eglise was covered by a small stream of water, which rendered the meadows in some places marshes, and also by several roads covered with hedges; which difficulties prevented our cavalry of the right wing from coming to action. As fast as the army of the allies arrived it was ranged in order of battle; with the left towards Bonnef, and the right towards Folz, and every thing was disposed in order to attack. To this end, four battalions were detached to attack the village of Franquenies, and 12 battalions to attack the village of Ramillies, which were to be supported by the whole infantry.

Our artillery began to cannonade the enemy at one; at about two, the attack began with the post of Franquenies, where our infantry had the good fortune to drive the enemy from the hedges, where they were advantageously posted, and at the same time all the cavalry of our left wing advanced to attack that of our enemy's right; soon after all was in action. Whilst the cavalry were engaged, the village of Ramillies was likewise attacked, and forced after a vigorous resistance.

The battle lasted about two hours, and was pretty obstinate; but so soon as our cavalry had gained ground enough to attack the enemy in flank, they began to give way; at the same time all their infantry were put in disorder, so that the whole retreated, in great confusion. The cavalry of their left wing formed a little upon the high ground, between Offuz and Mount St Andrew, to favour their retreat; but after the infantry and cavalry of our right wing had filed off between the bottom of the village of Ramillies and Offuz, the whole army marched in several columns to attack the enemy anew; but they gave way before we could come up with them, and retired in great confusion, some towards the defile of the abbey De la Ramée and towards Dongelberge, others towards Judogne, and others again towards Hougarda. They were pursued all night so closely that they were obliged to abandon all their artillery and baggage, part of which was found at Judogne and at Hougarde, with their chests of ammunition.

The enemy lost above 30,000 men, 60 cannon, eight mortars, standards, colours, baggage, &c.; we about 3000. The rest of the campaign was spent in the sieges of Ostend, Menin, and Aeth. In fourteen days the duke defeated and dispersed the best appointed army the French ever had, and recovered all Spanish Brabant, the marquisate of the holy Roman empire. The army of the enemy consisted of 76 battalians and 142 squadrons, including the king's houshold troops (*La Maison du Roi*); and the army of the allies was 74 battalions and 123 squadrons. Considering the importance of the victory, the loss of the allies was very small, not above 1100 being killed, and 2600 wounded.

RAMISSERAM, a small island about 20 miles from that of Manaar, and the nearest channel of communication between Ceylon and the continent of India. When Mr Cordiner and his companions landed here in 1804, they entered the nearest *choultry*, or place erected for the accommodation of strangers, half a mile beyond which is the grand pagoda, or temple of Shivven, having nothing remarkable in its external appearance, when seen from a distance; but on a nearer inspection it is almost impossible to describe the ornaments and laboured

Ramisseram || Ramphastos.

workmanship that strike the eye. Yet these are far outdone by the magnificence of the interior parts of the pagoda. Upon this island there are great numbers of small horses, constantly employed in conveying travellers and in transporting goods.

After dinner a number of brahmins with five well dressed dancing girls waited upon Mr Cordiner and his companions at the choultry, who very agreeably amused and entertained them for upwards of an hour, and would have continued much longer, had they not been informed that they were at liberty to depart.

The men of this island are stout, and the females have something in their appearance very engaging; they are remarkably clean, and dress with great neatness. They are seen only by accident, for they keep out of the way of travellers with as much caution as possible. The ordinary dress of the brahmins consists only of a piece of muslin folded about the middle, and a string composed of nine threads is used as an ornament for the neck. They shave their heads quite bare, and in general wear them uncovered; but turbans and jackets are occasionally worn by some of them.

So abundant are black catttle on this small island, that it is no uncommon thing to see numbers of them lying in the streets, none of which are ever killed, the food of the inhabitants being entirely composed of milk and vegetable productions. The island being almost wholly covered with shrubs, is verdant and beautiful, yet no vestige of a corn field is to be met with, nor any other appearance of cultivation, if we except the large trees by which the roads are shaded, and a few groves of cocoa nut-trees. The nature of the soil in general is sandy, like that of Manaar, and the circumference of the whole island does not appear to exceed 20 miles. The houses on it are far superior to the ordinary dwellings of India; but the buildings sacred to divine worship, and the choultries for the accommodation of strangers, are truly magnificent, and must have been very expensive.

In a word when Ramisseram is contrasted with the indigent and barren island of Manaar, only 20 miles distant, it must be pronounced rich, fruitful, and luxuriant, exhibiting so much liberty and plenty as warm the heart, and kindle in the bosom of every beholder a lively flame of pleasure.

RAMLA, the modern name of Arimathea. See Arimathea.

RAMMER, an instrument used for driving down stones or piles into the ground; or for beating the earth, in order to render it more solid for a foundation.

RAMMER of a Gun, the *Gun-stick;* a rod used in charging of a gun, to drive home the powder, as also the shot, and the wad which keeps the shot from rolling out.

RAMPANT, in *Heraldry*, a term applied to a lion, leopard, or other beast that stands on its hind legs, and rears up his fore-feet in the posture of climbing, showing only half his face, as one eye, &c. It is different from saliant, in which the beast seems springing forward as if making a sally.

Rampart, in *Fortification*, is an elevation of the earth round a place capable of resisting the cannon of an enemy; and formed into bastions, curtins, &c.

RAMPHASTOS, the Toucan. See Rhamphastos, Ornithology *Index*.

RAMSAY, Allan, a Scottish poet, was born at Leadhills in Lanarkshire, in October 1686. His father was employed in the management of Lord Hopeton's mines at that place; but died while the poet was yet in his infancy, in consequence of which and the marriage of his mother soon after his father's death, it seems probable that during the earlier part of his life he continued in rather a destitute situation. He remained at Leadhills till he reached his fifteenth year, and as we have been assured by the relations of some very old persons who were the contemporaries of Ramsay, and who died not many years ago, he was employed in washing, preparing the lead ore for smelting, and other operations about the works in which the children of miners and young persons are usually occupied. The period of his residence on his native spot is fixed by himself in the following descriptive verses which are part of a petition addressed to a Club in Edinburgh to be admitted a member. Ramsay.

Of Crawford Moor, born in Leadhill,
Where mineral springs Glengoner fill,
Which joins sweet-flowing Clyde.

Native of Clydesdale's upper ward,
Bred fifteen summers there.

The extent of Ramsay's education, it may well be presumed, did not exceed what he could derive from the parish schoolmaster; and even the acquisition of what little could thus be obtained, from the circumstances that attended his early life, must have been often and greatly interrupted.

In 1701, when he was in his 15th year, he was bound apprentice to a wigmaker in Edinburgh, and it appears from the record of his children's birth in the parish register that he continued in the same humble profession till the year 1716: for in that register his designation is wigmaker. One of the earliest of Ramsay's productions now known, an address to the most happy members of the Easy Club, appeared in 1712, when he was 26 years of age, and three years after he was humorously appointed their poet laureat. Many of his poems about this time were published in the form of separate pamphlets. When he had followed the occupation of a wigmaker for a considerable time, he at last abandoned it for that of a bookseller, as being more congenial to the literary turn of his mind. His detached pamphlets were afterwards published by him in the year 1721, in one volume 4to, which was encouraged by a very liberal subscription. It was advertised as follows in the Edinburgh Evening Courant. "The Poems of Allan Ramsay, in a large quarto volume; fairly printed, with notes, and a complete glossary, (as promised to the subscribers) being now finished; all who have generously contributed to carrying on of the design, may call for their copies as soon as they please, from the author, at the Mercury, opposite to Niddry's wynd, Edinburgh." The first volume of his well known collection, "The Tea-table Miscellany," was published in 1724, after which a second volume soon made its appearance; a third in 1727, and a fourth after another interval of time. He soon after published what is called the Evergreen, being a collection of Scots poems written by the ingenious prior to the year 1600. In 1725 appeared his Gentle Shepherd, part of which, called Patie and Roger, was printed in 1721, and Jenny and Meggy in 1723, the great success of

Ramſay

of which induced him to form them afterwards into a regular drama.

In the year 1728, he publiſhed a ſecond volume of his poems, which was afterwards reprinted in 8vo. Theſe performances ſo rapidly enlarged the circle of his fame and reputation, that in 1731, an edition of his poetical works was publiſhed by the bookſellers of London, and two years after they appeared at Dublin. He held an extenſive correſpondence with cotemporary poets, among whom we find the facetious Hamilton of Gilbertfield, and the celebrated author of the Chace ſent him two epiſtles. From his ſhop oppoſite to Niddry ſtreet, he removed to one at the eaſt end of the Luckenbooths. In this ſhop he continued to ſell and lend out books till he was far advanced in years; and we are informed that he was the firſt perſon who eſtabliſhed a circulating library in Scotland. His collection of Fables appeared in 1730, after which period he may be ſaid to have almoſt diſcontinued the occupation of an author.

Such, however, was his enterpriſing ſpirit, that he built at his own expence, the firſt theatre for dramatical performances ever known in Edinburgh, which took place in what is called Carubber's cloſe, in the year 1736; but he did not long enjoy his character of manager, for the magiſtrates of Edinburgh required him to ſhut it up, as an act of parliament prohibited all ſuch amuſements without a ſpecial licence and his Majeſty's letters patent. It is generally underſtood that he relinquiſhed the trade of a bookſeller about the year 1755, being then 69 years of age, and lived the remainder of his days in a ſmall houſe erected by himſelf on the north ſide of the Caſtle-hill. A ſcorbutic complaint attended with excruciating pain, deprived him of his teeth, and after corroding one of his jaw bones, put a period to his exiſtence on the 7th of June 1758, in the 71ſt year of his age.

Ramſay poſſeſſed a conſiderable ſhare of poetical genius: Of this his Gentle Shepherd, which will continue to be admired as long as the language in which it is written ſhall be underſtood, and eſpecially by the natives of North Britain, to whom only the peculiarities of dialect by which it is diſtinguiſhed can be familiar, affords the beſt proof. Some of his ſongs may contain farfetched allusions and childiſh conceits; but many of them are equal, if not ſuperior for their paſtoral ſimplicity, to productions of a ſimilar nature in any other language. Some of the imitations of the ancients by this poet are extremely happy, in particular Horace's Ode *Vides ut alta ſtet nive* &c.; and ſome of his tales have all the excellencies of that ſpecies of compoſition. But of a great proportion of his other productions, it may be pronounced with truth that they are mere proſaic compoſitions filled with the moſt common place obſervations, and deſtitute even of the ornament of ſmooth verſification and correct rhimes.

Ramsay, *Andrew Michael*, generally known by the name of the *Chevalier Ramſay*, was a polite Scots writer, born of a good family at Ayr in 1686. His good parts and learning recommended him to be tutor to the ſon of the earl of Wemyſs; after which, conceiving a diſguſt at the religion in which he had been educated, he in the ſame ill humour reviewed other Chriſtian churches; and, finding none to his liking, reſted for a while in Deiſm. While he was in this uncertain ſtate of mind, he went to Leyden; where, falling into the company of one Poiret a myſtic divine, he received the infection of myſticiſm: which prompted him to conſult M. Fenelon, the celebrated archbiſhop of Cambray, who had imbibed principles of the ſame nature; and who gained him over to the Catholic religion in 1709. The ſubſequent courſe of his life received its direction from his friendſhip and connections with this prelate; and being appointed governor to the duke de Chateau Thierry, and the prince de Turenne, he was made a knight of the order of St Lazarus. He was ſent for to Rome by the chevalier de St George, to undertake the education of his children; but he found ſo many intrigues and diſſenſions on his arrival there in 1724, that he obtained the chevalier's leave to return to Paris. He died in 1743, in the office of intendant to the duke of Bouillon, prince de Turenne. The moſt capital work of his writing is the *Travels of Cyrus*, which has been ſeveral times printed in Engliſh.

Ramſay.

Ramsay, *The Reverend James*, ſo juſtly celebrated for his philanthropy, was born on the 25th of July 1733, at Fraſerſburgh, a ſmall town in the county of Aberdeen, North Britain. His deſcent was honourable, being, through his father, from the Ramſays of Melroſe in Banffshire, and through his mother, from the Ogilvies of Purie in Angus. His parents were of characters the moſt reſpectable, but in circumſtances by no means affluent. From his earlieſt years he diſcovered a ſerious diſpoſition, and a ſtrong thirſt for knowledge; and after paſſing through the courſe of a Scotch grammar ſchool education, he was inclined to purſue the ſtudies requiſite to fit him for the profeſſion of a clergyman; an inclination with which the wiſhes of his mother, a woman of eminent piety, powerfully concurred. Several circumſtances, however, conſpired to divert him for a time from his favourite purſuit.

He was educated in the epiſcopal perſuaſion; and having been unhappy enough to loſe his father while yet very young, he found, upon his advancing towards the ſtate of manhood, that the joint fortunes of himſelf and his mother could not bear the expence of a regular education in either of the univerſities of Oxford or Cambridge, which he doubtleſs thought abſolutely neceſſary to one who aſpired to reſpectability in the church of England. Yielding therefore to neceſſity, he reſolved to ſtudy ſurgery and pharmacy; and was with this view bound apprentice to Dr Findlay, a phyſician (A) in Fraſerſburgh. But though obliged to relinquiſh for a time his favourite ſtudies, he did not think ignorance excuſable in a ſurgeon more than in a clergyman, or conceive that he could ever become eminent in the profeſſion in which circumſtances had placed him, merely by ſkill in ſetting a bone or compounding a medicine. He determined therefore, with the full approbation of his maſter, who

(A) In the remote towns of Scotland the ſame man generally acts in the triple capacity of phyſician, ſurgeon, and apothecary.

Ramſay. who very ſoon diſcovered his talents for literature, to make himſelf acquainted with at leaſt the outlines of the liberal arts and ſciences; and with this view he repaired in 1750 to the King's College and univerſity of Aberdeen, where he obtained one of the *burſaries* or *exhibitions* which are there annually beſtowed upon ſuch candidates for them as diſplay the moſt accurate knowledge of the Latin language. The ſmall ſum of five pounds, however (which none of theſe burſaries exceed), was ſtill inadequate to the expence of reſidence in college; but our young ſtudent was ſoon to obtain a more valuable exhibition, and to obtain it likewiſe by his own merit.

During the long vacation he returned to his maſter Dr Findlay, and was by him intruſted with a very deſperate caſe in ſurgery, of which his management may be ſaid to have laid the foundation of his future fortunes. A female ſervant of one of the judges of the Court of Seſſion, who, when the court was not ſitting, reſided in the neighbourhood of Fraſerſburgh, had been ſo dreadfully gored by a bull, that hardly any hopes were entertained of her recovery; but Mr Ramſay, to whoſe care ſhe was entirely left, treated the wound with ſuch ſkilful attention, that, contrary to general expectation, his patient recovered. This attracted the judge's notice, who having informed himſelf of the young man's circumſtances and character, recommended him ſo effectually to Sir Alexander Ramſay of Balmain, that he preſented him with a burſary of 15 pounds a-year, which commenced at the next *ſeſſion* or *term*, in the ſame college.

He now proſecuted his ſtudies with comfort; and though he was detained in college a year longer than is uſual, being obliged, upon his acceptance of a ſecond burſary, to begin his courſe anew, he always conſidered this as a fortunate circumſtance, becauſe it gave him the celebrated Dr Reid three years for his preceptor. To that great and amiable philoſopher he ſo recommended himſelf by his talents, his induſtry, and his virtues, that he was honoured with his friendſhip to the day of his death. Nor was it only to his maſters that his conduct recommended him; Sir Alexander Ramſay whom he viſited during ſome of the vacations, was ſo well pleaſed with his converſation, that he promiſed him another burſary, in his gift, of 25l. a-year, to commence immediately on the expiration of that which he enjoyed. This promiſe he performed in the beginning of the year 1755; and at the ſolicitation of Dr Findlay, even paid the money per advance to enable the exhibitioner to travel for the purpoſe of improving himſelf in his profeſſion.

Thus provided, Mr Ramſay went to London, and ſtudied ſurgery and pharmacy under the auſpices of Dr Macaulay; in whoſe family he lived for two years, careſſed and eſteemed both by him and by his lady. Afterwards, having paſſed the uſual examination at Surgeons-hall, he ſerved in his medical capacity for ſeveral years in the royal navy; but how long he was continued in the ſtation of a mate, or when and by whom he was firſt appointed ſurgeon, we have not been able to learn. We can ſay, however, upon the beſt authority, that by his humane and diligent diſcharge of his duty in either ſtation, he endeared himſelf to the ſeamen, and acquired the eſteem of his officers.

Of his humanity there is indeed one memorable inſtance, which muſt not be omitted. Whilſt he acted as ſurgeon of the Arundel, then commanded by Captain (now Vice-admiral Sir Charles) Middleton, a ſlave-ſhip on her paſſage from Africa to the Weſt Indies fell in with the fleet to which the Arundel belonged. An epidemical diſtemper, too common in ſuch veſſels, had ſwept away not only a great number of the unfortunate negroes, but alſo many of the ſhip's crew, and among others the ſurgeon. In this diſtreſſed ſituation the commander of the Guinea ſhip applied to the Engliſh commodore for medical aſſiſtance; but not a ſurgeon or ſurgeon's mate in the whole fleet, except Mr Ramſay, would expoſe himſelf to the contagion of ſo dangerous a diſtemper. Prompted, however, by his own innate benevolence, and fully authorized by his no leſs benevolent commander, the ſurgeon of the Arundel, regardleſs of perſonal danger, and truſting in that God to whom mercy is more acceptable than ſacrifice, went on board the infected ſhip, viſited all the patients, and remained long enough to leave behind him written directions for their future treatment. If a cup of cold water given in charity be entitled to a reward, how much more ſuch an action as this? But the rewards of Chriſtianity are not immediate. Mr Ramſay indeed eſcaped the contagion; but on his return to his own ſhip, juſt as he had got on the deck, he fell and broke his thigh-bone; by which he was confined to his apartment for ten months, and rendered in a ſmall degree lame through the remainder of his life.

The fearleſs humanity which he diſplayed on this occaſion gained him the friendſhip and eſteem of Sir Charles Middleton, which no future action of his life had the ſmalleſt tendency to impair; but the fracture of his thigh-bone and his ſubſequent lameneſs determined him to quit the navy, and once more turn his thoughts towards the church. Accordingly, while the Arundel lay at St Chriſtopher's, he opened his views to ſome of the principal inhabitants of that iſland, by whom he was ſo ſtrongly recommended to the biſhop of London, that on his coming home with Sir Charles Middleton, who warmly joined in the recommendation, he was admitted into orders; after which he immediately returned to St Chriſtopher's, where he was preſented by the governor to two rectories, valued at 700l. a-year.

As ſoon as he took poſſeſſion of his livings, in 1763, he married Miſs Rebecca Akers, the daughter of a planter of the beſt family-connections in the iſland, and began to regulate his houſehold on the pious plan inculcated in his *Eſſay on the Treatment and Converſion of the African Slaves in the Britiſh Sugar Colonies*. He ſummoned all his own ſlaves daily to the prayers of the family, when he took an opportunity of pointing out to them their duty in the plaineſt terms, reproving thoſe that had done amiſs, and commending ſuch as had ſhown any thing like virtue; but he confeſſed that his occaſions for reproof were more frequent than for commendation. As became his office and character, he inculcated upon others what he practiſed himſelf, and knew to be equally the duty of all. " On his firſt ſettlement as a miniſter in the Weſt Indies, he made ſome public attempts to inſtruct ſlaves. He began to draw up ſome eaſy plain diſcourſes for their inſtruction. He invited them to attend on Sundays, at particular hours. He appointed hours at home to inſtruct ſuch ſenſible ſlaves as

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as would of themſelves attend. He repeatedly exhorted their maſters to encourage ſuch in their attendance. He recommended the French cuſtom, of beginning and ending work by prayer. But inconceivable is the liſtleſſneſs with which he was heard, and bitter was the cenſure heaped on him in return. It was quickly ſuggeſted, and generally believed, that he wanted to interrupt the work of ſlaves, to give them time, forſooth, to ſay their prayers; that he aimed at the making of them Chriſtians, to render them incapable of being good ſlaves. In one word, he ſtood, in opinion, a rebel convict againſt the intereſt and majeſty of planterſhip. And as the Jews ſay, that in every puniſhment, with which they have been proved, ſince the bondage of Egypt, there has been an ounce of the golden calf of Horeb; ſo might he ſay, that in every inſtance of prejudice (and they were not a few) with which, till within a year or two of his departure from the country, he was exerciſed, there was an ounce of his fruitleſs attempts to improve the minds of ſlaves. In the bidding prayer, he had inſerted a petition for the converſion of thoſe perſons. But it was deemed ſo diſagreeable a momento, that ſeveral white people, on account of it, left off attending divine ſervice. He was obliged to omit the prayer entirely, to try and bring them back. In ſhort, neither were the ſlaves, at that time, deſirous of being taught, nor were their maſters inclined to encourage them."

That he was hurt by this neglect cannot be queſtioned, for he had a mind benevolent, warm, and irritable; but he ſtill retained many friends amongſt the moſt worthy members of the community; and as he was conſcious of having done nothing more than his duty, he conſoled himſelf with reflecting, that thoſe are "bleſſed whom men revile, and perſecute, and ſpeak all manner of evil againſt falſely, for the ſake of the goſpel."

Although his ſerious ſtudies were now theological, he conſidered himſelf as anſwerable to God, his country, and his own family, for a proper uſe of every branch of knowledge which he poſſeſſed. He therefore took the charge of ſeveral plantations around him in the capacity of a medical practitioner; and attended them with unremitting diligence, and with great ſucceſs. Thus he lived till the year 1777, when relinquiſhing the practice of phyſic entirely, he paid a viſit to the place of his nativity, which he had not ſeen ſince 1755. His mother, whoſe latter days he had made comfortable by a handſome annuity, had been dead for ſome years; but he rewarded all who had been attentive to her, or in early life ſerviceable to himſelf; and he continued the penſion to a ſiſter who had a numerous family, for which her huſband was unable to provide.

After remaining three weeks in Scotland, and near a year in England, during which time he was admitted into the confidence of Lord George Germaine, ſecretary of ſtate for the American department, Mr Ramſay was appointed chaplain to Admiral Barrington, then going out to take a command in the Weſt Indies. Under this gallant officer, and afterwards under Lord Rodney, he was preſent at ſeveral engagements, where he diſplayed a fortitude and zeal for the honour of his country which would not have diſgraced the oldeſt admiral. To the navy, indeed, he ſeems to have been ſtrongly attached; and he wrote, at an early period of his life, an *Eſſay on the Duty and Qualifications of a Sea-officer*, with ſuch a knowledge of the ſervice as would have done honour to the pen of the moſt experienced commander. Of the firſt edition of this eſſay the profits were by its benevolent author appropriated to the Magdalen and Britiſh lying-in hoſpitals, as thoſe of the ſecond and third (which laſt was publiſhed about the period of which we now write) were to the maritime ſchool, or, in the event of its failure, to the marine ſociety.

Although careſſed by both the admirals under whom he ſerved, and having ſuch influence with the latter as to be able to render eſſential ſervices to the Jews and other perſons whom he thought harſhly treated at the capture of St Euſtatius, Mr Ramſay once more quitted the ſea-ſervice, and retired to his paſtoral charge in the iſland of St Chriſtopher's. There, however, though the former animoſities againſt him had entirely ſubſided, and though his friendſhip was now ſolicited by every perſon of conſequence in the iſland, he remained but a little while. Sick of the life of a planter and of the proſpect of ſlavery around him, he reſigned his livings, bade adieu to the iſland, and returned to England with his wife and family in the end of the year 1781. Immediately on his arrival, he was, through the intereſt of his ſteady friend Sir Charles Middleton, preſented to the livings of Teſton and Nettleſtead in the county of Kent.

Here he was ſoon determined, by the advice of thoſe whom he moſt reſpected, to publiſh an *Eſſay*, which had been written many years before, *on the Treatment and Converſion of African Slaves in the Britiſh Sugar Colonies*. The controverſy in which this publication involved him, and the acrimony with which it was carried on, are ſo freſh in the memory of all our readers, that no man who thinks of the narrow limits within which our biographical articles muſt be confined, will blame us for not entering into a detail of the particulars.— Torrents of obloquy were poured upon the benevolent author by writers who were unfair enough to conceal their names; and it muſt be confeſſed, that his replies abounded with ſarcaſms, which the moſt rational friends to the cauſe which he ſupported would not have been ſorry to ſee blotted from his pages. The provocation, however, which he received was great; and Mr Ramſay, though an amiable, virtuous, and pious man, had a warmth of temper, which, though not deſerving of praiſe, will be cenſured by none who reflect on the frailties of our common nature. That the particular calumnies propagated againſt him on this occaſion were wholly groundleſs, it is impoſſible to doubt, if we admit him to have been poſſeſſed of common underſtanding. When ſome years ago a ſtory was circulated, of Swift's having, when prebendary of Kilroot, been convicted before a magiſtrate of an attempt to commit a rape on the body of one of his pariſhioners, it was thought a ſufficient confutation of the calumny to put the retailer of it in mind, that the dean of St Patrick's, though deteſted by the moſt powerful faction in the kingdom, lampooned without dread, and with great ſeverity, the dean of Ferns for the very crime, of which, had this anecdote been true, he muſt have been conſcious that all Ireland knew himſelf to be guilty! Such conduct cannot be reconciled to common ſenſe. Had Swift been a raviſher, though he might have been penitent, and reaſoned in general terms againſt giving way to ſuch licentious paſſions, he would never have ſatiriſed a

Ramsay, Ramsden's Machine.

a *particular person* for the crime of which he himself stood convicted. In like manner, had Mr Ramsay been a tyrant to his own slaves, though he might have argued against slavery in the abstract, on the broad basis of virtue and religion, he never could have arraigned for similar cruelty a number of individuals in the very island which witnessed his own enormities.

But the melancholy part of the narrative is behind. The agitation given to his mind by these calumnies, and the fatigues he underwent in his endeavours to rescue from misery the most helpless portion of the human race, contributed to shorten a life in no common degree useful. He had been for some time afflicted with a pain in his stomach, for which he was prevailed upon, though with great reluctance, to try the effects of air and exercise, by attempting a journey of 100 miles. But in London, being seized with a violent vomiting of blood, he was unable either to proceed or to be removed home; and in the house of Sir Charles Middleton he ended his days, on the 20th of July 1789, amidst the groans of his family, and the tears of many friends.—Thus died a man, of whom it is not too much to say, that "the blessing of many that were ready to perish came upon him;" for whatever be the fate of the slave-trade (see SLAVERY), it is certain that his writings have contributed much to meliorate the treatment of slaves. He left behind him a widow and three daughters: and his works, besides those to which we have alluded, consist of a volume of *Sea-sermons*, preached on board his majesty's ship the Prince of Wales, which show him to have been a master of true pulpit-eloquence; and a *Treatise on Signals*, which was certainly written, and we think printed, though we know not whether it was ever published.

RAMSDEN's MACHINE *for Dividing* MATHEMATICAL INSTRUMENTS, is an invention by which these divisions can be performed with exceeding great accuracy, such as would formerly have been deemed incredible. On discovering the method of constructing this machine, its inventor, Mr Ramsden of Piccadilly, received 615l. from the commissioners of longitude; engaging himself to instruct a certain number of persons, not exceeding ten, in the method of making and using this machine from the 28th October 1775 to 28th October 1777: also binding himself to divide all octants and sexants by the same engine, at the rate of three shillings for each octant, and six shillings for each brass sextant, with Nonius's divisions to half minutes, for as long time as the commissioners should think proper to let the engine remain in his possession. Of this sum of 615l. paid to Mr Ramsden, 300l. was given him as a reward for the improvement made by him in discovering the engine, and the remaining 315l. for his giving up the property of it to the commissioners. The following description of the engine, is that given upon oath by Mr Ramsden himself.

"This engine consists of a large wheel of bell-metal, supported on a mahogany stand, having three legs which are strongly connected together by braces, so as to make it perfectly steady. On each leg of the stand is placed a conical friction pulley, whereon the dividing-wheel rests: to prevent the wheel from sliding off the friction-pulleys, the bell-metal centre under it turns in a socket on the top of the stand.

"The circumference of the wheel is ratched or cut (by a method which will be described hereafter) into 2160 teeth, in which an endless screw acts. Six revolutions of the screw will move the wheel a space equal to one degree.

Ramsden's Machine.

Now a circle of brass being fixed on the screw arbor, having its circumference divided into 60 parts, each division will consequently answer to a motion of the wheel of 10 seconds, six of them will be equal to a minute, &c.

"Several different arbors of tempered steel are truly ground into the socket in the centre of the wheel. The upper parts of the arbors that stand above the plane are turned of various sizes, to suit the centres of different pieces of work to be divided.

"When any instrument is to be divided, the centre of it is very exactly fitted on one of these arbors; and the instrument is fixed down to the plane of the dividing wheel, by means of screws, which fit into holes made in the radii of the wheel for that purpose.

"The instrument being thus fitted on the plane of the wheel, the frame which carries the dividing-point is connected at one end by finger-screws with the frame which carries the endless screw; while the other end embraces that part of the steel arbor, which stands above the instrument to be divided, by an angular notch in a piece of hardened steel; by this means both ends of the frame are kept perfectly steady and free from any shake.

"The frame carrying the dividing-point, or tracer, is made to slide on the frame which carries the endless screw to any distance from the centre of the wheel, as the radius of the instrument to be divided may require, and may be there fastened by tightening two clamps; and the dividing-point or tracer being connected with the clamps by the double-jointed frame, admits a free and easy motion towards or from the centre for cutting the divisions, without any lateral shake.

"From what has been said, it appears, that an instrument thus fitted on the dividing-wheel may be moved to any angle by the screw and divided circle on its arbor, and that this angle may be marked on the limb of the instrument with the greatest exactness by the dividing-point or tracer, which can only move in a direct line tending to the centre, and is altogether freed from those inconveniences that attend cutting by means of a straight edge. This method of drawing lines will also prevent any error that might arise from an expansion or contraction of the metal during the time of dividing.

"The screw-frame is fixed on the top of a conical pillar, which turns freely round its axis, and also moves freely towards or from the centre of the wheel, so that the screw-frame may be entirely guided by the frame which connects it with the centre: by this means any excentricity of the wheel and arbor would not produce any error in the dividing; and, by a particular contrivance (which will be described hereafter), the screw when pressed against the teeth of the wheel always moves parallel to itself; so that a line joining the centre of the arbor and the tracer continued, will always make equal angles with the screw. Plate CCCCLIX.

"Figure 1. represents a perspective view of the engine. Plate CCCCLX.

"Fig. 2. is a plan, of which fig. 3. represents a section on the line ΠΑ. Fig. 2.

"The large wheel A is 45 inches in diameter, and has

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has ten radii, each being ſupported by edge-bars, as repreſented in fig. 3. Theſe bars and radii are connected by the circular ring B, 24 inches in diameter and three deep; and, for greater ſtrength, the whole is caſt in one piece in bell-metal.

"As the whole weight of the wheel A reſts on its ring B, the edge-bars are deepeſt where they join it; and from thence their depth diminiſhes, both towards the centre and the circumference, as repreſented in fig. 3.

"The ſurface of the wheel A was worked very even and flat, and its circumference turned true. The ring C, of fine braſs, was fitted very exactly on the circumference of the wheel; and was faſtened thereon with ſcrews, which, after being ſcrewed as tight as poſſible, were well rivetted. The face of a large chuck being turned very true and flat in the lathe, the flattened ſurface A of the wheel was faſtened againſt it with holdfaſts; and the two ſurfaces and circumference of the ring C, a hole through the centre and the plane part round (*b*) it, and the lower edge of the ring B, were turned at the ſame time. (Fig. 3.)

"D is a piece of hard bell-metal, having the hole, which receives the ſteel-arbor *d*, made very ſtraight and true. This bell-metal was turned very true on an arbor; and the face, which reſts on the wheel at *b*, was turned very flat, ſo that the ſteel arbor *d* might ſtand perpendicular to the plane of the wheel: this bell-metal was faſtened to the wheel by ſix ſteel ſcrews *l*.

"A braſs ſocket Z is faſtened on the centre of the mahogany ſtand, and receives the lower part of the bell-metal piece D, being made to touch the bell-metal in a narrow part near the mouth, to prevent any obliquity of the wheel from bending the arbor: good fitting is by no means neceſſary here; ſince any ſhake in this ſocket will produce no bad effect, as will appear hereafter when we deſcribe the cutting frame.

Fig. 1, 2, and 3. "The wheel was then put on its ſtand, the lower edge of the ring B reſting on the circumference of three conical friction-pulleys W, to facilitate its motion round its centre. The axis of one of theſe pulleys is in a line joining the centre of the wheel and the middle of the endleſs ſcrew, and the other two placed ſo as to be at equal diſtances from each other.

Fig. 1. "F is a block of wood ſtrongly faſtened to one of the legs of the ſtand; the piece *g* is ſcrewed to the upper ſide of the block, and has half holes, in which the tranſverſe axis *h* turns: the half holes are kept together by the ſcrews *i*. (Fig. 4.)

Fig. 1. & 4. "The lower extremity of the conical pillar P terminates in a cylindrical ſteel-pin *k*, which paſſes through and turns in the tranſverſe axis *h*, and is confined by a cheek and ſcrew. (Fig. 4.)

"To the upper end of the conical pillar is faſtened the frame G, in which the endleſs ſcrew turns: the pivots of the ſcrew are formed in the manner of two fruſtums of cones joined by a cylinder, as repreſented at X. Theſe pivots are confined between half poles, which preſs only on the conical parts, and do not touch the cylindric parts: the half holes are kept together by ſcrews *a*, which may be tightened at any time, to prevent the ſcrew from ſhaking in the frame. (Fig. 4. Fig. 5.)

Fig. 1, 2, 4, 5. "On the ſcrew-arbor is a ſmall wheel of braſs K, having its outſide edge divided into 60 parts, and numbered at every 6th diviſion with 1, 2, &c. to 10. The motion of this wheel is ſhown by the index *y* on the ſcrew-frame G. (Fig. 4. & 5.)

Fig. 1. "H repreſents a part of the ſtand, having a parallel ſlit in the direction towards the centre of the wheel, large enough to receive the upper part of the conical braſs pillar P, which carries the ſcrew and its frame: and as the reſiſtance, when the wheel is moved by the endleſs ſcrew, is againſt that ſide of the ſlit H which is towards the left hand, that ſide of the ſlit is faced with braſs, and the pillar is preſſed againſt it by a ſteel ſpring on the oppoſite ſide: by this means the pillar is ſtrongly ſupported laterally, and yet the ſcrew may be eaſily preſſed from or againſt the circumference of the wheel, and the pillar will turn freely on its axis to take any direction given it by the frame L.

Fig. 4. "At each corner of the piece I are ſcrews *n* of tempered ſteel, having poliſhed conical points: two of them turn in conical holes in the ſcrew-frame near *o*, and the points of the other two ſcrews turn in holes in the piece Q; the ſcrews *p* are of ſteel, which being tightened, prevent the conical pointed ſcrews from unturning when the frame is moved.

Fig. 1, 2, 6. "L is a braſs frame, which ſerves to connect the endleſs ſcrew, its frame, &c. with the centre of the wheel: each arm of this frame is terminated by a ſteel ſcrew, that may be paſſed through any of the holes *q* in the piece Q, as the thickneſs of work to be divided on the wheel may require, and are faſtened by the finger-nuts *r*. (Fig. 4. Fig. 1. & 2.)

Fig. 6. "At the other end of this frame is a flat piece of tempered ſteel *b*, wherein is an angular notch: when the endleſs ſcrew is preſſed againſt the teeth on the circumference of the wheel, which may be done by turning the finger-ſcrew S, to preſs againſt the ſpring *t*, this notch embraces and preſſes againſt the ſteel arbor *d*. This end of the frame may be raiſed or depreſſed by moving the priſmatic ſlide *u*, which may be fixed at any height by the four ſteel-ſcrews *v*. (Fig. 1. & 2. Fig. 2. Fig. 1, 2, 6.)

Fig. 1. & 6. "The bottom of this ſlide has a notch *k*, whoſe plane is parallel to the endleſs-ſcrew; and by the point of the arbor *d* reſting in this notch, this end of the frame is prevented from tilting. The ſcrew S is prevented from unturning, by tightening the finger-nut *w*. (Fig. 3. Fig. 1, 2.)

"The teeth on the circumference of the wheel were cut by the following method:

"Having conſidered what number of teeth on the circumference would be moſt convenient, which in this engine is 2160, or 360 multiplied by 6, I made two ſcrews of the ſame dimenſions, of tempered ſteel, in the manner hereafter deſcribed, the interval between the threads being ſuch as I knew by calculation would come within the limits of what might be turned off the circumference of the wheel: one of the ſcrews, which was intended for ratching or cutting the teeth, was notched acroſs the threads, ſo that the ſcrew, when preſſed againſt the edge of the wheel and turned round, cut in the manner of a ſaw. Then having a ſegment of a circle a little greater than 60 degrees, of about the ſame radius with the wheel, and the circumference made true, from a very fine centre, I deſcribed an arch near the edge, and ſet off the chord of 60 degrees on this arch. This ſegment was put in the place of the wheel, the edge of it was ratched, and the number of revolutions

Ramſden's Machine. revolutions and parts of the ſcrew contained between the interval of the 60 degrees were counted. The radius was corrected in the proportion of 360 revolutions, which ought to have been in 60 degrees, to the number actually found; and the radius, ſo corrected, was taken in a pair of beam-compaſſes: while the wheel was on the lathe, one foot of the compaſſes was put in the centre, and with the other a circle was deſcribed on the ring; then half the depth of the threads of the ſcrew being taken in dividers, was ſet from this circle outwards, and another circle was deſcribed cutting this point; a hollow was then turned on the edge of the wheel of the ſame curvature as that of the ſcrew at the bottom of the threads: the bottom of this hollow was turned to the ſame radius or diſtance from the centre of the wheel, as the outward of the two circles before-mentioned.

Fig. 3. "The wheel was now taken off the lathe; and the bell-metal piece D was ſcrewed on as before directed, which after this ought not to be removed.

Fig. 1, 2, 3. "From a very exact centre a circle was deſcribed on the ring C, about four-tenths of an inch within where the bottom of the teeth would come. This circle was divided with the greateſt exactneſs I was capable of, firſt into five parts, and each of theſe into three. Theſe parts were then biſected four times: (that is to ſay) ſuppoſing the whole circumference of the wheel to contain 2160 teeth, this being divided into five parts, each would contain 432 teeth; which being divided into three parts, each of them would contain 144; and this ſpace biſected four times would give 72, 36, 18, and 9: therefore each of the laſt diviſions would contain nine teeth. But, as I was apprehenſive ſome error might ariſe from quinqueſection and triſection; in order to examine the accuracy of the diviſions, I deſcribed another circle on

Fig. 7. the ring C, one-tenth of an inch within the former, and divided it by continual biſections, as 2160, 1080, 540, 270, 135, $67\frac{1}{2}$, and $33\frac{3}{4}$; and as the fixed wire (to be deſcribed preſently) croſſed both the circles, I could examine their agreement at every 135 revolutions; (after ratching, could examine it at every $33\frac{3}{4}$): but, not finding any ſenſible difference between the two ſets of diviſions, I, for ratching, made choice of the former; and, as the coincidence of the fixed wire with an interſection could be more exactly determined than with a dot or diviſion, I therefore made uſe of interſection in both circles before deſcribed.

Fig. 7. "The arms of the frame L were connected by a thin piece of braſs of three-fourths of an inch broad, having a hole in the middle of four-tenths of an inch in diameter; acroſs this hole a ſilver wire was fixed exactly in a line to the centre of the wheel; the coincidence of this wire with the interſections was examined by a lens ſeven-tenths of an inch focus, fixed in a tube which was attached to one of the arms L (A). Now a handle or winch being fixed on the end of the ſcrew, the diviſion marked on the end of the ſcrew, the diviſion marked 10 on the circle K was ſet to its index, and, by means of a clamp and adjuſting ſcrew for that purpoſe, the interſection marked 1 on the circle C was ſet exactly to coincide with the fixed wire; the ſcrew was then carefully preſſed againſt the circumference of the wheel, by turning the finger-ſcrew S; then, removing the clamp, I turned the ſcrew by its handle nine revolutions, till the interſection marked 240 came nearly to the wire; then, unturning the finger-ſcrew S, I releaſed the ſcrew from the wheel, and turned the wheel back till the interſection marked 2 exactly coincided with the wire, and, by means of the clamp before-mentioned, the diviſion 10 on the circle being ſet to its index, the ſcrew was preſſed againſt the edge of the wheel by the finger-ſcrew S; the clamps were removed, and the ſcrew turned nine revolutions till the interſection marked 1 nearly coincided with the fixed wire; the ſcrew was releaſed from the wheel by unturning the finger-ſcrew S as before, the wheel was turned back till the interſection 3 coincided with the fixed wire; the diviſion 10 on the circle being ſet to its index, the ſcrew was preſſed againſt the wheel as before, and the ſcrew was turned nine revolutions, till the interſection 2 nearly coincided with the fixed wire, and the ſcrew was releaſed; and I proceeded in this manner till the teeth were marked round the whole circumference of the wheel. This was repeated three times round, to make the impreſſion of the ſcrew deeper. I then ratched the wheel round continually in the ſame direction without ever diſengaging the ſcrew; and, in ratching the wheel about 300 times round, the teeth were finiſhed.

"Now it is evident, if the circumference of the wheel was even one tooth or ten minutes greater than the ſcrew would require, this error would in the firſt inſtance be reduced to $\frac{1}{240}$ part of a revolution, or two ſeconds and a half; and theſe errors or inequalities of the teeth were equally diſtributed round the wheel at the diſtance of nine teeth from each other. Now, as the ſcrew in ratching had continually hold of ſeveral teeth at the ſame time, and, theſe conſtantly changing, the above-mentioned inequalities ſoon corrected themſelves, and the teeth were reduced to a perfect equality. The piece of braſs which carries the wire was now taken away, and the cutting ſcrew was alſo removed, and a plain one (hereafter deſcribed) put in its place: on one end of the ſcrew is a ſmall braſs circle, having its edge divided into 60 equal parts, and numbered at every ſixth diviſion, as before-mentioned. On the other end of the ſcrew is a ratchet-wheel C, having 60 teeth, covered by the hollowed circle *d*, which carries two clicks that catch upon the oppoſite ſides of the ratchet when the ſcrew is to be moved forwards. The cylinder S turns on a ſtrong ſteel arbor F, which paſſes through and is firmly ſcrewed to the piece Y: this piece, for greater firmneſs, is attached to the ſcrew-frame G by the braces *v*; a ſpiral groove or thread is cut on the outſide of the cylinder S, which ſerves both for holding the ſtring, and alſo giving motion to the lever J on its centre by means of a ſteel tooth *n*, that works between the threads of the ſpiral. To the lever is attached a ſtrong ſteel pin *m*, on which a braſs ſocket *r* turns: this ſocket paſſes through a ſlit in Fig. 5. Fig. 4.

(A) The interſections are marked for the ſake of illuſtration, though properly inviſible, becauſe they lie under the braſs plate.

Ramsden's Machine.

in the piece p, and may be tightened in any part of the slit by the finger-nut f: this piece serves to regulate the number of revolutions of the screw for each tread of the treadle R.

Fig. 1. "T is a brass box containing a spiral string; a strong gut is fastened and turned three or forr times round the circumference of this box, the gut then passes several times round the cylinder S, and from thence down to the treadle R. Now, when the treadle is pressed down, the string pulls the cylinder S round its axis, and the clicks catching hold of the teeth on the ratchet carry the screw round with it, till, by the tooth n working in

Fig. 4. the spiral groove, the lever J is brought near the wheel d, and the cylinder stopped by the screw-head x striking on the top of the lever J; at the same time the spring is wound up by the other end of the gut passing round the box T. Now, when the foot is taken off the treadle, the spring unbending itself pulls back the cylinder, the

Fig. 1. clicks leaving the ratchet and screw at rest till the piece t strikes on the end of the piece p: the number of revolutions of the screw at each tread is limited by the number of revolutions the cylinder is allowed to turn back before the stop strikes on the piece p.

"When the endless screw was moved round its axis with a considerable velocity, it would continue that mo-

Fig. 1. & 4. tion a little after the cylinder S was stopped: to prevent this, the angular lever η was made; that when the lever J comes near to stop the screw x, it, by a small chamfer, presses down the piece $\varkappa$ of the angular lever; this brings the other end η of the same lever forwards, and stops the endless screw by the steel pin μ striking upon the top of it; the foot of the lever is raised again by a small spring pressing on the brace v.

Fig. 1, 2, 6. "D, two clamps, connected by the piece α, slide one on each arm of the frame L, and may be fixed at pleasure by the four finger-screws s, which press against steel springs to avoid spoiling the arms: the piece q is made to turn without shake between two conical pointed screws f, which are prevented from unturning by tightening the finger-nuts N.

Fig. 6. "The piece M is made to turn on the piece q by the conical pointed screws f resting in the hollow centers e.

"As there is frequent occasion to cut divisions on inclined planes, for that purpose the piece γ, in which the tracer is fixed, has a conical axis at each end, which turns in half holes: when the tracer is set to any inclination, it may be fixed there by tightening the steel screws β.

Description of the Engine by which the endless screw of the Dividing Engine was cut.

"Fig. 9. represents this engine of its full dimensions seen from one side.

"Fig. 8. the upper side of the same as seen from above.

"A represents a triangular bar of steel, to which the triangular holes in the pieces B and C are accurately fitted, and may be fixed on any part of the bar by the screws D.

"E is a piece of steel whereon the screw is intended to be cut; which, after being hardened and tempered, has its pivots turned in the form of two frustums of cones, as represented in the drawings of the dividing engine (fig. 5.). These pivots were exactly fitted to the half holes F, and T, which were kept together by the screw Z.

Ramsden's Machine, Ramsey.

"H represents a screw of untempered steel, having a pivot I, which turns in the hole K. At the other end of the screw is a hollow centre, which receives the hardened conical point of the steel pin M. When this point is sufficiently pressed against the screw, to prevent its shaking, the steel pin may be fixed by tightening the screws Y.

"N is a cylindric nut, moveable on the screw H; which, to prevent any shake, may be tightened by the screws O. This nut is connected with the saddle-piece P by means of the intermediate universal joint W, through which the arbor of the screw H passes. A front view of this piece, with the section across the screw arbor, is represented at X. This joint is connected with the nut by means of two steel slips S, which turn on pins between the cheeks T on the nut N. The other ends of these slips S turn in like manner on pins a. One axis of this joint turns in a hole in the cock b, which is fixed to the saddle-piece; and the other turns in a hole d, made for that purpose in the same piece on which the cock b is fixed. By this means, when the screw is turned round, the saddle-piece will slide uniformly along the triangular bar A.

"K is a small triangular bar of well-tempered steel, which slides in a groove of the same form on the saddle-piece P. The point of this bar or cutter is formed to the shape of the thread intended to be cut on the endless screw. When the cutter is set to take proper hold of the intended screw, it may be fixed by tightening the screw e, which presses the two pieces of brass G upon it.

"Having measured the circumference of the dividing-wheel, I found it would require a screw about one thread in a hundred coarser than the guide-screw H. The wheels on the guide-screw arbor H, and that on the steel E, on which the screw was to be cut, were proportioned to each other to produce that effect, by giving the wheel L 198 teeth, and the wheel Q 200. These wheels communicated with each other by means of the intermediate wheel R, which also served to give the threads on the two screws the same direction.

"The saddle-piece P is confined on the bar A by means of the pieces g, and may be made to slide with a proper degree of tightness by the screws n."

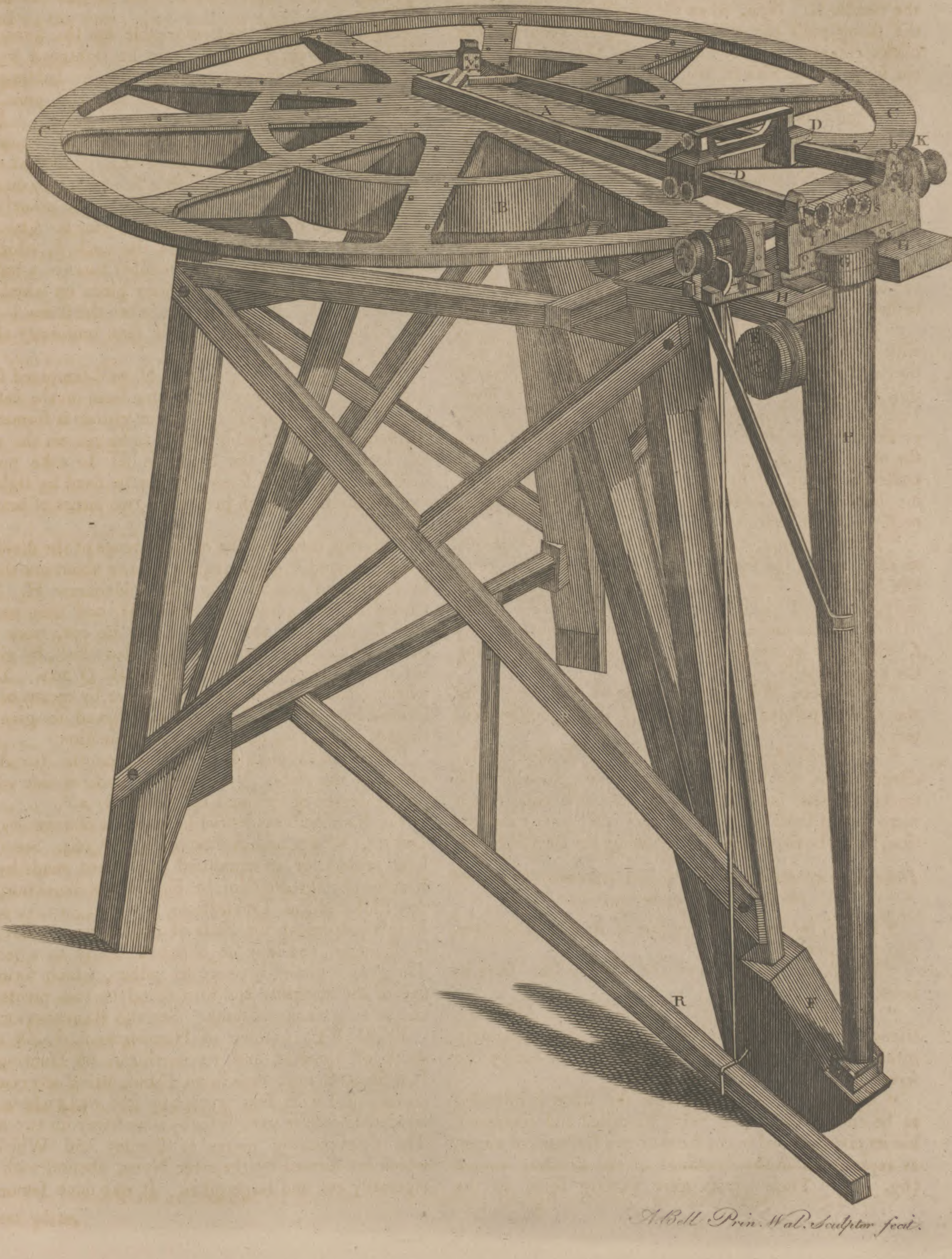
For Ramsden's equatorial or portable observatory, see Optics, N° 89. and Astronomy, N° 364. See also a long account of an equatorial instrument made by Mr Ramsden by the direction of Sir George Shuckburgh in the Philosophical Transactions for 1793, art. x. p. 67. In this instrument the circle of declinations is four feet in diameter, and may be observed nearly to a second. The glass is placed between six pillars, which form the axis of the machine, and turn round by two pivots placed on two blocks of stone. See also Barometer.

RAMSEY, a town of Huntingdonshire, 68 miles north of London, and 12 north-east of Huntingdon. It is situated as it were in an island, being everywhere encompassed with fens, except on the west, where it is separated from the *terra firma* by a causeway for two miles. The neighbouring meers of Ramsey and Whitlesey, which are formed by the river Nyne, abound with fish, especially eel and large pikes. It was once famous for a

RAMSDEN'S Machine. Plate CCCCLIX.

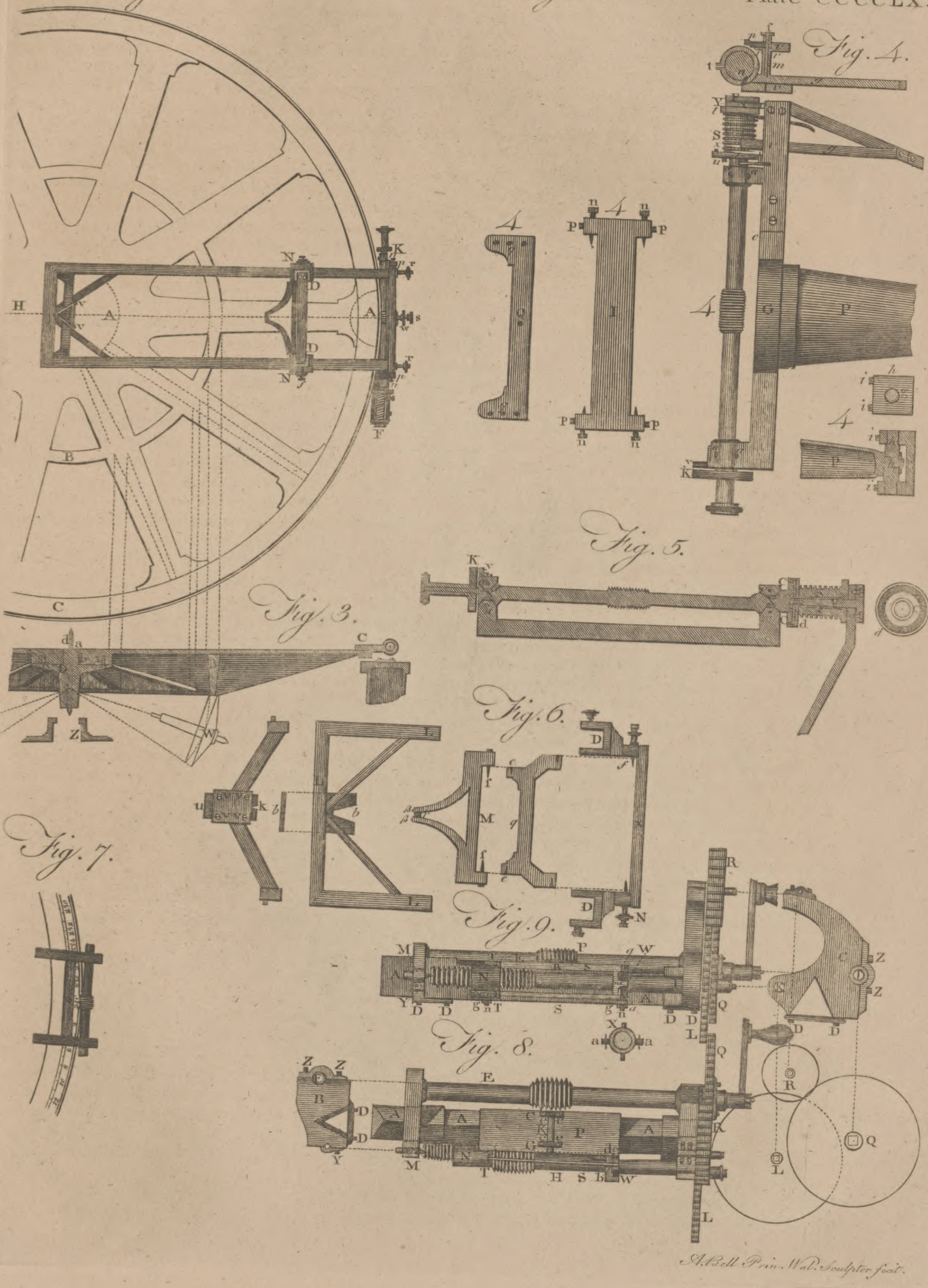
for dividing Mathematical Instruments.

Fig. 1.



A. Bell Prin. Wal. Sculptor fecit.

Fig. 2. RAMSDEN'S Engine. Plate CCCCLX.



A. Bell Prin. Wal. Sculptor fecit.

Ramsey || Ramtrut.

a very rich abbey, part of the gatehouse of which is still standing, and a neglected statue of Ailwin; the epitaph on whose tomb, which is reckoned one of the oldest pieces of English sculpture extant, styles him "kinsman of the famous King Edward, alderman of all England, and miraculous founder of this abbey." It was dedicated to St Dunstan, and its abbots were mitred and sat in parliament; and so many kings of England were benefactors to it, that its yearly rents, says Camden, were 7000l. The town was then called *Ramsey the Rich;* but by the dissolution of the abbey it soon became poor, and even lost its market for many years, till about 185 years ago it recovered it. It is held on Saturday, and is reckoned one of the most plentiful and cheapest in England. In the year 1721 a great number of Roman coins was found here, supposed to have been hid by the monks on some incursion of the Danes. There is a charity school in the town for poor girls. W. Long. 0. 19. N. Lat. 52. 26.

Ramsey, an island of South Wales, on the coast of Pembrokeshire, about two miles in length, and a mile and a half broad. Near it are several small ones, known by the name of the *bishop and his clerks.* It is four miles west of St David's, and 17 north-east of Milford haven. It belongs to the bishopric of St David's, and was in the last age, says Camden, famous for the death of one Justinian, a most holy man, who retiring hither from Britanny, in that age rich in saints, and devoting himself entirely to God, lived a long while in solitude, and being at last murdered by his servant was enrolled among the martyrs. W. Long. 5. 20. N. Lat. 51. 55.

Ramsey, in the Isle of Man, to the north, a most noted and spacious haven, in which the greatest fleet may ride at anchor with safety enough from all winds but the north-east, and in that case they need not be embayed. This town standing upon a beach of loose sand, or shingle, is in danger, if not timely prevented, of being washed away by the sea.

RAMSGATE, a sea-port town of Kent, in the isle of Thanet, five miles from Margate, where a very fine pier has been lately built for the security of ships that come into the harbour, being seated near the Downs between the north and south Foreland, 10 miles north-east of Canterbury. The town is situated in the cove of a chalky cliff. It was formerly but an obscure fishing village, but since the year 1688 has been improved and enlarged by a successful trade to Russia and the east country. But what renders it most worthy of notice, and attracts multitudes of strangers, is the new harbour, which is one of the most capacious in England, if not in Europe. It was begun in the year 1750, but delayed by various interruptions. It consists of two piers; that to the east is built wholly of Purbeck stone, and extends itself into the ocean near 800 feet before it forms an angle; its breadth on the top is 26 feet, including a strong parapet wall, which runs along the outside of it. The other to the west is constructed of wood as far as the low-water mark, but the rest is of stone. The angles, of which there are five in each pier, consist of 160 feet each, with octagons at the end of 60 feet diameter, leaving an entrance of 200 feet into the harbour, the depth of which admits of a gradual increase of 18 to 36 feet. E. Long. 1. 30. N. Lat. 51. 22.

RAMTRUT, a deity worshipped by the Ranazins of Hindostan, where he has a celebrated temple at Oner. He is represented as more resembling a monkey than a man.

Ramus.

RAMUS, in general, denotes a branch of any thing, as of a tree, an artery, &c. In the anatomy of plants it means the first or lateral branches, which go off from the petiolum, or middle rib of a leaf. The subdivisions of these are called *surculi;* and the final divisions into the most minute of all, are by some called *capillamenta;* but both kinds are generally denominated *surculus.*

Ramus, *Peter*, was one of the most famous professors of the 16th century. He was born in Picardy in 1515. A thirst for learning prompted him to go to Paris when very young, and he was admitted a servant in the college of Navarre. Spending the day in waiting on his masters, and the greatest part of the night in study, he made such surprising progress, that, when he took his master of arts degree, he offered to maintain a quite opposite doctrine to that of Aristotle. This raised him many enemies; and the two first books he published, *Institutiones Dialecticæ*, and *Aristotelicæ Animadversiones*, occasioned great disturbances in the university of Paris: and the opposition against him was not a little heightened by his deserting the Romish religion, and professing that of the Reformed. Being thus forced to retire from Paris, he visited the universities of Germany, and received great honours wherever he came. He returned to France in 1571, and lost his life miserably in the horrid massacre of St Bartholomew's day. He was a great orator, a man of universal learning, and endowed with very fine moral qualities. He published many books, which Teissier enumerates. Ramus's merit in his opposition to Aristotle, and his firmness in undermining his authority, is unquestionably great. But it has been doubted, and with much reason, whether he was equally successfully in his attempts after a new logical institute. We have the following general outline of his plan in Dr Enfield's History of Philosophy. "Considering dialectics as the art of deducing conclusions from premises, he endeavours to improve this art, by uniting it with that of rhetoric. Of the several branches of rhetoric, he considers invention and disposition as belonging equally to logic. Making Cicero his chief guide, he divides his treatise on dialectics into two parts, the first of which treats of the invention of arguments, the second of judgments. Arguments he derives not only from what the Aristotelians call middle terms, but from any kind of proposition, which, connected with another, may serve to prove any assertion. Of these he enumerates various kinds. Judgments he divides into axioms, or self-evident propositions, *dianœa*, or deductions by means of a series of arguments. Both these he divides into various classes; and illustrates the whole by examples from the ancient orators and poets.

"In the logic of Ramus, many things are borrowed from Aristotle, and only appear under new names; and many others are derived from other Grecian sources, particularly from the dialogues of Plato, and the logic of the Stoics. The author has the merit of turning the art of reasoning from the futile speculations of the schools to forensic and common use; but his plan is defective in confining the whole dialectic art to the single object of disputation, and in omitting many things, which respect the general culture of the understanding and the investigation of truth. Notwithstanding the defects of his system, we cannot, however, subscribe to the severe censure fure which has been paffed upon Ramus by Lord Bacon and others; for much is, we think, due to him for having with fo much firmnefs and perfeverance afferted the natural freedom of the human underftanding. The logic of Ramus obtained great authority in the fchools of Germany, Great Britain, Holland, and France; and long and violent contefts arofe between his followers and thofe of the Stagyrite, till his fame vanifhed before that of Defcartes."

RAN, in the old Englifh writers, means open or public robbery, fo manifeft as not to be denied. Ran *dicitur aperta rapina quæ negari non poteft.* Lamb. 125. Leg. Canut. cap. 58. Hence it is now commonly faid of one who takes the goods of another injurioufly and violently, that he has taken or fnatched all he could *rap* and *ran*.

RANA, or RANULA. See RANULA.

RANA, the frog; a genus of reptiles belonging to the order of amphibia. See ERPETOLOGY *Index*.

RANAI, one of the Sandwich iflands difcovered by Captain Cooke, is about nine miles diftant from MOWEE and MOROTOI, and is fituated to the fouth-weft of the paffage between thofe two ifles. The country towards the fouth is elevated and craggy; but the other parts of the ifland had a better appearance, and feemed to be well inhabited. It abounds in roots, fuch as fweet potatoes, *taro*, and yams; but produces very few plantains and bread fruit trees. The fouth point of Ranai is in the latitude of 20° 46′ north, and in the longitude of 203° 8′ eaft.

RANCID, denotes a fatty fubftance that is become rank or mufty, or that has contracted an ill fmell by being kept clofe.

RANDIA, a genus of plants belonging to the pentandria clafs; and in the natural method ranking with thofe of which the order is doubtful. See BOTANY *Index*.

RANDOLPH, THOMAS, an eminent Englifh poet in the 17th century, was born in Northamptonfhire 1605. He was educated at Weftminfter and Cambridge, and very early diftinguifhed for his excellent genius; for at about nine or ten years of age he wrote the Hiftory of the Incarnation of our Saviour in verfe. His fubfequent writings eftablifhed his character, and gained him the efteem and friendfhip of fome of the greateft men of that age, particularly of Ben Johnfon, who adopted him one of his fons in the mufes. He died in 1634, and was honourably interred. He wrote, 1. The Mufes Looking-glafs, a comedy. 2. Amyntas, or the Impoffible Dowry, a paftoral, acted before the king and queen. 3. Ariftippus, or the Jovial Philofopher. 4. The Conceited Pedlar. 5. The Jealous Lovers, a comedy. 6. Hey for Honefty, down with Knavery, a comedy; and feveral poems.

RANDOM SHOT, in *Gunnery*, is a fhot made when the muzzle of a gun is raifed above the horizontal line, and is not defigned to fhoot directly or point blank.

The utmoft random of any piece is about ten times as far as the bullet will go point-blank. The bullet will go fartheft when the piece is mounted to about 45° above the level range. See GUNNERY and PROJECTILES.

RANGE, in *Gunnery*, the path of a bullet, or the line it defcribes from the mouth of the piece to the point where it lodges. If the piece lie in a line parallel to the horizon, it is called the *right* or *level range*: if it be mounted to 45°, it is faid to have the *utmoft range*; all others between 00 and 45° are called the *intermediate ranges*.

RANGER, a fworn officer of a foreft, appointed by the king's letters patent; whofe bufinefs is to walk through his charge, to drive back the deer out of the purlieus, &c. and to prefent all trefpaffes within his jurifdiction at the next foreft court.

RANK, the order or place affigned a perfon fuitable to his quality or merit.

RANK, is a ftraight line made by the foldiers of a battalion or fquadron, drawn up fide by fide: this order was eftablifhed for the marches, and for regulating the different bodies of troops and officers which compofe an army.

RANK and Precedence, in the army and navy, are as follow:

Engineers RANK. Chief, as colonel; director, as lieutenant-colonel; fub-director, as major; engineer in ordinary, as captain; engineer extraordinary, as captain-lieutenant; fub-engineer, as lieutenant; practitioner engineer, as enfign.

Navy RANK. Admiral, or commander in chief of his Majefty's fleet, has the rank of a field-marfhal; admirals, with their flags on the main-top-maft-head, rank with generals of horfe and foot; vice-admirals, with lieutenant-generals; rear-admirals, as major-generals; commodores, with broad pendants, as brigadier-generals; captains of poft-fhips, after three years from the date of their firft commiffion, as colonels; other captains, as commanding poft-fhips, as lieutenant-colonels; captains, not taking poft, as majors; lieutenants, as captains.

Rank
||
Rape.

Rape.

RANK between the Army, Navy, and Governors.

ARMY.	NAVY.	GOVERNORS.
General in Chief	Admiral in chief	Commander in chief of the forces in America
Generals of horſe	Admiral with a flag at the main-top-maſt	Captain-general of provinces
Lieutenant-generals	Vice-admirals	Lieutenant generals of provinces
Major-generals	Rear-admirals	Lieutenant-governors and preſidents
Colonels	Poſt-captains of 3 years	Lieutenant-governors not commanding
Lieutenant-colonels	Poſt-captains	Governors of charter colones
Majors	Captains	Deputy-governors
Captains	Lieutenants	Eſtabliſhed by the king, 1760

Doubling of the RANKS, is the placing two ranks in one, frequently uſed in the manœuvres of a regiment.

RANKS and Files, are the horizontal and vertical lines of ſoldiers when drawn up for ſervice.

RANSOM, a ſum of money paid for the redemption of a ſlave, or the liberty of a priſoner of war. In our law books, ranſom is alſo uſed for a ſum paid for the pardon of ſome great offence, and to obtain the offender's liberty.

RANULA, a tumor under a child's tongue, which, like a ligature, hinders it from ſpeaking or ſucking.

RANUNCULUS, CROWFOOT; a genus of plants of the polygamia order, belonging to the polyandria claſs; and in the natural method ranking under the 26th order, *Multiſiliquæ*. See BOTANY *Index*.

RAPACIOUS ANIMALS, are ſuch as live upon prey.

RAPE, in *Law*, the carnal knowledge of a woman forcibly and againſt her will. This, by the Jewiſh law, was puniſhed with death, in caſe the damſel was betrothed to another man: and, in caſe ſhe was not betrothed, then a heavy fine of fifty ſhekels was to be paid to the damſel's father, and ſhe was to be the wife of the raviſher all the days of his life; without that power of divorce, which was in general permitted by the Moſaic law.

The civil law puniſhes the crime of raviſhment with death and confiſcation of goods: under which it includes both the offence of forcible abduction, or taking away a woman from her friends; and alſo the preſent offence of forcibly diſhonouring her; either of which, without the other, is in that law ſufficient to conſtitute a capital crime. Alſo the ſtealing away a woman from her parents or guardians, and debauching her, is equally penal by the emperor's edict, whether ſhe conſent or is forced. And this, in order to take away from women every opportunity of offending in this way; whom the Roman laws ſuppoſe never to go aſtray without the ſeduction and arts of the other ſex; and therefore, by reſtraining and making ſo highly penal the ſolicitations of the men, they meant to ſecure effectually the honour of the women. But our Engliſh law does not entertain quite ſuch ſublime ideas of the honour of either ſex, as to lay the blame of a mutual fault upon one of the tranſgreſſors only; and therefore makes it a neceſſary ingredient in the crime of rape, that it muſt be againſt the woman's will.

Rape was puniſhed by the Saxon laws, particularly thoſe of King Athelſtan, with death; which was alſo agreeable to the old Gothic or Scandinavian conſtitution. But this was afterwards thought too hard: and in its ſtead another ſevere, but not capital, puniſhment was inflicted by William the Conqueror, viz. caſtration and loſs of eyes; which continued till after Bracton wrote, in the reign of Henry III. But in order to prevent malicious accuſations, it was then the law, (and, it ſeems, ſtill continues to be ſo in appeals of rape), that the woman ſhould, immediately after, go to the next town, and there make diſcovery to ſome credible perſons of the injury ſhe has ſuffered; and afterwards ſhould acquaint the high conſtable of the hundred, the coroners, and the ſheriff, with the outrage. This ſeems to correſpond in ſome degree with the laws of Scotland and Arragon, which require that complaint muſt be made within 24 hours: though afterwards by ſtatute Weſtm. 1. c. 13. the time of limitation in England was extended to 40 days. At preſent there is no time of limitation fixed: for, as it is uſually now puniſhed by indictment at the ſuit of the king, the maxim of law takes place, that "nullum tempus occurrit regi:" but the jury will rarely give credit to a ſtale complaint. During the former period alſo it was held for law, that the woman (by conſent of the judge and her parents) might redeem the offender from the execution of his ſentence, by accepting him for her huſband; if he alſo was willing to agree to the exchange, but not otherwiſe.

In the 3 Edw. I. by the ſtatute Weſtm. 1. c. 13. the puniſhment of rape was much mitigated: the offence itſelf, of raviſhing a damſel within age, (that is, twelve years old) either with her conſent or without, or of any other woman againſt her will, being reduced to a treſpaſs, if not proſecuted by appeal within 40 days, and ſubjecting the offender only to two years impriſonment,

ment, and a fine at the king's will. But this lenity being productive of the most terrible consequences, it was, in ten years afterwards, 13 Edw. I. found necessary to make the offence of forcible rape felony by statute Westm. 2. c. 34. And by statute 18 Eliz. c. 7. it is made felony without benefit of clergy: as is also the abominable wickedness of carnally knowing or abusing any woman-child under the age of ten years; in which case the consent or non-consent is immaterial, as by reason of her tender years she is incapable of judgment and discretion. Sir Matthew Hale is indeed of opinion, that such profligate actions committed on an infant under the age of twelve years, the age of female discretion by the common law, either with or without consent, amount to rape and felony; as well since as before the statute of Queen Elizabeth: but that law has in general been held only to extend to infants under ten; though it should seem that damsels between ten and twelve are still under the protection of the statute Westm. 1. the law with respect to their seduction not having been altered by either of the subsequent statutes.

A male infant, under the age of fourteen years, is presumed by law incapable to commit a rape, and therefore it seems cannot be found guilty of it. For though in other felonies "malitia supplet ætatem;" yet, as to this particular species of felony, the law supposes an imbecillity of body as well as mind.

The civil law seems to suppose a prostitute or common harlot incapable of any injuries of this kind: not allowing any punishment for violating the chastity of her, who hath indeed no chastity at all, or at least hath no regard to it. But the law of England does not judge so hardly of offenders, as to cut off all opportunity of retreat even from common strumpets, and to treat them as never capable of amendment. It therefore holds it to be felony to force even a concubine or harlot; because the woman may have forsaken that unlawful course of life: for, as Bracton well observes, "licet meretrix fuerit antea, certe tunc temporis non fuit, cum reclamando nequitiæ ejus consentire noluit."

As to the material facts requisite to be given in evidence and proved upon an indictment of rape, they are of such a nature, that, though necessary to be known and settled, for the conviction of the guilty and preservation of the innocent, and therefore are to be found in such criminal treatises as discourse of these matters in detail, yet they are highly improper to be publicly discussed, except only in a court of justice. We shall therefore merely add upon this head a few remarks from Sir Matthew Hale, with regard to the competency and credibility of witnesses; which may, *salvo pudore*, be considered.

And, first, the party ravished may give evidence upon oath, and is in law a competent witness: but the credibility of her testimony, and how far forth she is to be believed, must be left to the jury upon the circumstances of fact that concur in that testimony. For instance: if the witness be of good fame; if she presently discovered the offence, and made search for the offender; if the party accused fled for it; these and the like are concurring circumstances, which give greater probability to her evidence. But, on the other side, if she be of evil fame, and stand unsupported by others; if she concealed the injury for any considerable time after she had opportunity to complain; if the place, where the fact was alleged to be committed, was where it was possible she might have been heard, and she made no outcry: these and the like circumstances carry a strong, but not conclusive, presumption that her testimony is false or feigned.

Moreover, if the rape be charged to be committed on an infant under 12 years of age, she may still be a competent witness, if she hath sense and understanding to know the nature and obligations of an oath, and, even if she hath not, it is thought by Sir Matthew Hale, that she ought to be heard without oath, to give the court information; though that alone will not be sufficient to convict the offender. And he is of this opinion, first, Because the nature of the offence being secret, there may be no other possible proof of the actual fact; though afterwards there may be concurrent circumstances to corroborate it, proved by other witnesses: and secondly, Because the law allows what the child told her mother, or other relations, to be given in evidence, since the nature of the case admits frequently of no better proof; and there is much more reason for the court to hear the narration of the child herself, than to receive it at second-hand from those who swear they heard her say so. And indeed it seems now to be settled, that in these cases infants of any age are to be heard; and, if they have any idea of an oath, to be also sworn: it being found by experience, that infants of very tender years often give the clearest and truest testimony. But in any of these cases, whether the child be sworn or not, it is to be wished, in order to render her evidence credible, that there should be some concurrent testimony of time, place, and circumstances, in order to make out the fact; and that the conviction should not be grounded singly on the unsupported accusation of an infant under years of discretion. There may be therefore, in many cases of this nature, witnesses who are competent, that is, who may be admitted to be heard; and yet, after being heard, may prove not to be credible, or such as the jury is bound to believe. For one excellence of the trial by jury is, that the jury are triers of the credit of the witnesses, as well as of the truth of the fact.

"It is true (says this learned judge), that rape is a most detestable crime, and therefore ought severely and impartially to be punished with death; but it must be remembered, that it is an accusation easy to be made, hard to be proved, but harder to be defended by the party accused, though innocent." He then relates two very extraordinary cases of malicious prosecution for this crime, that had happened within his own observation; and concludes thus: "I mention these instances, that we may be the more cautious upon trials of offences of this nature, wherein the court and jury may with so much ease be imposed upon, without great care and vigilance; the heinousness of the offence many times transporting the judge and jury with so much indignation, that they are over-hastily carried to the conviction of the persons accused thereof, by the confident testimony of sometimes false and malicious witnesses."

RAPHAEL D'URBINO, the greatest, most sublime, and most excellent painter that has appeared, since the revival of the fine arts, was the son of an indifferent painter named *Sanzio*, and was born at Urbino on Good

Friday 1482. The popes Julius II. and Leo X. who employed him, loaded him with wealth and honour; and it is ſaid that Cardinal de St Bibiana had ſuch a value for him, that he offered him his niece in marriage. His genius is admired in all his pictures; his contours are free, his ordonnances magnificent, his deſigns correct, his figures elegant, his expreſſions lively, his attitudes natural, his heads graceful; in fine, every thing is beautiful, grand, ſublime, juſt, and adorned with graces. Theſe various perfections he derived not only from his excellent abilities, but from his ſtudy of antiquity and anatomy; and from the friendſhip he contracted with Arioſto, who contributed not a little to the improvement of his taſte. His pictures are principally to be found in Italy and Paris. That of the Transfiguration, preſerved at Rome in the church of St Peter Monterio, paſſes for his maſterpiece. He had a handſome perſon, was well proportioned, and had great ſweetneſs of temper; was polite, affable, and modeſt. He, however, lived in the utmoſt ſplendor; moſt of the eminent maſters of his time were ambitious of working under him; and he never went out without a crowd of artiſts and others, who followed him purely through reſpect. He was not only the beſt painter in the world, but perhaps the beſt architect too; on which account Leo X. charged him with building St Peter's church at Rome: but he was too much addicted to pleaſure, which occaſioned his death at 37 years of age. He left a great number of diſciples; among whom were Julio Romano and John Francis Penni, who were his heirs. Many able engravers, as Raimondi, George Mantuan, and Bloemart, engraved after Raphael. See PAINTING.

RAPHAIM, or REPHAIM, (Moſes), a name ſignifying *Giants*, as they really were, and an actual people too, ſituated in Baſan or Batanea, beyond Jordan, ſeparated from the Zanzummim by the river Jabbok. Alſo a valley near Jeruſalem; Joſhua x.

RAPHANUS, RADISH; a genus of plants belonging to the tetradynamia claſs; and in the natural method ranking under the 39th order, *Siliquoſæ*. See BOTANY *Index*; and for the method of culture, ſee GARDENING.

RAPHANIDOSIS, a puniſhment inflicted at Athens upon adulterers. The manner of it was this: The hair was plucked off from the privities of the offenders, hot-aſhes laid upon the place, and a radiſh or mullet thruſt up his fundament, as has been mentioned under ADULTERY. To this Juvenal alludes, Sat. x. ver. 317. *Quoſdam mœchos et mugilis intrat.* Perſons who had been thus puniſhed were called ευπρωκτοι. The word *raphanidoſis* is derived from ραφανις, "a radiſh."

RAPHIDIA, a genus of inſects, of the neuroptera order. See ENTOMOLOGY *Index*.

RAPIER, formerly ſignified a long old-faſhioned ſword, ſuch as thoſe worn by the common ſoldiers: but it now denotes a ſmall ſword, as contradiſtinguiſhed from a back-ſword.

RAPIN, RENE, a Jeſuit and eminent French writer, was born at Tours in 1621. He taught polite literature in the ſociety of the Jeſuits with great applauſe, and was juſtly eſteemed one of the beſt Latin poets and greateſt wits of his time. He died at Paris in 1687. He wrote, 1. A great number of Latin poems, which have rendered him famous throughout all Europe; among which are his *Hortorum libri quatuor*, which is reckoned his maſterpiece. 2. Reflections on Eloquence, Poetry, Hiſtory, and Philoſophy. 3. Compariſons between Virgil and Homer, Demoſthenes and Cicero, Plato and Ariſtotle, Thucydides and Titus Livius. 4. The Hiſtory of Janſeniſm. 5. Several works on religious ſubjects. The beſt edition of his Latin poems is that of Paris in 1723, in 3 vols. 12mo.

RAPIN *de Thoyras, Paul de*, a celebrated hiſtorian, was the ſon of James de Rapin lord of Thoyras, and was born at Caſtres in 1661. He was educated at firſt under a tutor in his father's houſe; and afterwards ſent to Puylaurens, and thence to Samur. In 1679 he returned to his father, with a deſign to apply himſelf to the ſtudy of the law, and was admitted an advocate: but ſome time after, reflecting that his being a Proteſtant would prevent his advancement at the bar, he reſolved to quit the profeſſion of the law, and apply himſelf to that of the ſword; but his father would not conſent to it. The revocation of the edict of Nantes in 1685, and the death of his father, which happened two months after, made him reſolve to come to England; but as he had no hopes of any ſettlement here, his ſtay was but ſhort. He therefore ſoon after went to Holland, and liſted himſelf in the company of French volunteers at Utrecht, commanded by M. Rapin his couſin-german. He attended the prince of Orange into England in 1688: and the following year the lord Kingſton made him an enſign in his regiment, with which he went into Ireland, where he gained the eſteem of his officers at the ſiege of Carrickfergus, and had ſoon a lieutenant's commiſſion. He was preſent at the battle of the Boyne, and was ſhot through the ſhoulder at the ſiege of Limerick. He was ſoon after captain of the company in which he had been enſign; but, in 1693, reſigned his company to one of his brothers, in order to be tutor to the earl of Portland's ſon. In 1699, he married Marianne Teſtard; but this marriage neither abated his care of his pupil, nor prevented his accompanying him in his travels. Having finiſhed this employment, he returned to his family, which he had ſettled at the Hague; and here he continued ſome years. But as he found his family increaſe, he reſolved to retire to ſome cheap country; and accordingly removed, in 1707, to Weſel, where he wrote his Hiſtory of England, and ſome other pieces. Though he was of a ſtrong conſtitution, yet 17 years application (for ſo long was he in compoſing the hiſtory juſt mentioned) entirely ruined his health. He died in 1725. He wrote in French, 1. A Diſſertation on the Whigs and Tories. 2. His Hiſtory of England, printed at the Hague in 1726 and 1727, in 9 vols 4to, and reprinted at Trevoux in 1728, in 10 vols 4to. This laſt edition is more complete than that of the Hague. It has been tranſlated into Engliſh, and improved with Notes, by the reverend Mr Tindal, in 2 vols folio. This performance, though the work of a foreigner, is deſervedly eſteemed as the fulleſt and moſt impartial collection of Engliſh political tranſactions extant. The readers of wit and vivacity, however, may be apt to complain of him for being ſometimes rather tedious and dull.

RAPINE, in *Law*, the taking away another's goods, &c. by violence.

RAPPERSWIL, a town of Swiſſerland, on the confines of the canton of Zurich, and of the territory of Gafter, with an old caftle. It is ftrong by fituation, being feated on a neck of land which advances into the lake of Zurich, and over which there is a bridge 850 paces long. It is fubject to the cantons of Zurich and Berne. E. Long. 8. 57. N. Lat. 47. 20.

RAPPOLSTEIN, a town of France in Upper Alface, which, before the revolution, had the title of a barony. All the muficians of Alface likewife depended upon this baron, and were obliged to pay him a certain tribute, without which they could not play upon their inftruments. E. Long. 7. 28. N. Lat. 48. 15.

RAPTURE, an ecftafy or tranfport of mind. See Extasy.

RARE, in *Phyfic*, ftands oppofed to denfe; and denotes a body that is very porous, whofe parts are at a great diftance from one another, and which is fuppofed to contain but little matter under a large bulk. See the following article.

RAREFACTION, in *Phyfics*, the act whereby a body is rendered rare; that is, brought to poffefs more room, or appear under a larger bulk, without acceffion of any new matter.—This is very frequently the effect of fire, as has long been univerfally allowed. In many cafes, however, philofophers have attributed it to the action of a repulfive principle. However, from the many difcoveries concerning the nature and properties of the electric fluid and fire, there is the greateft reafon to believe, that this repulfive principle is no other than elementary fire. See Repulsion.

RAS-el-Feel, one of the frontier provinces of Abyffinia, of which the late celebrated traveller Mr Bruce was made governor while in that country. It is but of fmall extent, and in its moft profperous ftate contained only 39 villages. The climate is extremely hot, in Mr Bruce's opinion one of the hotteft in the world. He informs us, that on the firft day of March, at three o'clock in the afternoon, the thermometer ftood at 114° in the fhade, and in the evening at 82°; though at funrife it had been no higher than 61. Notwithftanding this appearance of extreme heat, however, the fenfation was by no means intolerable; they could hunt at midday, and felt the evenings rather cold. The foil is a fat, loofe, black earth, which our author fays is the fame from 13° to 16° of north latitude; at leaft till we come to the deferts of Atbara, where the tropical rains ceafe. This country divides that of the Shangalla into two parts, nearly equal. Thefe people inhabit a belt of land about 60 miles broad, all along the northern frontier of Abyffinia, excepting two large gaps or fpaces which have been left open for the fake of commerce, and which are inhabited by ftrangers, to keep the Shangalla in awe. The latter trade in gold, which they pick up in the ftreams as it is wafhed down from the mountains; for there are no mines in their country, neither is there any gold in Abyffinia, excepting what is imported from this or fome other country. The Shangalla are the natural enemies of the inhabitants of Ras-el-Feel, and much blood has been fhed in the various incurfions they have made upon one another; though of late thofe of Ras-el-Feel, by the affiftance of the emperors, have been enabled to keep the Shangalla at bay.

RAS-Sem, a city of Tripoli in Barbary, concerning which a number of fables were told by the Tripoline ambaffador, all of which were believed in England and other parts of Europe in the beginning of this century. (See *Petrified City*). Mr Bruce informs us, that it is fituated about five days journey fouth from Bengazi; but has no water excepting one fountain, which has a difagreeable tafte, and feems to be impregnated with alum. Hence it has obtained the name of *Ras-Sem*, or the fountain of poifon. The only remains of antiquity in this place confift of the ruins of a tower or fortification, which, in the opinion of Mr Bruce, is as late as the time of the Vandals; but he fays he cannot imagine what ufe they made of the water, and they had no other within two days journey of the place.—Here our traveller faw many of the animals called *jerboa*, a kind of mice; which, he fays, feem to partake as much of the nature of a bird as of a quadruped.

RASAY, one of the Hebrides iflands, is about 13 miles long and two broad. It contains 700 inhabitants, has plenty of limeftone and freeftone; feeds great numbers of black cattle; but has neither deers, hares, nor rabbits. The only appearance of a harbour in Rafay is at Clachan bay, where Mr Macleod the proprietor of the ifland refides. Rafay prefents a bold fhore, which rifes to the height of mountains; and here the natives have, with incredible labour, formed many little corn fields and potato grounds. Thefe heights decreafe at the fouth end, where there are fome farms and a good-looking country. Mr Macleod is fole proprietor of this ifland, and of Rona and Fladda at the north end of it, which are only proper for grazing.

The houfe of Rafay is pleafantly fituated near the fouth-weft end of the ifland, which is the moft level part of it. It has an extenfive and excellent garden, and is furrounded with foreft trees of confiderable magnitude; another proof that trees will grow upon the edge of the fea, though it muft be allowed that the channel here is narrow. Immediately behind the houfe of Rafay are the ruins of an ancient chapel, now ufed as the family burying-place.

RASCIANS, a poor oppreffed people who dwelt on both fides of the Danube, and who, about the year 1594, being weary of the Turkifh thraldom, firft took 13 of their veffels upon that river; and then drawing together a body of 15,000 men between Buda and Belgrade, twice defeated the pâfhâ of Temefwar with a body of 14,000 Turks. They afterwards took Baczkerek, four miles from Belgrade, and the caftle of Ottadt; then laying fiege to that of Beche, on the Theyffa, the old pâfhâ of Temefwar marched to relieve it with 11,000 men; but the Rafcians encountering them, flew near 10,000, and took 18 pieces of cannon. The confequence of this victory was the reduction of Werfetza and Lutz. Then, fending to the archduke for aid and gunners, they offered to put themfelves and their country under the emperor's protection.

RASOR-bill, a fpecies of alca. See Alca, Ornithology *Index*.

RASOR-Fifh, a genus of fhell-fifh. See Solen, Conchology *Index*.

RASTALL, John, a printer and mifcellaneous writer, was born in London, probably about the end of the 15th century, and educated at Oxford. Returning from the univerfity, he fettled in the metropolis, and commenced printer, "then efteemed (fays Wood) a profeffion fit for any fcholar or ingenious man." He married the

the ſiſter of Sir Thomas More, with whom, we are told, he was very intimate, and whoſe writings he ſtrenuouſly defended. From the title-page of one of his books, he appears to have lived in Cheapſide, at the ſign of the Mermaid. He died in the year 1536; and left two ſons, William and John: the firſt of whom became a judge in Queen Mary's reign, and the latter a juſtice of peace. This John Raſtall, the ſubject of the preſent article, was a zealous Papiſt; but Bale ſays, that he changed his religion before his death. He wrote, 1. *Natura naturata.* Pits calls it a copious (*prolixa*) and ingenious comedy, deſcribing Europe, Aſia, and Africa; with cuts. What ſort of a comedy this was, is not eaſy to conceive. Probably it is a coſmographical deſcription, written in dialogue, and therefore ſtyled a *comedy.* 2. The paſtyme of the people; the cronycles of diverſe realmys, and moſt eſpecially of the realm of England, brevely compiled and emprinted in Cheapeſyde, at the ſign of the mearmaid, next Pollyſgate, *cum privilegio*, fol. 3. *Eccleſia Johannis Raſtall*, 1542, was one of the prohibited books in the reign of Henry VIII. 4. *Legum Anglicanarum vocabula explicata.* French and Latin. Lond. 1567, 8vo. And ſome other works.

RASTADT, a town of Germany, in the circle of Suabia and marquiſate of Baden, with a handſome caſtle. It is remarkable for a treaty concluded here between the French and imperialiſts in 1714; and near this place the French defeated the imperial troops in July 1796; in 1798 a congreſs was held here for the concluſion of a peace between France and Germany; but it broke up in 1799, when, not far from Raſtadt, the French plenipotentiaries, on their return, were murdered by a party of Auſtrian huſſars. See FRANCE, N° 501. Raſtadt is ſeated on the river Merg, near the Rhine. E. Long. 8. 14. N. Lat. 48. 54.

RASTENBURG, a fine city in Pruſſia, on the Guber, ſurrounded with a wall, and ſince 1629 alſo with a rampart. It is 46 miles ſouth-eaſt of Koningſberg. E. Long. 21. 30. N. Lat. 54. 20.

RAT. See MUS, MAMMALIA *Index;* and for an account of the methods of deſtroying rats, ſee VERMIN, *Deſtruction of.*

RAT-Iſland, a ſmall detached part of the iſland of Lundy, off the north coaſt of Devon. Though noted in Donn's map of the county, it is not worth mention here, but as giving opportunity to ſubjoin a farther notice of Lundy, which iſland was purchaſed a few years ſince by Mr Cleveland, M. P. for about 1200 guineas, who has a ſmall villa on it: not more than 400 acres are cultivated: it is let altogether for 70l. a-year. The ſoil is good, though no trees will grow on the iſland. It has fine ſprings of water: the houſes are ſeven: the inhabitants, men, women, and children, do not exceed 24. The bird called *murr*, whoſe eggs are very large and fine, the Lundy parrot, and rabbits, are the chief produce; theſe abound, and are taken for the feathers, eggs, and ſkins, principally. They have now (1794) 70 bullocks and 400 ſheep, but the latter do not thrive. They pay no taxes: fiſhing ſkiffs often call with neceſſaries: the ſituation is very pleaſant, and the rocks around, which are large, and partly granite, are wild and romantic. It had probably more inhabitants once, as human bones have been ploughed up. It has no place of worſhip, and no public-houſe; but ſtrangers are always welcome. Eight cannon lie on the battlements on the top of a very ſteep precipice, under which is a curious cavern. Lord Gower, Mr Benſon, and Sir J. B. Warren, K. B. have been former proprietors. See LUNDY.

RAT-Tails, or *Arreſts.* See FARRIERY *Index.*

RATAFIA, a fine ſpirituous liquor, prepared from the kernels, &c. of ſeveral kinds of fruits, particularly of cherries and apricots.

Ratafia of cherries is prepared by bruiſing the cherries, and putting them into a veſſel wherein brandy has been long kept; then adding to them the kernels of cherries, with ſtrawberries, ſugar, cinnamon, white pepper, nutmeg, cloves; and to 20 pounds of cherries 10 quarts of brandy. The veſſel is left open 10 or 12 days, and then ſtopped cloſe for two months before it be tapped. Ratafia of apricots is prepared two ways, viz. either by boiling the apricots in white-wine, adding to the liquor an equal quantity of brandy, with ſugar, cinnamon, mace, and the kernels of apricots; infuſing the whole for eight or ten days; then ſtraining the liquor, and putting it up for uſe: or elſe by infuſing the apricots, cut in pieces, in brandy, for a day or two, paſſing it through a ſtraining bag, and then putting in the uſual ingredients.

RATCH, or RASH, in clock-work, a ſort of wheel having twelve fangs, which ſerve to lift up the detents every hour, and make the clock ſtrike. See CLOCK.

RATCHETS, in a watch, are the ſmall teeth at the bottom of the fuſy, or barrel, which ſtops it in winding up.

RATE, a ſtandard or proportion, by which either the quantity or value of a thing is adjuſted.

RATES, in the navy, the orders or claſſes into which the ſhips of war are divided, according to their force and magnitude.

The regulation, which limits the rates of men of war to the ſmalleſt number poſſible, ſeems to have been dictated by conſiderations of political economy, or of that of the ſimplicity of the ſervice in the royal dock-yards. The Britiſh fleet is accordingly diſtributed into ſix rates, excluſive of the inferior veſſels that uſually attend on naval armaments; as ſloops of war, armed ſhips, bomb-ketches, fire-ſhips and cutters, or ſchooners commanded by lieutenants.

Ships of the firſt rate mount 100 cannon, having 42-pounders on the lower deck, 24-pounders on the middle deck, 12-pounders on the upper deck, and 6-pounders on the quarter-deck and fore-caſtle. They are manned with 850 men, including their officers, ſeamen, marines, and ſervants.

In general, the ſhips of every rate, beſides the captain, have the maſter, the boatſwain, the gunner, the chaplain, the purſer, the ſurgeon, and the carpenter; all of whom, except the chaplain, have their mates or aſſiſtants, in which are comprehended the ſail-maker, the maſter at arms, the armourer, the captain's clerk, the gunſmith, &c.

The number of other officers is always in proportion to the rate of the ſhip. Thus a firſt-rate has ſix lieutenants, ſix maſter's mates, twenty-four midſhipmen, and five ſurgeon's mates, who are conſidered as gentlemen: beſides the following petty officers; quarter-maſters and their mates, fourteen; boatſwain's mates and yeomen, eight; gunner's mates and aſſiſtants, ſix; quarter-gunners, twenty-five; carpenter's mates, two, beſides fourteen

fourteen aſſiſtants; with one ſteward and ſteward's mate to the purſer.

If the dimenſions of all ſhips of the ſame rate were equal, it would be the ſimpleſt and moſt perſpicuous method to collect them into one point of view in a table: but as there is no invariable rule for the general dimenſions, we muſt content ourſelves with but a few remarks on ſhips of each rate, ſo as to give a general idea of the difference between them.

The Victory, one of the laſt built of our firſt rates, is 222 feet 6 inches in length, from the head to the ſtern; the length of her keel, 151 feet 3 inches; that of her gun-deck, or lower deck, 186 feet; her extreme breadth is 51 feet 10 inches; her depth in the hold, 21 feet 6 inches; her burden, 2162 tons; and her poop reaches 6 feet before the mizen-maſt.

Ships of the ſecond rate carry 90 guns upon three decks, of which thoſe on the lower battery are 32-pounders; thoſe on the middle, 18-pounders; on the upper deck, 12-pounders; and thoſe on the quarter-deck, 6-pounders, which uſually amount to four or ſix. Their complement of men is 750, in which there are ſix lieutenants, four maſter's mates, 24 midſhipmen, and four ſurgeon's mates, 14 quarter-maſters and their mates, eight boatſwain's mates and yeomen, ſix gunner's mates and yeomen, with 22 quarter-gunners, two carpenter's mates, with 10 aſſiſtants, and one ſteward and ſteward's mate.

Ships of the third rate carry from 64 to 80 cannon, which are 31, 18, and 9 pounders. The 80-gun ſhips, however, begin to grow out of repute, and to give way to thoſe of 74, 70, &c. which have only two whole batteries; whereas the former have three, with 28 guns planted on each, the cannon of their upper deck being the ſame as thoſe on the quarter-deck and fore-caſtle of the latter, which are 9-pounders. The complement in a 74 is 650, and in a 64, 500 men; having, in peace, four lieutenants, but in war, five; and when an admiral is aboard ſix. They have three maſter's mates, 16 midſhipmen, three ſurgeon's mates, 10 quarter-maſter, and their mates, ſix boatſwain's mates and yeomen, four gunner's mates and yeomen, with 18 quarter-gunners, one carpenter's mate, with eight aſſiſtants, and one ſteward and ſteward's mate under the purſer.

Ships of the fourth rate mount from 60 to 50 guns, upon two decks, and the quarter-deck. The lower tier is compoſed of 24-pounders, the upper tier of 12-pounders, and the cannon on the quarter-deck and fore-caſtle are 6-pounders. The complement of a 50 gun ſhip is 350 men, in which there are three lieutenants, two maſter's mates, 10 midſhipmen, two ſurgeon's mates, eight quarter-maſters and their mates, four boatſwain's mates and yeomen, one gunner's mate and one yeoman, with 12 quarter-gunners, one carpenter's mate and ſix aſſiſtants, and a ſteward and ſteward's mate.

All veſſels of war, under the fourth rate, are uſually comprehended under the general name of *frigates*, and never appear in the line of battle. They are divided into the 5th and 6th rates; the former mounting from 40 to 32 guns, and the latter from 28 to 20. The largeſt of the fifth rate have two decks of cannon, the lower battery being of 18-pounders, and that of the upper deck of 9-pounders; but thoſe of 36 and 32 guns have one complete deck of guns, mounting 12-pounders, beſides the quarter-deck and fore-caſtle, which carry 6-pounders. The complement of a ſhip of 44 guns is 280 men; and that of a frigate of 36 guns, 240 men. The firſt has three, and the ſecond two lieutenants; and both have two maſter's mates, ſix midſhipmen, two ſurgeon's mates, ſix quarter-maſters and their mates, two boatſwain's mates, and one yeoman, one gunner's mate and one yeoman, with 10 or 11 quarter-gunners, and one purſer's ſteward.

Frigates of the 6th rate carry 9-pounders, thoſe of 28 guns having 3 pounders on their quarter-deck, with 200 men for their complement; and thoſe of 24, 160 men: the former has two lieutenants, the latter, one; and both have two maſter's mates, four midſhipmen, one ſurgeon's mate, four quarter-maſters and their mates, one boatſwain's mate and one yeoman, one gunner's mate and one yeoman, with ſix or ſeven quarter-gunners, and one purſer's ſteward.

The ſloops of war carry from 18 to 8 cannon, the largeſt of which have ſix-pounders; and the ſmalleſt, viz. thoſe of 8 or 10 guns, four-pounders. Their officers are generally the ſame as in the 6th rates, with little variation; and their complements of men are from 120 to 60, in proportion to their force or magnitude. N. B. Bomb-veſſels are on the ſame eſtabliſhment as ſloops; but fire-ſhips and hoſpital ſhips are on that of fifth-rates.

Nothing more evidently manifeſts the great improvement of the marine art, and the degree of perfection to which it has arrived in Britain, than the facility of managing our firſt rates; which were formerly eſteemed incapable of government, unleſs in the moſt favourable weather of the ſummer.

Ships of the ſecond rate, and thoſe of the third, which have three decks, carry their ſails remarkably well, and labour very little at ſea. They are excellent in a general action, or in cannonading a fortreſs. Thoſe of the third rate, which have two tiers, are fit for the line of battle, to lead the convoys and ſquadrons of ſhips of war in action, and in general to ſuit the different exigencies of the naval ſervice.

The fourth-rates may be employed on the ſame occaſions as the third-rates, and may be alſo deſtined amongſt the foreign colonies, or on expeditions of great diſtance; ſince theſe veſſels are uſually excellent for keeping and ſuſtaining the ſea.

Veſſels of the fifth rate are too weak to ſuffer the ſhock of a line of battle; but they may be deſtined to lead the convoys of merchant ſhips, to protect the commerce in the colonies, to cruize in different ſtations, to accompany ſquadrons, or be ſent expreſs with neceſſary intelligence and orders. The ſame may be obſerved of the ſixth rates.

The frigates, which mount from 28 to 38 guns upon one deck, with the quarter-deck, are extremely proper for cruizing againſt privateers, or for ſhort expeditions, being light, long, and uſually excellent ſailers.

RATEEN, or RATTEN, in commerce, a thick woollen ſtuff, quilled, woven on a loom with four treddles, like ſerges and other ſtuffs that have the whale or quilling. There are ſome rateens dreſſed and prepared like cloths; others left ſimply in the hair, and others where the hair or knap is frized. Rateens are chiefly manufactured in France, Holland, and Italy, and are moftly ufed in linings. The frize is a fort of coarfe rateen, and the drugget is a rateen half linen half woollen.

RATIFICATION, an act of approving and confirming fomething done by another in our name.

RATIO, in *Arithmetic and Geometry*, is that relation of homogeneous things which determines the quantity of one from the quantity of another, without the intervention of a third.

The numbers, lines, or quantities, A and B, being propofed, their relation one to another may be confidered under one of thefe two heads: 1. How much A exceeds B, or B exceeds A? And this is found by taking A from B, or B from A, and is called *arithmetic reafon* or *ratio*. 2. Or how many times, or parts of a time, A contains B, or B contains A? and this is called *geometric reafon* or *ratio*; (or, as Euclid defines it, it is the *mutual habitude*, or *refpect*, of two magnitudes of the fame kind, according to quantity; that is, as to how often the one contains, or is contained in, the other); and is found by dividing A by B, or B by A. And here note, that that quantity which is referred to another quantity is called the *antecedent of the ratio*: and that to which the other is referred is called the *confequent of the ratio*; as, in the ratio of A to B, A is the antecedent, and B the confequent. Therefore any quantity, as antecedent, divided by any quantity as a confequent, gives the ratio of that antecedent to the confequent.

Thus the ratio of A to B is $\frac{A}{B}$, but the ratio of B to A is $\frac{B}{A}$; and, in numbers, the ratio of 12 to 4 is $\frac{12}{4}=3$, or triple; but the ratio of 4 to 12 is $\frac{4}{12}=\frac{1}{3}$, or fubtriple.

And here note, that the quantities thus compared muft be of the fame kind; that is, fuch as by multiplication may be made to exceed one the other, or as thefe quantities are faid to have a ratio between them, which, being multiplied, may be made to exceed one another. Thus a line, how fhort foever, may be multiplied, that is, produced fo long as to exceed any given right line; and confequently thefe may be compared together, and the ratio expreffed: but as a line can never, by any multiplication whatever, be made to have breadth, that is, to be made equal to a fuperficies, how fmall foever; thefe can therefore never be compared together, and confequently have no ratio or refpect to one another, according to quantity; that is, as to how often the one contains, or is contained in, the other. See QUANTITY.

RATIOCINATION, the act of reafoning. See REASONING.

RATION, or RATIAN, in the army, a portion of ammunition, bread, drink, and forage, diftributed to each foldier in the army, for his daily fubfiftence, &c. The horfe have rations of hay and oats when they cannot go out to forage. The rations of bread are regulated by weight. The ordinary ration of a foot foldier is a pound and a half of bread per day. The officers have feveral rations according to their quality and the number of attendants they are obliged to keep.—When the ration is augmented on occafions of rejoicing, it is called a *double ration*. The fhip's crews have alfo their rations or allowances of bifket, pulfe, and water, proportioned according to their ftock.

RATIONALE, a folution or account of the principles of fome opinion, action, hypothefis, phenomenon or the like.

RATIBOR, a town of Germany, in Silefia, and capital of a duchy of the fame name, with a caftle. It has been twice taken by the Swedes, and is feated on the river Oder, in a country fertile in corn and fruits, 15 miles north-eaft of Troppaw, and 142 eaft of Prague, E. Long. 22. 24. N. Lat. 50. 14.

RATISBON, an ancient, large, rich, handfome, and ftrong city of Germany, in Bavaria, free and imperial, with a bifhop's fee, whofe bifhop is a prince of the empire. It is called by the Germans Regenfburg, from the river Regens, which runs under a fine ftone bridge, and throws itfelf into the Danube below the city; and the rivers Luber and Nab mix with it above the city. The French call it Ratifbon, in imitation of the Latins; it hath formerly been fubject to the kings of Bavaria, who made it the place of their refidence; but it was declared free by the emperor Frederick I. which does not, however, hinder the dukes of Bavaria from dividing the toll with the citizens, according to an agreement between them. Thefe princes have alfo the criminal jurifdiction, for which the magiftrates of the city pay them homage. It is the firft city of the bench of Suabia, and contains at prefent within its walls five different free ftates of the empire; namely, the bifhop, the abbot of St Emmeran, the abbeffes of the Low and High Munfter, and the city. The inhabitants of Ratifbon have the privilege not to be cited before other tribunals, unlefs for actions above 400 florins. The fenate is compofed of 17 members, and there is a council of 10, which is charged with the government of the ftate. The citizens have a right to elect a chief, who judges of the affairs of police. The catholics have the exercife of their religion in the cathedral church and others, and the Lutherans in three churches which they have built. The magiftrates and officers of the city are all Proteftants; and it is to be remarked, that although there are about 22 Catholic churches, yet there are very few Catholic citizens, the magiftracy not allowing the freedom of the town to be given to Catholics living there. As this city is large, elegant, and full of magnificent houfes, it has been chofen many years for the place of holding the diet, upon account of the conveniency, to many neighbouring princes and ftates, of fending their provifions by land and water, without great expence. The town-houfe, in the midft of which the diet meets, is extremely magnificent. In the year 1740, however, when there was a war in Germany, the diet met at Frankfort on the Main, till after the death of the emperor Charles VII. Provifions are very plentiful at Ratifbon in time of peace. The inhabitants have a good deal of trade, the river on which it ftands being navigable, and communicating with a great part of Germany. It is 55 miles fouth-eaft of Nuremberg, 62 north of Munich, and 195 weft of Vienna. E. Long. 12. 5. N. Lat. 48. 59.

RATLINES, or, as the failors call them, *ratlins*, thofe lines which make the ladder fteps to go up the fhrouds and puttocks, hence called the *ratlins of the fhrouds*.

RATOLFZEL,

RATOLFZEL, a ſtrong town of Germany, in Suabia, near the weſt end of the lake Conſtance. It is ſeated on that part of it called *Bodenſee*, and belongs to the houſe of Auſtria, who took it from the duke of Wirtemburg, after the battle of Nordlingen. It is 12 miles weſt of the city of Conſtance. It is defended by the impregnable caſtle of Hohen Dwel, on an inacceſſible hill in the middle of a plain, the rock of which is flint, ſo that a few men may hold it out againſt an army.

RATTLESNAKE. See CROTALUS, OPHIOLOGY *Index*.

RATTLESNAKE Root. See POLYGALA, BOTANY *Index*.

RATZEBURG, or RATZEMBURG, an ancient town of Germany, in the circle of Lower Saxony, and in the duchy of Lawenburg, with a biſhop's ſee and a caſtle. The town depends on the duchy of Lawenburg, and the cathedral church on that of Ratzburg. It is ſeated on an eminence, and almoſt ſurrounded with a lake 25 miles in length and three in breadth. The duke of Lawenburg ſeized and fortified it in 1689, and the king of Denmark took it in 1693; but it was diſmantled, and reſtored in 1700 to the duke, who refortified it. This town has been frequently pillaged, particularly in 1552, by Francis duke of Saxe Lawenburg, becauſe the canons refuſed to elect his ſon Magnus their biſhop. It is nine miles ſouth of Lubec. This place is noted for its excellent beer. E. Long. 10. 58. N. Lat. 53. 47.

RAVA, a town of Great Poland, and capital of a palatinate of the ſame name, with a fortified caſtle, where they keep ſtate priſoners. The houſes are built of wood, and there is a Jeſuit's college. It is ſeated in a moraſs covered with water, which proceeds from the river Rava, with which it is ſurrounded. It is 45 miles ſouth of Bloſko, and 50 ſouth-weſt of Warſaw. The palatinate is bounded on the north by that of Bloſko, on the eaſt by that of Mazovia, on the ſouth by that of Sandomer, and on the weſt by that of Lencieza.

RAVELIN, in *Fortification*, was anciently a flat baſtion placed in the middle of a curtain; but now a detached work compoſed only of two faces, which make a ſaliant angle without any flanks, and raiſed before the counterſcarp of the place. See FORTIFICATION.

RAVEN. See CORVUS, ORNITHOLOGY *Index*.

Sea RAVEN, or *corvo marino* of Kongo in Africa, in *Ichthyology*, is about ſix feet long; but the moſt ſingular circumſtance appertaining to this creature is the ſtone found in its head, to which the natives aſcribe ſome medicinal virtues, and the delicate taſte of its hard roe, which is ſtill much admired, when died in the ſun, and becomes as hard as a ſtone.

RAVENGLAS, a town of Cumberland in England, ſituated between the rivers Irt and Eſk, which, with the ſea, encompaſs three parts of it. It is a well built place, and has a good road for ſhipping, which brings it ſome trade. E. Long. 0. 5. N. Lat. 54 20.

RAVENNA, in *Ancient Geography*, a noble city of Gallia Ciſpadana; a colony of Theſſalians, on the Adriatic, in waſhes or a boggy ſituation, which proved a natural ſecurity to it. The houſes were all of wood, the communication by bridges and boats, and the town kept ſweet and clean by the tides carrying away the mud and ſoil, (Strabo). Anciently it had a port at the mouth of the Bedeſis; Auguſtus added a new port, capacious to hold a fleet, for the ſecurity of the Adriatic, between which and the city lay the Via Cæſaris. In the lower age it was the ſeat of the Oſtrogoths for 72 years; but being recovered by Narſes, Juſtinian's general, it became the reſidence of the exarchs, magiſtrates ſent by the emperor from Conſtantinople, for 175 years, when it was taken by the Longobards. It is ſtill called *Ravenna*, capital of Romania. The ſeat of the weſtern or Roman empire was by Honorius tranſlated to Ravenna about the year 404, and hence the country in which it ſtood was called *Romania*, in the pope's territory. It had a very flouriſhing trade till the ſea withdrew two miles from it, which has been a great detriment. The fortifications are of little importance, and the citadel is gone to ruin. It is now moſt remarkable for the excellent wine produced in its neighbourhood. The mauſoleum of Theodoric is ſtill to be ſeen, remarkable for being covered by a ſingle ſtone 28 feet in diameter and 15 thick. It was at Ravenna that the duke of Nemours fell, after having gained a moſt deciſive victory over the confederate army, in 1511. See FRANCE, N° 129, and Modern Univerſal Hiſtory, vol. xx. p. 324. &c.

RAVENSBURG, a county of Germany, in Weſtphalia, bounded on the north by the biſhoprics of Oſnaburg and Minden, on the eaſt by Lemgow, on the ſouth by the biſhopric of Paderborn, and on the weſt by that of Munſter. It belongs to the king of Pruſſia, and has its name from the caſtle of Ravenſburg. The population amounts to about 81,812.

RAVENSBURG, a free and imperial town of Germany, in Algow, in the circle of Suabia. It is well built, and the public ſtructures are handſome. The inhabitants are partly Proteſtants and partly papiſts. It is ſeated on the river Chenſs, in E. Long. 9. 46. N. Lat. 47. 44.

RAVET, an inſect ſhaped like a may-bug, or cockchafer, (ſee SCARABÆUS), with which the iſland of Guadaloupe is much peſtered. It has a ſtinking ſmell, preys upon paper, books, and furniture, and whatever they do not gnaw is diſcoloured by their ordure. Theſe naſty inſects, which are very numerous, and appear chiefly by night, would be intolerable, were it not for a large ſpider, ſome of them as long as a man's fiſt, which intangles them in its web, and otherwiſe ſurpriſes them. On which account the inhabitants of the iſland are very careful of theſe ſpiders.

RAVILLIAC, FRANCIS, the infamous aſſaſſin of Henry IV. of France, was a native of Angouleſme, and at the time of his execution was about one or two and thirty years of age. See FRANCE, N° 146, and HENRY IV. of France. Ravilliac was the ſon of parents who lived upon alms. His father was that ſort of inferior retainer to the law, to which the vulgar give the name of a *pettifogger*, and his ſon had been bred up in the ſame way. Ravilliac had ſet up a claim to an eſtate, but the cauſe went againſt him: this diſappointment affected his mind deeply: he afterwards taught a ſchool, and, as himſelf ſaid, received charitable gifts, though but of a very ſmall value, from the parents of thoſe whom he taught; and yet his diſtreſs was ſo great, that he had much ado to live. When he was ſeized for the king's murder, he was very looſely guarded; all were permitted to ſpeak with him who pleaſed; and it was thought

Mod. Univ. Hiſt. vol. xxi. p. 147. note A, &c.

Ravilliac. thought very remarkable that a Jesuit should say to him, "Friend, take care, whatever you do, that you don't charge honest people." He was removed next day from the house of Espernon to the Conciergerie, the proper prison of the parliament of Paris. When he was first interrogated, he answered with great boldness, "That he had done it, and would do it if it were to do again." When he was told that the king, though dangerously wounded, was living, and might recover, he said that he had struck him home, and that he was sure he was dead. In his subsequent examinations he owned that he had long had an intention to kill the king, because he suffered two religions in his kingdom; and that he endeavoured to obtain an audience of him, that he might admonish him. He also said that he understood the king's great armament to be against the pope, and that, in his opinion, to make war against the pope, was to make war against God. We have no distinct account of the three last examinations; but he is said to have persisted, in the most solemn asseverations, that he had no accomplices, and that nobody had persuaded him to the fact. He appeared surprised at nothing so much as at the universal abhorrence of the people, which, it seems, he did not expect. They were forced to guard him strictly from his fellow-prisoners, who would otherwise have murdered him. The butchers of Paris desired to have him put into their hands, affirming that they would flay him alive, and that he should still live 12 days. When he was put to the torture, he broke out into horrid execrations, and always insisted that he did the fact from his own motive, and that he could accuse nobody. On the day of his execution, after he had made the *amende honourable* before the church of Notre Dame, he was carried to the Greve; and, being brought upon a scaffold, was tied to a wooden engine in the shape of a St Andrew's cross. The knife with which he did the murder being fastened in his right hand, it was first burnt in a slow fire; then the fleshy parts of his body were torn with red-hot pincers, and melted lead, oil, pitch, and rosin, poured into the wounds, and through a clay funnel into his bowels by the navel. The people refused to pray for him; and when, according to the sentence pronounced upon him, he came to be dragged to pieces by four horses, one of those that were brought appearing to be but weak, one of the spectators offered his own, with which the criminal was much moved: he is said to have then made a confession, which was so written by the greffier Voisin, that not so much as one word of it could ever be read. He was very earnest for absolution, which his confessor refused, unless he would reveal his accomplices; "Give it me conditionally (said he), upon condition that I have told the truth," which they did. His body was so robust, that it resisted the force of the horses; and the executioner was at length obliged to cut him into quarters, which the people dragged through the streets. The house in which he was born was demolished, and a column of infamy erected; his father and mother were banished from Angoulesme, and ordered to quit the kingdom upon pain of being hanged, if they returned, without any form of process; his brothers, sisters, uncles, and other relations, were commanded to lay aside the name of Ravilliac, and to assume some other. Such was the fate of this execrable monster, who, according to his own account, suffered himself to be impelled to such a fact by the seditious sermons and books of the Jesuits, whom Henry, rather out of fear than love, had recalled and caressed, and to whom he had bequeathed his heart.

Ravilliac || Ray.

Neither the dying words of Ravilliac, nor so much of his process as was published, were credited by his cotemporaries. Regalt the historian says, that there were two different opinions concerning this assassination; one, that it was conducted by some grandees, who sacrificed that monarch to their old resentments; the other, that it was done by the emissaries of the Spaniards. Letters from Brussels, Antwerp, Mechlin, and other places, were received before the 15th of May, with a report of the king's death. Though nothing occurs in the examinations of Ravilliac that were first published, in reference to his journeys to Naples and other places; yet as these are set down as certain truths by good authors, so there are probable grounds to believe that they were not fictitious. It appears from Sir Ralph Winwood's Memorials, that Ravilliac had been not long before at Brussels. Amongst other circumstances that created a very great doubt, whether the assassin spoke truth, were the things found in his pocket at the time he was seized; amongst which was a chaplet, the figure of a heart made in cotton, in the centre of which he said there was a bit of the true cross, but when cut there was none, which he affirmed was given him by a canon at Angoulesme, a piece of paper with the arms of France painted upon it, another full of characters, and a third containing verses for the meditation of a criminal going to execution. The provost of Pluviers, or Petiviers, in Beauce, about six miles from Paris, had said openly on the day that Henry IV. was murdered, "This day the king is either slain or dangerously wounded." After the king's death was known, he was seized and sent prisoner to Paris; but, before he was examined, he was found hanged in the strings of his drawers. His body was, notwithstanding, hung up by the heels on the common gibbet on the 19th of June. What increased the suspicions grounded on this man's end, was his having two sons Jesuits, and his being a dependent on the family of Monsieur d'Entragues.

RAUN, a town of some strength, upon the river Miza, remarkable for a bloody skirmish between the Prussians and Austrians, in August 1744. The king of Prussia, intending to get possession of Beraun, sent thither six battalions, with eight cannon, and 800 hussars; but General Festititz being there with a great party of his corps, and M. Luchesi with 1000 horse, they not only repulsed the Prussians, but attacked them in their turn, and, after a warm dispute, obliged them to retire with considerable loss.

RAURICUM, in *Ancient Geography*, a town of the Raurici, situated over against Abnoba, a mountain from which the Danube takes its rise. A Roman colony led by L. Manutius Plancus the scholar and friend of Cicero: called *Colonia Rauriaca* (Pliny), *Raurica* (Inscription), *Augusta Rauricorum*. The town was destroyed in Julian's time. It is now commonly called *Augst*, a village greatly decayed from what it formerly was. It is situated on the Rhine, distant about two hours to the east of Basil. The country is now the canton of Basil.

RAY, John, a celebrated naturalist, was the son of Mr Roger Ray a blacksmith, and was born at Black Notly

Ray.

Notly in Essex in 1628. He received the first rudiments of learning at the grammar-school at Braintree; and in 1644 was admitted into Catharine-Hall in Cambridge, from whence he afterwards removed to Trinity college in that university. He took the degree of master of arts, and became at length a senior fellow of the college; but his intense application to his studies having injured his health, he was obliged at his leisure hours to exercise himself by riding or walking in the fields, which led him to the study of plants. He noted from Johnson, Parkinson, and the *Phytologia Britannica*, the places where curious plants grew; and in 1658 rode from Cambridge to the city of Chester, from whence he went into North Wales, visiting many places, and among others the famous hill of Snowdon; returning by Shrewsbury and Gloucester. In 1660 he published his *Catalogus Plantarum circa Cantabrigiam nascentium*, and the same year was ordained deacon and priest. In 1661 he accompanied Francis Willoughby, Esq. and others in search of plants and other natural curiosities, in the north of England and Scotland; and the next year made a western tour from Chester, and through Wales, to Cornwall, Devonshire, Dorsetshire, Hampshire, Wiltshire, and other counties. He afterwards travelled with Mr Willoughby and other gentlemen through Holland, Germany, Italy, France, &c. took several tours in England, and was admitted fellow of the Royal Society. In 1672, his intimate and beloved friend Mr Willoughby died in the 37th year of his age, at Middleton Hall, his seat in Yorkshire; "to the infinite and unspeakable loss and grief (says Mr Ray) of myself, his friends, and all good men." There having been the closest and sincerest friendship between Mr Willoughby and Mr Ray, who were men of similar natures and tastes, from the time of their being fellow collegians, Mr Willoughby not only confided in Mr Ray, in his lifetime, but also at his death: for he made him one of the executors of his will, and charged him with the education of his sons Francis and Thomas, leaving him also for life 60l. per annum. The eldest of these young gentlemen, not being four years of age, Mr Ray, as a faithful trustee, betook himself to the instruction of them; and for their use composed his *Nomenclator Classicus*, which was published this very year, 1672. Francis the eldest dying before he was of age, the younger became Lord Middleton. Not many months after the death of Mr Willoughby, Mr Ray lost another of his best friends, Bishop Wilkins; whom he visited in London the 18th of November 1672, and found near expiring by a total suppression of urine for eight days. As it is natural for the mind, when it is hurt in one part, to seek relief from another; so Mr Ray, having lost some of his best friends, and being in a manner left destitute, conceived thoughts of marriage; and accordingly, in June 1673, did actually marry a gentlewoman of about 20 years of age, the daughter of Mr Oakley of Launton in Oxfordshire. Towards the end of this year, came forth his "Observations Topographical, Moral, &c." made in foreign countries; to which was added his *Catalogus Stirpium in exteris regionibus observatarum*: and about the same time, his *Collection of unusual or local English words*, which he had gathered up in his travels through the counties of England. After having published many books on subjects foreign to his profession, he at length resolved to publish in the character of a divine, as well as in that of a natural philosopher: in which view he published his excellent demonstration of the being and attributes of God, entitled *The Wisdom of God manifested in the Works of the Creation*, 8vo, 1697. The rudiments of this work were read in some college lectures; and another collection of the same kind he enlarged and published under the title of *Three Physico-theological Discourses, concerning the Chaos, Deluge, and Dissolution of the World*, 8vo, 1692. He died in 1705. He was modest, affable, and communicative; and was distinguished by his probity, charity, sobriety, and piety. He wrote a great number of works; the principal of which, besides those already mentioned, are, 1. *Catalogus Plantarum Angliæ*. 2. *Dictionariolum Trilingue secundum locos communes*. 3. *Historia Plantarum, Species hactenus editas, aliasque insuper multas noviter inventas et descriptas complectens*, three vols. 4. *Methodus Plantarum nova, cum Tabulis*, 8vo, and several other works on plants. 6. *Synopsis Methodica Animalium Quadrupedum et Serpentini generis*, 8vo. 6. *Synopsis Methodica Avium et Piscium*. 7. *Historia Insectorum, opus posthumum*. 8. *Methodus Insectarum*. 9. Philosophical Letters, &c.

Ray, Raynal.

RAYNAL, William Thomas, or the Abbé Raynal, was born about the year 1712, and received his education among the celebrated order of the Jesuits, and became one of their number. Their value and excellence chiefly consisted in assigning to each member his proper employment. Among them it was that Raynal acquired a taste for literature and science, and by them he was afterwards expelled, but for what reason is not certainly known, although the abbé Barruel ascribes it to impiety. Soon after this event he associated with Voltaire, D'Alembert, and Diderot, by whom it is said, he was employed to furnish the articles in theology for the *Encyclopedie*; but he employed the abbé Yvon to furnish them for him, whom Barruel allows to have been an inoffensive and upright man.

His first work, which is justly regarded as an eminent performance, is entitled "Political and Philosophical History of the European Settlements in the East and West Indies." The stile of this work is animated; it contains many just reflections both of a political and philosophical nature, and has been translated into every European language. We believe this performance was followed by a small tract in the year 1780, entitled "The Revolution of America," in which he pleads the cause of the colonists with much zeal, censures the conduct of the British government, and discovers an acquaintance with the principles of the different factions, which has induced a belief that he had been furnished with materials by those who knew the merits of the dispute much better than any foreigner could reasonably be supposed to do.

The French government instituted a prosecution against him on account of his history of the East and West Indies; but with so little severity was it conducted, that sufficient time was allowed him to retire to the dominions of his Prussian majesty, by whom he was protected, notwithstanding he had treated the character of that sovereign with very little ceremony. Even the most despotic princes shewed him much kindness, although he always animadverted on their conduct without reserve; and he lived in the good graces of the empress prefs of Ruffia. At one period the Britifh houfe of commons fhewed him a very fingular mark of refpect. The fpeaker having been informed that Raynal was a fpectator in the gallery, public bufinefs was inftantly fufpended, and the ftranger was conducted to a more honourable fituation. But when a friend of Dr Johnfon's afked him refpecting the fame perfonage, "Will you give me leave, doctor, to introduce to you the abbé Raynal?" he turned on his heel, and faid, "No fir."

A love of liberty was the principal trait in Raynal's character, of which he gave no proper or accurate definition in his earlier writings; but when he beheld the abufe of liberty in the progrefs of the French Revolution, he nobly attempted to retrieve his errors. In the month of May 1791, he addreffed to the Conftituent Affembly, a letter the moft eloquent, argumentative, and impreffive, that perhaps was ever compofed upon any fubject whatever. He obferves among other things; "I have long dared to fpeak to kings of their duty; fuffer me now to fpeak to the people of their errors, and to their reprefentatives of the dangers which threaten us. I am, I own to you, deeply afflicted at the crimes which plunge this empire into mourning. It is true that I am to look back with horror at myfelf for being one of thofe who, by feeling a noble indignation againft arbitrary power, may perhaps have furnifhed arms to licentioufnefs. Do then religion, the laws, the royal authority, and public order, demand back from philofophy and reafon the ties which united them to the grand fociety of the French nation, as if, by expofing abufes, and teaching the rights of the people and the duties of princes, our criminal efforts had broken thefe ties? But, no!——never have the bold conceptions of philofophy been reprefented by us as the ftrict rule for acts of legiflation."

He afterwards completely proves, that it was not the bufinefs of the affembly to abolifh every ancient inftitution; that the genius of the French people is fuch, that they never can be happy or profperous but under a well regulated monarchical government; and that, if they wifhed not the nation to fall under the worft kind of defpotifm, they muft increafe the power of the king.

Befides the works already mentioned, he was the author of "A Hiftory of the Parliament of England," &c. "Hiftory of the Stadtholderate"; "The Hiftory of the Divorce of Catharine of Arragon by Henry VIII." and a "Hiftory of the Revocation of the Edict of Nantz," in four volumes; but he committed many of his papers to the flames during the fanguinary reign of Robefpierre. He was deprived of all his property during the revolution, and died in poverty in the month of March 1796, in the 84th year of his age.

RAY, in *Optics*, a beam of light emitted from a radiant or luminous body. See LIGHT and OPTICS.

Inflected RAYS, thofe rays of light which, on their near approach to the edges of bodies, in paffing by them, are bent out of their courfe, being turned either from the body or towards it. This property of the rays of light is generally termed *diffraction* by foreigners, and Dr Hooke fometimes called it *deflection*.

Reflected RAYS, thofe rays of light which, after falling upon the body, do not go beyond the furface of it, but are thrown back again.

Refracted RAYS, thofe rays of light which, after falling upon any medium, enter its furface, being bent either towards or from a perpendicular to the point on which they fell.

Pencil of RAYS, a number of rays iffuing from a point of an object, and diverging in the form of a cone.

RAZOR, a well-known inftrument, ufed by furgeons, barbers, &c. for fhaving off the hair from various parts of the body.—As fhaving to many people is a moft painful operation, cutlers in different countries have long applied their fkill to remove that inconvenience. Some have invented foaps of a peculiar kind to make the operation more eafy, and fome have invented ftraps. With refpect to razors, fome artifts have fucceeded rather by accident than from any fixed principle; and therefore we have found great inequality in the goodnefs of razors made by the fame artift.

A correfpondent affures us, that he has for 40 years paft been at much pains to find out razors made by the beft makers both in England and Scotland, and was fortunate enough, at laft, to difcover a kind made by a Scotchman of the name of *Logan*, which he called magnetical razors, becaufe they were directed to be touched with an artificial magnet before ufing. Thefe, our friend affures us, are moft excellent razors, and he has ufed them for upwards of 20 years. He fays likewife that they continue in good order, without requiring to be ground; but that the great draw-back on their being generally ufed, is the price, which is higher than moft people are able or difpofed to give for that inftrument. Our correfpondent, who refides in the vicinity of London, alfo informs us, that lately the famous furgeon's inftrument-maker, Mr Savigny in Pall Mall, after numberlefs experiments, in the courfe of above 20 years, has at length brought razors to a degree of perfection never yet equalled; and with fuch certainty, that the purchafer is in no danger of a difappointment, though the price is very moderate. By thefe, we are told, the operation of fhaving is performed with greater eafe, more perfectly, and more expeditioufly than with any other.

RE, in *Grammar*, an infeparable particle added to the beginning of words to double or otherwife modify their meaning; as in re-action, re-move, re-export, &c.

RE-ACTION, in *Phyfiology*, the refiftance made by all bodies to the action or impulfe of others that endeavour to change its ftate whether of motion or reft, &c.

READING, the art of delivering written language with propriety, force, and elegance.

"We muft not judge fo unfavourably of eloquence or good reading (fays the illuftrious Fenelon), as to reckon it only a frivolous art, that a declaimer ufes to impofe upon the weak imagination of the multitude, and to ferve his own ends. It is a very ferious art, defigned to inftruct people; to fuppress their paffions and reform their manners; to fupport the laws, direct public councils, and to make men good and happy."

I Delivery in reading fhould be lefs animated than in interefted fpeaking.

Reafon and experience demonftrate, that *delivery in reading ought to be lefs animated than in interefted fpeaking*. In every exercife of the faculty of fpeech, and thofe expreffions of countenance and gefture with which it is generally attended, we may be confidered to be always in one of the two following fituations: Firft, delivering our *bofom fentiments* on circumftances which relate to ourfelves or others; or, fecondly, *repeating* fomething that was fpoken on a certain occafion for the

 amufement

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amusement or information of an auditor. Now, if we observe the deliveries natural to these two situations, we shall find, that the first may be accompanied with every degree of expression which can manifest itself in us, from the lowest of sympathy to the most violent and energetic of the superior passions; while the latter, from the speaker's chief business being to repeat what he heard *with accuracy*, discovers only a faint imitation of those signs of the emotions which we suppose agitated him from whom the words were first borrowed.—The use and necessity of this difference of manner is evident; and if we are attentive to these natural signs of expression, we shall find them conforming with the greatest nicety to the slightest and most minute movements of the breast.

This repetition of another's words might be supposed to pass through the mouth of a second or third person; and in these cases, since they were not ear and eye witnesses of him who first spoke them, their manner of delivery would want the advantage necessarily arising from an immediate idea of the original one; hence, on this account, this would be a still less lively representation than that of the first *repeater*. But as, from a daily observation of every variety of speech and its associated signs of emotion, mankind soon become pretty well acquainted with them, and this in different degrees, according to their discernment, sensibility, &c. experience shows us that these latter *repeaters* (as we call them) might conceive and use a manner of delivery which, though less *characteristic* perhaps, would on the whole be no way inferior to the first, as to the *common* natural expression proper for their situation. It appears, therefore, that repeaters *of every degree* may be esteemed upon a level as to animation, and that our twofold distinction above contains accurately enough the whole variety of ordinary delivery;—we say *ordinary*, because

There is another very peculiar kind of delivery sometimes used in the person of a *repeater*, of which it will in this place be necessary to take some notice. What we mean here is *mimicry*; an accomplishment which, when perfectly and properly displayed, never fails of yielding a high degree of pleasure. But since this pleasure chiefly results from the principle of *imitation* respecting *manner*, and not from the purport of the *matter* communicated; since, comparatively speaking, it is only attainable by few persons, and practised only on particular occasions;—on these accounts it must be refused a place among the modes of useful delivery taught us by *general* nature, and esteemed a qualification purely anomalous.

These distinctions with regard to a speaker's situation of mind premised, let us see to which of them an *author* and his *reader* may most properly be referred, and how they are circumstanced with regard to one another.

The matter of all books is, either what the author says in his *own* person, or an acknowledged recital of the words of *others*: hence an author may be esteemed both an *original* speaker and a *repeater*, according as what he writes is of the first or second kind. Now a reader must be supposed either actually to personate the author, or one whose office is barely to communicate what he has said to an auditor. But in the first of these suppositions he would, in the delivery of what is the author's own, evidently commence *mimic*; which being, as above observed, a character not acknowledged by general nature in this department, ought to be rejected as generally improper. The other supposition therefore must be accounted right; and then, as to the *whole* matter of the book, the reader is found to be exactly in the situation of a *repeater*, save that he takes what he delivers from the page before him instead of his memory. It follows then, in proof of our initial proposition, that, if we are directed by nature and propriety, the manner of our delivery in reading ought to be inferior in warmth and energy to what we should use, were the language before us the spontaneous effusions of our own hearts in the circumstances of those out of whose mouths it is supposed to proceed.

Evident as the purport of this reasoning is, it has not so much as been glanced at by the writers on the subject we are now entered upon, or any of its kindred ones; which has occasioned a manifest want of accuracy in several of their rules and observations. Among the rest, this precept has been long reverberated from author to author as a perfect standard for propriety in reading. "Deliver yourselves in the same manner you would do, were the matter your own original sentiments uttered directly from the heart." As all kinds of delivery must have many things in common, the rule will in many articles be undoubtedly right; but, from what has been said above, it must be as certainly faulty in respect to several others; as it is certain nature never confounds by like signs two things so very different, as a *copy* and an *original*, an emanation darted immediately from the sun, and its weaker appearance in the lunar reflection.

The precepts we have to offer for improving the above-mentioned rule, shall be delivered under the heads of *accent*, *emphasis*, *modulation*, *expression*, *pauses*, &c.

2 Accent.

I. *Accent.*—In attending to the affections of the voice when we speak, it is easy to observe, that, independent of any other consideration, one part of it differs from another, in *stress*, *energy*, or *force* of utterance. In words we find one syllable differing from another with respect to this mode; and in sentences one or more words as frequently vary from the rest in a similar manner. This stress with regard to *syllables* is called *accent*, and contributes greatly to the variety and harmony of language. Respecting *words*, it is termed *emphasis*; and its chief office is to assist the sense, force, or perspicuity of the sentence—of which more under the next head.

"Accent (as described in the Lectures on Elocution) is made by us two ways; either by dwelling longer upon one syllable than the rest, or by giving it a smarter percussion of the voice in utterance. Of the first of these we have instances in the words *glōry*, *fāther*, *hōly*; of the last in *bat'tle*, *hab'it*, *bor'row*. So that accent with us is not referred to tune, but to time; to quantity, not quality; to the more equable or precipitate motion of the voice, not to the variation of the notes or inflexions."

In *theatric declamation*, in order to give it more pomp and solemnity, it is usual to dwell longer than common upon the unaccented syllables; and the author now quoted has endeavoured to prove (p. 51. 54.) the practice faulty, and to show (p. 55.) that "though it (i. e. true solemnity) may demand a slower utterance than usual, yet (it) requires that the same proportion in point of

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of quantity be obſerved in the ſyllables, as there is in muſical notes when the ſame tune is played in quicker or ſlower time." But that this deviation from ordinary ſpeech is not a fault, as our author aſſerts; nay, that on the contrary it is a real beauty when kept under proper regulation, the following obſervations it is hoped will ſufficiently prove.

(I.) It is a truth of the moſt obvious nature, that thoſe things which on their application to their proper ſenſes have a power of raiſing in us certain ideas and emotions, are ever *differently* modified in their conſtituent parts when different effects are produced in the mind: and alſo (II.) that, within proper bounds, were we to ſuppoſe theſe conſtituent parts to be proportionally increaſed or diminiſhed as to *quantity*, this effect would ſtill be the ſame as to *quality*.—For inſtance: The different ideas of ſtrength, ſwiftneſs, &c. which are raiſed in us by the ſame ſpecies of animals, is owing to the different form of their correſponding parts; the different effects of muſic on the paſſions, to the different airs and movements of the melody; and the different expreſſions of human ſpeech, to a difference in tone, ſpeed, &c. of the voice. And theſe peculiar effects would ſtill remain the ſame, were we to ſuppoſe the animals above alluded to, to be *greater* or *leſſer*, within their proper bounds; the movement of the muſic *quicker* or *ſlower*, provided it did not palpably interfere with that of ſome other ſpecies; and the pitch of the voice *higher* or *lower*, if not carried out of the limits in which it is obſerved on ſimilar occaſions naturally to move. Farther (III.) ſince, reſpecting the emotions more eſpecially, there are no rules to determine *à priori* what effect any particular attribute or modification of an object will have upon a percipient, our knowledge of this kind muſt evidently be gained from experience. Laſtly, (IV.) In every art imitating nature we are pleaſed to ſee the characteriſtic members of the pattern *heightened* a little farther than perhaps it ever was carried in any real example, provided it be not bordering upon ſome ludicrous and diſagreeable provinces of exceſs.

Now for the application of theſe premiſſes.—To keep pace and be conſiſtent with the *dignity* of the tragic muſe, the delivery of her language ſhould neceſſarily be dignified; and this it is plain from obſervation (I.) cannot be accompliſhed otherwiſe than by ſomething different in the manner of it from that of ordinary ſpeech; ſince *dignity* is eſſentially different from *familiarity*. But how muſt we diſcover this different manner? By attending to nature: and in this caſe ſhe tells us, that beſides uſing a *ſlower* delivery, and greater *diſtinctneſs* of the words (which every thing merely *grave* requires, and gravity is a *concomitant* of dignity, though not its *eſſence*), we muſt dwell a little *longer* upon the *unaccented* ſyllables than we do in common. As to what our author obſerves in the above quotation, of *dignity's* only requiring a *ſlower* utterance than ordinary, while the proportion of the ſyllables as to quantity continues the ſame; it is apprehended the remark (II.) reſpecting *quickneſs* and *ſlowneſs* of movement will ſhow it to be not altogether true. For ſince the delivery is not altered in *form*, its expreſſion muſt be ſtill of the ſame kind, and perhaps what may be rightly ſuggeſted by the term *gravely familiar*.

But ſomething farther may be yet ſaid in defence of this *artificial* delivery, as our author calls it. Is not the movement of any thing, of whatever ſpecies, when dignified or ſolemn, in general of an *equable* and *deliberate* nature (as in the minuet, the military ſtep, &c.)? And in theatrical declamation, is not the propenſity to introduce this *equableneſs* ſo ſtrong, that it is almoſt *impoſſible* to avoid it wholly, were we ever ſo determined to do it? If theſe two queries be anſwered in the affirmative (as we are perſuaded they will), while the firſt ſupports our argument for the *propriety* of the manner of delivery in queſtion, the ſecond diſcovers a kind of *neceſſity* for it. And that this manner may be carried a little *farther* in quantity on the *ſtage* than is uſual in *real life*, the principle (IV.) of heightening nature will juſtify, provided faſhion (which has ever ſomething to do in theſe articles) give it a ſanction; for the *preciſe* quantity of ſeveral heightenings may be varied by this great legiſlator almoſt at will.

II. *Emphaſis*.—As *emphaſis* is not a thing annexed to particular words, as *accent* is to ſyllables, but owes its riſe chiefly to the *meaning* of a paſſage, and muſt therefore vary its ſeat according as that meaning varies, it will be neceſſary to explain a little farther the general idea given of it above. 3 Emphaſis.

> Of man's firſt diſobedience, and the fruit
> Of that forbidden tree, whoſe mortal taſte
> Brought death into the world, and all our woe, &c.
> Sing heav'nly muſe, &c.

Suppoſing, in reference to the above well-known lines, that originally other beings, beſides men, had diſobeyed the commands of the Almighty, and that the circumſtance were well known to us, there would fall an *emphaſis* upon the word *man's* in the firſt line, and hence it would be read thus;

> Of *man's* firſt diſobedience, and the fruit, &c.

But if it were a notorious truth, that mankind had tranſgreſſed in a peculiar manner more than once, the *emphaſis* would fall on *firſt*, and the line be read,

> Of man's *firſt* diſobedience, &c.

Again, admitting death (as was really the caſe) to have been an unheard of and dreadful puniſhment brought upon man in conſequence of his tranſgreſſion; on that ſuppoſition the third line would be read,

> Brought *death* into the world, &c.

But if we were to ſuppoſe mankind knew there was ſuch an evil as death in other regions, though the place they inhabited had been free from it till their tranſgreſſion; the line would run thus,

> Brought death into the *world*, &c.

Now from a proper delivery of the above lines, with regard to any one of the ſuppoſitions we have choſen, out of ſeveral others that might in the ſame manner have been imagined, it will appear that the *emphaſis* they illuſtrate is effected by a manifeſt *delay* in the pronunciation, and a tone ſomething *fuller* and *louder* than is uſed in ordinary; and that its office is ſolely to determine the meaning of a ſentence with reference to ſomething ſaid before, preſuppoſed by the author as general knowledge, or in order to remove an ambiguity where a paſſage is capable of having more ſenſes given it than one.

But,

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But, ſuppoſing in the above example, that none of the ſenſes there pointed out were preciſely the true one, and that the meaning of the lines were no other than what is obviouſly ſuggeſted by their ſimple conſtruction; in that caſe it may be aſked, if in reading them there ſhould be no word dignified with the emphatical accompanyments above deſcribed ?—The anſwer is, Not one with an emphaſis of the *ſame* kind as that we have juſt been illuſtrating; yet it is nevertheleſs true, that on hearing theſe lines well read, we ſhall find ſome words diſtinguiſhed from the reſt by a manner of delivery bordering a little upon it (A). And theſe words will in general be ſuch as ſeem the moſt important in the ſentence, or on other accounts to merit this diſtinction. But as at beſt it only *enforces*, *graces*, or *enlivens*, and not *fixes* the meaning of any paſſage, and even caprice and faſhion (B) have often a hand in determining its place and magnitude, it cannot properly be reckoned an *eſſential* of delivery. However, it is of too much moment to be neglected by thoſe who would wiſh to be good readers; and, for the ſake of diſtinction, we may not unaptly denominate both the kinds of energies in queſtion, by the terms *emphaſis of ſenſe*, and *emphaſis of force* (C).

Now from the above account of theſe two ſpecies of emphaſis it will appear, "that in reading, as in ſpeaking, the firſt of them muſt be determined entirely by the *ſenſe* of the paſſage, and always made *alike*: But as to the other, *taſte* alone ſeems to have a right of fixing its ſituation and quantity."—Farther: Since the more eſſential of theſe two energies is ſolely the work of *nature* (as appears by its being *conſtantly* found in the common converſation of people of all kinds of capacities and degrees of knowledge), and the moſt ignorant perſon never fails of uſing it *rightly* in the effuſions of his own heart, it happens very luckily, and ought always to be remembered, that provided we underſtand what we read, and give way to the dictates of our own feeling, the *emphaſis of ſenſe* can ſcarce ever avoid falling ſpontaneouſly upon its proper place.

Here it will be neceſſary to ſay ſomething by way of reply to a queſtion which will naturally occur to the mind of every one. As the rule for the *emphaſis of ſenſe* requires we ſhould underſtand what we read before it can be properly uſed, it is incumbent upon us never to attempt to read what we have not previouſly ſtudied for that purpoſe ? In anſwer to this, it muſt be obſerved, that though ſuch a ſtep will not be without its advantages; yet, as from the fairneſs of printed types, the well-known pauſes of punctuation, and a long acquaintance with the phraſeology and conſtruction of our language, &c. experience tells us it is *poſſible* to comprehend the ſenſe at the firſt reading, a previous peruſal of what is to be read does not ſeem *neceſſary* to *all*, though, if they would wiſh to appear to advantage, it may be *expedient* to *many;* and it is this circumſtance which makes us venture upon extemporary reading, and give it a place among our amuſements.—Similar remarks might be made with regard to *modulation*, *expreſſion*, &c. did not what is here obſerved naturally anticipate them.

4

Modulation.

III. *Modulation* (D.) Every perſon muſt have obſerved,

(A) The following lines will illuſtrate both theſe kinds of ſtreſſes: For, to convey their right meaning, the word ANY is evidently to be pronounced louder and fuller than thoſe with the accents over them.

Get wéalth and pláce, if poſſible with gráce;
If not, by ANY méans get wéalth and pláce.—POPE.

This couplet is accented in the manner we find it in the *Eſſay on Elocution* by *Maſon*. And if, according to the judgement of this author, the words thus diſtinguiſhed are to have an emphatical ſtreſs, it muſt be of the inferior kind above-mentioned, and which a little farther on we call *emphaſis of force;* while the word ANY in a different type alone poſſeſſes the other ſort of energy, and which is there contradiſtinguiſhed by the term *emphaſis of ſenſe*.

(B) Among a number of people who have had proper opportunities of learning to read in the beſt manner it is now taught, it would be difficult to find two, who, in a given inſtance, would uſe the *emphaſis of force* alike, either as to place or quantity. Nay ſome ſcarcely uſe any at all: and others will not ſcruple to carry it *much* beyond any thing we have a precedent for in common diſcourſe; and even now and then throw it upon words ſo very trifling in themſelves, that it is evident they do it with no other view, than for the ſake of the *variety* it gives to the modulation.—This practice, like the introduction of diſcords into muſic, may without doubt be indulged now and then; but were it too frequent, the capital intent of theſe energies would manifeſtly either be deſtroyed or rendered dubious.

(C) The firſt of theſe terms anſwers to the *ſimple emphaſis* deſcribed in the *Lectures on Elocution*, and the ſecond *nearly* to what is there called *complex*. The difference lies in this. Under *complex emphaſis* the author ſeems (for he is far from being clear in this article) to include the *tones* ſimply conſidered of all the emotions of the mind; as well the *tender* and *languid*, as the *forcible* and *exulting*. Our term is intended to be confined to ſuch modes of expreſſion alone as are marked with an apparent *ſtreſs* or *increaſe* of the voice.

(D) The author of the *Introduction to the Art of Reading*, not allowing that there is any variation of tone, as to *high* and *low*, in the delivery of a complete period or ſentence, places modulation ſolely in the diverſification of the key-note and the variety of ſyllables, as to *long* or *ſhort*, *ſwift* or *ſlow*, *ſtrong* or *weak*, and *loud* or *ſoft*. As we are of a different opinion, our idea of modulation is confined purely to *harmonious inflexions of voice*. Theſe qualities of words, it is true, add greatly both to the force and beauty of delivery; yet, ſince ſome of them are fixed and not arbitrary (as *long* and *ſhort*), and the others (of *ſwift* and *ſlow*, *ſtrong* and *weak*, *loud* and *ſoft*) may be conſidered as modes of expreſſion which do not affect the modulation as to *tone*, it will agree beſt with our plan to eſteem ved, that, in ſpeaking, the voice is ſubject to an alteration of ſound, which in ſome meaſure reſembles the movement of a tune. Theſe ſounds, however, are evidently nothing like ſo much varied as thoſe that are ſtrictly muſical; and we have attempted to ſhow in the preceding chapter, that, beſides this, they have an eſſential difference in themſelves. Nevertheleſs, from the general ſimilitude of theſe two articles, they poſſeſs ſeveral terms in common; and the particular we have now to examine is in both of them called *modulation.* This affection of the voice, being totally *arbitrary*, is differently characterized in different parts of the world; and, through the power of cuſtom, every place is inclined to think their own the only one natural and agreeable, and the reſt affected with ſome barbarous twang or ungainly variation (E). It may be obſerved, however, that though there is a general uniform caſt or faſhion of modulation peculiar to every country, yet it by no means follows that there is or can be any thing fixed in its application to particular paſſages; and therefore we find different people will, in any given inſtance, uſe modulations ſomething different, and nevertheleſs be each of them equally agreeable.

But, quitting theſe general remarks, we ſhall (as our purpoſe requires it) conſider the properties of modulation a little more minutely.

Firſt, then, we may obſerve, that, in ſpeaking, there is a particular ſound (or *key-note*, as it is often called) in which the modulation for the moſt part runs, and to which its occaſional inflexions, either above or below, may in ſome reſpects be conceived to have a reference, like that which common muſic has to its key-note. Yet there is this difference between the two kinds of modulation, that whereas the firſt always concludes in the key-note, the other frequently concludes a little below it (F). This key-note, in ſpeaking, is generally the ſound given at the outſet of every complete ſentence or period; and it may be obſerved on ſome occaſions to vary its pitch through the limits of a muſical interval of a conſiderable magnitude. The tones, that fall a little lower than the key at the cloſe of a ſentence or period, are called *cadences.* Theſe cadences, if we are accurate in our diſtinctions, will, with reſpect to their offices, be found of two kinds; though they meet ſo frequently together, that it may be beſt to conceive them only as anſwering a double purpoſe. One of theſe offices is to aſſiſt the ſenſe, and the other to decorate the modulation. An account of the firſt may be ſeen in the ſection on *Pauſes;* and the latter will be found to ſhow itſelf pretty frequently in every thing grave and plaintive, or in poetic deſcription and other highly ornamented language, where the mind is by its influence brought to feel a placid kind of dignity and ſatisfaction. Theſe two cadences, therefore, may be conveniently diſtinguiſhed by applying to them reſpectively the epithets *ſignificant* and *ornamental.*

We have already obſerved, that reading ſhould in ſome things differ from ſpeaking; and the particular under conſideration ſeems to be one which ought to vary a little in theſe arts. For,

Modulation in reading ſerves a twofold purpoſe. At the ſame time that it gives pleaſure to the ear on the principles of harmony, it contributes through that medium to preſerve the attention. And ſince written language (when not purely dramatical) is in general more elegant in its conſtruction, and muſical in its periods, than the oral one; and ſince many intereſting particulars are wanting in reading, which are preſent in ſpeaking, that contribute greatly to fix the regard of the hearer; it ſeems reaſonable, in order to do juſtice to the language, and in part to ſupply the incitements of attention juſt alluded to, that in the former of theſe two articles a modulation ſhould be uſed ſomething more harmonious and artificial than in the latter. Agreeably to this reaſoning, it is believed, we ſhall find every reader, on a narrow examination, adopt more or leſs a modulation thus ornamented: though, after all, it muſt be acknowledged there are better grounds to believe, that the

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eſteem theſe properties as reſpectively belonging to the eſtabliſhed laws of *pronunciation* and the *imitative* branch of expreſſion mentioned in the end of the enſuing head.

(E) From what accounts we have remaining of the modulation of the ancients, it appears to have been highly ornamented, and apparently ſomething not unlike our modern *recitative;* particularly that of their theatric declamation was muſic in its ſtricteſt ſenſe, and accompanied with inſtruments. In the courſe of time and the progreſs of refinement, this modulation became gradually more and more ſimple, till it has now loſt the genius of muſic, and is entirely regulated by taſte. At home here, every one has heard the *ſing-ſong* cant, as it is called, of

Ti ti dum dum, ti ti dum ti dum de,
Ti dum ti dum, ti dum ti dum dum de;

which, though diſguſtful now to all but mere ruſtics on account of its being out of faſhion, was very probably the favourite modulation in which heroic verſes were recited by our anceſtors. So fluctuating are the taſte and practices of mankind! But whether the power of language over the paſſions has received any advantage from the change juſt mentioned, will appear at leaſt very doubtful, when we recollect the ſtories of its former triumphs, and the inherent charms of muſical ſounds.

(F) As muſical ſounds have always an harmonical reference to a key or fundamental note, and to which the mind is ſtill ſecretly attending, no piece of muſic would appear perfect, that did not cloſe in it, and ſo naturally put an end to expectation. But as the tones uſed in ſpeech are not muſical, and therefore cannot refer harmonically to any other ſound, there can be no neceſſity that this terminating ſound (and which we immediately below term the *cadence*) ſhould either be uſed at all, or follow any particular law as to form, &c. farther than what is impoſed by taſte and cuſtom.

the practice has been hitherto directed intuitively by nature, than that it was discovered by the inductions of reason. We shall conclude this head with a rule for modulation in reading. "In every thing dramatic, colloquial, or of simple narrative, let your modulation be the same as in speaking; but when the subject is flowery, solemn, or dignified, add something to its harmony diversify the key-note, and increase the frequency of cadences in proportion to the merit of the composition."

It will readily be seen, that the precepts here drawn from a comparison between speaking and reading, would be very inadequate, were they left destitute of the assistance of *taste*, and the opportunity of *frequently hearing and imitating masterly readers*. And indeed, to these two great auxiliaries we might very properly have referred the whole matter at once, as capable of giving sufficient directions, had we not remembered that our plan required us to found several of our rules as much on the principles of a philosophical analysis, as on those more familiar ones which will be found of greater efficacy in real practice.

5 Expression as to the tones of the voice.

IV. *Expression.* 1. There is no composition in music, however perfect as to key and melody, but, in order to do justice to the subject and ideas of the author, will require, in the performing, something more than an exact adherence to *tune* and *time*. This something is of a nature, too, which perhaps can never be adequately pointed out by any thing graphic, and results entirely from the taste and feeling of the performer. It is that which chiefly gives music its power over the passions, and characterises its notes with what we mean by the words *sweet*, *harsh*, *dull*, *lively*, *plaintive*, *joyous*, &c. for it is evident every sound, considered abstractedly, without any regard to the movement, or high and low, may be thus modified. In practical music, this commanding particular is called *Expression;* and as we find certain tones analogous to it frequently coalescing with the modulation of the voice, which indicate our passions and affections (thereby more particularly pointing out the meaning of what we say) the term is usually applied in the same sense to speaking and reading.

These tones are not altogether peculiar to man.—Every animal, that is not dumb, has a power of making several of them. And from their being able, unassisted by words, to manifest and raise their kindred emotions, they constitute a kind of language of themselves. In this language of the heart man is eminently conversant; for we not only understand it in one another, but also in many of the inferior creatures subjected by providence to our service.

The expression here illustrated is one of the most essential articles in good reading, since it not only gives a finishing to the sense, but, on the principles of sympathy and antipathy, has also a peculiar efficacy in interesting the heart. It is likewise an article of most difficult attainment; as it appears from what follow, that a masterly reader ought not only to be able to incorporate it with the modulation properly as to *quality*, but in any degree as to *quantity*.

Every thing written being a proper imitation of speech, expressive reading must occasionally partake of all its tones. But from what was said above, of the difference between reading and speaking, it follows, that these signs of the emotions should be less strongly characterised in the former article than in the latter. Again, as several of these tones of expression are in themselves agreeable to the mind, and raise in us agreeable emotions (as those of *pity*, *benevolence*, or whatever indicates *happiness* and *goodness* of heart), and others disagreeable (as those of a *boisterous*, *malevolent*, and *depraved* nature, &c.) it farther appears, since reading is an art *improving* and not *imitating* nature, that, in whatever degree we abate the expressions of the tones above alluded to in the first case, it would be eligible to make a greater abatement in the latter. But as to the quantities and proportional magnitudes of these abatements, they, like many other particulars of the same nature, must be left solely to the taste and judgment of the reader.

To add one more remark, which may be of service on more accounts than in suggesting another reason for the doctrine above. Let it be remembered, that though in order to acquit himself agreeably in this article of expression, it will be necessary every reader should *feel* his subject as well as *understand* it; yet, that he may preserve a proper ease and masterliness of delivery, it is also necessary he should guard against discovering too much emotion and perturbation.

From this reasoning we deduce the following rule, for the tones which indicate the passions and emotions.

"In reading, let all your tones of expression be borrowed from those of common speech, but something more faintly characterised. Let those tones which signify any disagreeable passion of the mind, be still more faint than those which indicate their contrary; and preserve yourself so far from being affected with the subject, as to be able to proceed through it with that peculiar kind of ease and masterliness, which has its charms in this as well as every other art."

We shall conclude this section with the following observation, which relates to speaking as well as reading. When words fall in our way, whose "sounds seem an echo to the sense," as *squirr*, *buzz*, *hum*, *rattle*, *hiss*, *jar*, &c. we ought not to pronounce them in such a manner as to heighten the imitation, except in light and ludicrous subjects. For instance, they should not in any other case be sounded *squir.r.r—buzz.z.z—hum.m.m—r.r.rattle*, &c. On the contrary, when the imitation lies in the *movement*, or *flow and structure of a whole passage* (which frequently happens in poetry), the delivery may always be allowed to give a heightening to it with the greatest propriety; as in the following instances, out of a number more which every experienced reader will quickly recollect.

In these deep solitudes and awful cells,
Where heav'nly pensive Contemplation dwells,
And ever-musing Melancholy reigns—
POPE's *Eloisa to Abelard.*

With easy course
The vessels glide unless their speed be stopp'd
By dead calms, that oft lie on these smooth seas.
DYER's *Fleece.*

Softly sweet in Lydian measure,
Soon he sooth'd her soul to pleasure.
DRYDEN's *Ode on St Cecilia's day.*

Still

Still gathering force it ſmokes, and, urg'd amain,
Whirls, leaps, and *thunders down impetuous to the plain.*
POPE's *Iliad*, b. 13.

For who to dumb forgetfulneſs a prey,
This pleaſing anxious being ere reſign'd,
Left the warm precincts of the cheerful day,
Nor caſt *one longing ling'ring look behind?*
GRAY's *Elegy*.

6
Expreſſion as to the face and geſture.

2. Beſides the particular tones and modifications of voice above deſcribed, which always accompany and expreſs our inward agitations, nature has in theſe caſes endowed us with another language, which, inſtead of the ear, addreſſes itſelf to the eye, thereby giving the communications of the heart a double advantage over thoſe of the underſtanding, and *us* a double chance to preſerve ſo ineſtimable a bleſſing. This language is what ariſes from the different, almoſt involuntary, movements and configurations of the face and body in our emotions and paſſions, and which, like that of tones, every one is formed to underſtand by a kind of intuition.

When men are in any violent agitation of mind, this co-operating *expreſſion* (as it is called) of face and geſture is very ſtrongly marked, and totally free from the mixture of any thing which has a regard to gracefulneſs, or what appearance they may make in the eyes of others. But in ordinary converſation, and where the emotions are not ſo warm, faſhionable people are perpetually inſinuating, into their countenance and action, whatever they imagine will add to the eaſe and elegance of their deportment, or impreſs on the ſpectator an idea of their amiableneſs and breeding. Now, though the above mentioned natural organical ſigns of the emotions ſhould accompany every thing ſpoken, yet from what was obſerved in the introductory part of this article (like the tones we have juſt treated upon), they ſhould in reading be much leſs ſtrongly expreſſed, and thoſe ſuffer the greateſt diminution that are in themſelves the moſt ungainly. And as it was in the laſt ſection recommended to the reader to preſerve himſelf as far from being affected in all paſſionate ſubjects as to be able to keep a temperate command over the various affections of the voice, &c. ſo under the ſanction of this ſubordinate feeling he may accompany his delivery more frequently with any eaſy action or change of face, which will contribute to ſet off his manner, and make it agreeable on the principles of art.

As theſe calm decorations of action (as we may call them) are not altogether natural, but have their riſe from a kind of inſtitution, they muſt be modelled by the practices of the polite. And though mankind differ from one another ſcarce more in any particular than in that of talents for adopting the graceful actions of the body, and hence nothing determinate can be ſaid of their nature and frequency, yet even thoſe, moſt happily calculated to acquit themſelves well in their uſe, might profit by conſidering that it is better greatly to abridge the diſplay, than to over-do it ever ſo little. For the peculiar modeſty of deportment with which the inhabitants of this kingdom are endowed, makes us in common endeavour to ſuppreſs many ſigns of an agitated mind; and in ſuch caſes the bodily ones in particular are very ſparingly uſed. We have alſo a natural and rooted diſlike to any kind of affectation; and to no ſpecies, that we can recollect, a greater, than to that which is ſeen in a perſon who pretends to mimicry and courtly geſture, without poſſeſſing the advantages and talents they require; and of which not many people, comparatively ſpeaking, have any remarkable ſhare.

The inference of this is too obvious to need drawing out, and we would particularly recommend it to the conſideration of thoſe readers who think the common occurrences of a newſpaper, &c. cannot be properly delivered without a good deal of elbow-room.

Although it is impoſſible to come to particulars in any directions of this kind, yet there is one article of our preſent ſubject on which a ſerviceable remark may be made. In ordinary diſcourſe, when we are particularly preſſing and earneſt in what we ſay, the eye is naturally thrown upon thoſe to whom we addreſs ourſelves: And in reading, a turn of this organ now and then upon the hearers, when any thing very remarkable or intereſting falls in the way, has a good effect in gaining it a proper attention, &c. But this ſhould not be too frequently uſed; for if ſo, beſides its having a tendency to confound the natural importance of different paſſages, it may not be altogether agreeable to ſome to have their own reflections broken in upon by a ſignal, which might be interpreted to hint at their wanting regulation.

One obſervation more, and then we ſhall attempt to recapitulate the ſubſtance of this ſection in the form of a precept. Though it is, when ſtrictly examined, inconſiſtent, both in ſpeaking and reading, to imitate with action what we are deſcribing, yet as in any thing *comic* ſuch a practice may ſuggeſt ideas that will *accord* with thoſe of the ſubject, it may there be now and then indulged in either of theſe articles.

"In a manner ſimilar to that directed with regard to tones, moderate your bodily expreſſions of the ſigns of the emotions. And in order to ſupply, as it were, this deficiency, introduce into your carriage ſuch an eaſy gracefulneſs, as may be conſiſtent with your acquirements in theſe particulars, and the neceſſary dread which ſhould ever be preſent of falling into any kind of affectation or grimace."

V. *Pauſes*. Speech conſiſting of a ſucceſſion of diſtinct words, muſt naturally be liable (both from a kind of accident, and a difficulty there may be in beginning certain ſounds or portions of phraſes immediately on the ending of certain others) to ſeveral ſmall intermiſſions of voice; of which, as they can have no meaning, nothing farther need here be ſaid. There are, however, ſome pauſes, which the ſenſe neceſſarily demands; and to theſe the ſubſtance of this ſection is directed.

The pauſes are in part to diſtinguiſh the members of ſentences from one another, the terminations of complete periods, and to afford an opportunity for taking breath. Beſides this, they have a very graceful effect in the modulation, on the ſame account they are ſo eſſential in muſic.—In both articles, like blank ſpaces in pictures, they ſet off and render more conſpicuous whatſoever they disjoin or terminate.

Were language made up of nothing but ſhort colloquial ſentences, theſe pauſes, though they might do no harm, and would generally be graceful, would however be ſuperſeded as to uſe by the completeneſs and *narrowneſs*,

rowness, as we may say, of the meaning. But in more diffuse language, composed of several detached sentences, and which require some degree of attention in order to take in the sense, the intermissions of voice under consideration are of the greatest service, by signifying to the mind the progress and completion of the whole passage. Now, though in extensive and differently formed periods there may be members whose completeness of sense might be conceived of various degrees, and hence might seem to require a set of pauses equally numerous; yet, since the sense does not altogether depend upon these intermissions, and their ratios to one another, if capable of being properly defined, could not be accurately observed, grammarians have ventured to conceive the whole class of pauses as reducible to the four or five kinds now in use, and whose marks and ratios are well known (G); presuming that under the eye of taste, and with the assistance of a particular to be next mentioned, they would not fail in all cases to suggest intermissions of voice suitable to the sense. But in many of these extensive and complex periods, rounded with a kind of redundancy of matter, where the full sense is long suspended, and the final words are not very important, there would be some hazard of a misapprehension of the termination, had we not more evident and infallible notice of it than that which is given by the pause. This notice is the *cadence*, referred to in the section on *Modulation;* which, as is there observed, besides the ornamental variety it affords, appears from these remarks to be a very necessary and serviceable article in perspicuous delivery.

As this cadence naturally accompanies the end of every entire sense, circumstanced as above-mentioned, it may sometimes fall before the *semicolon*, but more generally before the *colon*, as well as the period: For these marks are often found to terminate a complete sense; and in these cases, the relation what follows has to what went before, is signified to the mind by the relative shortness of the stop, and the form of introducing the additional matter. Nor can any bad consequence arise from thus founding distinctions on ratios of time, which it may be said are too nice to be often rightly hit upon: for if a confusion should happen between that of the *colon* and *period*, there is perhaps so trifling a difference between the nature of the passages they succeed, as to make a small inaccuracy of no consequence. And as to the rests of the semicolon and period, it will not be easy to mistake about them, as their ratio is that of two to one. Add to this the power which the matter and introduction of the subsequent passages have to rectify any slight error here made, and we shall be fully satisfied, that the pauses as usually explained, with the cadence above described, and a proper knowledge of the language, will convey sufficient information to the understanding of the constructive nature of the passages after which they are found.

It may be observed, that in natural speech, according to the warmth and agitation of the speaker, the rests are often short and injudiciously proportioned, and hence that every thing thus delivered cannot be so graceful as it might have been from a proper attention to their magnitude and effects.

Pauses then, though chiefly subjected to the sense are, as was remarked at the outset, serviceable in beautifying the modulation, &c.—And since books are often inaccurately printed as to points, and people's tastes differ some little about their place and value, it appears, that, "although in reading great attention should be paid to the stops, yet a greater should be given to the sense, and their correspondent times occasionally lengthened beyond what is usual in common speech; which observation contains all that we shall pretend to lay down by way of rule for the management of pauses in the delivery of written language.

As there are two or three species of writing, which have something singular in them, and with regard to the manner in which they should be read, a few *particular* remarks seem necessarily required, we shall conclude this article with laying them before the reader:

1. Of PLAYS, and such like CONVERSATION-PIECES. Writings of this kind may be considered as intended for two different purposes; one to unfold subject matter for the exercise of theatric powers; and the other to convey amusement, merely as fable replete with pleasing incidents and characteristic manners. Hence there appears to be great latitude for the display of a *consistent* delivery of these performances: for while, on one hand, a good reader of very inferior talents for mimicry may be heard with a tolerable degree of pleasure; on the other, if any person is qualified to give a higher degree of life and force to the dialogue and characters by delivering them as an actor, he must be fully at liberty to start from the confinement of a chair to a posture and area more suited to his abilities; and, if he be not deceived in himself, his hearers will be considerable gainers by the change.—The next article is,

2. SERMONS or other ORATIONS, which in like manner may be conceived intended for a double purpose. First, as matter for the display of oratorical powers; and, secondly, as persuasive discourses, &c. which may be

(G) Supposing the *comma* (,) one *time*, the *semicolon* (;) will be two; the *colon* (:) three, and the *period* (.) as also the marks of *interrogation* (?) and *admiration* (!) four of these times. The blank line (— or ---), and the *breaks* between *paragraphs*, intimate still greater times; and by the same analogy may be reckoned a double and quadruple period respectively. Now and then these blank lines are placed immediately *after* the ordinary points, and then they are conceived only as separating for the *eye* the different natures of the matter;—as a question from an answer,—precept from example,—premises from inferences, &c. in which case their import is evident. But of late some authors have not scrupled to confound these distinctions; and to make a blank serve for all the pauses universally, or the mark of an indefinite rest, the quantity of which is left to the determination of the reader's taste. A practice, it is imagined, too destructive of the intended precision of these typical notices to be much longer adopted.

Reading. be read like any other book. Therefore it appears (for reafons fimilar to thofe above) that according as clergymen are poffeffed of the talents of elocution, they may confiftently either rehearfe their fermons, in the manner of an extemporary harangue, or deliver them in the more humble capacity of one who is content to entertain and inftruct his hearers with reading to them his own or fome other perfon's written difcourfe.

That either of thefe manners of delivery (or a mixture of them), in either of the cafes above-mentioned, is agreeable, we find on a careful examination. For this will fhow us how frequently they run into one another; and that we are fo far from thinking fuch tranfitions wrong, that, without a particular attention that way, we fcarce ever perceive them at all.

3. POETRY is the next and laft object of our prefent remarks. This is a very peculiar kind of writing, and as much different from the language of ordinary difcourfe as the movements of the dance are from common walking. To ornament and improve whatever is fubfervient to the pleafures and amufements of life, is the delight of human nature. We are alfo pleafed with a kind of *excefs* in any thing which has a power to amufe the fancy, infpire us with enthufiafm, or awaken the foul to a confcioufnefs of its own importance and dignity. Hence one pleafure, at leaft, takes its rife, that we feel in contemplating the performances of every art; and hence the language of poetry, confifting of a meafured rythmus, harmonious cadences, and an elevated picturefque diction, has been ftudied by the ingenious, and found to have a powerful influence over the human breaft in every age and region. There is fuch an affinity between this language and mufic, that they were in the earlier ages never feparated; and though modern refinement has in a great meafure deftroyed this union, yet it is with fome degree of difficulty in rehearfing thefe divine compofitions we can forget the finging of the mufe.

From thefe confiderations (and fome kindred ones mentioned in fect. iii.) in repeating verfes, they are generally accompanied with a modulation rather more ornamented and mufical than is ufed in any other kind of writing. And accordingly, as there feems to be the greateft propriety in the practice, the rule for this particular in the fection juft referred to, will allow any latitude in it that can gain the fanction of tafte and pleafure.

Rhymes in the lighter and more foothing provinces of poetry are found to have a good effect; and hence (for reafons like thofe juft fuggefted) it is certainly abfurd to endeavour to fmother them by a feeble pronunciation, and running one line precipitately into another, as is often affected to be done by many of our modern readers and fpeakers. By this method they not only deftroy one fource of pleafure intended by the compofer (which though not great is neverthelefs genuine), but even often fupply its place with what is really difagreeable, by making the rhymes, as they are interruptedly perceived, appear accidental blemifhes of a different ftyle, arifing from an unmeaning recurrence of fimilar founds. With regard then to reading verfes terminated with rhyme, the common rule, which directs to pronounce the final words *full*, and to diftinguifh them by a flight paufe even where there is none required by the fenfe, feems the moft rational, and confequently moft worthy, of being followed. See DECLAMATION, NARRATION, and ORATORY.

Reading || Reality.

READING, a town of Berkfhire in England, pleafantly feated on the river Kenneth, near its confluence with the Thames. It had once a fine rich monaftery, of which there are large ruins remaining. It had alfo a caftle built by King Henry I. but it was afterwards levelled with the ground. It is a corporation, enjoys feveral privileges, and fends two members to parliament. The two navigable rivers render it a fit place for trade. W. Long. 1. 0. N. Lat. 51. 25.

READINGS, or *Various Readings*, in criticifm, are the different manners of reading the texts of authors in ancient manufcripts, where a diverfity has arifen from the corruption of time, or the ignorance of copyifts. A great part of the bufinefs of critics lies in fettling the readings by confronting the various readings of the feveral manufcripts, and confidering the agreement of the words and fenfe.

Readings are alfo ufed for a fort of commentary or glofs on a law, text, paffage, or the like, to fhow the fenfe an author takes it in, and the application he conceives to be made of it.

RE-AGGRAVATION, in the Romifh ecclefiaftical law, the laft monitory, publifhed after three admonitions, and before the laft excommunication. Before they proceed to fulminate the laft excommunication, they publifh an aggravation, and a re-aggravation. Fevret obferves, that in France the minifter is not allowed to come to re-aggravation, without the permiffion of the bifhop or official, as well as that of the lay judge. See EXCOMMUNICATION.

REAL, CÆSAR VICHARD DE ST, a polite French writer, fon of a counfellor to the fenate of Chamberry in Savoy. He came young to France, diftinguifhed himfelf at Paris by feveral ingenious productions, and refided there a long time without title or dignity, intent upon literary purfuits. He died at Chamberry in 1692, advanced in years, though not in circumftances. He was a man of great parts and penetration, a lover of the fciences, and particularly fond of hiftory. A complete edition of his works was printed at Paris, in 3 vols 4to, 1745, and another in 6 vols 12mo.

REAL Prefence. See TRANSUBSTANTIATION.

REALGAR, a preparation of arfenic. See ARSENIC, CHEMISTRY *Index*.

REALISTS, a fect of fchool philofophers formed in oppofition to the Nominalifts. Under the Realifts are included the Scotifts, Thomifts, and all excepting the followers of Ocham. Their diftinguifhing tenet is, that univerfals are realities, and have an actual exiftence out of an idea or imagination; or, as they exprefs it in the fchools, *a parte rei*; whereas the nominalifts contend, that they exift only in the mind, and are only ideas, or manners of conceiving things.—Dr Odo, or Oudard, a native of Orleans, afterwards abbot of St Martin de Tournay, was the chief of the fect of the realifts. He wrote three books of dialectics, where, on the principles of Boëthius and the ancients, he maintained that the object of that art is things, not words; whence the fect took its rife and name.

REALITY, in the fchools, a diminutive of *res*, "thing," firft ufed by the Scotifts, to denote a thing which may exift of itfelf; or which has a full and abfolute being of itſelf, and is not conſidered as a part of any other.

REALM, a country which gives its head or governor the denomination of a *king*.

RE-ANIMATION means the reviving or reſtoring to life thoſe who are apparently dead. Sudden death is dreaded by every human being, and it is one of thoſe evils againſt which the Church of England prays in her Litany. Accidents, however, cannot always be prevented; but, after they have happened, it is often poſſible to prevent their effects. This, by the eſtabliſhment of what with great propriety has been called the *Humane Society*, has been abundantly proved: for, in the courſe of 12 years immediately after their inſtitution, they were the means of ſaving the lives of 850 perſons, who otherwiſe would in all human probability have been loſt to the community. Since that period, they have ſaved many more; and various perſons, even in the moſt diſtant parts of the kingdom, by following their directions, have done the ſame. To preſerve one human being from premature death, we muſt conſider as of the utmoſt conſequence both as citizens and Chriſtians; how much more the preſervation of thouſands. It appears from the writings of Doctors Mead, Winſlow, Bruhier, Fothergill, Haller, Lecat, Tiſſot, Van Engelen, Gummer, and others, that they had prepared the way for inſtitutions ſimilar to the Humane Society: for in their works they have elucidated the principles on which they go, and furniſhed directions for the practice they favour. See DEATH, *Premature INTERMENT*, and DROWNING.

REAR, a term frequently uſed in compoſition, to denote ſomething behind, or backwards, in reſpect of another; in oppoſition to *van*.

REAR of an Army, ſignifies, in general, the hindermoſt part of an army, battalion, regiment, or ſquadron; alſo the ground behind either.

REAR-Guard, is that body of an army which marches after the main-body; for the march of an army is always compoſed of an advance-guard, a main body, and a rear-guard; the firſt and laſt commanded by a general. The old grand guards of the camp always form the rear-guard of the army, and are to ſee that every thing come ſafe to the new camp.

REAR Half files, are the three hindmoſt ranks of the battalion, when it is drawn up ſix deep.

REAR-Line, of an army encamped, is always 1200 feet at leaſt from the centre line; both of which run parallel to the front line, as alſo to the reſerve.

REAR-Rank, is the laſt rank of a battalion, when drawn up, and generally 16 or 18 feet from the centre-line when drawn in open order.

REASON, a faculty or power of the mind, whereby it diſtinguiſhes good from evil, truth from falſehood. See METAPHYSICS.

REASONING, RATIOCINATION, the exerciſe of that faculty of the mind called *reaſon*; or it is an act or operation of the mind, deducing ſome unknown propoſition from other previous ones that are evident and known. See LOGIC, Part III.

REAUMUR, RENE ANTOINE FERCHAULT, SIEUR DE, a perſon diſtinguiſhed for his laborious reſearches into natural knowledge, was born at Rochelle in 1683, of a family belonging to the law. After having finiſhed his early ſtudies in the place of his birth, he began a courſe of philoſophy at Poitiers, and of civil law at Bourges; but ſoon relinquiſhed the latter, to apply himſelf, according to his taſte, to mathematics, phyſics, and natural hiſtory. Being come to Paris, he was received into the Academy of Sciences in 1708. From that hour he was wholly employed in natural hiſtory, to which his inclination particularly led him, and his inquiries were not confined to any one part of it. His memoirs, his obſervations, his diſcoveries on the formation of ſhells, ſpiders, muſcles, the marine flea, the berry which affords the purple colour, and on the cauſe of the numbneſs of the torpedo, excited the curioſity of the public, and early procured our author the character of an able, curious, and entertaining naturaliſt. Filled with zeal for the welfare and advantage of ſociety, and the progreſs and perfection of arts, he endeavoured in all his reſearches to promote the public good. We were indebted to him for the diſcovery of the Turquois mines in Languedoc. He alſo found out a ſubſtance, which is uſed to give falſe ſtones a colour, which is obtained from a certain fiſh called in the French *Able* or *Ablete* * on account of its whiteneſs, and which is the *Bleak* or *Blay* of our writers †. His experiments on the art of turning iron into ſteel obtained him a penſion of 12,000 livres; and this reward was to be continued to the Academy to ſupport the expence which might accrue in this art.

He continued his inquiries on the art of making tin and porcelain ‡, and endeavoured to render our thermometers more uſeful than thoſe of former times: he compoſed a curious hiſtory of rivers where gold duſt is found in France; and gave ſo ſimple and eaſy a detail of the art of gathering this duſt, that perſons have been employed for that purpoſe.

He alſo made curious and important obſervations on the nature of flints, on the banks of foſſil ſhells, from whence is obtained in Touraine an excellent manure for land; as likewiſe on birds and their preſervation, on their method of building neſts; on inſects; and a great number of other ſubjects, not leſs curious than uſeful.

He imagined at firſt, that a certain varniſh would keep eggs freſh; but the waſte of time and money, &c. ſhowed him the inconveniences of ſuch a proceſs. He afterwards adopted the method practiſed for time immemorial in Greece and the iſlands of the Archipelago, which is to ſteep or immerſe eggs in oil, or melted fat; by this means, not being expoſed to the air or to froſt, they are well preſerved, and contract no bad ſmell. Another experiment ſtill more important, made by our author, was to introduce into France the art of hatching fowls and birds, as practiſed in Egypt, without covering the eggs. Active, ſedulous, and attentive, he was early in his ſtudy, often at ſix in the morning. Exact in his experiments and obſervations, he let no circumſtance eſcape him. His writings muſt be of great uſe to future philoſophers. In ſociety, he was diſtinguiſhed through life for his modeſt and agreeable behaviour. His probity, benevolence, goodneſs of heart, and other amiable qualities, as well natural as acquired, endeared him to his countrymen. He died in the 76th year of his age, on the 18th of October 1757, and left this world filled with ſentiments of piety. His death was the conſequence of a fall, which happened at the caſtle of Barnardiere on the Maine, where he went to paſs his vacation. He bequeathed to the Academy of Sciences his

* See Belon, 319. and *Pennant's Zoology*, vol. iii. p. 315.

† See *Cyprinus*, N° 9.

‡ See *Porcelain*.

his manufcripts and all his natural productions. His works are, 1. A very great number of memoirs and obfervations on different parts of natural hiftory; they are printed in the collections of the Academy of Sciences. 2. A large work printed feparately in 6 vols in 4to, intitled, A Natural Hiftory of Infects. This important work contains a defcription of vaft numbers of caterpillers, moths, gall infects, flies with two and four wings, lady birds, and thofe ephemeron flies which live only in that form a few hours; and laftly, of thofe fingular and wonderful infects which are called *polypes*, which being cut into feveral pieces, each piece lives, grows, and becomes an infect, and affords to our eyes a great number of prodigies*. The works of M. de Reaumur are exact, curious, interefting, and very ingenious. They are written with much candour, clearnefs, and elegance; but it muft be acknowledged his manner is fomewhat too diffufe. But we muft not deceive the reader; he often raifes our expectations, and does not give us all the fatisfaction we promife ourfelves from his writings. His method of raifing poultry, in particular, rather difappoints us. He fpared neither care, time, nor expence, to render it practicable: he flattered himfelf and his countrymen with the greateft hopes; but notwithftanding his affiduous induftry, and vaft charges, it proved abortive. The late M. l'Advocat recommended him to obtain better information from Egypt on the fubject; and if poffible to procure a perfon verfed in the art to inftruct him in it; but his death prevented the completion of the fcheme. If the native of Egypt had arrived, fhowed M. de Reaumur a better method than his own, and practifed it with fuccefs, as in his country, the community would have been benefited; on the other hand he would have feen, had it failed, that the climate of France was not proper for fuch experiments. M. Maillet, conful at Cairo, to whom Monfieur the regent had written to obtain the art, offered to fend over a native of Egypt, if the government would pay the expence of his voyage, and allow him a penfion of 1500 livres. M. Maillet rightly judged, when he preferred this method of proceeding. M. de Reaumur was not ignorant of the defign; but he flattered himfelf, that his efforts would be fuccefsful without further aid, and thought he fhould acquire fome honour. He certainly had great talents, induftry, fagacity, and every other requifite which are neceffary in fuch attempts; but it is morally impoffible that a fingle man, in a different climate, can attain fuch knowledge in an art as thofe who live in a more favourable country, and have had the experience of many ages to profit by: however M. de Reaumur may have been unfuccefsful, pofterity is indebted to him for his repeated trials. He has removed fome difficulties in the road, and thofe that travel it may difcover what he only faw at a diftance.

* See *Polypus*, *Helminthology Index*.

REAUMURIA, a genus of plants belonging to the pentandria clafs; and in the natural method ranking under the 13th order, *Succulentæ*. See BOTANY *Index*.

REBATE, or REBATEMENT, in *Commerce*, a term much ufed at Amfterdam for an abatement in the price of feveral commodities, when the buyer, inftead of taking time, advances ready money.

REBATEMENT, in *Heraldry*, a diminution or abatement, of the bearings in a coat of arms. See ABATEMENT.

REBELLION, *Rebellio*, among the Romans, was where thofe who had been formerly overcome in battle, and yielded to their fubjection, made a fecond refiftance: but with us it is generally ufed for the taking up of arms traiteroufly againft the king, whether by natural fubjects, or others when once fubdued; and the word *rebel* is fometimes applied to him who wilfully breaks a law; alfo to a villein difobeying his lord.

There is a difference between enemies and rebels. Enemies are thofe who are out of the king's allegiance: therefore fubjects of the king, either in open war, or rebellion, are not the king's enemies, but traitors. And David prince of Wales, who levied war againft Edw. I. becaufe he was within the allegiance of the king, had fentence pronounced againft him as a traitor and rebel. Private perfons may arm themfelves to fupprefs rebels, enemies, &c.

REBELLIOUS ASSEMBLY, is a gathering together of twelve perfons or more, intending or going about to practife or put in ufe unlawfully, of their own authority, any thing to change the law or ftatutes of the realm; or to deftroy the inclofures of any ground, or banks of any fifh-pond, pool, or conduit, to the intent the fame fhall lie wafte and void; or to deftroy the deer in any park, or any warren of conies, dove-houfes, or fifh in ponds; or any houfe, barns, mills, or bays; or to burn ftacks of corn; or abate rents, or prices of victuals, &c.

REBUS, an enigmatical reprefentation of fome name, &c. by ufing figures or pictures inftead of words, or parts of words. Camden mentions an inftance of this abfurd kind of wit in a gallant who expreffed his love to a woman named *Rofe Hill*, by painting in the border of his gown a rofe, a hill, an eye, a loaf, and a well; which, in the ftyle of the rebus, reads, "*Rofe Hill I love well.*" This kind of wit was long practifed by the great, who took the pains to find devices for their names. It was, however, happily ridiculed by Ben Johnfon, in the humorous defcription of Abel Drugger's device in the Alchemift; by the Spectator, in the device of Jack of Newberry; at which time the rebus, being raifed to fign-pofts, was grown out of fafhion at court.

REBUS is alfo ufed by the chemical writers fometimes to fignify four milk, and fometimes for what they call the ultimate matter of which all bodies are compofed.

REBUS, in *Heraldry*, a coat of arms which bears an allufion to the name of the perfon; as three caftles, for Caftleton; three cups, for Butler; three conies, for Conifby; a kind of bearings which are of great antiquity.

REBUTTER (from the Fr. *bouter*, i. e. *repellere*, to put back or bar), is the anfwer of defendant to plaintiff's *furrejoinder*; and plaintiff's anfwer to the rebutter is called a *furrebutter*: but it is very rare the parties go fo far in pleading.

Rebutter is alfo where a man by deed or fine grants to warranty any land or hereditament to another; and the perfon making the warranty, or his heir, fues him to whom the warranty is made, or his heir or affignee, for the fame thing; if he who is fo fued plead the deed or fine with warranty, and pray judgement, if the plaintiff fhall be received to demand the thing which he ought to warrant to the party againft the warranty in the deed, &c. this is called a *rebutter*. And if I grant to a te-grant to hold without impeachment of waſte, and afterwards implead him for waſte done, he may debar me of this action by ſhewing my grant, which is a rebutter.

RECAPITULATION, is a ſummary, or a conciſe and tranſient enumeration of the principal things inſiſted on in the preceding diſcourſe, whereby the force of the whole is collected into one view. See ORATORY, N° 37 and 127.

RECEIPT, or RECEIT, in *Commerce*, an acquittance, or diſcharge, in writing, intimating that the party has received a certain ſum of money, either in full for the whole debt, or in part, or on account.

RECEIVER, in *Pneumatics*, a glaſs veſſel for containing the thing on which an experiment in the air-pump is to be made.

RECEIVER, *receptor* or *receptator*, in *Law*, is commonly underſtood in a bad ſenſe, and uſed for ſuch as knowingly receive ſtolen goods from thieves, and conceal them. This crime is felony, and the puniſhment is tranſportation for 14 years.

RECENSIO, was an account taken by the cenſors, every luſtrum, of all the Roman people. It was a general ſurvey, at which the equites, as well as the reſt of the people, were to appear. New names were now put upon the cenſor's liſt, and old ones cancelled. The *recenſio*, in ſhort, was a more ſolemn and accurate ſort of *probatio*, and anſwered the purpoſe of a review, by ſhowing who were fit for military ſervice.

RECEPTACULUM, in *Botany*, one of the ſeven parts of fructification, defined by Linnæus to be the baſe which connects or ſupports the other parts.

RECEPTACULUM Chyli, or *Pecquet's Reſervatory*, the reſervoir or receptacle for the chyle, ſituated in the left ſide of the upper vertebra of the loins, under the aorta and the veſſels of the left kidney.

RECHABITES, a kind of religious order among the ancient Jews, inſtituted by Jonadab the ſon of Rechab, comprehending only his own family and poſterity. Their founder preſcribed them three things: firſt, not to drink any wine; ſecondly, not to build any houſes, but to dwell in tents; and thirdly, not to ſow any corn, or plant vines.

The Rechabites obſerved theſe rules with great ſtrictneſs, as appears from Jer. xxxv. 6, &c. Whence St Jerome, in his 13th epiſtle to Paulinus, calls them *monachi, monks*. Jonadab, their founder, lived under Jehoaſh, king of Judah, contemporary with Jehu king of Iſrael; his father Rechab, from whom his poſterity were denominated, deſcended from Raguel or Jethro, father-in-law to Moſes, who was a Kenite, or of the race of Ken: whence Kenite and Rechabite are uſed as ſynonymous in Scripture.

RECHEAT, in hunting, a leſſon which the huntſman plays on the horn, when the hounds have loſt their game, to call them back from purſuing a counter ſcent.

RECIPE, in *Medicine*, a preſcription, or remedy, ſo called becauſe always beginning with the word *recipe*, i. e. *take;* which is generally denoted by the abbreviature ℞. See *PRESCRIPTION, Extemporaneous*.

RECIPROCAL, in general, ſomething that is mutual, or which is returned equally on both ſides, or that affects both parties alike.

RECIPROCAL Terms, among logicians, are thoſe which have the ſame ſignification; and conſequently are convertible, or may be uſed for each other.

RECIPROCAL, in *Mathematics*, is applied to quantities which multiplied together produce unity. Thus $\frac{1}{x}$ and x, y and $\frac{1}{y}$, are reciprocal quantities. Likewiſe $\frac{1}{x}$ is ſaid to be the reciprocal of x, which is again the reciprocal of $\frac{1}{x}$.

RECIPROCAL Figures, in *Geometry*, thoſe which have the antecedents and conſequents of the ſame ratio in both figures.

RECIPROCAL Proportion, is when in four numbers the fourth is leſs than the ſecond by ſo much as the third is greater than the firſt, and *vice verſa*. See PROPORTION and ARITHMETIC, chap. vi. Great uſe is made of this reciprocal proportion by Sir Iſaac Newton and others, in demonſtrating the laws of motion.

RECITAL, in *Law*, means the rehearſal or making mention in a deed or writing of ſomething which has been done before.

RECITATIVO, or RECITATIVE, in *Muſic*, a kind of ſinging, that differs but little from ordinary pronunciation; ſuch as that in which the ſeveral parts of the liturgy are rehearſed in cathedrals; or that wherein the actors commonly deliver themſelves on the theatre at the opera, when they are to expreſs ſome action or paſſion; to relate ſome event; or reveal ſome deſign.

RECKENHAUSEN, a ſtrong town of Cologne, in Germany, in the middle territory of that name. The abbeſs of its nunnery has power of puniſhing offenders with death, and ſhe alone is obliged to the vow of chaſtity.

RECKONING, or a *Ship's RECKONING*, in *Navigation*, is that account whereby at any time it may be known where the ſhip is, and on what courſe or courſes ſhe is to ſteer, in order to gain her port; and that account taken from the log-board is called the *dead reckoning*. See NAVIGATION.

RECLAIMING, or RECLAMING, in our ancient cuſtoms, a lord's purſuing, proſecuting, and recalling, his vaſſal, who had gone to live in another place without his permiſſion.

Reclaiming is alſo uſed for the demanding of a perſon, or thing, to be delivered up to the prince or ſtate to which it properly belongs: when, by any irregular means, it is come into another's poſſeſſion.

RECLAIMING, in *Falconry*, is taming a hawk, &c. and making her gentle and familiar.

A partridge is ſaid to reclaim, when ſhe calls her young ones together, upon their ſcattering too much from her.

RECLINATION of a plane in dialling. See DIALLING.

RECLUSE, among the Papiſts, a perſon ſhut up in a ſmall cell of a hermitage, or monaſtery, and cut off, not only from all converſation with the world, but even with the houſe. This is a kind of voluntary impriſonment, from a motive either of devotion or penance.

The word is alſo applied to incontinent wives, whom their huſbands procure to be thus kept in perpetual impriſonment in ſome religious houſe.

Recluses were anciently very numerous. They took an oath never to ſtir out of their retreat: and having entered it, the biſhop ſet his ſeal upon the door; and the recluſe was to have every thing neceſſary for the ſupport of life conveyed to him through a window. If he was a prieſt, he was allowed a ſmall oratory, with a window, which looked into the church, through which he might make his offerings at the maſs, hear the ſinging, and anſwer thoſe who ſpoke to him; but this window had curtains before it, ſo that he could not be ſeen. He was allowed a little garden, adjoining to his cell, in which he might plant a few herbs, and breathe a little freſh air. If he had diſciples, their cells were contiguous to his, with only a window of communication, through which they conveyed neceſſaries to him, and received his inſtructions. If a recluſe fell ſick, his door might be opened for perſons to come in and aſſiſt him, but he himſelf was not to ſtir out.

RECOGNITION, in *Law*, an acknowledgment; a word particularly uſed in our law-books for the firſt chapter of the ſtatute 1 Jac. I. by which the parliament acknowledged, that, after the death of Queen Eliſabeth, the crown had rightfully deſcended to King James.

RECOGNIZANCE, in *Law*, is an obligation of record, which a man enters into before ſome court of record or magiſtrate duly authoriſed, with condition to do ſome particular act; as to appear at the aſſizes, to keep the peace, to pay a debt, or the like. It is in moſt reſpects like another bond: the difference being chiefly this, that the bond is the creation of a freſh debt or obligation *de novo*, the recognizance is an acknowledgment of a former debt upon record; the form whereof is, "that A. B. doth acknowledge to owe to our lord the king, to the plaintiff, to C. D. or the like, the ſum of ten pounds," with condition to be void on performance of the thing ſtipulated: in which caſe the king, the plaintiff, C. D. &c. is called the cognizee, *is cui cognoſcitur;* as he that enters into the recognizance is called the cognizor, *is qui cognoſcit*. This being certified to, or taken by the officer of ſome court, is witneſſed only by the record of that court, and not by the party's ſeal: ſo that it is not in ſtrict propriety a deed, though the effects of it are greater than a common obligation; being allowed a priority in point of payment, and binding the lands of the cognizor from the time of enrolment on record.

RECOIL, or REBOUND, the ſtarting backward of a fire-arm after an exploſion. Merſennus tells us, that a cannon 12 feet in length, weighing 6400 lb. gives a ball of 24 lb. an uniform velocity of 640 feet per ſecond. Putting, therefore, $W=6400$, $w=14$, $V=640$, and $v=$ the velocity with which the cannon recoils; we ſhall have (becauſe the momentums of the cannon and ball are equal) $Wv=wV$; and ſo $v=\frac{wV}{W}=\frac{24\times 64}{6400}=2{,}4$; that is, it would recoil at the rate of $2\frac{4}{10}$ feet per ſecond, if free to move.

RECOLLECTION, a mode of thinking, by which ideas ſought after by the mind are found and brought to view.

RECONNOITRE, in military affairs, implies to view and examine the ſtate of things, in order to make a report thereof.

Parties ordered to reconnoitre are to obſerve the country and the enemy; to remark the routes, conveniences, and inconveniences of the firſt; the poſition, march, or forces of the ſecond. In either caſe, they ſhould have an expert geographer, capable of taking plans readily: he ſhould be the beſt mounted of the whole, in caſe the enemy happen to ſcatter the eſcorte, that he may ſave his works and ideas. See WAR.

RECORD, an authentic teſtimony in writing, contained in rolls of parchment, and preſerved in a court of record. See COURT.

Trial by RECORD, a ſpecies of trial which is uſed only in one particular inſtance: and that is where a matter of record is pleaded in any action, as a fine, a judgment, or the like; and the oppoſite party pleads, *nul tiel record*, that there is no ſuch matter of record exiſting. Upon this, iſſue is tendered and joined in the following form, "and this he prays may be inquired of by the record, and the other doth the like;" and hereupon the party pleading the record has a day given him to bring it in, and proclamation is made in court for him to "bring forth the record by him in pleading alleged, or elſe he ſhall be condemned;" and, on his failure, his antagoniſt ſhall have judgement to recover. The trial, therefore, of this iſſue, is merely by the record: for, as Sir Edward Coke obſerves, a record or enrolment is a monument of ſo high a nature, and importeth in itſelf ſuch abſolute verity, that if it be pleaded that there is no ſuch record, it ſhall not receive any trial by witneſs, jury, or otherwiſe, but only by itſelf. Thus titles of nobility, as whether earl or not earl, baron or not baron, ſhall be tried by the king's writ or patent only, which is matter of record. Alſo in caſe of an alien, whether alien friend or enemy, ſhall be tried by the league or treaty between his ſovereign and ours; for every league or treaty is of record. And alſo, whether a manor be held in ancient demeſne or not, ſhall be tried by the record of domeſday in the king's exchequer.

RECORDE, ROBERT, phyſician and mathematician, was deſcended of a reſpectable family in Wales, and lived in the time of Henry VIII. Edward VI. and Mary. The time of his birth is not exactly known, but it muſt have been about the beginning of the 16th century, for he was entered of the univerſity of Oxford about 1525, and was elected fellow of All Souls college in 1531. As he made phyſic his profeſſion, he went to Cambridge, where he was honoured with the degree of doctor in that faculty in 1545, and very much eſteemed by all who were acquainted with him, for his extenſive knowledge of many of the arts and ſciences. He afterwards returned to Oxford, where he publicly taught arithmetic and mathematics, as he had done prior to his going to Cambridge, and that with great applauſe. It appears that he afterwards went to London, and was, it is ſaid, phyſician to Edward VI. and to Mary, to whom ſome of his books are dedicated; yet he died in the king's-bench priſon, Southwark, where he was confined for debt, in the year 1558, at a very immature age.

He publiſhed ſeveral works on mathematical ſubjects, chiefly in the form of dialogue between maſter and ſcholar, of which the following is a liſt.

The Pathway to Knowledge, containing the firſt principles

Recorde || Recovery. ciples of geometry, as they may moste aptly be applied unto practice, bothe for the use of Instrumentes Geometricall and Astronomicall, and also for projection of Plattes, much necessary for all sortes of men. Lond. 4to, 1551.

The Ground of Arts, teaching the perfect worke and practice of Arithmeticke, both in whole numbers and fractions, after a more easie and exact forme then in former time hath been set furth, 8vo, 1552.

The Castle of Knowledge, containing the Explication of the Sphere both Celestiall and Materiall, and divers other things incident thereto. With sundry pleasaunt proofes and certaine newe demonstrations not written before in any vulgare woorkes. Lond. fol. 1556.

The Whetstone of Witte, which is the second part of Arithmetike, containing the extraction of rootes; the Cossike practice, with the rules of equation; and the woorkes of surde numbers. Lond. 4to, 1557.

Wood says that he was the author of several pieces on physic, anatomy, politics, and divinity, but it is uncertain whether these were ever published. Sherburne says that he also published *Cosmographiæ Isagogen;* that he wrote a book, *De arte faciendi horologium*, and another *De usu globorum, et de statu temporum*, none of which we have had an opportunity of seeing.

RECORDER, a person whom the mayor and other magistrates of a city or corporation associate to them, for their better direction in matters of justice and proceedings in law; on which account this person is generally a counsellor, or other person well skilled in the law.

The recorder of London is chosen by the lord mayor and aldermen; and as he is held to be the mouth of the city, delivers the judgment of the courts therein, and records and certifies the city-customs. See LONDON, Nº 38.

RECOVERY, or *Common RECOVERY*, in English law, a species of assurance by matter of record; concerning the original of which it must be remarked, that common recoveries were invented by the ecclesiastics to elude the statutes of mortmain (see TAIL); and afterwards encouraged by the finesse of the courts of law in 12 Edward IV. in order to put an end to all fettered inheritances, and bar not only estates-tail, but also all remainders and reversions expectant thereon. We have here, therefore, only to consider, first, the *nature* of a common recovery; and, secondly, its *force* and *effect*.

Blackst. Comment. 1. A common recovery is a suit or action, either actual or fictitious: and in it the lands are recovered against the tenant of the freehold; which recovery, being a supposed abjudication of the right, binds all persons, and vests a free and absolute fee-simple in the recoverer. To explain this as clearly and concisely as possible, let us, in the first place, suppose David Edwards to be tenant of the freehold, and desirous to suffer a common recovery, in order bar all entails, remainders, and reversions, and to convey the same in fee-simple, to Francis Golding. To effect this, Golding is to bring an action against him for the lands; and he accordingly sues out a writ called a *præcipe quod reddat*, because these were its initial or most operative words when the law proceedings were in Latin. In this writ the demandant Golding alleges, that the defendant Edwards (here called the tenant) has no legal title to the land; but that he came into possession of it after one Hugh Hunt had turned the demandant out of it. The subsequent proceedings are made up into a record or recovery roll, in which the writ and complaint of the demandant are first recited: whereupon the tenant appears, and calls upon one Jacob Morland, who is supposed, at the original purchase, to have warranted the title to the tenant; and thereupon he prays, that the said Jacob Morland may be called in to defend the title which he so warranted. This is called the *voucher*, "vocatio," or calling of Jacob Morland to warranty; and Morland is called the *vouchee*. Upon this Jacob Morland, the vouchee, appears, is impleaded, and defends the title. Whereupon Golding the demandant desires leave of the court to imparl, or confer with the vouchee in private; which is (as usual) allowed him. And soon afterwards the demandant Golding returns to court; but Morland the vouchee disappears, or makes default. Whereupon judgment is given for the demandant Golding, now called the *recoverer*, to recover the lands in question against the tenant Edwards, who is now the recoveree: and Edwards has judgment to recover of Jacob Morland lands of equal value, in recompense for the lands so warranted by him, and now lost by his default; which is agreeable to the doctrine of warranty mentioned in the preceding chapter. This is called the *recompense*, or *recovery in value*. But Jacob Morland having no lands of his own, being usually the crier of the court, who, from being frequently thus vouched, is called the *common vouchee*, it is plain that Edwards has only a nominal recompense for the lands so recovered against him by Golding; which lands are now absolutely vested in the said recoverer by judgment of law, and seisin thereof is delivered by the sheriff of the county. So that this collusive recovery operates merely in the nature of a conveyance in fee-simple, from Edwards the tenant in tail to Golding the purchaser.

The recovery here described, is with a single voucher only; but sometimes it is with a double, treble, or farther voucher, as the exigency of the case may require. And indeed it is now usual always to have a recovery with double voucher at the least: by first conveying an estate of freehold to any indifferent person, against whom the *præcipe* is brought; and then he vouches the tenant in tail, who vouches over the common vouchee. For, if a recovery be had immediately against tenant in tail, it bars only such estate in the premises of which he is then actually seised; whereas if the recovery be had against another person, and the tenant in tail be vouched, it bars every latent right and interest which he may have in the lands recovered. If Edwards therefore be tenant of the freehold in possession, and John Barker be tenant in tail in remainder, here Edwards doth first vouch Barker, and then Barker vouches Jacob Morland the common vouchee; who is always the last person vouched, and always makes default; whereby the demandant Golding recovers the land against the tenant Edwards, and Edwards recovers a recompense of equal value against Barker the first vouchee; who recovers the like against Morland the common vouchee, against whom such ideal recovery in value is always ultimately awarded.

This supposed recompense in value is the reason why the issue in tail is held to be barred by a common recovery. For, if the recoveree should obtain a recompense

pense in lands from the common vouchee (which there is a possibility in contemplation of law, though a very improbable one, of his doing), these lands would supply the place of those so recovered from him by collusion, and would descend to the issue in tail. The reason will also hold with equal force as to most remainder-men and reversioners, to whom the possibility will remain and revert, as a full recompense for the reality which they were otherwise entitled to: but it will not always hold; and therefore, as Pigott says, the judges have been even *astuti*, in inventing other reasons to maintain the authority of recoveries. And, in particular, it hath been said, that though the estate-tail is gone from the recoveree; yet it is not destroyed, but only transferred, and still subsists; and will ever continue to subsist (by construction of law) in the recoverer, his heirs and assigns: and as the estate-tail so continues to subsist for ever, the remainders or reversions expectant on the determination of such estate-tail can never take place.

To such aukward shifts, such subtile refinements, and such strange reasoning, were our ancestors obliged to have recourse, in order to get the better of that stubborn statute *de donis*. The design for which these contrivances were set on foot, was certainly laudable; the unrivetting the fetters of estates-tail, which were attended with a legion of mischiefs to the commonwealth: but, while we applaud the end, we cannot but admire the means. Our modern courts of justice have indeed adopted a more manly way of treating the subject; by considering common recoveries in no other light than as the formal mode of conveyance by which tenant in tail is enabled to aliene his lands. But, since the ill consequences of fettered inheritances are now generally seen and allowed, and of course the utility and expedience of setting them at liberty are apparent, it hath often been wished that the process of this conveyance was shortened, and rendered less subject to niceties, by either totally repealing the statute *de donis;* which perhaps, by reviving the old doctrine of conditional fees, might give birth to many litigations: or by vesting in every tenant in tail, of full age, the same absolute fee-simple at once, which now he may obtain whenever he pleases, by the collusive fiction of a common recovery; though this might possibly bear hard upon those in remainder or reversion, by abridging the chances they would otherwise frequently have, as no recovery can be suffered in the intervals between term and term, which sometimes continue for near five months together: or, lastly, by empowering the tenant in tail to bar the estate-tail by a solemn deed, to be made in term-time, and enrolled in some court of record; which is liable to neither of the other objections, and is warranted not only by the usage of our American colonies, but by the precedent of the statute 21 Jac. I. c. 19. which, in the case of a bankrupt tenant in tail, empowers his commissioners to sell the estate at any time, by deed indented and enrolled. And if, in so national a concern, the emoluments of the officers concerned in passing recoveries are thought to be worthy attention, those might be provided for in the fees to be paid upon each enrollment.

2. The force and effect of common recoveries may appear, from what has been said, to be an absolute bar not only of all estates tail, but of remainders and reversions expectant on the determination of such estates. So that a tenant in tail may, by this method of assurance, convey the lands held in tail to the recoverer, his heirs and assigns, absolutely free and discharged of all conditions and limitations in tail, and of all remainders and reversions, But, by statute 34 and 35 H. VII. c. 20. no recovery had against tenant in tail of the king's gift, whereof the remainder or reversion is in the king, shall bar such estate-tail, or the remainder or reversion of the crown. And by the statute 11 H. VII. c. 20. no woman, after her husband's death, shall suffer a recovery of lands settled on her by her husband, or settled on her husband and her by any of his ancestors. And by statute 14 Eliz. c. 8. no tenant for life, of any sort, can suffer a recovery so as to bind them in remainder or reversion. For which reason, if there be tenant for life, with remainder in tail, and other remainders over, and the tenant for life is desirous to suffer a valid recovery, either he, or the tenant to the *præcipe* by him made, must vouch the remainder-man in tail, otherwise the recovery is void: but if he does vouch such remainder-man, and he appears and vouches the common vouchee, it is then good; for if a man be vouched and appears, and suffers the recovery to be had, it is as effectual to bar the estate-tail as if he himself were the recoveree.

In all recoveries, it is necessary that the recoveree, or tenant to the *præcipe*, as he is usually called, be actually seised of the freehold, else the recovery is void. For all actions to recover the seisin of lands must be brought against the actual tenant of the freehold, else the suit will lose its effect; since the freehold cannot be recovered of him who has it not. And, though these recoveries are in themselves fabulous and fictitious, yet it is necessary that there be *actores fabulæ*, properly qualified. But the nicety thought by some modern practitioners to be requisite in conveying the legal freehold, in order to make a good tenant to the *præcipe*, is removed by the provisions of the statute 14 Geo. II. c. 20. which enacts, with a retrospect and conformity to the ancient rule of law, that, though the legal freehold be vested in lessees, yet those who are entitled to the next freehold estate in remainder, or reversion, may make a good tenant to the *præcipe;* and that, though the deed or fine which creates such tenant be subsequent to the judgement of recovery, yet if it be in the same term, the recovery shall be valid in law: and that though the recovery itself do not appear to be entered, or be not regularly entered on record, yet the deed to make a tenant to the *præcipe*, and declare the uses of the recovery, shall after a possession of 20 years be sufficient evidence on behalf of a purchaser for valuable consideration, that such recovery was duly suffered.

Recovery of persons drowned, or apparently dead. See Re-animation, and the articles there referred to.

RECREANT, Cowardly, *Faint-hearted;* formerly a word very reproachful. See Battel.

RECREMENT, in *Chemistry*, some superfluous matter separated from some other that is useful; in which sense it is the same with *scoriæ*, *fæces*, and *excrements*.

RECRIMINATION, in *Law*, an accusation brought by the accused against the accuser upon the same fact.

RECRUITS, in military affairs, new-raised soldiers designed to supply the place of those who have lost their

their lives in the service, or who are disabled by age or wounds.

RECTANGLE, in *Geometry*, the same with a right-angled parallelogram. See GEOMETRY.

RECTIFICATION, in *Chemistry*, is nothing but the repetition of a distillation or sublimation several times, in order to render the substance purer, finer, and freer from aqueous and earthy parts.

RECTIFICATION, in *Geometry*, is the method of finding a right line equal to a curve. The rectification of curves is a branch belonging to the higher geometry, in which the use of the inverse method of fluxions is of singular utility.

RECTIFICATION of Spirits. See DISTILLATION.

RECTIFIER, in *Navigation*, an instrument consisting of two parts, which are two circles, either laid one upon, or let into the other, and so fastened together in their centres, that they represent two compasses, one fixed, the other moveable; each of them divided into the 32 points of the compass, and 360°, and numbered both ways, from the north and the south, ending at the east and west, in 90°.

The fixed compass represents the horizon, in which the north and all the other points of the compass are fixed and immoveable.

The moveable compass represents the mariner's compass; in which the north and all other points are liable to variation.

In the centre of the moveable compass is fastened a silk thread, long enough to reach the outside of the fixed compass. But if the instrument be made of wood, there is an index instead of the thread.

Its use is to find the variation of the compass, to rectify the course at sea; having the amplitude or azimuth given.

RECTIFYING the GLOBE. See GEOGRAPHY *Index*.

RECTILINEAR, in *Geometry*, right-lined; thus figures whose perimeter consists of right lines, are said to be rectilinear.

RECTITUDE, in *Philosophy*, refers either to the act of judging or of willing; and therefore whatever comes under the denomination of rectitude, is either what is true or what is good, these being the only objects about which the mind exercises its two faculties of judging and willing.

Moral rectitude, or uprightness, is the choosing and pursuing those things which the mind, upon due inquiry and attention, clearly perceives to be good; and avoiding those that are evil. See *MORAL Philosophy*.

RECTOR, a term applied to several persons whose offices are very different: as, 1. The rector of a parish is a clergyman that has the charge and cure of a parish, and possesses all the tithes, &c. 2. The same name is also given to the chief elective officer in several foreign universities, particularly in that of Paris, and also in those of Scotland. It is also applied to the head master of large schools in Scotland, as in the high school of Edinburgh. 3. Rector is also used in several convents for the superior officer who governs the house: and the Jesuits give this name to the superiors of such of their houses as are either seminaries or colleges.

RECTORY, a parish church, parsonage, or spiritual living, with all its rights, tithes, and glebes.

RECTORY is also sometimes used for the rector's mansion or parsonage-house.

RECTUM, in *Anatomy*, the third and last of the large intestines or guts. See ANATOMY, N° 93.

RECTUS, in *Anatomy*, a name common to several pairs of muscles, so called on account of the straightness of their fibres.

RECUPERATORES, among the Romans, were commissioners appointed to take cognizance of private matters in dispute, between the subjects of the state and foreigners, and to take care that the former had justice done them. It came at last to be used for commissioners, to whom the prætor referred the determination of any affair between one subject and another.

RECURRENTS, in *Anatomy*, a name given to several large branches of nerves sent out by the par vagum from the upper part of the thorax to the larynx.

RECURVIROSTRA, a genus of birds belonging to the order of grallæ of Linnæus, and that of palmipedes of Pennant and Latham. See ORNITHOLOGY *Index*.

RECUSANTS, such persons as acknowledge the pope to be the supreme head of the church, and refuse to acknowledge the king's supremacy; who are hence called *Popish recusants*. The penal laws against Papists are now abolished in Britain and in Ireland; and in all probability they will quickly be allowed the amplest privileges.

RED, one of the colours called *simple* or *primary*: being one of the shades into which the light naturally divides itself when refracted through a prism. See CHROMATICS.

RED, in *Dyeing*, see that article.—Some reckon six kinds or casts of red, viz. scarlet-red, crimson-red, madder red, half-grain red, lively orange-red, and scarlet of cochineal: but it is easy to see that there can be but one proper species of red; namely, the reflection of the light exactly in such a manner as it is refracted by the prism; all other shades being adulterations of that pure colour, with yellow, brown, &c.

RED, in *Heraldry*. See GULES.

RED-Bird. See MUSCICAPA, ORNITHOLOGY *Index*.

RED-Breast. See MOTACILLA, ORNITHOLOGY *Index*.

RED-Book of the exchequer, an ancient record or manuscript volume, in the keeping of the king's remembrancer, containing divers miscellany treatises relating to the times before the conquest.

RED-Lead. See CHEMISTRY *Index*.

RED Precipitate of Mercury. See CHEMISTRY *Index*.

RED-Russia, or *Little Russia*, a province of Poland, bounded on the west by Upper Poland, on the north by Lithuania, on the east by Little Tartary, and on the south by Moldavia, Transylvania, and a part of Hungary. It comprehends Russia properly so called, Volhynia, and Podolia. It is about 650 miles in length, and from 150 to 250 in breadth. It consists chiefly of large fields, but little cultivated on account of the frequent inroads of the Tartars, and because there is no water-carriage. It had the name of *Red Russia*, from the colour of the hair of its inhabitants. Russia, properly so called, comprehends the three palatinates of Leopol or Lemburg, Belsko, and Chelm.

RED-Sea, or *Arabic Gulf*, so much celebrated in sacred

Red Sea.

cred hiftory, feparates Arabia from Upper Ethiopia and part of Egypt. This fea is 350 leagues in length and 40 in breadth. As no river falls into it of fufficient force to counteract the influence of the tide, it is more affected by the motions of the great ocean than any of the inland feas nearly in the fame latitude. It is not much expofed to tempefts: the winds ufually blow from north to fouth, and being periodical, like the monfoons of India, invariably determine the feafon of failing into or out of this fea. It is divided into two gulfs; that to the eaft was called the *Ælanitic gulf*, from the city Ælana at the north end of it; and that to the weft the *Heroopolitic*, from the city of Heroopolis; the former of which belongs to Arabia, and the latter to Egypt.

Mr Bruce has made many obfervations on this fea, which are worthy of notice.—With regard to the name, he fays it was certainly derived from Edom or Efau the fon of Jacob; though in another place he fays, he wonders that writers have not rather fuppofed it to have got the epithet of *Red*, from the colour of the fand on its coafts, than for other reafons they have alleged. With regard to any rednefs in the water itfelf, or in the bottom, which fome have afferted, our traveller affures us that there is no fuch thing. It is more difficult to affign a reafon for the Hebrew name of it, which fignifies the *Sea of Weeds*; as he never faw a weed throughout the whole extent of it. "Indeed, (fays he) upon the flighteft confideration, it will occur to any one, that a narrow gulf, under the immediate influence of the monfoons, blowing from contrary points fix months each year, would have too much agitation to produce fuch vegetables, feldom found but in ftagnant waters, and feldom, if ever, found in falt ones. My opinion then is, that it is from the large trees or plants of white coral, fpread everywhere over the bottom of the Red fea, perfectly in imitation of plants on land, that the fea has obtained this name.—I faw one of thefe, which, from a root nearly central, threw out ramifications of an almoft circular form, meafuring 26 feet every way."

Our author has alfo made many ufeful obfervations on the navigation of this fea. "All the weftern fhore (he fays) is bold, and has more depth of water than the eaft; but on this fide there is neither anchoring ground nor fhoals. It is rocky, with a confiderable depth of water everywhere; and there are a number of funken rocks, which, though not vifible, are fufficiently near the furface to deftroy a large fhip." The caufe of this, in Mr Bruce's opinion, is, that the mountains on the fide of Abyffinia and Egypt are all of hard ftone, porphyry, many different kinds of marble, granite, alabafter, and bafaltes. Thefe being all compofed of folid materials, therefore, can part with very little duft or fand, which might otherwife be blown from them into the fea. On the oppofite coaft, viz. that of Hejaz and Tahamah, on the Arabian fide, the whole confifts of moving fands; a large quantity of which is blown from the fouth-eaft by the dry winter monfoons; which being lodged among the rocks on that fide, and confined there by the north-eaft or fummer monfoon, which is in a contrary direction, hinders them from coming over to the Egyptian fide. Hence the weftern coaft is full of funk rocks for want of fand to cover them, with which they would otherwife become iflands. They are naked and bare all round, with fharp points like fpears; while, on the eaft fide, every rock becomes an ifland, and every two or three iflands become an harbour. On the ends of the principal of thefe harbours the people have piled up great heaps of ftones to ferve as fignals: "and it is in thefe (fays Mr Bruce) that the large veffels from Cairo to Jidda, equal in fize to our large 74-gun fhips (but from the cifterns of mafon-work built within for holding water, I fuppofe double their weight), after navigating their portion of the channel in the day-time, come fafely and quietly to at four o'clock in the afternoon; and in thefe little harbours pafs the night, to fail into the channel again next morning."

The weftern channel of the Red fea was chofen, in the days of the Ptolemies, for the track of the Indian and African commerce. Thefe monarchs erected a great number of cities all along the weftern coaft; and notwithftanding the dangers of the navigation, we do not hear that it was ever abandoned on account of them.

From the obfervations made by our author on the navigation of the Red fea, he undertakes to point out a fafe paffage for large fhips to the gulf of Suez, fo that they may be able to judge of the propriety of their own courfe themfelves, without trufting implicitly to the pilots they meet with, who are often very ignorant of their profeffion. This fea, according to Mr Bruce, may be divided into four parts, of which the channel occupies two, till near the latitude of 26°, or that of Cofleir. On the weft it is deep water, with many rocks; and on the eaft it is full of iflands, as has been already mentioned. Between thefe iflands there are channels and harbours of deep water, where fhips may be protected in any wind; but a pilot is neceffary in failing among thefe from Mocha to Suez, and the voyage befides can be continued only during part of the day. Ships bound to Suez without the confent of the fheriffe of Mecca, that is, without any intention of felling their cargo at Jidda, or paying cuftom there, ought to take in their frefh water at Mocha; or if there be any reafon againft this, a few hours will carry them to Azab or Saba on the Abyffinian coaft, where they may be plentifully fupplied: but it muft be remembered, "that the people here are *Galla*, the moft treacherous and villanous wretches on earth." Here not only water may be procured, but plenty of fheep, goats, with fome myrrh, and incenfe in the proper feafon.—Great caution, however, muft be ufed in dealing with the people, as even thofe of Mocha, who are abfolutely neceffary to them in their commercial dealings, cannot truft them without furety or hoftages. Not many years ago, the furgeon and mate of the Elgin Eaft Indiaman, with feveral other failors, were murdered by thefe favages as they went afhore to purchafe myrrh, though they had a letter of fafe conduct from the fhekh.

To fuch as do not want to be known, our author recommends a low black ifland on the coaft of Arabia, named *Camaran*, in latitude 15° 30'. It is diftinguifhed by a white houfe or fortrefs on the weft end of it; where water is to be had in ftill greater plenty than at Azab; but no provifions, or fuch only as are very bad, can be procured. If it is neceffary not to be feen at all on the coaft, the ifland of Foofht is recommended by our author as having excellent water, with a faint or monk, whofe office is to keep the wells clean. This is one of the chain of iflands which ftretches almoft

4 P 2 acrofs

across the gulf from Loheia to Masuah, and from actual observation by Mr Bruce, is found to be situated in N. Lat. 15° 59′ 43″. E. Long. 42° 47′. From this to Yambo there is a safe watering-place; and there is an absolute necessity for having a pilot before you come to Ras Mahomet; because over the Ælanitic gulf, the mountains of Aucha, and the cape itself, there is often a thick haze, which lasts for many days together, and a number of ships are lost by mistaking the eastern bay or Ælanitic gulf for the entrance of the gulf of Suez; the former has a ridge of rocks nearly across it. After reaching Sheduan, a large island, about three leagues farther in a north-by-west direction, there is a bare rock distinguished by no particular name; but so situated that ships ought not to come within three leagues of it. This rock is to be left to the westward at the distance just mentioned; after passing which you meet with shoals forming a pretty broad channel, with soundings from 15 to 30 fathoms; and again, on standing directly for Tor, there are two other oval sands with sunk rocks in the channel, between which you are to steer. Tor may be known at a distance by two hills that stand near the water side; which, in clear weather, may be seen six leagues off. Just to the south-east of these is the town and harbour, where there are some palm trees about the houses, the more remarkable, as being the first that are seen on the coast. The soundings in the way to Tor harbour are clean and regular; "and, by giving the beacon a small birth on the larboard hand, you may haul in a little to the northward, and anchor in five or six fathom." In spring-tides, it is high water at Tor nearly about 12 o'clock: in the middle of the gulf there is no perceptible tide, but at the sides it runs at the rate of more than two knots in the hour. Tor itself is but a small village, with a convent of monks belonging to those of Mount Sinai. It was taken by Don John de Castro, and fortified soon after its discovery by the Portuguese; but has never since been a place of any consideration; serving now only for a watering place to the ships trading to or from Suez.—From this place there is a distinct view of Mounts Horeb and Sinai, which appear above and behind the others, with their tops frequently covered with snow in the winter.

Mr Bruce next proceeds to consider some questions which may be reckoned matters of curiosity rather than any thing else. One of these is concerning the level of the water of this sea itself, which has been supposed several feet above that of the Mediterranean. "To this (says our author) I answer, that the fact has been supposed to be so by antiquity, and alleged as a reason why Ptolemy's canal was made from the bottom of the Heroopolitic gulf rather than brought due north across the isthmus of Suez; in which last case it was feared it would submerge a great part of Asia Minor. But who has ever attempted to verify this by experiment? or who is capable of settling the difference of levels, amounting, as supposed, to some feet and inches, between two points 120 miles distant from each other, over a desert that has no settled surface, but is changing its height every day? Besides, since all seas are in fact but one, what is it that hinders the Indian ocean to flow to its level? What is it that keeps the Indian ocean up? Till this last branch of the question is resolved, I shall take it for granted that no such difference of level exists, whatever Ptolemy's engineers might have pretended to him; because, to suppose it fact, is to suppose the violation of one very material law of nature."

The next thing considered by our author is the passage of the Israelites through the Red sea. At the place where he supposes the passage to have been, the sea is not quite four leagues broad, so that it might easily have been crossed in one night without any miracle. There is about 14 fathom water in the channel, and nine at the sides, with good anchorage every where; the farthest side is a low sandy coast, and a very easy landing place. "The draught of the bottom of the gulf (says he) given by Dr Pococke, is very erroneous in every part of it. It was proposed to Mr Niebuhr, when in Egypt, to inquire upon the spot, whether there were not some ridges of rocks where the water was shallow, so that an army at particular times might pass over? Secondly, whether the Etesian winds, which blow strongly all summer from the north-west, could not blow so violently against the sea, as to keep it back on a heap, so that the Israelites might have passed without a miracle? And a copy of these queries was left for me to join my inquiries likewise. But I must confess, however learned the gentlemen were who proposed these doubts, I did not think they merited any attention to solve them. If the Etesian winds, blowing from the north-west in summer, could heap up the sea as a wall on the right or to the south, of fifty feet high, still the difficulty would remain of building the wall on the left hand or to the north. Besides, water standing in that position for a day, must have lost the nature of a fluid. Whence came that cohesion of particles that hindered that wall to escape at the sides? This is as great a miracle as that of Moses. If the Etesian winds had done this once, they must have repeated it many a time before and since, from the same causes. Yet Diodorus Siculus says, the Troglodytes, the indigenous inhabitants of that very spot, had a tradition from father to son, from their very earliest and remotest ages, that once this division of the sea did happen there; and that, after leaving the bottom some time dry, the sea again came back and covered it with great fury. The words of this author are of the most remarkable kind. We cannot think this heathen is writing in favour of revelation. He knew not Moses, nor says a word about Pharaoh and his host; but records the miracle of the division of the sea in words nearly as strong as those of Moses, from the mouths of unbiassed undesigning pagans."

Red-Shank. See Scolopax, } Ornithology *Index*.
Red-Start. See Motacilla, } Ornithology *Index*.
Red-Wing. See Turdus, } Ornithology *Index*.

REDANS, in *Field Fortification*. See the article Redans.

REDDENDUM, in *Law*, is used substantively for the clause in a lease wherein the rent is reserved to the lessor. The proper place for it is next after the limitation of estate.

REDDITIO, was the third part of the sacrifice of the heathens, and consisted of the solemn act of putting in again the entrails of the victims, after they had been religiously inspected. See Sacrifice.

REDDLE, a soft, heavy, red, ferruginous earth, of great

great uſe in colouring; and being waſhed and freed from ſand, is often ſold by our druggiſts under the name of *bole armeniac*.

REDEMPTION, in *Law*, a faculty or right of re-entering upon lands, &c. that have been ſold and aſſigned, upon reimburſing the purchaſe-money with legal coſts.

REDEMPTION, in *Theology*, denotes the recovery of mankind from ſin and death, by the obedience and ſacrifice of Chriſt, who on this account is called the *Redeemer of the world*. See THEOLOGY.

REDENS, REDANS, or *Redant*, in *Fortification*, a kind of indented work in form of the teeth of a ſaw, with ſaliant and re-entering angles; to the end that one part may flank or defend another. It is likewiſe called *ſaw-work* and *indented work*. The lines or faces in this flank one another.

Redens are uſed in fortifying walls, where it is not neceſſary to be at the expence of building baſtions; as when they ſtand on the ſide of a river running through a garriſon town, a marſh, the ſea, &c. But the fault of ſuch fortification is, that the beſiegers from one battery may ruin both the ſides of the tenaille or front of a place, and make an aſſault without fear of being enfiladed, ſince the defences are mined. The parapet of the corridor is likewiſe often redented or carried on by the way of redens. The redens was uſed before baſtions were invented, and ſome people think them preferable.

REDI, FRANCIS, an Italian phyſician and polite ſcholar, was born at Arezzo in Tuſcany in 1626. His ingenuity and learning recommended him to the office of firſt phyſician to Ferdinand II. duke of Tuſcany; and he contributed not a little toward the compiling of the Dictionary of La Cruſca. He wrote upon vipers, upon the generation of inſects, and compoſed a good deal of poetry. All his writings are in Italian; and his language is ſo fine and pure, that the authors of the Dictionary of La Cruſca have often cited it as a ſtandard of perfection. He died in 1697.

REDINTEGRATION, is the finding the integral or fluent again from the fluxion. See FLUXIONS.

REDOUBT, in *Fortification*, a ſmall ſquare fort, without any defence but in front; uſed in trenches, lines of circumvallation, contravallation, and approach; as alſo for the lodgings of corps de-gard, and to defend paſſages.

REDUCTION, in the ſchools, a manner of bringing a term or propoſition, which was before oppoſite to ſome other, to be equivalent to it.

REDUCTION, in *Arithmetic*, that rule whereby numbers of different denominations are brought into one denomination. See ARITHMETIC.

REDUCTION of Equations, in *Algebra*, is the clearing them from all ſuperfluous quantities, bringing them to their loweſt terms, and ſeparating the known from the unknown, till at length only the unknown quantity is found on one ſide, and known ones on the other. The reduction of an equation is the laſt part of the reſolution of the problem. See ALGEBRA.

REDUCTION of a figure, deſign, or draught, is the making a copy thereof, either larger or ſmaller than the original; ſtill preſerving the form and proportion. The great uſe of the proportional compaſſes is the reduction of figures, &c. whence they are called *compaſſes of reduction*. See the article COMPASS.

There are various methods of reducing figures, &c. the moſt eaſy is by means of the pentagraph, or parallelogram; but this hath its defects. See the article PENTAGRAPH.

The beſt and moſt uſual methods of reduction are as follow: 1. To reduce a figure, as ABCDE (fig. 1.), into a leſs compaſs. About the middle of the figure, as *z*, pitch on a point, and from this point draw lines to its ſeveral angles A, B, C, &c. then drawing the line *a b* parallel to AB, *b c* parallel to BC, &c. you will have the figure *a b c d e* ſimilar to ABCDE. Plate CCCCXLVIII Fig. 1.

If the figure *a b c d e* had been required to be enlarged, there needed nothing but to produce the lines from the point beyond the angles, as *z* D, *z* C, &c. and to draw lines, viz. DC, CB, &c. parallel to the ſides *d c*, *c b*, &c.

2. To reduce a figure by the angle of proportion, ſuppoſe the figure ABCDE (fig. 2.) required to be diminiſhed in the proportion of the line AB to *a b* (fig. 3.) draw the indefinite line GH (fig. 4.), and from G to H ſet off the line AB. On G deſcribe the arch HI. Set off the line *a b* as a chord on HI, and draw GI. Then with the angle IGH you have all the meaſures of the figure to be drawn. Thus to lay down the point *c*, take the interval BC, and upon the point G deſcribe the arch KL. Alſo on the point G deſcribe MN; and upon A, with the diſtance MN, deſcribe an arch cutting the preceding one in *c*, which will determine the ſide *b c*. And after the ſame manner are the other ſides and angles to be deſcribed. The ſame proceſs will alſo ſerve to enlarge the figure. Fig. 2. Fig. 3. and 4.

3. To reduce a figure by a ſcale. Meaſure all the ſides of the figure, as ABCDE (fig. 2.) by a ſcale, and lay down the ſame meaſures reſpectively from a ſmaller ſcale in the proportion required.

4. To reduce a map, deſign, or figure, by ſquares. Divide the original into little ſquares, and divide a freſh paper of the dimenſions required into the ſame number of ſquares, which are to be larger or leſs than the former, as the map is to be enlarged or diminiſhed. This done in every ſquare of the ſecond figure, draw what you find in its correſpondent one in the firſt.

REDUCTION, in *Metallurgy*, is the bringing back metalline ſubſtances which have been changed into ſcoriæ or aſhes, or otherwiſe diveſted of their metallic form, into their natural and original ſtate of metals again. See ORES, *reduction of*.

REDUCTION, in *Surgery*, denotes an operation whereby a diſlocated, luxated, or fractured bone, is reſtored to its former ſtate or place.

REDUNDANCY, a fault in diſcourſe, conſiſting in the uſe of a ſuperfluity of words. Words perfectly ſynonymous are redundant, and ought to be retrenched.

REDUNDANT, in *Muſic*. What the French call *une accord ſuperflue*, which we have tranſlated *a redundant chord* in the article MUSIC (from D'Alembert), has by others been rendered *a chord extremely ſharp*, as in the tranſlation of Rameau's Principles of Compoſition. Their nature will be beſt underſtood by a few examples, and an account of the number of tones, ſemitones, or leſſer intervals, contained in each.

The *ſecond redundant* is compoſed of a major tone, and

and a minor semitone; as from *fa* to *sol* sharp. Its proportion is as 64 to 75.

The *third redundant* consists of two tones and a semitone, as *fa la*, sharp. Its proportion is as 96 to 125.

The *fourth redundant* is the same with the tritone.

From these examples compared with the same intervals in their natural state, the reader may form a general idea of what is meant by *redundant*.

REE, REIS, or *Res*, a little Portuguese coin. See *MONEY-Table*.

REED, in *Botany*. See ARUNDO and BAMBOO.

There are two sorts of reeds, says Hasselquist, growing near the Nile. One of them has scarce any branches; but is furnished with numerous leaves, which are narrow, smooth, channeled on the upper surface; and the plant is about 11 feet high. The Egyptians make ropes of the leaves. They lay them in water like hemp, and then make them into good strong cables. These, with the bark of the date tree, form almost the only cable used in the Nile. The other sort is of great consequence. It is a small reed, about two or three feet high, full branched, with short, sharp, lancet-shaped leaves. The roots, which are thick as the stem, creep and mat themselves together to a considerable distance. This plant seems useless in common life; but to it, continues the learned author, is the very soil of Egypt owing: for the matted roofs have stopped the earth which floated in the waters, and thus formed, out of the sea, a country that is habitable.

Fire-REEDS. See *FIRE-Ship*.

REED, a term in the west of England for the straw used by thatchers, which is wheat straw finely combed, consisting of stiff, unbruised, and unbroken stalks of great length, carefully separated from the straw used for fodder by the thresher, and bound in sheaves or nitches, each of which weighs 28 lb. and are sold from 21s. to 31s. per hundred nitches, according to the season. This is a great improvement in the art of thatching, as it gives a finish to the work which cannot be attained by straw, rough and tumbled together, without any separation of the long and short: it is also a readier mode of working.

REEF, a term in navigation. When there is a great gale of wind, they commonly roll up part of the sail below, that by this means it may become the narrower, and not draw so much wind; which contracting or taking up the sail they call a *reef*, or *reefing the sail*: so also when a *top-mast is sprung*, as they call it, that is when it is cracked, or almost broken in the cap, they cut off the lower piece that was near broken off, and setting the other part, now much shorter, in the step again, they call it a *reefed top-mast*.

REEL, in the manufactories, a machine serving for the office of reeling. There are various kinds of reels; some very simple, others very complex.

REELING, in the manufactories, the winding of silk, cotton, or the like, into a skain, or upon a button, to prevent its entangling. It is also used for the charging or discharging of bobbins, or quills, to use them in the manufacture of different stuffs, as thread, silk, cotton, &c. Reeling is performed in different ways, and on different engines.

REEVING, in the sea-language, the putting a rope through a block: hence to pull a rope out of a block is called *unreeving*.

RE-EXCHANGE, in commerce, a second payment of the price of exchange, or rather the price of a new exchange due upon a bill of exchange that comes to be protested, and to be refunded the bearer by the drawer or indorser.

REFECTION, among ecclesiastics, a spare meal or repast, just sufficient for the support of life: hence the hall in convents, and other communities, where the monks, nuns, &c. take their refections or meals in common, is called the *refectory*.

REFERENCE, in writing, &c. a mark relative to another similar one in the margin, or at the bottom of the page, where something omitted in the text is added, and which is to be inserted either in reading or copying.

REFINING, in general, the art of purifying a thing; including not only the essaying or refining of metals, but likewise the depuration or clarification of liquors. See CLARIFICATION; and PHARMACY, under MATERIA MEDICA; and ORES, *Reduction of*.

Gold and silver may be refined by several methods, which are all founded on the essential properties of these metals, and acquire different names according to their kinds. Thus, for instance, gold having the property which no other metal, not even silver, has of resisting the action of sulphur, of antimony, of nitrous acid, or marine acid, may be purified by these agents from all other metallic substances, and consequently may be refined. These operations are distinguished by proper names, as *purification of gold by antimony*, *parting*, *concentrated parting*, *dry parting*. The term *refining* is chiefly applied to the purification of gold and silver by lead in the cupel. See ORES, *Reduction of*.

REFLECTION, the return or progressive motion of a moving body, occasioned by some obstacle which hindered it from pursuing its former direction.

Circular Instrument of REFLECTION, an instrument for measuring angles to a very great degree of accuracy. It was invented by the celebrated astronomer Mr Tobias Mayer of Gottingen, principally with a view to do away the errors of the divisions of the limb; and has since been much improved by the Chevalier de Borda, and M. J. H. de Magellan. This instrument is particularly applicable to the measuring of the distances of the heavenly bodies, and was used by the French in their part of the operation for determining the difference of meridians of Paris and Greenwich. For the description, rectification, and use of this instrument, see NAVIGATION.

REFLECTION of the Rays of Light, in *Catoptrics*, is their return, after approaching so near the surface of bodies as to be thereby repelled or driven backwards. For the causes of reflection, see OPTICS *Index*, at *Rays of Light*, and *Reflection of Light*, &c. For the application of the doctrine of reflection to mirrors, see OPTICS. See also MIRROR, *BURNING-Glass*, and *Glass-GRINDING*; and for the *coating* or *foliating* of mirrors, see the article *FOLIATING of Looking-glasses*, &c. See also TELESCOPE.

REFLECTION of Heat, see CHEMISTRY, N° 170.

REFLECTION of Cold. For an account of this curious phenomenon, see also CHEMISTRY, N° 272.

It has been generally supposed that this fact was first noticed by Professor Pictet of Geneva; but we have been informed from good authority (for we have not

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yet had an opportunity of feeing the book), that the fame fact is diftinctly mentioned by Baptifta de Porta in his *Magia Naturalis*.

Reflection is alfo ufed, figuratively, for an operation of the mind, whereby it turns its view backwards as it were upon itfelf, and makes itfelf and its own operations the object of its difquifition; and by contemplating the manner, order, and laws, which it obferves in perceiving ideas, comparing them together, reafoning, &c. it frames new ideas of the relations difcovered therein. See Metaphysics.

Reflectors *for Light-Houfes*, have of late years been very fuccefsfully adopted inftead of coal fires. They are compofed of a number of fquare pane glafs mirrors, fimilar to thofe which, it is faid, were employed by Archimedes in fetting fire to the Roman fleet at the fiege of Syracufe. The mirrors are an inch fquare, and are difpofed clofe to each other in the concave of a parabolic fegment, formed of ftucco, or any other fubftance which retains them in their place. Stucco, however, is found to anfwer fufficiently well, and is employed in the reflectors of all the light-houfes which have been erected round the coaft of Scotland.

The parabolic moulds are from three to five or fix feet in diameter, and in the centre of each there is a long fhallow lamp of tin plate, filled with whale oil. There are fix cotton wicks in each lamp, nearly contiguous to each other, and fo difpofed as to ftand in no need of trimming for the fpace of fix hours. The light is reflected from each mirror fpread over the concave furface, and is as it were multiplied by the number of mirrors. Tin plate covers the back of the ftucco moulding, from which a tube, immediately over the lamp, proceeds to the roof of the light room, and anfwers the purpofe of a funnel, through which the fmoke paffes without fullying the face of the mirrors. The light-room is a lantern of from eight to twelve fides, entirely made of glafs, fixed in frames of caft-iron, and roofed with copper. The reflectors with their lamps are placed on circular benches paffing round the infide of this lantern, at about 18 inches from the glafs frames, fo that the concave furfaces of two or three of the reflectors front every point of the compafs, and throw a blaze of light in all directions.

There is a hole in the roof, directly over the centre of the room, through which all the funnels pafs, and by which frefh air is alfo conveyed to the lamps. This light-room is fixed in fuch a manner on the top of a round tower, that no weather can move it; and the number of the reflectors, and the height of the tower, are greater or lefs, according as the light is intended to be feen at a greater or lefs diftance.

It has been propofed to make the concave furface of the parabola one fpeculum of metal, inftead of covering it over with a number of plain glafs mirrors, or to diminifh the fize of each mirror, if they are preferred to the metallic fpeculum. It muft be obvious to every man who knows any thing of optics, that either of thefe alterations would be improper. The brighteft metal does not reflect fo much light as plain clear glafs, and if the fize of the mirrors was diminifhed, the number of joinings would be increafed, in each of which fome light is loft.

A man wholly guided by theory, would be ready to condemn light-houfes of this defcription; becaufe a violent ftorm will fhake the firmeft building, which, in his opinion, would throw the whole rays of light into the air, and thus miflead the bewildered mariner. Experience, however fhows, that fuch apprehenfions are groundlefs, and that light-houfes with lamps and reflectors, are in all refpects preferable to thofe with fires burning in the open air. They are lefs expenfive; they give a more brilliant light, and are feen at a greater diftance, and cannot be obfcured by fmoke, or driven down on the lee-fide by the moft violent wind. If to this we add, that the lamps do not ftand in need of trimming fo often as fires require fuel, and that the light-man is never expofed to the weather, we muft allow that light-houfes with reflectors are not fo liable to be neglected in ftormy weather as thofe with open fires, which alone muft give the former a preference over the latter.

It has been afferted, and particularly ftated, in the fupplement to the third edition of this work, that Mr Smith of Edinburgh, the principal, and we believe now the fole contractor for managing and keeping in repair the light-houfes round the coaft of Scotland, is the firft who conceived the idea of illuminating light-houfes by means of lamps and reflectors. We do not underftand that Mr Smith himfelf ever claimed the merit of this invention; but it appears that reflectors, fuch as are defcribed above, were invented by Mr Ezekiel Walker of Lynn Regis, who fays, in a letter dated October 1801, and addreffed to the editor of the Monthly Magazine *, that fuch reflectors were made and fixed up under his direction, in a light-houfe on the coaft of Norfolk, in the year 1779; and adds farther, that in the year 1787, at the requeft of the truftees appointed by act of parliament for erecting four light-houfes on the northern coaft of Great Britain, he inftructed Mr Smith in this method of conftructing light-houfes. Mr Walker's ftatement of the fact is confirmed by a letter from Mr Grieve, then lord provoft of Edinburgh, who informs Mr Walker that the truftees had agreed to pay the premium required for communicating the invention, and that Mr Smith was engaged to go to Lynn Regis to receive inftructions from Mr Walker in the method of conftructing the new reflectors.

* Vol. xii. p. 402.

REFLEX, in *Painting*, means thofe places in a picture which are fuppofed to be illuminated by light reflected from fome other body in the fame piece. See Painting, Part I. fect. 2. and 5.

REFLUX, the backward courfe of water, has the fame meaning as the ebbing of the fea, and is oppofed to flood, flux, or the flowing of the fea. See Tides.

REFORM means a change from worfe to better, a re-eftablifhment or revival of former neglected difcipline, or a correction of abufes therein. The term is much ufed in a monaftic fenfe for the reducing an order or congregation of religious to the ancient feverity of the rule from which it had gradually fwerved, or even for improving on the ancient rule and inftitution itfelf, and voluntarily making it more fevere. In this fenfe the order of St Bernard is faid to be only a reform of that of St Benedict. In this country it is applied both to politics and religion, and may innocently be applied to

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to any endeavours to change an eſtabliſhment from worſe to better. But it appears at preſent to have been chiefly made a pretence for deſigns which could not fairly or ſafely be avowed.

A reform in religion and in parliament (ſee PARLIAMENT), has, we know, been moſt loudly called for by men whoſe religious notions are immenſely different from what has been generally reckoned chriſtianity, and whoſe deſigns, as has been legally proved, went to the overthrow of all civil order. For inſidious purpoſes like theſe, the word reform is a good cloak, eſpecially if any thing can be fixed upon, either in the religion or government of the ſtate, which, with the help of exaggeration and diſtortion, can be repreſented to the weak and unthinking as extremely defective and erroneous.

The general error of theſe men ſeems to be, that having picked up a ſet of ſpeculative notions which flatter their own pride and the pride of thoſe who liſten to them, they will allow nothing to the arguments of their opponents or the experience of mankind. They think ſo often and ſo much upon their ideal reforms, that while they imagine their notions are liberal and extenſive, they become contracted beyond imagination; while their judgements, of courſe, are warped with the moſt inveterate prejudices (ſee PREJUDICE). They ſee, or think they ſee, the propriety of their ſchemes; but they ſeldom, perhaps never, reflect, that that may be true in ſpeculation or in theory which cannot poſſibly be reduced to practice. They will not take the world as it is, and allow it to profit by the wiſdom and experience of ages; but they will reform it according to thoſe ideas of right which they have learned from their own ſpeculations and airy theories; ſeldom conſidering what may be done, they are determined to do what they think ought to be done. Liberty of conſcience, and liberty of action, have been claimed by them as the unalienable rights of man; and ſo we ourſelves are diſpoſed to think them: nor have we heard that in this country they have been denied to any man, or ſet of men, ſo far as has been thought conſiſtent with the ſafety of the ſtate, and that of the other individuals who compoſe it. At the ſame time, the very ſame men heſitate not to blame, with acrimony the moſt violent, and to the utmoſt of their power to reſtrain, the actions and opinions of thoſe who, with equal conviction, often on better grounds, and generally with more modeſty, differ from them.

Amidſt that exceſſive ardour, too, with which they propagate their opinions, they forget the extreme danger of withdrawing the attention of that part of the community, who muſt earn their bread by the ſweat of their brow, from their proper occupations, to the tempeſtuous ſea of political debate, for which their education and mode of life cannot poſſibly have qualified them. It requires but very little penetration, however, to be able to ſee, that it can be of no real ſervice either to the individuals themſelves, or to the community at large, in whatever light we look upon it. Indeed, to make thoſe the judges of the law, and the reformers of the legiſlature, who have all their lives been employed in manual labour, is the extreme of folly; and yet it is what ſome men of conſiderable abilities, and from whom we had reaſon to expect better things, have more than once attempted. The effect of ſuch a mode of ſeduction, (and it deſerves no better name), when it ſhall become general, inſtead of ſerving the purpoſes of a real reform, muſt be to annihilate all civil order. Diſſatisfaction is the moſt powerful check to honeſt induſtry; and diſſatisfaction and idleneſs muſt be the effect of the wanderings of ſuch men in the labyrinths of politics; which, for uncultivated minds eſpecially, paves the way for every ſpecies of vice, and gradually ripens them for any wickedneſs, however atrocious. For the truth of theſe remarks, we appeal to the hiſtory of mankind from the creation to the preſent time: and we would ſeriouſly requeſt the *ſober friends of reform*, and many ſuch, we doubt not, there are, to reflect, that in the preſent day we have more to fear from licentiouſneſs than from deſpotiſm; from reform carried to an extreme than from the pretended attempts either of kings or miniſters to annihilate our real liberty.

It may alſo be worth their while to conſider, that times of public danger are not generally the beſt adapted to attempt changes of government; becauſe what might ſatisfy one party would probably be thought too little by another, and diviſions at ſuch a period are moſt dangerous. When, therefore, attempts are made for reform which appear to be inconſiſtent with the ſafety of the ſtate, reſtrictions muſt be uſed, which may by ſpeculative men be thought ſevere and unneceſſary, but of which they themſelves are the cauſes. Theſe reſtrictions too will be patiently ſubmitted to by the wiſer part of the community, when in more peaceable times they would neither have been thought of nor allowed.

Speculative reaſoners may ſpeak as much as they will of enlightening the minds of men, and of reforming government by the dictates of a refined and diſpaſſionate philoſophy; but when they come to apply their notions to practice, they will either find their repreſentations little better than empty ſounds, and therefore ineffectual; or, as is more generally found to be the caſe, theſe ſchemes which in theory appeared to be perfect, will in practice, when combined with the malignant and ambitious paſſions of men, lead to ruin and diſorder. The firſt inſtitution of government, except among the Jews, was unqueſtionably the effect of paſſion and intereſt combined: and this paſſion and this intereſt, reſtrained within due bounds, is productive of much happineſs. That government, we believe, too, will be beſt ſupported, and moſt productive of happineſs, in which the mutual paſſions and intereſts of the individuals who compoſe it are ſo equally poiſed as to ſupport one another, and to promote each the ends and ſucceſs of the other: and this by the ableſt reaſoners and the beſt men has been thought to be the caſe with the Britiſh conſtitution. If the modern favourers of reform ſhould think this an unſtable ſupport, if they will conſider the world as it ever has been, and as it is, they will find it the only one we have, except religion; and they will thence be inclined to make the beſt of it. If, after all, however, they ſhould be diſpoſed to doubt the poſition, we have only further to requeſt them, with the ſincerity of men and of Chriſtians, to conſult their own breaſts, and ſeriouſly to conſider the probable motives of thoſe who act with them. They will then perhaps ſee, and they ſurely ought to acknowledge, that few

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few men have acted more according to the impulse of passion, interest, and ambition, than those who have for some time past sounded the toczin of reform.

REFORMATION, in general, an act of reforming or correcting an error or abuse in religion, discipline, or the like. By way of eminence the word is used for that great alteration and reformation in the corrupted system of Christianity, begun by Luther in the year 1517.

Under the article HISTORY (sect. ii.), the various corruptions in religion, the oppressions and usurpations of the clergy, and the extreme insolence of the popes, have been so fully treated of, that any further detail here is unnecessary. It is sufficient to observe, that, before the period of the Reformation, the Pope had in the most audacious manner declared himself the sovereign of the whole world. All the parts of it which were inhabited by those who were not Christians, he accounted to be inhabited by *no-body*; and if Christians took it into their heads to possess any of those countries, he gave them full liberty to make war upon the inhabitants without any provocation, and to treat them with no more humanity than they would have treated wild beasts. The countries, if conquered, were to be parcelled out according to the pope's pleasure; and dreadful was the situation of that prince who refused to obey the will of the holy pontiff, of which many instances will occur to the reader in the various historical articles of this work. In consequence of this extraordinary authority which the pope had assumed, he at last granted to the king of Portugal all the countries to the eastward of Cape Non in Africa, and to the king of Spain all the countries to the westward of it. In this, according to the opinions of some, was completed in his person the character of *Antichrist sitting in the temple of God, and showing himself as God* *. He had long before, say they, assumed the supremacy belonging to the Deity himself in spiritual matters; and now he assumed the same supremacy in worldly matters also, giving the extreme regions of the earth to whom he pleased. The Reformation, therefore, they consider as the immediate effect of divine power taking vengeance on this and all other deviations from the system of truth; while others consider it merely as an effect of natural causes, and which might have been foreseen and prevented, without abridging the papal power in any considerable degree.

1 The pope assumes the disposal of the whole world.

* 2 Thess. ii. 4.

Be this as it will, however, the above-mentioned partition was the last piece of insolence which the pope ever had, or in all probability ever will have, in his power to exercise, in the way of parcelling out the globe to his adherents. Every thing was quiet, every heretic exterminated, and the whole Christian world supinely acquiesced in the enormous absurdities which were inculcated upon them; when, in 1517, the empire of superstition began to decline, and has continued to do so ever since. The person who made the first attack on the extravagant superstitions then prevailing was Martin Luther; the occasion of which is fully related under the article LUTHER. By some it is pretended, that the only motive which Luther had in beginning the Reformation was his enmity to the Dominican friars, who had excluded his order (the Augustins) from all share in the gainful traffic of indulgences. But this does not seem at all probable, if we consider that such a motive would not naturally have led him to deny the virtue of indulgences, as such conduct could not but exclude him for ever from any chance of a share in the traffic, which otherwise perhaps he might have obtained. Besides, the extreme contrariety of this traffic to the common principles of reason and honesty was so great, that we cannot wonder at finding *one* man in the world who had sense enough to discern it, and virtue enough to oppose such an infamous practice. In all probability, however, the insignificancy of the first reformer was the reason why he was not persecuted and exterminated at his first beginning, as others had been before him. Another reason probably might be, that he did not at once attack the whole errors of Popery, but brought about his reformation gradually, probably as it occurred to himself, and as we have related in the account of his life.

2 Reformation begun by Luther.

The Reformation began in the city of Wittemberg in Saxony, but was not long confined either to that city or province. In 1520 the Franciscan friars, who had the care of promulgating indulgences in Switzerland, were opposed by Zuinglius, a man not inferior in understanding and knowledge to Luther himself. He proceeded with the greatest vigour, even at the very beginning, to overturn the whole fabric of Popery; but his opinions were declared erroneous by the universities of Cologne and Louvain. Notwithstanding this, the magistrates of Zurich approved of his proceedings; and that whole canton, together with those of Bern, Basil, and Chaffausen, embraced his opinions.

3 In Switzerland by Zuinglius.

In Germany, Luther continued to make great advances, without being in the least intimidated by the ecclesiastical censures which were thundered against him from all quarters, he being continually protected by the German princes either from religious or political motives, so that his adversaries could not accomplish his destruction as they had done that of others. The princes, who were upon bad terms with the court of Rome, took advantage of the success of the new doctrines; and in their own dominions easily overturned a church which had lost all the respect and veneration of the inferior ranks. The court of Rome had disobliged some of the smaller princes in the north of Germany, whom the pope probably thought too insignificant to be worth the managing, and they universally established the Reformation in their own dominions. Melancthon, Carlostadius, and other men of eminence, also greatly forwarded the work of Luther; and in all probability the Popish hierarchy would have soon come to an end, in the northern parts of Europe at least, had not the emperor Charles V. given a severe check to the progress of reformation in Germany. In order to follow out the schemes dictated by his ambition, he thought it necessary to ingratiate himself with the pope; and the most effectual method of doing this was by destroying Luther. The pope's legates insisted that Luther ought to be condemned by the diet of Worms without either trial or hearing; as being a most notorious, avowed, and incorrigible heretic. However, this appeared unjust to the members of the diet, and he was summoned to appear; which he accordingly did without hesitation *. There is not the least doubt that his appearance there had been his last in this world, had not the astonishing respect that was paid him, and the

4 Opposed in Germany by Char. V.

* See *Luther*.

the crowds who came daily to see him, deterred his judges from delivering the church from the author of such a pestilent heresy; which they were strongly solicited by the pope's party to do. He was therefore permitted to depart with a safe conduct for a certain time; after which he was in the state of a proscribed criminal, to whom it was unlawful to perform any of the offices of humanity.

5 Form of worship first altered by Wittemberg.

During the confinement of Luther in a castle near Warburg, the Reformation advanced rapidly; almost every city in Saxony embracing the Lutheran opinions. At this time an alteration in the established forms of worship was first ventured upon at Wittemberg, by abolishing the celebration of private masses, and by giving the cup as well as the bread to the laity in the Lord's supper. In a short time, however, the new opinions were condemned by the university of Paris, and a refutation of them was attempted by Henry VIII. of England. But Luther was not to be thus intimidated. He published his animadversions on both with as much acrimony as if he had been refuting the meanest adversary; and a controversy managed by such illustrious antagonists drew a general attention, and the Reformers daily gained new converts both in France and England.

6 Disputes among the Reformers.

But while the efforts of Luther were thus everywhere crowned with success, the divisions began to prevail which have since so much agitated the reformed churches. The first dispute was between Luther and Zuinglius concerning the manner in which the body and blood of Christ were present in the eucharist. Luther and his followers, though they had rejected the notion of transubstantiation, were nevertheless of opinion that the body and blood of Christ were really present in the Lord's supper, in a way which they could not pretend to explain. Carlostadt, who was Luther's colleague, first suggested another view of the subject, which was afterwards confirmed and illustrated by Zuinglius, namely, that the body and blood of Christ were not really present in the eucharist; and that the bread and wine were no more than external symbols to excite the remembrance of Christ's sufferings in the minds of those who received it. Both parties maintained their tenets with the utmost obstinacy; and, by their divisions, first gave their adversaries an argument against them, which to this day the Catholics urge with great force; namely, that the Protestants are so divided, that it is impossible to know who is right or wrong; and that there cannot be a stronger proof than these divisions, that the whole doctrine is false.

7 Disturbances in Germany.

To these intestine divisions were added the horrors of a civil war, occasioned by oppression on the one hand, and enthusiasm on the other. In 1525, a great number of seditious fanatics arose on a sudden in different parts of Germany, took arms, united their forces, and made war against the empire, laying waste the country with fire and sword, and committing everywhere the greatest cruelties. The greatest part of this furious mob was composed of peasants and vassals, who groaned under heavy burdens, and declared that they were no longer able to bear the despotic government of their chiefs; and hence this sedition had the name of *the rustic war*, or the *war of the peasants*. At first this rabble declared, that they had no other motives than the redress of their grievances; but no sooner had the enthusiast Munzer, or Munster, the anabaptist, put himself at their head, than the face of things was entirely changed, and the civil commotions in Saxony and Thuringia exceedingly increased, of which an account is given under the article ANABAPTISTS.

8 Reformation established in Saxony.

In the mean time Frederic, surnamed the *Wise*, elector of Saxony, and Luther's great patron, departed this life, and was succeeded by his brother John. Frederic, though he had protected and encouraged Luther, yet was at no pains to introduce the reformed religion into his dominions. But with his successor it was otherwise; for he, convinced that Luther's doctrine must soon be totally destroyed and suppressed unless it received a speedy and effectual support, ordered Luther and Melancthon to draw up a body of laws relating to the form of ecclesiastical government, the method of public worship, &c. which was to be proclaimed by heralds throughout his dominions. This example was followed by all the princes and states of Germany who renounced the papal supremacy; and a like form of worship, discipline, and government, was thus introduced into all the churches which dissented from that of Rome. This open renunciation of the Romish jurisdiction soon changed the face of affairs; and the patrons of Popery soon intimated, in a manner not at all ambiguous, that they intended to make war on the Lutheran party; which would certainly have been put in execution, had not the troubles that took place in Europe disconcerted their measures. On the other hand, the Lutherans, apprised of these hostile intentions, began also to deliberate on a proper plan of defence against that superstitious violence with which they were in danger of being assailed.

9 Resolutions at the diet of Spire favourable to the Reformation.

The diet of the empire assembled at Spire, in the year 1526; where the emperor's ambassadors were desired to use their utmost endeavours to suppress all disputes about religion, and to insist upon the rigorous execution of the sentence which had been pronounced against Luther and his followers at Worms. The greatest part of the German princes opposed this motion with the utmost resolution, declaring that they could neither execute that sentence, nor come to any determination with regard to the doctrines by which it had been occasioned, before the whole matter was submitted to the decision of a council lawfully assembled; alleging farther, that the decision of controversies of this nature belonged properly to it, and to it alone. This opinion, after long and very warm debates, was adopted by a great majority, and at length consented to by the whole assembly: for it was unanimously agreed to present a solemn address to the emperor, intreating him to assemble, without delay, a free and general council; while in the mean time it was also agreed, that the princes of the empire should, in their respective dominions, be at liberty to manage ecclesiastical affairs in the manner they should think most proper; yet so as to be able to give to God and the emperor a proper account of their administration when it should be required of them.

These resolutions proved extremely favourable to the cause of reformation; neither had the emperor any leisure for some time to give disturbance to the reformed. The war, which at this time ensued between him and the pope, gave the greatest advantage to the friends of the reformed, and considerably augmented their number. Several princes, whom the fear of persecution and punishment

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punishment had hitherto prevented from lending their assistance, publicly renounced the Romish superstition, and introduced among their subjects the same forms of religious worship, and the same system of doctrine, that had been received in Saxony. Others, though placed in such circumstances as discouraged them from acting in an open manner against the interests of the Roman pontiff, were, however, far from discovering the smallest opposition to those who withdrew the people from his despotic yoke; nor did they molest the private assemblies of those who had separated themselves from the church of Rome. And in general, all the Germans who, before these resolutions of the diet of Spire, had rejected the papal discipline and doctrine, were now, in consequence of the liberty they enjoyed, wholly employed in bringing their schemes and plans to a certain degree of consistence, and in adding vigour and firmness to the cause in which they were engaged. But this tranquillity and liberty was of no long duration. In 1529, a new diet was assembled at the same place by the emperor, after he had quieted the troubles in various parts of his dominions, and concluded a peace with the pope. The power which had been granted to princes of managing ecclesiastical affairs till the meeting of a general council, was now revoked by a majority of votes; and every change declared unlawful that should be introduced into the doctrine, discipline, or worship of the established religion, before the determination of the approaching council was known. This decree was considered as iniquitous and intolerable by the elector of Saxony, the landgrave of Hesse, and other members of the diet, who were persuaded of the necessity of a reformation. The promise of speedily assembling a general council, they looked upon to be an artifice of the church of Rome; well knowing, that a free and lawful council would be the last thing to which the pope would consent. When, therefore, they found that all their arguments and remonstrances made no impression upon Ferdinand the emperor's brother, who presided in the diet, Charles himself being then at Barcelona, they entered a solemn protest against this decree on the 19th of April, and appealed to the emperor and a future council. Hence arose the denomination of *Protestants*, which from this period has been given to those who separated from the communion of the church of Rome. The princes of the empire who entered this protest, were John elector of Saxony; George elector of Brandenburg; Ernest and Francis dukes of Lunenburg; the landgrave of Hesse; and the prince of Anhalt. These were seconded by 13 imperial towns, viz. Strasburg, Ulm, Nuremberg, Constance, Rottengen, Windseim, Memmingen, Nortlingen, Lindaw, Kempton, Heilbron, Wissemburg, and St Gall.

10 Revoked by the emperor.

11 Origin of the name *Protestants*.

The dissenting princes, who were the protectors and heads of the reformed churches, had no sooner entered their protest, than they sent proper persons to the emperor, who was then upon his passage from Spain to Italy, to acquaint him with their proceedings in this matter. The ministers employed in this commission executed it with the greatest intrepidity, and presence of mind; but the emperor, exasperated at the audacity of those who presumed to differ from him, caused the ambassadors to be arrested. The news of this violent step made the Protestant princes conclude, that their personal safety, and the success of their cause, depended entirely upon their own courage and union. They determined, therefore, to enter into a solemn confederacy: for which purpose they held several meetings at Rot, Nuremberg, Smalcald, and other places: but so different were their opinions and views, that they could determine upon nothing.

12 Conference between Luther and Zuinglius.

One great obstacle to the intended confederacy was the dispute which had arisen between Luther and Zuinglius concerning the real presence of Christ in the Lord's Supper. To terminate this dispute, if possible, Philip, landgrave of Hesse, invited, in the year 1529, to a conference at Marpurg, Luther and Zuinglius, together with several other of the more eminent doctors who adhered to the respective parties of these contending chiefs: but this measure was not attended with the salutary effects which were expected from it. The divines disputed for four days in presence of the landgrave. Luther attacked Oecolampadius, and Zuinglius was attacked by Melancthon. Zuinglius was accused of heresy, not only on account of his explanation of the nature and design of the Lord's Supper, but also in consequence of the false notions he was supposed to have adopted concerning the divinity of Christ, the efficacy of the divine word, original sin, and some other parts of the Christian doctrine. This illustrious reformer, however, cleared himself from the greatest part of these charges with the most triumphant evidence, and in such a manner as appeared satisfactory even to Luther himself: but their dissension concerning the manner of Christ's presence in the eucharist still remained; nor could either of the contending parties be persuaded to abandon, or even to modify, their opinions on that matter. The only advantage, therefore, which resulted from the meeting was, that the jarring doctors formed a kind of truce, by agreeing to a mutual toleration of their sentiments, and leaving to the disposal of Providence the cure of their divisions.

In the mean time news were received that the emperor designed to come into Germany, with a view to terminate all religious differences at the approaching diet of Augsburg. Having foreseen some of the consequences of those disputes, and, besides, taken the advice of men of wisdom, sagacity, and experience, he became at certain times more cool in his proceedings, and more impartial in his opinions both of the contending parties and the merits of the cause. He, therefore, in an interview with the pope at Bologna, insisted, in the most serious and urgent manner, on the necessity of a general council. His remonstrances and expostulations, however, could not move the pontiff; who maintained with zeal the papal prerogatives, reproached the emperor with an ill-judged clemency, and alleged that it was the duty of that prince to support the church, and to execute speedy vengeance upon that obstinate heretical faction who dared to call in question the authority of Rome and its pontiff. To this discourse the emperor paid no regard; looking upon it as a most iniquitous thing, and a measure directly opposite to the laws of the empire, to condemn unheard a set of men who had always approved themselves good citizens, and deserved well of their country in several respects. Hitherto indeed it was not easy for the emperor to form a clear idea of the matters in debate, since there was no regular

13 Origin of the confession of Augsburg.

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regular ſyſtem as yet compoſed, by which it might be known with certainty what were the true cauſes of Luther's oppoſition to the pope. The elector of Saxony, therefore, ordered Luther, and other eminent divines, to commit to writing the chief articles of their religious ſyſtem, and the principal points in which they differed from the church of Rome. Luther, in compliance with this order, delivered to the elector at Torgaw 17 articles which had been agreed upon in a conference at Sultzbach in 1529; from whence theſe received the name of *the articles of Torgaw*. But though theſe were deemed by Luther a ſufficient declaration of the ſentiments of the reformers, yet it was judged proper to enlarge them, in order to give perſpicuity to their arguments, and ſtrength to their cauſe. In this work Melancthon was employed; in which he ſhowed a proper deference to the counſels of Luther, and expreſſed his ſentiments and doctrine with the greateſt elegance and perſpicuity; and thus came forth to view the famous *Confeſſion of Augsburg*.

On the 15th of June 1530, Charles arrived at Augſburg, and the diet was opened five days after. The Proteſtants received a formal permiſſion to preſent an account of their tenets to the diet on the 25th of the ſame month; in conſequence of which, at the time appointed, Chriſtian Bayer, chancellor of Saxony, read, in the German language, before the emperor and the princes aſſembled, the confeſſion of Augſburg abovementioned. It contained 28 chapters, of which 21 were employed in repreſenting the religious opinions of the Proteſtants, and the other ſeven in pointing out the errors and ſuperſtitions of the church of Rome. The princes heard it with the deepeſt attention and recollection of mind: it confirmed ſome in the principles they had embraced; ſurpriſed others: and many, who before this time had little or no idea of the religious ſentiments of Luther, were now not only convinced of their

14 It is preſented to the emperor.

innocence, but delighted with their purity and ſimplicity. The copies of this Confeſſion, which after being read were delivered to the emperor, were ſigned by John elector of Saxony, George marquis of Brandenburg, Erneſt duke of Lunenburg, Philip landgrave of Heſſe, Wolfgang prince of Anhalt, and by the imperial cities of Nuremburg and Reutlingen.

15 A refutation of it, in which the Proteſtants are ordered to acquieſce.

The creatures of the church of Rome who were preſent at this diet employed John Faber, afterwards biſhop of Vienna, together with Eckius, and another doctor named *Cocklæus*, to draw up a refutation of the Proteſtant confeſſion: which refutation having been publicly read, the emperor required the Proteſtant members to acquieſce in it, and put an end to the religious diſputes by an unlimited ſubmiſſion to the opinions and doctrines contained in this anſwer. But this demand was far from being complied with. The Proteſtants declared on the contrary, that they were by no means ſatisfied with the reply of their adverſaries; and earneſtly deſired a copy of it, that they might more fully demonſtrate its extreme inſufficiency and weakneſs. But this reaſonable requeſt was refuſed by the emperor; who interpoſed his ſupreme authority to prevent any farther proceedings in this matter, and ſolemnly prohibited the publication of any new writings or declarations that might contribute to lengthen out theſe religious debates. This, however, did not reduce the Proteſtants to ſilence. The divines of that communion, who had been preſent at the diet, endeavoured to recollect the arguments and objections employed by Faber, and had again recourſe to the pen of Melancthon, who refuted them in an ample and ſatisfactory manner, in a piece which was preſented to the emperor on the 22d of September, but which Charles refuſed to receive. This anſwer was afterwards enlarged by Melancthon, when he had obtained a copy of Faber's reply; and was publiſhed in the year 1531, with the other pieces that related to the doctrine and diſcipline of the Lutheran church, under the title of *A Defence of the Confeſſion of Augsburg*.

Matters now began to draw towards a criſis. There were only three ways of bringing to a concluſion theſe religious differences. 1. To grant the Proteſtants a toleration and privilege of ſerving God as they thought proper: 2. To compel them to return to the church of Rome by the violent methods of perſecution: or, 3. That a reconciliation ſhould be made, upon fair, candid, and equitable terms, by engaging each of the parties to temper their zeal with moderation, to abate reciprocally the rigour of their pretenſions, and remit ſomething of their reſpective claims. The third expedient was moſt generally approved of, being peculiarly agreeable to all who had at heart the welfare of the empire; nor did the pope ſeem to look upon it either with averſion or contempt. Various conferences therefore were held between perſons eminent for piety and learning on both ſides; and nothing was omitted that might have the leaſt tendency to calm the animoſities and heal the diviſions which reigned between the contending parties. But the differences were too great to admit of a reconciliation; and therefore the votaries of Rome had recourſe to the powerful arguments of imperial edicts, and the force of the ſecular arm. On the 19th of November, a ſevere 16

16 Severe decree againſt the Proteſtants.

decree was iſſued out by the expreſs order of the emperor (during the abſence of the Heſſian and Saxon princes, who were the chief ſupporters of the Proteſtant cauſe), in which every thing was manifeſtly adapted to deject the friends of religious liberty, excepting only a faint and dubious promiſe of engaging the pope to aſſemble a general council about ſix months after the ſeparation of the diet. In this decree the dignity and excellence of the Popiſh religion were extolled beyond meaſure, a new degree of ſeverity and force was added to that which had been publiſhed at Worms againſt Luther and his adherents, the changes which had been introduced into the doctrine and diſcipline of the Proteſtant churches were ſeverely cenſured, and a ſolemn order was addreſſed to the princes, cities, and ſtates, who had thrown off the Papal yoke, to return to their allegiance to Rome, on pain of incurring the indignation and vengeance of the emperor as the patron and protector of the church. Of this formidable decree the elector of Saxony and confederated princes were no ſooner informed than they aſſembled in order to deliberate on the meaſures proper to be taken in ſuch a criſis. In the years 1530 and 1531 17

17 The league of Smalcald.

they met, firſt at Smalcald, and afterwards at Francfort, where they formed a ſolemn alliance and confederacy, with the intention of defending vigorouſly their religion and liberties againſt the dangers and encroachments with which they were threatened by the edict of Augſburg, without attempting, however, any thing offenſive againſt the votaries of Rome; and into this confederacy they invited

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vited the kings of England, France, Denmark, &c. leaving no means unemployed that might corroborate and cement this important alliance.

This confederacy was at first opposed by Luther, from an apprehension of the calamities and troubles which it might produce; but at last, perceiving the necessity of it, he consented; though he uncharitably, as well as imprudently, refused to comprehend in it the followers of Zuinglius among the Swiss, together with the German states and cities who had adopted the sentiments and confession of Bucer. In the invitation addressed to Henry VIII. of England, whom the confederate princes were willing to declare the head and protector of their league, the following things, among others, were expressly stipulated: That the king should encourage, promote, and maintain, the true doctrine of Christ as it was contained in the confession of Augsburg, and defend the same at the next general council: that he should not agree to any council summoned by the bishop of Rome, but protest against it; and neither submit to its decrees, nor suffer them to be respected in his dominions: that he should never allow the Roman pontiff to have any pre-eminence or jurisdiction in his dominions; that he should advance 100,000 crowns for the use of the confederacy, and double that sum if it became necessary: all which articles the confederate princes were equally obliged to observe on their part. To these demands the king replied, that he would maintain and promote the true doctrine of Christ; but, at the same time, as the true ground of that doctrine lay only in the holy Scriptures, he would not accept at any one's hand what should be his own faith, or that of his kingdom; and therefore desired that they would send over two learned men to confer with him, in order to promote a religious union between him and the confederates. However, he declared himself of their opinion with regard to the meeting of a free general council, and promised to join with them in all such councils for the defence of the true doctrine; but thought the regulation of the ceremonial part of religion, being a matter of indifference, ought to be left to the choice of each sovereign for his own dominions. After this the king gave them a second answer more full and satisfactory; but after the execution of Queen Anne, this negotiation came to nothing. On the one hand, the king grew cold when he perceived that the confederates were no longer of use to him in supporting the validity of his marriage; and, on the other hand, the German princes became sensible that they could never succeed with Henry unless they allowed him an absolute dictatorship in matters of religion.

18 Invitation to Henry VIII. of England.

While every thing thus tended to an open war between the two opposite parties, the elector Palatine, and the elector of Mentz, offered their mediation, and endeavoured to procure a reconciliation. The emperor himself, for various reasons, was at this time inclined to peace: for, on the one hand, he stood in need of succours against the Turks, which the Protestant princes refused to grant as long as the edicts of Worms and Augsburg remained in force; and, on the other, the election of his brother Ferdinand to the dignity of king of the Romans, which had been carried by a majority of votes at the diet of Cologne in 1631, was by the same princes contested, as being contrary to the fundamental laws of the empire. In consequence of all this after many negotiations and projects of reconciliation, a treaty of peace was concluded at Nuremberg in 1532, between the emperor and the Protestant princes, on the following conditions; *viz.* That the latter should furnish a subsidy for carrying on the war against the Turks, and acknowledge Ferdinand lawful king of the Romans; and that the emperor on his part should abrogate and annul the edicts of Worms and Augsburg, and allow the Lutherans the free and undisturbed exercise of their religious doctrine and discipline, until a rule of faith was fixed either in the free general council that was to be assembled in the space of six months, or in a diet of the empire.

19 Peace of Nuremberg concluded.

Soon after the conclusion of the peace at Nuremberg died John elector of Saxony, who was succeeded by his son John Frederic, a prince of invincible fortitude and magnanimity, but whose reign was little better than one continued train of disappointments and calamities. The religious truce, however, gave new vigour to the reformation. Those who had hitherto been only secret enemies to the Roman pontiff, now publicly threw off his yoke; and various cities and provinces of Germany enlisted themselves under the religious standards of Luther. On the other hand, as the emperor had now no other hope of terminating the religious disputes but by the meeting of a general council, he repeated his requests to the pope for that purpose. The pontiff (Clement VII.), whom the history of past councils filled with the greatest uneasiness, endeavoured to retard what he could not with decency refuse. At last, in 1533, he made a proposal by his legate to assemble a council at Mantua, Placentia, or Bologna; but the Protestants refused their consent to the nomination of an Italian council, and insisted that a controversy which had its rise in the heart of Germany, should be determined within the limits of the empire. The pope, by his usual artifices, eluded the performance of his own promise; and, in 1534, was cut off by death, in the midst of his stratagems. His successor Paul III. seemed to show less reluctance to the assembling a general council, and in the year 1535 expressed his inclination to convoke one at Mantua; and, the year following, actually sent circular letters for that purpose through all the states and kingdoms under his jurisdiction. This council was summoned by a bull issued out on the 2d of June 1536, to meet at Mantua the following year: but several obstacles prevented its meeting; one of the most material of which was, that Frederic duke of Mantua had no inclination to receive at once so many guests, some of them very turbulent, into the place of his residence. On the other hand, the Protestants were firmly persuaded that, as the council was assembled in Italy, and by the authority of the pope alone, the latter must have had an undue influence in that assembly; of consequence, that all things must have been carried by the votaries of Rome. For this reason they assembled at Smalcald in the year 1537, where they solemnly protested against this partial and corrupt council, and, at the same time, had a new summary of their doctrine drawn up by Luther, in order to present it to the assembled bishops if it should be required of them. This summary, which had the title of *The Articles of Smalcald*, is commonly joined with the creeds and confessions of the Lutheran church.

20 A general council proposed.

21 Protestation against it.

After the meeting of the general council in Mantua was thus prevented, many schemes of accommodation were proposed both by the emperor and the Protestants; but

22 Fruitless schemes of accommodation.

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but, by the artifices of the church of Rome, all of them came to nothing. In 1541, the emperor appointed a conference at Worms on the fubject of religion, between perfons of piety and learning chofen from the contending parties. This conference, however, was, for certain reafons, removed to the diet which was to be held at Ratifbon that fame year, and in which the principal fubject of deliberation was a memorial prefented by a perfon unknown, containing a project of peace. But the conference produced no other effect than a mutual agreement of the contending parties to refer their matters to a general council, or, if the meeting of fuch a council fhould be prevented, to the next German diet.

This refolution was rendered ineffectual by a variety of incidents, which widened the breach, and put off to a farther day the deliberations which were defigned to heal it. The pope ordered his legate to declare to the diet of Spire, affembled in 1542, that he would, according to the promife he had already made, affemble a

23 Council of Trent propofed.

general council, and that Trent fhould be the place of its meeting, if the diet had no objection to that city. Ferdinand, and the princes who adhered to the caufe of the pope, gave their confent to this propofal; but it was vehemently objected to by the Proteftants, both becaufe the council was fummoned by the authority of the pope only, and alfo becaufe the place was within the jurifdiction of the pope; whereas they defired a free council, which fhould not be biaffed by the dictates, nor awed by the proximity, of the pontiff. But this proteftation produced no effect. Paul III. perfifted in his purpofe, and iffued out his circular letters for the convocation of

24 Plan of reformation propofed by the pope.

the council, with the approbation of the emperor. In juftice to this pontiff, however, it muft be obferved, that he fhowed himfelf not to be averfe to every reformation. He appointed four cardinals, and three other perfons eminent for their learning, to draw up a plan for the reformation of the church in general, and of the church of Rome in particular. The reformation propofed in this plan was indeed extremely fuperficial and partial, yet it contained fome particulars which could fcarcely have been expected from thofe who compofed it. They complained of the pride and ignorance of the bifhops, and propofed that none fhould receive orders but learned and pious men; and that therefore care fhould be taken to have proper mafters for the inftruction of youth. They condemned tranflations from one benefice to another, grants of refervation, non-refidence, and pluralities. They propofed that fome convents fhould be abolifhed; that the liberty of the prefs fhould be reftrained and limited; that the colloquies of Erafmus fhould be fuppreffed; that no ecclefiaftic fhould enjoy a benefice out of his own country; that no cardinal fhould have a bifhopric; that the queftors of St Anthony and feveral other faints fhould be abolifhed; and, which was the beft of all their propofals, that the effects and perfonal eftates of ecclefiaftics fhould be given to the poor. They concluded with complaining of the prodigious number of indigent and ragged priefts who frequented St Peter's church; and declared, that it was a great fcandal to fee the whores lodged fo magnificently at Rome, and riding through the ftreets on fine mules, while the cardinals and other ecclefiaftics accompanied them in the moft courteous manner.—This plan of reformation was turned into ridicule by Luther and Sturmius; and indeed it left unredreffed the moft intolerable grievances of which the Proteftants complained.

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25 War between the emperor and the Proteftants.

All this time the emperor had been labouring to perfuade the Proteftants to confent to the meeting of the council at Trent; but when he found them fixed in their oppofition to this meafure, he began to liften to the fanguinary meafures of the pope, and refolved to terminate the difputes by force of arms. The elector of Saxony and landgrave of Heffe, who were the chief fupporters of the Proteftant caufe, upon this took proper meafures to prevent their being furprifed and overwhelmed by a fuperior force; but, before the horrors of war commenced, the great reformer Luther died in peace at Ayfelben, the place of his nativity, in 1546.

The emperor and the pope had mutually refolved on the deftruction of all who fhould dare to oppofe the council of Trent. The meeting of it was to ferve as a fignal for taking up arms; and accordingly its deliberations were fcarcely begun in 1546, when the Proteftants perceived undoubted figns of the approaching ftorm, and a formidable union betwixt the emperor and pope, which threatened to crufh and overwhelm them at once. This year indeed there had been a new conference at Ratifbon upon the old fubject of accommodating differences in religion; but from the manner in which the debates were carried on, it plainly appeared that thefe differences could only be decided in the field of battle. The council of Trent, in the mean time, promulgated their decrees; while the reformed princes, in the diet of Ratifbon, protefted againft their authority, and were on that account profcribed by the emperor, who raifed an army to reduce to them to obedience. See *Father Paul's Hiftory of the Council of Trent*, and our articles *Father* PAUL, and TRENT.

The elector of Saxony and the landgrave of Heffe led their forces into Bavaria againft the emperor, and cannonaded his camp at Ingolftadt. It was fuppofed that this would bring on an engagement, which would probably have been advantageous to the caufe of the reformed; but this was prevented, chiefly by the perfidy of Maurice duke of Saxony, who invaded the dominions of his uncle. Divifions were alfo fomented among the confederate princes, by the diffimulation of the emperor; and France failed in paying the fubfidy which had been promifed by its monarch: all which fo difcouraged the heads of the Proteftant party, that their army foon difperfed, and the elector of Saxony was obliged to direct his march homewards. But he was purfued by the emperor, who made feveral forced marches, with a view to deftroy his enemy before he fhould have time to recover his vigour. The two armies met near Mulberg, on the Elbe, on the 24th of April 1547; and, after a bloody action, the elector was entirely defeated, and himfelf taken prifoner.—Maurice, who had fo bafely betrayed him, was now declared elector of Saxony; and by his intreaties Philip landgrave of Heffe, the other chief of the Proteftants, was perfuaded to throw himfelf on the mercy of the emperor, and to implore his pardon. To this he confented, relying on the promife of Charles for obtaining forgivenefs, and being reftored to liberty; but, notwithftanding thefe expectations, he was unjuftly detained prifoner, by a fcandalous violation of the moft folemn convention. It is faid that the emperor retracted his promife, and deluded this unhappy prince by the ambiguity

26 Elector of Saxony defeated and taken prifoner.

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ambiguity of two German words. History indeed can scarcely afford a parallel to the perfidious, mean-spirited, and despotic behaviour of the emperor in the present case. After having received in public the humble submission of the prince on his knees, and after having set him at liberty by a solemn treaty, he had him arrested anew without any reason, nay, without any pretence, and kept him close prisoner for several years. When Maurice remonstrated against this new confinement, the emperor answered, that he had never promised that the landgrave should not be imprisoned anew, but only that he should be exempted from perpetual imprisonment; and, to support this assertion, he produced the treaty, into which his ministers had perfidiously foisted *ewiger gefangnis*, which signifies a "perpetual prison," instead of *einiger gefangnis*, which signifies "any prison." This, however, is contested by some historians.

The affairs of the Protestants now seemed to be desperate. In the diet of Augsburg, which was soon after called, the emperor required the Protestants to leave the decision of these religious disputes to the wisdom of the council which was to meet at Trent. The greatest part of the members consented to this proposal, being convinced by the powerful argument of an imperial army, which was at hand to dispel the darkness from the eyes of such as might otherwise have been blind to the force of Charles's reasoning. However, this general submission did not produce the effect which was expected from it. A plague which broke out, or was said to do so, in the city, caused the greatest part of the bishops to retire to Bologna; by which means the council was in effect dissolved, nor could all the intreaties and remonstrances of the emperor prevail upon the pope to re-assemble it without delay. During this interval, therefore, the emperor judged it necessary to fall upon some method of accommodating the religious differences, and maintaining peace until the council so long expected should be finally obtained. With this view he ordered Julius Pelugius, bishop of Naumberg, Michael Sidonius, a creature of the pope, and John Agricola, a native of Ayselben, to draw up a formulary which might serve as a rule of faith and worship, till the council should be assembled: but as this was only a temporary expedient, and had not the force of a permanent or perpetual institution, it thence obtained the name of the *Interim*.

27 The council suddenly dissolved.

28 A formulary drawn up by the emperor.

This project of Charles was formed partly with a design to vent his resentment against the pope, and partly to answer other political purposes. It contained all the essential doctrines of the church of Rome, though considerably softened by the artful terms which were employed, and which were quite different from those employed before and after this period by the council of Trent. There was even an affected ambiguity in many of the expressions, which made them susceptible of different senses, and applicable to the sentiments of both communions. The consequence of all this was, that the imperial creed was reprobated by both parties. However, it was promulgated with great solemnity by the emperor at Augsburg. The elector of Mentz, without even asking the opinion of the princes present, gave a sanction to this formula, as if he had been commissioned to represent the whole diet. Many kept silence through fear, and that silence was interpreted as a tacit consent. Some had the courage to oppose it, and these were reduced by force of arms; and the most deplorable scenes of bloodshed and violence were acted throughout the whole empire. Maurice, elector of Saxony, who had hitherto kept neutral, now assembled the whole of his nobility and clergy, in order to deliberate on this critical affair. At the head of the latter was Melancthon, whose word was respected as a law among the Protestants. But this man had not the courage of Luther; and was therefore on all occasions ready to make concessions, and to propose schemes of accommodation. In the present case, therefore, he gave it as his opinion, that the whole of the book called *Interim* could not by any means be adopted by the Protestants; but at the same time he declared, that he saw no reason why this book might not be approved, adopted, and received, as an authoritative rule in things that did not relate to the essential parts of religion, and which he accounted indifferent. But this scheme, instead of cementing the differences, made them worse than ever; and produced a division among the Protestants themselves, which might have overthrown the Reformation entirely, if the emperor and pope had seized the opportunity.

29 Displeases both parties.

30 Scheme of reconciliation by Melancthon.

In the year 1549, the pope (Paul III.) died; and was succeeded by Julius III. who, at the repeated solicitations of the emperor, consented to the re-assembling of a council at Trent. A diet was again held at Augsburg under the cannon of an imperial army, and Charles laid the matter before the princes of the empire. Most of those present gave their consent to it, and among the rest Maurice elector of Saxony; who consented on the following conditions: 1. That the points of doctrine which had already been decided there, should be re-examined. 2. That this examination should be made in presence of the Protestant divines. 3. That the Saxon Protestants should have a liberty of voting as well as of deliberating in the council. 4. That the pope should not pretend to preside in that assembly, either in person or by his legates. This declaration of Maurice was read in the diet, and his deputies insisted upon its being entered into the registers which the archbishop of Mentz obstinately refused. The diet was concluded in the year 1551; and, at its breaking up, the emperor desired the assembled princes and states to prepare all things for the approaching council, and promised to use his utmost endeavours to procure moderation and harmony, impartiality and charity, in the transactions of that assembly.

31 A new council proposed at Trent.

On the breaking up of the diet, the Protestants took such steps as they thought most proper for their own safety. The Saxons employed Melancthon, and the Wurtembergers Brengius, to draw up Confessions of Faith to be laid before the new council. The Saxon divines, however, proceeded no farther than Nuremberg, having received secret orders from Maurice to stop there: For the elector, perceiving that Charles had formed designs against the liberties of the German princes, resolved to take the most effectual measures for crushing his ambition at once. He therefore entered with the utmost secrecy and expedition into an alliance with the king of France, and several of the German princes, for the security of the rights and liberties of the empire; after which, assembling a powerful army in 1552, he marched against the emperor, who lay with a handful of troops at Inspruck, and expected no such thing. By this sudden and unforeseen accident Charles was so much dispirited, that he was willing to make peace

32 The emperor is surprised, and forced to a peace by the elector of Saxony.

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The aſſembling of the diet promiſed by Charles was prevented by various incidents; however, it met at Augſburg in 1555, where it was opened by Ferdinand in name of the emperor, and terminated thoſe deplorable calamities which had ſo long deſolated the empire. After various debates, the following acts were paſſed, on

33 Treaty of Augſburg. the 25th of September: That the Proteſtants who followed the Confeſſion of Augſburg ſhould be for the future conſidered as entirely free from the juriſdiction of the Roman pontiff, and from the authority and ſuperintendance of the biſhops; that they were left at perfect liberty to enact laws for themſelves relating to their religious ſentiments, diſcipline, and worſhip; that all the inhabitants of the German empire ſhould be allowed to judge for themſelves in religious matters, and to join themſelves to that church whoſe doctrine and worſhip they thought the moſt pure and conſonant to the ſpirit of true Chriſtianity; and that all thoſe who ſhould injure or perſecute any perſon under religious pretences, and on account of their opinions, ſhould be declared and proceeded againſt as public enemies of the empire, invaders of its liberty, and diſturbers of its peace.

Thus was the Reformation eſtabliſhed in many parts of the German empire, where it continues to this day; nor have the efforts of the Popiſh powers at any time been able to ſuppreſs it, or even to prevent it from gaining ground.

34 Account of the Reformation in Sweden. It was not, however, in Germany alone that a reformation of religion took place. Almoſt all the kingdoms of Europe began to open their eyes to the truth about the ſame time. The reformed religion was propagated in Sweden, ſoon after Luther's rupture with the church of Rome, by one of his diſciples named *Olaus Petri*. The zealous efforts of this miſſionary were ſeconded by Guſtavus Vaſa, whom the Swedes had raiſed to the throne in place of Chriſtiern king of Denmark, whoſe horrid barbarity loſt him the crown. This prince, however, was as prudent as he was zealous; and, as the minds of the Swedes were in a fluctuating ſtate, he wiſely avoided all kind of vehemence and precipitation in ſpreading the new doctrine. Accordingly, the firſt object of his attention was the inſtruction of his people in the ſacred doctrines of the Holy Scriptures: for which purpoſe he invited into his dominions ſeveral learned Germans, and ſpread abroad through the kingdom the Swediſh tranſlation of the Bible that had been made by Olaus Petri. Some time after this, in 1526, he appointed a conference at Upſal, between this reformer and Peter Gallius, a zealous defender of the ancient ſuperſtition, in which each of the champions was to bring forth his arguments, that it might be ſeen on which ſide the truth lay. In this diſpute Olaus obtained a ſignal victory; which contributed much to confirm Guſtavus in his perſuaſion of the truth of Luther's doctrine, and to promote its progreſs in Sweden. The following year another event gave the finiſhing ſtroke to its propagation and ſucceſs. This was the aſſembly of the ſtates at Weſteraas, where Guſtavus recommended the doctrine of the reformers with ſuch zeal, that, after warm debates fomented by the clergy in general, it was unanimouſly reſolved that the reformation introduced by Luther ſhould have place in Sweden. This reſolution was principally owing to the firmneſs and magnanimity of Guſtavus, who declared publicly, that he would lay down the ſceptre and retire from the kingdom, rather than rule a people enſlaved by the orders and authority of the pope, and more controuled by the tyranny of their biſhops than by the laws of their monarch. From this time the papal empire in Sweden was entirely overthrown, and Guſtavus declared head of the church.

In Denmark, the reformation was introduced as early 35 In Denmark.
as the year 1521, in conſequence of the ardent deſire diſcovered by Chriſtiern II. of having his ſubjects inſtructed in the doctrines of Luther. This monarch, notwithſtanding his cruelty, for which his name has been rendered odious, was neverthelefs deſirous of delivering his dominions from the tyranny of the church of Rome. For this purpoſe, in the year 1520, he ſent for Martin Reinard, one of the diſciples of Carloſtadt, out of Saxony, and appointed him profeſſor of divinity at Hafnia; and after his death, which happened in 1521, he invited Carloſtadt himſelf to fill that important place. Carloſtadt accepted of this office indeed, but in a ſhort time returned to Germany; upon which Chriſtiern uſed his utmoſt endeavours to engage Luther to viſit his dominions, but in vain. However, the progreſs of Chriſtiern, in reforming the religion of his ſubjects, or rather of advancing his own power above that of the church, was checked, in the year 1523, by a conſpiracy, by which he was depoſed and baniſhed; his uncle Frederic, duke of Holſtein and Sleſwic, being appointed his ſucceſſor.

Frederic conducted the reformation with much greater prudence than his predeceſſor. He permitted the Proteſtant doctors to preach publicly the ſentiments of Luther, but did not venture to change the eſtabliſhed government and diſcipline of the church. However, he contributed greatly to the progreſs of the reformation, by his ſucceſsful attempts in favour of religious liberty in an aſſembly of the ſtates held at Odenſee in

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1527. Here he procured the publication of a famous edict, by which every subject of Denmark was declared free either to adhere to the tenets of the church of Rome, or to the doctrine of Luther. The papal tyranny was totally destroyed by his successor Christiern III. He began by suppressing the despotic authority of the bishops, and restoring to their lawful owners a great part of the wealth and possessions which the church had acquired by various stratagems. This was followed by a plan of religious doctrine, worship, and discipline, laid down by Bugenhagius, whom the king had sent for from Wittemberg for that purpose; and in 1539 an assembly of the states at Odensee gave a solemn sanction to all these transactions.

36 In France.

In France also, the reformation began to make some progress very early. Margaret queen of Navarre, sister to Francis I. the perpetual rival of Charles V. was a great friend to the new doctrine; and it appears that, as early as the year 1523, there were in several of the provinces of France great numbers of people who had conceived the greatest aversion both to the doctrine and tyranny of the church of Rome; among whom were many of the first rank and dignity, and even some of the episcopal order. But as their number increased daily, and troubles and commotions were excited in several places on account of the religious differences, the authority of the king intervened, and many persons eminent for their virtue and piety were put to death in the most barbarous manner. Indeed Francis, who had either no religion at all, or, at best, no fixed and consistent system of religious principles, conducted himself towards the Protestants in such a manner as best answered his private views. Sometimes he resolved to invite Melancthon into France, probably with a view to please his sister the queen of Navarre, whom he loved tenderly, and who had strongly imbibed the Protestant principles. At other times he exercised the most infernal cruelty towards the reformed; and once made the following mad declaration, That if he thought the blood in his arm was tainted by the Lutheran heresy, he would have it cut off; and that he would not spare even his own children, if they entertained sentiments contrary to those of the Catholic church.

About this time the famous Calvin began to draw the attention of the public, but more especially of the queen of Navarre. His zeal exposed him to danger; and the friends of the reformation, whom Francis was daily committing to the flames, placed him more than once in the most perilous situation, from which he was delivered by the interposition of the queen of Navarre. He therefore retired out of France to Basil in Swisserland; where he published his Christian Institutions, and became afterwards so famous.

Those among the French who first renounced the jurisdiction of the Romish church, are commonly called *Lutherans* by the writers of those early times. Hence it has been supposed that they had all imbibed the peculiar sentiments of Luther. But this appears by no means to have been the case: for the vicinity of the cities of Geneva, Lausanne, &c. which had adopted the doctrines of Calvin, produced a remarkable effect upon the French Protestant churches; insomuch that, about the middle of this century, they all entered into communion with the church of Geneva. The French Protestants were called *Huguenots* * by their adversaries, by way of contempt. Their fate was very severe, being persecuted with unparalleled fury; and though many princes of the blood, and of the first nobility, had embraced their sentiments, yet in no part of the world did the reformers suffer so much †. At last all commotions were quelled by the fortitude and magnanimity of Henry IV. who in the year 1598 granted all his subjects full liberty of conscience by the famous Edict of Nantes, and seemed to have thoroughly established the reformation throughout his dominions. During the minority of Louis XIV. however, this edict was revoked by Cardinal Mazarine, since which time the Protestants have often been cruelly persecuted; nor was the profession of the reformed religion in France at any time so safe as in most other countries of Europe.

* See *Huguenots*.

† See *France*, N° 137, 141—149.

37 In the Netherlands, &c.

In the other parts of Europe the opposition to the church of Rome was but faint and ambiguous before the diet of Augsburg. Before that period, however, it appears from undoubted testimony, that the doctrine of Luther had made a considerable, though probably secret, progress through Spain, Hungary, Bohemia, Britain, Poland, and the Netherlands; and had in all these countries many friends, of whom several repaired to Wittemberg, in order to enlarge their knowledge by means of Luther's conversation. Some of these countries threw off the Romish yoke entirely, and in others a prodigious number of families embraced the principles of the reformed religion. It is certain indeed, and some Roman Catholics themselves acknowledge it without hesitation, that the Papal doctrines and authority would have fallen into ruin in all parts of the world at once, had not the force of the secular arm been employed to support the tottering edifice. In the Netherlands particularly, the most grievous persecutions took place, so that by the emperor Charles V. upwards of 100,000 were destroyed, while still greater cruelties were exercised upon the people by his son Philip II. The revolt of the United Provinces, however, and motives of real policy, at last put a stop to these furious proceedings; and, though in many provinces of the Netherlands, the establishment of the Popish religion was still continued, the Protestants have been long free of the danger of persecution on account of their principles.

38 In Italy.

The reformation made considerable progress in Spain and Italy soon after the rupture between Luther and the Roman pontiff. In all the provinces of Italy, but more especially in the territories of Venice, Tuscany, and Naples, the superstition of Rome lost ground, and great numbers of people of all ranks expressed an aversion to the Papal yoke. This occasioned violent and dangerous commotions in the kingdom of Naples in the year 1546; which, however, were at last quelled by the united efforts of Charles V. and his viceroy Don Pedro di Toledo. In several places the pope put a stop to the progress of the reformation, by letting loose the inquisitors; who spread dreadful marks of their barbarity through the greatest part of Italy. These formidable ministers of superstition put so many to death, and perpetrated such horrid acts of cruelty and oppression, that most of the reformed consulted their safety by a voluntary exile, while others returned to the religion of Rome, at least in external appearance. But the inquisition, which frighted into the profession of Popery several Protestants in other parts of Italy, could never make its way into the kingdom of Naples; nor could either the

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the authority or intreaties of the pope engage the Neapolitans to admit even visiting inquisitors.

39 In Spain.

In Spain, several people embraced the Protestant religion, not only from the controversies of Luther, but even from those divines whom Charles V. had brought with him into Germany in order to refute the doctrines of Luther. For these doctors imbibed the pretended heresy instead of refuting it, and propagated it more or less on their return home. But the inquisition, which could obtain no footing in Naples, reigned triumphant in Spain, and by the most dreadful methods frightened the people back into Popery, and suppressed the desire of exchanging their superstition for a more rational plan of religion. It was indeed presumed that Charles himself died a Protestant; and it seems to be certain, that, when the approach of death had dissipated those schemes of ambition and grandeur which had so long blinded him, his sentiments became much more rational and agreeable to Christianity than they had ever been. All the ecclesiastics who had attended him, as soon as he expired, were sent to the inquisition, and committed to the flames, or put to death by some other method equally terrible. Such was the fate of Augustine Casal, the emperor's preacher; of Constantius Pontius, his confessor; of Egidius, whom he had named to the bishopric of Tortosa; of Bartholomew de Caranza, a Dominican, who had been confessor to King Philip and Queen Mary; with 20 others of less note.

40 In England.

In England, the principles of the reformation began to be adopted as soon as an account of Luther's doctrines could be conveyed thither. In that kingdom there were still great remains of the sect called *Lollards*, whose doctrine resembled that of Luther; and among whom, of consequence, the sentiments of our reformer gained great credit. Henry VIII. king of England at that time was a violent partisan of the church of Rome, and had a particular veneration for the writings of Thomas Aquinas. Being informed that Luther spoke of his favourite author with contempt, he conceived a violent prejudice against the reformer, and even wrote against him, as we have already observed. Luther did not hesitate at writing against his majesty, overcame him in argument, and treated him with very little ceremony. The first step towards public reformation, however, was not taken till the year 1529. Great complaints had been made in England, and of a very ancient date, of the usurpations of the clergy; and by the prevalence of the Lutheran opinions, these complaints were now become more general than before. The house of commons, finding the occasion favourable, passed several bills, restraining the impositions of the clergy: but what threatened the ecclesiastical order with the greatest danger were the severe reproaches thrown out almost without opposition in the house against the dissolute lives, ambition, and avarice of the priests, and their continual encroachments on the privileges of the laity. The bills for regulating the clergy met with opposition in the house of lords; and Bishop Fisher imputed them to want of faith in the commons, and to a formed design, proceeding from heretical and Lutheran principles, of robbing the church of her patrimony, and overturning the national religion. The commons, however, complained to the king, by their speaker Sir Thomas Audley, of these reflections thrown out against them; and the bishop was obliged to retract his words.

Though Henry had not the least idea of rejecting any, even of the most absurd Romish superstitions, yet as the oppressions of the clergy suited very ill with the violence of his own temper, he was pleased with every opportunity of lessening their power. In the parliament of 1531, he showed his design of humbling the clergy in the most effectual manner. An obsolete statute was revived, from which it was pretended that it was criminal to submit to the legatine power which had been exercised by Cardinal Wolsey. By this stroke the whole body of clergy was declared guilty at once. They were too well acquainted with Henry's disposition, however, to reply, that their ruin would have been the certain consequence of their not submitting to Wolsey's commission, which had been given by royal authority. Instead of making any defence of this kind, they chose to throw themselves on the mercy of their sovereign; which, however, it cost them 118,840l. to procure. A confession was likewise extorted from them, that the king was protector and supreme head of the church of England; though some of them had the dexterity to get a clause inserted, which invalidated the whole submission, viz. *in so far as is permitted by the law of Christ*.

The king, having thus begun to reduce the power of the clergy, kept no bounds with them afterwards. He did not indeed attempt any reformation in religious matters; nay, he persecuted most violently such as did attempt this in the least. Indeed, the most essential article of his creed seems to have been his own supremacy: for whoever denied this, was sure to suffer the most severe penalties, whether Protestant or Papist. But an account of the absurd and cruel conduct of this prince, and of his final quarrel with the pope on account of his refusing a dispensation to marry Anne Boleyn, is given under the article England, N° 253—292.

He died in 1547, and was succeeded by his only son Edward VI. This amiable prince, whose early youth was crowned with that wisdom, sagacity, and virtue, that would have done honour to advanced years, gave new spirit and vigour to the Protestant cause, and was its brightest ornament, as well as its most effectual support. He encouraged learned and pious men of foreign countries to settle in England, and addressed a particular invitation to Martin Bucer and Paul Fagius, whose moderation added a lustre to their other virtues, that, by the ministry and labours of these eminent men, in concert with those of the friends of the Reformation in England, he might purge his dominions from the sordid fictions of popery, and establish the pure doctrines of Christianity in their place. For this purpose, he issued out the wisest orders for the restoration of true religion; but his reign was too short to accomplish fully such a glorious purpose. In the year 1553, he was taken from his loving and afflicted subjects, whose sorrow was inexpressible, and suited to their loss. His sister Mary (the daughter of Catharine of Arragon, from whom Henry had been separated by the famous divorce), a furious bigot to the church of Rome, and a princess whose natural character, like the spirit of her religion, was despotic and cruel, succeeded him on the British throne, and imposed anew the arbitrary laws and the tyrannical yoke of Rome upon the people of England. Nor were the methods she employed in the cause of

Reformation. of ſuperſtition better than the cauſe itſelf, or tempered by any ſentiments of equity or compaſſion. Barbarous tortures, and death in the moſt ſhocking forms, awaited thoſe who oppoſed her will, or made the leaſt ſtand againſt the reſtoration of Popery. And among many other victims, the learned and pious Cranmer, archbiſhop of Canterbury, who had been one of the moſt illuſtrious inſtruments of the Reformation in England, fell a ſacrifice to her fury. This odious ſcene of perſecution was happily concluded in the year 1558, by the death of the queen, who left no iſſue; and, as ſoon as her ſucceſſor the lady Elizabeth aſcended the throne, all things aſſumed a new and a pleaſing aſpect. This illuſtrious princeſs, whoſe ſentiments, councils, and projects, breathed a ſpirit ſuperior to the natural ſoftneſs and delicacy of her ſex, exerted this vigorous and manly ſpirit in the defence of oppreſſed conſcience and expiring liberty, broke anew the deſpotic yoke of Papal authority and ſuperſtition, and, delivering her people from the bondage of Rome, eſtabliſhed that form of religious doctrine and eccleſiaſtical government which ſtill ſubſiſts in England. This religious eſtabliſhment differs, in ſome reſpects, from the plan that had been formed by thoſe whom Edward VI. had employed for promoting the cauſe of the Reformation, and approaches nearer to the rites and diſcipline of former times; though it is widely different, and, in the moſt important points, entirely oppoſite to the principles of the Roman hierarchy. See ENGLAND, N° 293, &c.

41 In Ireland. The cauſe of the reformation underwent in Ireland the ſame viciſſitudes and revolutions that had attended it in England. When Henry VIII. after the abolition of the Papal authority, was declared ſupreme head upon earth of the church of England, George Brown, a native of England, and a monk of the Auguſtine order, whom that monarch had created, in the year 1535, archbiſhop of Dublin, began to act with the utmoſt vigour in conſequence of this change in the hierarchy. He purged the churches of his dioceſe from ſuperſtition in all its various forms, pulled down images, deſtroyed relics, aboliſhed abſurd and idolatrous rites, and, by the influence as well as authority he had in Ireland, cauſed the king's ſupremacy to be acknowledged in that nation. Henry ſhowed, ſoon after, that this ſupremacy was not a vain title; for he baniſhed the monks out of that kingdom, confiſcated their revenues, and deſtroyed their convents. In the reign of Edward VI. ſtill farther progreſs was made in the removal of Popiſh ſuperſtitions, by the zealous labours of Biſhop Brown, and the auſpicious encouragement he granted to all who exerted themſelves in the cauſe of the Reformation. But the death of this excellent prince, and the acceſſion of Queen Mary, had like to have changed the face of affairs in Ireland as much as in England; but her deſigns were diſappointed by a very curious adventure, of which the following account has been copied from the papers of Richard earl of Corke. "Queen Mary having dealt ſeverely with the Proteſtants in England, about the latter end of her reign

42 Curious diſappointment of a Popiſh doctor in Ireland. ſigned a commiſſion for to take the ſame courſe with them in Ireland; and to execute the ſame with greater force, ſhe nominates Dr Cole one of the commiſſioners. The doctor coming, with the commiſſion, to Cheſter on his journey, the mayor of that city hearing that her majeſty was ſending a meſſenger into Ireland, and he being a churchman, waited on the doctor, who in diſcourſe with the mayor taketh out of a cloke-bag a leather box, ſaying unto him, *Here is a commiſſion that ſhall laſh the Heretics of Ireland*, calling the Proteſtants by that title. The good woman of the houſe being well affected to the Proteſtant religion, and alſo having a brother named *John Edmonds* of the ſame perſuaſion, then a citizen in Dublin, was much troubled at the doctor's words, but watching her convenient time while the mayor took his leave, and the doctor complimented him down the ſtairs, ſhe opens the box, takes the commiſſion out, and places in lieu thereof a ſheet of paper with a pack of cards wrapt up therein, the knave of clubs being faced uppermoſt. The doctor coming up to his chamber, ſuſpecting nothing of what had been done, put up the box as formerly. The next day going to the water-ſide, wind and weather ſerving him, he ſails towards Ireland, and landed on the 7th of October 1558 at Dublin. Then coming to the caſtle, the lord Fitz-Walters being lord-deputy, ſent for him to come before him and the privy-council; who, coming in, after he had made a ſpeech relating upon what account he came over, he preſents the box unto the lord-deputy; who cauſing it to be opened, that the ſecretary might read the commiſſion, there was nothing ſave a pack of cards with the knave of clubs uppermoſt; which not only ſtartled the lord-deputy and council, but the doctor, who aſſured them he had a commiſſion, but knew not how it was gone. Then the lord-deputy made anſwer: Let us have another commiſſion, and we will ſhuffle the cards in the meanwhile. The doctor being troubled in his mind, went away, and returned into England, and coming to the court obtained another commiſſion: but ſtaying for a wind on the water-ſide, news came to him that the queen was dead: and thus God preſerved the Proteſtants of Ireland." Queen Elizabeth was ſo delighted with this ſtory, which was related to her by Lord Fitz-Walter on his return to England, that ſhe ſent for Elizabeth Edmonds, whoſe huſband's name was *Matterſhad*, and gave her a penſion of 40l. during her life.

In Scotland, the ſeeds of reformation were very early 43 Of the Reformation in Scotland.
ſown, by ſeveral noblemen who had reſided in Germany during the religious diſputes there. But for many years it was ſuppreſſed by the power of the pope, ſeconded by inhuman laws and barbarous executions. The moſt eminent oppoſer of the Papal juriſdiction was John Knox, a diſciple of Calvin, a man of great zeal and invincible fortitude. On all occaſions he raiſed the drooping ſpirits of the reformers, and encouraged them to go on with their work notwithſtanding the oppoſition and treachery of the queen-regent; till at laſt, in 1561, by the aſſiſtance of an Engliſh army ſent by Elizabeth, Popery was in a manner totally extirpated throughout the kingdom. From this period the form of doctrine, worſhip, and diſcipline eſtabliſhed by Calvin at Geneva, has had the aſcendancy in Scotland. But for an account of the difficulties which the Scottiſh reformers had to ſtruggle with, and the manner in which theſe were overcome, &c. ſee SCOTLAND.

For further information on the ſubject of the reformation in general we refer our readers to the works of Burnet and Brandt, to Beauſobre's *Hiſtoire de la Reformation dans l'Empire, et les Etats de la Confeſſion d'Augſbourg depuis* 1517—1530, in 4 vols 8vo, Berlin 1785, Refraction.

1785, and Mosheim's Ecclesiastical History. See also Sleidan *De Statu Religionis et Reipublicæ, Carolo V. Cæsare, Commentarii;* and Father Paul's History of the Council of Trent.

REFRACTION, in general, is the deviation of a moving body from its direct course, occasioned by the different density of the medium in which it moves; or it is a change of direction occasioned by a body's falling obliquely out of one medium into another. The word is chiefly made use of with regard to the rays of light. See Optics *Index*, at *Refraction*.

Refraction of Altitude, the arc or portion of a vertical circle, by which the altitude of a star is increased by the refraction of light.

Refraction of Ascension and Descension, an arc of the equator, by which the ascension and descension of a star, whether right or oblique, is increased or diminished by the refraction.

Refraction of Declination, is an arc of a circle of declination, by which the declination of a star is increased or diminished by refraction.

Refraction of Latitude, an arc of a circle of latitude, by which the latitude of a star is increased or diminished by the refraction.

Refraction of Longitude, an arc of the ecliptic, by which the longitude of a star is increased or diminished by means of the refraction.

Refraction, Terrestrial, is that which makes terrestrial objects appear to be raised higher than they are in reality, in observing their altitudes. The quantity of this refraction is estimated at one-tenth by Dr Maskelyne; at one-fourteenth by Le Gendre; and by De Lambre at one eleventh. But there can be no fixed quantity of this refraction, since it depends upon the state of the atmosphere, which is extremely variable. Some singular effects of this refraction have been noticed, and in particular the following, which were observed by Mr Latham at Hastings, during a very hot day, on which it was high water about two o'clock P. M. The day was also perfectly calm.

"On Wednesday, July 26. about five o'clock in the afternoon, while I was sitting in my dining-room at this place, which is situated upon the Parade, close to the sea-shore, nearly fronting the south, my attention was excited by a number of people running down to the sea-side. Upon enquiring the reason, I was informed that the coast of France was plainly to be distinguished by the naked eye. I immediately went down to the shore, and was surprised to find that, even without the assistance of a telescope, I could very plainly see the cliffs on the opposite coast; which, at the nearest part, are between 40 and 50 miles distant, and are not to be discerned, from that low situation, by the aid of the best glasses. They appeared to be only a few miles off, and seemed to extend for some leagues along the coast. I pursued my walk along the shore eastward, close to the water's edge, conversing with the sailors and fishermen upon the subject. They at first could not be persuaded of the reality of the appearance; but they soon became so thoroughly convinced, by the cliffs gradually appearing more elevated, and approaching nearer, as it were, that they pointed out and named to me the different places they had been accustomed to visit; such as the Bay, the Old Head or Man, the Windmill, &c. at Boulogne; St Vallery, and other places on the coast of Picardy; which they afterwards confirmed when they viewed them through their telescopes. Their observations were, that the places appeared as near as if they were sailing, at a small distance, into the harbours." *

Refraction || Refugees.

* Phil. Trans. 1798.

REFRANGIBILITY of Light, the disposition of rays to be refracted. The term is chiefly applied to the disposition of rays to produce different colours, according to their different degrees of refrangibility. See Chromatics and Optics *passim*.

REFRIGERATIVE, in *Medicine*, a remedy which refreshes the inward parts by cooling them; as clysters, ptisans, &c.

REFRIGERATORY, in *Chemistry*, a vessel filled with cold water, through which the worm passes in distillations; the use of which is to condense the vapours as they pass through the worm.

Cities of REFUGE, were places provided as *Asyla*, for such as against their will should happen to kill a man. Of these cities there were three on each side Jordan: on this side were Kedesh of Naphtali, Hebron, and Shechem; beyond Jordan were Bezer, Golan, and Ramoth-Gilead. When any of the Hebrews, or strangers that dwelt in their country, happened to spill the blood of a man, they might retire thither to be out of the reach of the violent attempts of the relations of the deceased, and to prepare for their defence and justification before the judges. The manslayer underwent two trials: first before the judges of the city of refuge to which he had fled; and secondly before the judges of his own city. If found guilty, he was put to death with all the severity of the law. If he was acquitted, he was not immediately set at liberty; but, to inspire a degree of horror against even involuntary homicide, he was reconducted to the place of refuge, and obliged to continue there in a sort of banishment till the death of the high-priest. If, before this time, he ventured out, the revenger of blood might freely kill him; but after the high-priest's death he was at liberty to go where he pleased without molestation. It was necessary that the person who fled to any of the cities of refuge should understand some trade or calling, that he might not be burthensome to the inhabitants. The cities of refuge were required to be well supplied with water and necessary provisions. They were also to be easy of access, to have good roads leading to them, with commodious bridges where there was occasion. The width of the roads was to be 32 cubits or 48 feet at least. It was further required, that at all cross-ways direction-posts should be erected, with an inscription pointing out the road to the cities of refuge. The 15th of Adar, which answers to our February moon, was appointed for the city magistrates to see that the roads were in good condition. No person in any of these cities was allowed to make weapons, lest the relations of the deceased should be furnished with the means of gratifying their revenge. Deut. xix. 3. iv. 41. 43.; Josh. xx. 7. Three other cities of refuge were conditionally promised, but never granted. See Asylum.

REFUGEES, a term at first applied to the French Protestants, who, by the revocation of the edict of Nantz, were constrained to fly from persecution, and take refuge in foreign countries. Since that time, however, it has been extended to all such as leave their country in times of distress; and hence, since the revolt of the British

British colonies in America, we have frequently heard of *American refugees.*

REGALE, a magnificent entertainment or treat, given to ambassadors and other persons of distinction, to entertain or do them honour.

It is usual in Italy, at the arrival of a traveller of eminence, to send him a regale, that is, a present of sweetmeats, fruits, &c. by way of refreshment.

REGALIA, in *Law*, the rights and prerogatives of a king. See PREROGATIVE.

Regalia is also used for the apparatus of a coronation; as the crown, the sceptre with the cross, that with the dove, St Edward's staff, the globe, and the orb with the cross, four several swords, &c.—The regalia of Scotland were deposited in the castle of Edinburgh in the year 1707, in what is called the *jewel office*. The room was a few years ago opened by some commissioners appointed by the king, when the large chest in which it is supposed they were placed was examined; but nothing was found in it. It is very generally thought that the regalia were carried to the Tower of London in the reign of Queen Anne; and a crown is there shown which is called the Scotch crown. This, however, does not appear to be the real crown of Scotland. It seems, therefore, most probable that the Scottish regalia must have been taken away by stealth, and either destroyed or melted down.

LORD of REGALITY, in *Scots Law*. See LAW, N° clviii. 4.

COURT of REGARD. See *FOREST-Courts.*

REGARDANT, in *Heraldry*, signifies looking behind; and it is used for a lion, or other beast, with his face turned towards his tail.

REGARDER, an ancient officer of the king's forest, sworn to make the regard of the forest every year; that is, to take a view of its limits, to inquire into all offences and defaults committed by the foresters within the forest, and to observe whether all the officers execute their respective duties. See *FOREST-Laws.*

REGATA, or REGATTA, a species of amusement peculiar to the republic of Venice. This spectacle has the power of exciting the greatest emotions of the heart, admiration, enthusiasm, a sense of glory, and the whole train of our best feelings. The grand regata is only exhibited on particular occasions, as the visits of foreign princes and kings at Venice.

It is difficult to give a just idea of the ardour that the notice of a *regata* spreads among all classes of the inhabitants of Venice. Proud of the exclusive privilege of giving such a spectacle, through the wonderful local circumstances of that city, they are highly delighted with making preparations a long time before, in order to contribute all they can towards the perfection and enjoyment of the spectacle. A thousand interests are formed and augmented every day; parties in favour of the different competitors who are known; the protection of young noblemen given to the gondoliers in their service; the desire of honours and rewards in the aspirants; and, in the midst of all this, that ingenious national industry, which awakes the Venetians from their habitual indolence, to derive advantage from the business and agitation of the moment; all these circumstances united give to the numerous inhabitants of this lively city a degree of spirit and animation which render it during that time a delightful abode in the eyes of the philosopher and the stranger. Crowds of people flock from the adjacent parts, and travellers joyfully repair to this scene of gaiety and pleasure.

Although it is allowable for any man to go and inscribe his name in the list of combatants until the fixed number is complete, it will not be amiss to remark one thing, which has relation to more ancient times. The state of a gondolier * is of much consideration among the people; which is very natural, that having been the primitive condition of the inhabitants of this country. But, besides this general consideration, there are among them some families truly distinguished and respected by their equals, whose antiquity is acknowleged, and who, on account of a succession of virtuous men, able in their profession, and honoured for the prizes they have carried off in these contests, form the body of noble gondoliers; often more worthy of that title than the higher order of nobility, who only derive their honours from the merit of their ancestors, or from their own riches. The consideration for those families is carried so far, that, in the disputes frequently arising among the gondoliers in their ordinary passage of the canals, we sometimes see a quarrel instantly made up by the simple interposition of a third person, who has chanced to be of this revered body. They are rigid with respect to misalliances in their families, and they endeavour reciprocally to give and take their wives among those of their own rank. But we must remark here, with pleasure, that these distinctions infer no inequality of condition, nor admit any oppression of inferiors, being founded solely on laudable and virtuous opinions. Distinctions derived from fortune only, are those which always outrage nature, and often virtue.

* See *Gondola.*

In general, the competitors at the great regatas are chosen from among these families of reputation. As soon as they are fixed upon for this exploit, they spend the intermediate time in preparing themselves for it, by a daily, assiduous, and fatiguing exercise. If they are in service, their masters during that time not only give them their liberty, but also augment their wages. This custom would seem to indicate, that they look upon them as persons consecrated to the honour of the nation, and under a sort of obligation to contribute to its glory.

At last the grand day arrives. Their relations assemble together; they encourage the heroes, by calling to their minds the records of their families; the women present the oar, beseeching them, in an epic tone, to remember that they are the sons of famous men, whose steps they will be expected to follow: this they do with as much solemnity as the Spartan women presented the shield to their sons, bidding them either return with or upon it. Religion, as practised among the lower class of people, has its share in the preparations for this enterprise. They cause masses to be said; they make vows to some particular church; and they arm their boats for the contest with the images of those saints who are most in vogue. Sorcerers are not forgotten upon this occasion. For gondoliers who have lost the race often declare, that witchcraft had been practised against them, or certainly they must have won the day. Such a supposition prevents a poor fellow from thinking ill of himself; an opinion that might be unfavourable to him another time.

Regata.

The courſe is about four miles. The boats ſtart from a certain place, run through the great winding canal, which divides the town into two parts, turn round a picket, and, coming back the ſame way, go and ſeize the prize, which is fixed at the acuteſt angle of the great canal, on the convex ſide, ſo that the point of ſight may be the more extended, and the prize ſeized in the ſight of the ſpectators on both ſides.

According to the number of competitors, different races are performed in different ſorts of boats; ſome with one oar and others with two. The prizes propoſed are four, indicated by four flags of different colours, with the different value of the prizes marked upon them.—Theſe flags, public and glorious monuments, are the prizes to which the competitors particularly aſpire. But the government always add to each a genteel ſum of money; beſides that the conquerors, immediately after the victory, are ſurrounded by the *beau monde*, who congratulate and make them preſents; after which they go, bearing their honourable trophy in their hand down the whole length of the canal, and receive the applauſe of innumerable ſpectators.

This grand canal, ever ſtriking by the ſingularity and beauty of the buildings which border it, is, upon theſe occaſions, covered with an infinity of ſpectators, in all ſorts of barges, boats, and gondolas. The element on which they move is ſcarcely ſeen; but the noiſe of oars, the agitation of arms and bodies in perpetual motion, indicate the ſpectacle to be upon the water. At certain diſtances, on each ſide of the ſhore, are erected little amphitheatres and ſcaffoldings, where are placed bands of muſic; the harmonious ſound of which predominates now and then over the buzzing noiſe of the people. Some days before a *regata*, one may ſee on the great canal many boats for pleaſure and entertainment. The young noble, the citizen, the rich artizan, mounts a long boat of ſix or eight oars; his gondoliers decorated with rich and ſingular dreſſes, and the veſſel itſelf adorned with various ſtuffs. Among the nobles there are always a number who are at a conſiderable expence in theſe decorations; and at the *regata* itſelf exhibit on the water perſonages of mythologic ſtory, with the heroes of antiquity in their train, or amuſe themſelves with repreſenting the coſtumes of different nations: in ſhort, people contribute with a mad ſort of magnificence, from all quarters, to this maſquerade, the favourite diverſion of the Venetians. But theſe great machines, not being the leſs in motion on account of their ornaments, are not merely deſtined to grace the ſhow: they are employed at the regata, at every moment, to range the people, to protect the courſe, and to keep the avenue open and clear to the goal. The nobility, kneeling upon cuſhions at the prow of their veſſels, are attentive to theſe matters, and announce their orders to the moſt reſtive, by darting at them little gilded or ſilvered balls, by means of certain bows, with which they are furniſhed on this occaſion. And this is the only appearance of coercion in the Venetian police on theſe days of the greateſt tumult: nor is there to be ſeen, in any part of the city, a body of guards or patrol, nor even a gun or a halbert. The mildneſs of the nation, its gaiety, its education in the habit of believing that the government is ever awake, that it knows and ſees every thing; its reſpectful attachment to the body of patricians; the ſole aſpect of certain officers of the police in their robes, diſperſed in different places, at once operate and explain that tranquillity, that ſecurity, which we ſee in the midſt of the greateſt confuſion, and that ſurpriſing docility in ſo lively and fiery a people. Regatas have been attempted on the river Thames, but they were but humble imitations of the Venetian amuſement.

Regata || Regent.

REGEL, or Rigel, a fixed ſtar of the firſt magnitude, in Orion's left foot.

REGENERATION, in *Theology*, the act of being born again by a ſpiritual birth, or the change of heart and life experienced by a perſon who forſakes a courſe of vice, and ſincerely embraces a life of virtue and piety.

REGENSBURG, or Ratisbon. See Ratisbon.

REGENT, one who governs a kingdom during the minority or abſence of the king.

In France, the queen-mother had the regency of the kingdom during the minority of the king, under the title of *queen-regent*.

In England, the methods of appointing this guardian or regent have been ſo various, and the duration of his power ſo uncertain, that from hence alone it may be collected that his office is unknown to the common law; and therefore (as Sir Edward Coke ſays, 4 Inſt. 58.) the ſureſt way is to have him made by authority of the great council in parliament. The earl of Pembroke by his own authority aſſumed in very troubleſome times the regency of Henry III. who was then only nine years old; but was declared of full age by the pope at 17, confirmed the great charter at 18, and took upon him the adminiſtration of the government at 20. A guardian and councils of regency were named for Edward III. by the parliament, which depoſed his father; the young king being then 15, and not aſſuming the government till three years after. When Richard II. ſucceeded at the age of 11, the duke of Lancaſter took upon him the management of the kingdom till the parliament met, which appointed a nominal council to aſſiſt him. Henry V. on his death-bed named a regent and a guardian for his infant ſon Henry VI. then nine months old: but the parliament altered his diſpoſition, and appointed a protector and council, with a ſpecial limited authority. Both theſe princes remained in a ſtate of pupilage till the age of 23. Edward V. at the age of 13, was recommended by his father to the care of the duke of Glouceſter; who was declared protector by the privy-council. The ſtatutes 25 Hen. VIII. c. 12. and 28 Henry VIII. c. 7. provided, that the ſucceſſor, if a male and under 18, or if a female and under 16, ſhould be till ſuch age in the governance of his or her natural mother, (if approved by the king), and ſuch other counſellors as his majeſty ſhould by will or otherwiſe appoint: and he accordingly appointed his 16 executors to have the government of his ſon Edward VI. and the kingdom, which executors elected the earl of Hartford protector. The ſtatutes 24 Geo. II. c. 24. in caſe the crown ſhould deſcend to any of the children of Frederic late prince of Wales under the age of 18, appointed the princeſs dowager;—and that of 5 Geo. III. c. 27. in caſe of a like deſcent to any of his preſent majeſty's children, empowers the king to name either the queen or princeſs dowager, or any deſcendant of King George II. reſiding in this kingdom;—to be guardian and regent till the ſucceſſor attains ſuch age, aſſiſted by a a council of regency; the powers of them all being expressly defined and set down in the several acts.

REGENT also signifies a professor of arts and sciences in a college, having pupils under his care; but it is generally restrained to the lower classes, as to rhetoric, logic, &c. those of philosophy being called *professors*. In the English universities it is applied to masters of arts under five years standing, and to doctors under two, as non-regent is to those above that standing.

REGGIO, an ancient and considerable town of Italy, in the kingdom of Naples, and in the Farther Calabria, with an archbishop's see, and a woollen manufactory. It is seated in a delightful country, which produces plenty of oranges, and all their kindred fruits. The olives are exquisite, and high-flavoured. The town, however, can boast of neither beautiful buildings nor strong fortifications. Of its edifices the Gothic cathedral is the only striking one, but it affords nothing curious in architecture. The citadel is far from formidable, according to the present system of tactics; nor could the city walls make a long resistance against any enemy but Barbary corsairs; and even these they have not always been able to repel, for in 1543 it was laid in ashes by Barbarossa. Mustapha sacked it 15 years after, and the desolation was renewed in 1593 by another set of Turks. Its exposed situation, on the very threshold of Italy, and fronting Sicily, has from the earliest period rendered it liable to attacks and devastation. The Chalcidians seized upon it, or, according to the usual Greek phrase, founded it, and called the colony *Rhegion*, from a word that means a break or crack, alluding to its position on the point where Sicily broke off from the continent. Anaxilas oppressed its liberties. Dionysius the Elder took it, and put many of the principal citizens to death, in revenge for their having refused his alliance. The Campanian legion, sent to protect the Rhegians, turned its sword against them, massacred many inhabitants, and tyrannized over the remainder, till the Roman senate thought proper to punish these traitors with exemplary severity, though at the same time it entered into league with the revolted garrison of Messina. This union with a set of villains, guilty of the same crime, proved that no love of justice, but political reasons alone, drew down its vengeance on the Campanians.—It is about 12 miles S. E. of Messina, and 190 S. by E. of Naples. E. Long. 16. 0. N. Lat. 38. 4.

REGGIO, an ancient, handsome, and strong town of Italy, in the duchy of Modena, with a strong citadel, and a bishop's see. It has been ruined several times by the Goths, and other nations. In the cathedral are paintings by the greatest masters; and in the square is the statue of Brennus, chief of the Gauls. The inhabitants are about 22,000, who carry on a great trade in silk. It was taken by Prince Eugene in 1706, and by the king of Sardinia in 1742. It is seated in a fertile country to the south of the Apennines, and to the north of a spacious plain, 15 miles north-west of Modena, and 80 south-east of Milan. E. Long. 11. 5. N. Lat. 44. 43.—The duchy of this name is bounded on the west by that of Modena, and produces a great deal of silk, and till it fell under the dominion of the French along with the rest of Italy, belonged to the duke of Modena, except the marquisate of St Martin, which belonged to a prince of that name.

REGIAM MAJESTATEM. See LAW, N° clv. 3.

REGICIDE, KING-KILLER, a word chiefly used with us in speaking of the persons concerned in the trial, condemnation, and execution, of Charles I.

REGIFUGIUM was a feast celebrated at Rome on the 24th of February, in commemoration of the expulsion of *Tarquinius Superbus*, and the abolition of regal power. It was also performed on the 26th of May, when the king of the sacrifices, or *Rex Sacrorum*, offered bean flour and bacon, in the place where the assemblies were held. The sacrifice being over, the people hasted away with all speed, to denote the precipitate flight of King Tarquin.

REGIMEN, the regulation of diet, and, in a more general sense, of all the non-naturals, with a view to preserve or restore health. See ABSTINENCE, ALIMENT, FOOD, DIET, DRINK, and MEDICINE.

The vicissitude of exercise and rest forms also a necessary part of regimen. See EXERCISE.

It is beneficial to be at rest now and then, but more so frequently to use exercise; because inaction renders the body weak and listless, and labour strengthens it. But a medium is to be observed in all things, and too much fatigue is to be avoided: for frequent and violent exercise overpowers the natural strength, and wastes the body; but moderate exercise ought always to be used before meals. Now, of all kinds of exercise, riding on horseback is the most convenient: or if the person be too weak to bear it, riding in a coach, or at least in a litter: next follow fencing, playing at ball, running, walking. But it is one of the inconveniencies of old age, that there is seldom sufficient strength for using bodily exercise, though it be extremely requisite for health: wherefore frictions with the flesh-brush are necessary at this time of life; which should be performed by the person himself, if possible; if not, by his servants.

Sleep is the sweet soother of cares, and restorer of strength; as it repairs and replaces the wastes that are made by the labours and exercises of the day. But excessive sleep has its inconveniences; for it blunts the senses, and renders them less fit for the duties of life. The proper time for sleep is the night, when darkness and silence invite and bring it on: day-sleep is less refreshing; which rule if it be proper for the multitude to observe, much more is the observance of it necessary for persons addicted to literary studies, whose minds and bodies are more susceptible of injuries.

REGIMEN, in *Grammar*, that part of syntax, or construction, which regulates the dependency of words, and the alterations which one occasions in another.

REGIMEN for Seamen. See SEAMEN.

REGIMENT, is a body of men, either horse, foot, or artillery, commanded by a colonel, lieutenant-colonel, and major. Each regiment of foot is divided into companies; but the number of companies differs: though in Britain our regiments are generally 10 companies, one of which is always grenadiers, exclusive of the two independent companies. Regiments of horse are commonly six troops, but there are some of nine. Dragoon regiments are generally in war time 8 troops, and in time of peace but 6. Each regiment has a chaplain, quarter-master, adjutant, and surgeon. Some German regiments consist of 2000 foot; and the regiment of Picardy in France consisted of 6000, being 120 companies, of 50 men in each company.

Regiomontanus, Regis.

Regiments were first formed in France in the year 1558, and in England in the year 1660.

REGIOMONTANUS. See MULLER.

REGION, in *Geography*, a large extent of land, inhabited by many people of the same nation, and inclosed within certain limits or bounds.

The modern astronomers divide the moon into several regions, or large tracts of land, to each of which they give its proper name.

REGION, in *Physiology*, is taken for a division of our atmosphere, which is divided into the upper, middle, and lower regions.

The upper region commences from the tops of the mountains, and reaches to the utmost limits of the atmosphere. In this region reign a perpetual equable calmness, clearness, and serenity. The middle region is that in which the clouds reside, and where meteors are formed, extending from the extremity of the lowest to the tops of the highest mountains. The lowest region is that in which we breathe, which is bounded by the reflection of the sun's rays; or by the height to which they rebound from the earth. See ATMOSPHERE and AIR.

Æthereal REGION, in *Cosmography*, is the whole extent of the universe, in which is included all the heavenly bodies, and even the orb of the fixed stars.

Elementary REGION, according to the Aristotelians, is a sphere terminated by the concavity of the moon's orb, comprehending the atmosphere of the earth.

REGION, in *Anatomy*, a division of the human body, otherwise called *cavity*, of which anatomists reckon three, viz. the upper region, or that of the head; the middle region, that of the thorax or breast; and the lower, the abdomen, or belly. See ANATOMY.

REGION, in ancient Rome, was a part or division of the city. The regions were only four in number, till Augustus Cæsar's time, who divided the city into fourteen; over each of which he settled two surveyors, called *curatores viarum*, who were appointed annually, and took their divisions by lot. These fourteen regions contained four hundred and twenty-four streets, thirty-one of which were called *greater* or *royal streets*, which began at the gilt pillar that stood at the entry of the open place in the middle of the city. The extent of these divisions varied greatly, some being from 12,000 or 13,000 to 33,000 feet or upwards in circumference. Authors, however, are not agreed as to the exact limits of each. The curatores viarum wore the purple, had each two lictors in their proper divisions, had slaves under them to take care of fires that happened to break out. They had also two officers, called *denunciatores*, in each region, to give account of any disorders. Four *vico-magistri* also were appointed in each street, who took care of the streets allotted them, and carried the orders of the city to each citizen.

REGIS, PETER SYLVAIN, a French philosopher, and a great propagator of the doctrines of Des Cartes, was born in Agenois in the year 1632. He studied languages and philosophy under the Jesuits at Cahors; and as his views were then directed to the church, he was afterwards occupied in the study of divinity at the university of that town. His progress in learning was so uncommon, that at the end of four years he was offered a doctor's degree without the usual charges; but he did not think it became him to accept of it till he had studied also in the Sorbonne at Paris. He went thither, but was soon disgusted with theology; and as the philosophy of Des Cartes began at that time to make a noise through the lectures of Rohault, he conceived a taste for it, and gave himself up entirely to it. He frequented these lectures; and becoming an adept, went to Toulouse in 1665, and read lectures in it himself. Having fine parts, a clear and fluent manner, and a happy way of making himself understood, he drew all sorts of people; the magistrates, the learned, the ecclesiastics, and the very women, who now all affected to abjure the ancient philosophy. In 1680 he returned to Paris; where the concourse about him was such, that the sticklers for Peripateticism began to be alarmed. They applied to the archbishop of Paris, who thought it expedient, in the name of the king, to put a stop to the lectures; which accordingly were discontinued for several months. The whole life of Regis was spent in propagating the new philosophy. In 1690 he published a formal system of it, containing logic, metaphysics, physics, and morals, in 3 vols. 4to, and written in French. It was reprinted the year after at Amsterdam, with the addition of a discourse upon ancient and modern philosophy. He wrote afterwards several pieces in defence of his system; in which he had disputes with M. Huet, Du Hamel, Malebranche, and others. His works, though abounding with ingenuity and learning, have been disregarded, in consequence of the great discoveries and advancement in philosophic knowledge that have been since made. He died in 1707. He had been chosen member of the academy of sciences in 1699.

Regis, Register.

The works of this author are the following:—*A System of Philosophy*, containing Logic, Metaphysics, and Morals; in 1690, 3 vols. 4to. being a compilation of the different ideas of Des Cartes.

The Use of Reason and of Faith.

An Answer to Huet's Censures of the Cartesian Philosophy; and an Answer to Du Hamel's Critical Reflections.

Some pieces against Malebranche, to shew that the apparent magnitude of an object depends solely on the magnitude of its image, traced on the retina.

A small piece upon the question, Whether pleasure makes our present happiness?

REGISTER, a public book, in which are entered and recorded memoirs, acts, and minutes, to be had recourse to occasionally for knowing and proving matters of fact. Of these there are several kinds; as,

1. Register of deeds in Yorkshire and Middlesex, in which are registered all deeds, conveyances, wills, &c. that affect any lands or tenements in those counties, which are otherwise void against any subsequent purchasers or mortgagees, &c.; but this does not extend to any copyhold estate, nor to leases at a rack-rent, or where they do not exceed 21 years. The registered memorials must be ingrossed on parchment, under the hand and seal of some of the granters or grantees, attested by witnesses who are to prove the signing or sealing of them and the execution of the deed. But these registers, which are confined to two counties, are in Scotland general, by which the laws of North Britain are rendered very easy and regular. Of these there are two kinds; the one general, fixed at Edinburgh, under the direction of the lord register; and the other is kept in

in the feveral fhires, ftewartries, and regalities, the clerks of which are obliged to tranfmit the regifters of their refpective courts to the general regifter.

2. Parifh-regifters are books in which are regiftered the baptifms, marriages, and burials, of each parifh.

Registers were kept both at Athens and Rome, in which were inferted the names of fuch children as were to be brought up, as foon as they were born. Marcus Aurelius required all free perfons to give in accounts of their children, within 30 days after the birth, to the treafurer of the empire, in order to their being depofited in the temple of Saturn, where the public acts were kept. Officers were alfo appointed as public regifters in the provinces, that recourfe might be had to their lifts of names, for fettling difputes, or proving any perfon's freedom.

Register Ships, in *Commerce*, are veffels which obtain a permiffion, either from the king of Spain, or the council of the Indies, to traffic in the ports of the Spanifh Weft Indies; which are thus called, from their being regiftered before they fet fail from Cadiz for Buenos Ayres.

REGISTERS, in *Chemiftry*, are holes, or chinks with ftopples, contrived in the fides of furnaces, to regulate the fire; that is, to make the heat more intenfe or remifs, by opening them to let in the air, or keeping them clofe to exclude it. There are alfo regifters in the fteam-engine. See *STEAM-Engine*.

REGISTRAR, an officer in the Englifh univerfities, who has the keeping of all the public records.

REGIUM, Regium *Lepidi*, *Regium Lepidum*, in *Ancient Geography*, a town of Cifalpine Gaul, on the Via Æmilia, fo called from Æmilius Lepidus, who was conful with C. Flaminius; but whence it was furnamed *Regium* is altogether uncertain. Tacitus relates, that at the battle of Bedriacum, a bird of an unufual fize was feen perching in a famous grove near Regium Lepidum. Now called *Reggio*, a city of Modena. E. Long. 11. 0. N. Lat. 44. 45. See Reggio.

REGNARD, John Francis, one of the beft French comic writers after Moliere, was born at Paris in 1647. He had fcarcely finifhed his ftudies, when an ardent paffion for travelling carried him over the greateft part of Europe. When he fettled in his own country, he was made a treafurer of France, and lieutenant of the waters and forefts: he wrote a great many comedies; and, though naturally of a gay genius, died of chagrin in the 52d year of his age. His works, confifting of comedies and travels, were printed at Rouen, in 5 vols. 12mo, 1732.

REGNIER, Mathurin, the firft French poet who fucceeded in fatire, was born at Chartres in 1573. He was brought up to the church, a place for which his debaucheries rendered him very unfuitable; and thefe by his own confeffion were fo exceffive, that at 30 he had all the infirmities of age. Yet he obtained a canonry in the church of Chartres, with other benefices; and died in 1613. There is a neat Elzevir edition of his works, 12mo, 1652, Leyden; but the moft elegant is that with notes by M. Broffette, 4to, 1729, London.

Regnier des Marets, *Seraphin*, a French poet, born at Paris in 1632. He diftinguifhed himfelf early by his poetical talents, and in 1684 was made perpetual fecretary to the French academy on the death of Mezeray: it was he who drew up all thofe papers in the name of the academy againft Furetiere: the king gave him the priory of Grammont, and he had alfo an abbey. He died in 1713, and his works are, French, Italian, Spanifh, and Latin poems, 2 vols.; a French grammar; and an Italian tranflation of Anacreon's odes, with fome other tranflations.

REGNUM, in *Ancient Geography*, a town of the Regni, a people in Britain, next the Cantii, now Surry, Suffex, and the coaft of Hampfhire, (Camden); a town fituated, by the Itinerary numbers, on the confines of the Belgæ, in a place now called *Ringwood*, in Hampfhire, on the rivulet Avon, running down from Salifbury, and about ten miles or more diftant from the fea.

REGRATOR, fignifies him who buys and fells any wares or victuals in the *fame* market or fair: and regrators are particularly defcribed to be thofe who buy, or get into their hands, in fairs or markets, any grain, fifh, butter, cheefe, fheep, lambs, calves, fwine, pigs, geefe, capons, hens, chickens, pigeons, conies, or other dead victuals whatfoever, brought to a fair or market to be fold there, and do fell the fame again in the fame fair, market, or place, or in fome other within four miles thereof.

Regrating is a kind of *huckftry*, by which victuals are made dearer; for every feller will gain fomething, which muft of confequence enhance the price. And, in ancient times, both the engroffer and regrator were comprehended under the word *foreftaller*. Regrators are punifhable by lofs and forfeiture of goods, and imprifonment, according to the firft, fecond, or third offence, &c.

REGENSBERG, a handfome though fmall town of Swifferland, in the canton of Zurich, and capital of a bailiwick of the fame name, with a ftrong caftle; feated on a hill, which is part of Mount Jura. There is a well funk through a rock, 36 fathoms deep.

REGULAR, denotes any thing that is agreeable to the rules of art: thus we fay, a regular building, verb, &c.

A regular figure in geometry, is one whofe fides, and confequently angles, are equal; and a regular figure with three or four fides is commonly termed an *equilateral triangle* or *fquare*, as all others with more fides are called *regular polygons*.

Regular *Body*, called alfo *Platonic Body*, is a body or folid comprehended by like, equal, and regular plane figures, and whofe folid angles are all equal.

The plane figures by which the folid is contained are the faces of the folid; and the fides of the plane figures are the edges or linear fides of the folid.

There are only five regular folids, viz.

The tetrahedron, or regular triangular pyramid, having four triangular faces;

The hexahedron, or cube, having fix fquare faces;

The octahedron, having eight triangular faces;

The dodecahedron, having twelve pentagonal faces;

The icofahedron, having twenty triangular faces.

Befides thefe five, there can be no other regular bodies in nature.

Regular, in a monaftery, a perfon who has taken the vows; becaufe he is bound to obferve the rules of the order he has embraced.

REGULATION, a rule or order prefcribed by a fuperior, for the proper management of fome affair.

REGULATOR *of a* Watch, the fmall fpring be-

longing

longing to the balance; serving to adjust its motions, and make it go faster or slower. See WATCH.

REGULBIUM, or REGULVIUM, (Notitia Imperii); mentioned nowhere else more early: a town of the Cantii, in Britain. Now Reculver, a village on the coast, near the island Thanet, towards the Thames, to the north of Canterbury, (Camden).

REGULUS, M. ATTILIUS, a consul during the first Punic war. He reduced Brundusium, and in his second consulship he took 64 and sunk 30 galleys of the Carthaginian fleet, on the coasts of Sicily. Afterwards he landed in Africa; and so rapid was his success, that in a short time he made himself master of about 200 places of consequence on the coast. The Carthaginians sued for peace, but the conqueror refused to grant it; and soon after he was defeated in a battle by Xanthippus, and 30,000 of his men were left on the field of battle, and 15,000 taken prisoners. Regulus was in the number of the captives, and he was carried in triumph to Carthage. He was sent by the enemy to Rome, to propose an accommodation and an exchange of prisoners; and if his commission was unsuccessful, he was bound by the most solemn oaths to return to Carthage without delay. When he came to Rome, Regulus dissuaded his countrymen from accepting the terms which the enemy proposed; and when his opinion had had due influence on the senate, Regulus retired to Carthage agreeable to his engagements. The Carthaginians were told that their offers of peace had been rejected at Rome by the means of Regulus; and therefore they prepared to punish him with the greatest severity. His eye-brows were cut, and he was exposed for some days to the excessive heat of the meridian sun, and afterwards confined in a barrel, whose sides were everywhere filled with large iron spikes, till he died in the greatest agonies. His sufferings were heard of at Rome; and the senate permitted his widow to inflict whatever punishment she pleased on some of the most illustrious captives of Carthage which were in their hands. She confined them also in presses filled with sharp iron points; and was so exquisite in her cruelty, that the senate interfered, and stopped the barbarity of her punishment. Regulus died about 251 years before Christ.—Memmius, a Roman, made governor of Greece by Caligula. While Regulus was in his province, the emperor wished to bring the celebrated statue of Jupiter Olympius by Phidias to Rome, but this was supernaturally prevented; and according to ancient authors, the ship which was to convey it was destroyed by lightning, and the workmen who attempted to remove the statue were terrified away by sudden noises.—A man who condemned Sejanus. —Roscius, a man who held the consulship but for one day, in the reign of Vitellius.

REGULUS, in *Astronomy*, a star of the first magnitude, in the constellation Leo; called also, from its situation, *Cor Leonis*, or the *Lion's Heart*; by the Arabs, *Alhabor*; and by the Chaldeans, *Kalbeleced*, or *Karbeleceid*; from an opinion of its influencing the affairs of the heavens.

REGULUS, in *Chemistry*, the metallic matter that falls to the bottom of the crucible, in the melting of ores or impure metallic substances. It is the finest or purest part of the metal; and, according to the alchemists, is denominated *regulus*, or *little king*, as being the first-born of the royal metallic blood. According to them, it is really a son, but not a perfect man; i. e. not yet a perfect metal, for want of time and proper nourishment. To procure the regulus of metals, &c. flux powders are commonly used; as nitre, tartar, &c. which purge the sulphureous part adhering to the metal, by attracting and absorbing it to themselves.

REHEARSAL, in *Music* and the *Drama*, an essay or experiment of some composition, generally made in private, previous to its representation or performance in public, in order to render the actors and performers more perfect in their parts.

REICHENBERG, in Bohemia, 95 miles west of Prague, 205 north-west of Vienna, N. Lat 50. 2. E. Long. 12. 25. is only remarkable as the place where the Prussian army defeated the Austrians on the 21st of April 1757. The Austrian army, commanded by Count Konigseek, was posted near Reichenberg, and was attacked by the Prussians under the command of the prince of Brunswick Bevern. The Prussians were 20,000 and the Austrians 28,000: the action began at half after six in the morning, when the Prussian lines were formed, and attacked the Austrian cavalry, which was ranged in three lines of 30 squadrons, and their two wings sustained by the infantry, which was posted among felled trees and intrenchments. The Austrians had a village on their right, and a wood on their left, where they were intrenched. The Prussian dragoons and grenadiers cleared the intrenchment and wood, and entirely routed the Austrian cavalry; at the same time, the redoubts that covered Reichenberg were taken by General Lestewitz; and the Austrians were entirely defeated. The Prussians had seven officers and 100 men killed; 14 officers and 150 men wounded. The Austrians had 1000 men killed and wounded; 20 of their officers and 400 men taken prisoners. The action ended at eleven.

REID, THOMAS, D. D. an eminent philosopher and distinguished literary character, was the son of Lewis Reid, minister of the parish of Strachan in the county of Kincardine, North Britain. His mother was the daughter of Mr Gregory of Kinnairdie in Banffshire, was one of twenty-nine children, and was sister to David, James, and Charles Gregories, who were at the same period professors of astronomy or mathematics, in the universities of Oxford, Edinburgh, and St Andrews.

Dr Reid was born at the parsonage house of Strachan, in April 1710, and received the elementary parts of his education at the parish-school of Kincardine-o-niel. The parochial schools of Scotland are said to have been much superior at that period to what they are at present, and young men went from them well furnished with philological learning to the different universities. The early progress of young Reid must have been very extraordinary, since he was qualified to profit by the lectures of the professors at the age of twelve. He soon gave very striking proofs that he inherited the genius of his mother's family, and was conspicuous among the students of mathematics, in a college where that science has always been cultivated with zeal and success. He continued longer at the university than the usual term of years, as he had been appointed to the office of librarian, which was a situation every way agreeable to him, as it gave him such an ample opportunity of gratifying his passion for study. About this time he became intimately attached to John Stewart, afterwards professor of mathematics in Marischal college, which connection greatly strengthened his predilection for mathematical studies.

He

Reid.

He resigned the office of librarian in the year 1736, and accompanied Mr Stewart to England, when they paid a visit to London, Oxford, and Cambridge, and were introduced to several persons of the first literary distinction. On account of his relation to Dr David Gregory, he had ready access to the celebrated Martin Folkes, whose house might be said to contain many of the most interesting objects to be met with in the metropolis. He saw Dr Bentley at Cambridge, with whose erudition he was much delighted, as well as amused with his vanity; and he also conversed frequently with Saunderson, the blind mathematician. Dr Reid refers in his speculations to this gentleman's blindness, as a singular phenomenon in the history of the human mind.

Dr Reid maintained an uninterrupted friendship with the learned and amiable Mr Stewart till the year 1766, at which time Mr Stewart was carried off by a malignant fever. The circumstances attending the death of this excellent man deeply wounded the sensibility of Dr Reid; for his wife and daughter were carried off by the same disorder, and buried with him in one grave.

The King's college of Aberdeen presented Dr Reid to the living of New-Machar in the year 1737; but such was the zeal of the people against the law of patronage at that time, that he not only met with violent opposition, but was also exposed to personal danger. But his attention to the duties of his office was so exemplary, his temper so mild and forbearing, and his spirit of humanity so active, that in a short time he subdued their prejudices; and when at last called in the course of providence to a different situation, the very people who had been guilty of gross and indecent outrages against him followed him, on his departure, with their benedictions and tears.

In 1740, he married Elizabeth, daughter of his uncle, Dr George Reid, physician in London, after which his popularity at New-Machar very much increased. Her manners were so accommodating, and so numerous were her kind offices to the sick and the indigent, that the departure of the family from the neighbourhood was looked upon as a general misfortune. The manner in which several old men were accustomed to speak upon the subject is worthy of being kept in remembrance. "We fought, said they, *against* Dr Reid when he came, and we would have fought *for* him when he went away."

The greater part of his residence at New-Machar was devoted to the most intense study, particularly directing his attention to the laws of external perception, and of the other principles which constitute the basis of human knowledge. He unbended his mind by the amusements of gardening and botany, of which he was extremely fond, even in old age.

The professors of *King's College*, in the year 1752, made choice of Dr Reid to be professor of philosophy, originating wholly from the high opinion they were led to entertain of his talents and erudition. We are not acquainted with the particular plan which he adopted and pursued in the course of his lectures; but his department at that period comprehended mathematics and physics, logic and ethics,—a practice then followed in the other universities of Scotland, instead of appointing a professor for each distinct branch.

Dr Reid had not been long in Aberdeen, till in conjunction with Dr John Gregory, he projected a literary society which continued for a number of years, and met once a week. The writings of Reid, Gregory, Campbell, Beattie and Gerard, evince the numerous advantages which the members derived from this institution, as they were in the habit of subjecting such works as they intended for publication, to the test of friendly criticism.

Reid.

It is perhaps not too much to assert, that of all the publications which appeared about this time, the Inquiry into the Human Mind by Dr Reid, discovered by far the greatest originality and profound thinking. It appears that he had conceived the plan, and deeply meditated upon it, long before its publication; yet without the applause of his literary associates, it is more than probable that his native modesty might have prevented him from giving it to the world.

The publication of Mr Hume's *Treatise of Human Nature*, in 1739, led him to question the principles commonly received with regard to the human understanding. He admitted, when a youth, but without any attentive examination, the opinions on which Mr Hume's scepticism was raised; but when he carefully adverted to the consequences which these principles appeared to involve, he instantly began to suspect their truth. To subvert the sceptical theory of Mr Hume was the grand object of Dr Reid's *Inquiry*, which he submitted to the examination of Mr Hume himself. That philosopher, even after he had seen some parts of the Work, discovers not a little of the Jewish spirit of unbelief that any good thing should come out of Nazareth; and considering his antagonist as a clergyman, and belonging to an order of men from whom prejudice would not allow him to expect any soundness of reasoning in matters of science, he betrays more than want of good humour, as Dr Reid's biographer expresses himself, when he says in no very courteous language in a letter to Dr Blair, "I wish that the parsons would confine themselves to their old occupation of worrying one another, and leave philosophers to argue with temper, moderation, and good manners." But though Mr Hume, as appears from the words just quoted, was very angry that a clergyman should become a philosopher, on a second perusal of the Inquiry, he seems to have held very different sentiments, when he wrote to the author himself in the following terms. "By Dr Blair's means, I have been favoured with the perusal of your performance, which I have read with great pleasure and attention. It is certainly very rare, that a piece so deeply philosophical is wrote (written) with so much spirit, and affords so much entertainment to the reader; though I must still regret the disadvantages under which I read it, as I never had the whole performance at once before me, and could not be able fully to compare one part with another. To this reason, chiefly, I ascribe some obscurities, which, in spite of your short analysis or abstract, still seem to hang over your system. For I must do you the justice to own, that when I entered into your ideas, no man appears to express himself with greater perspicuity than you do; a talent which, above all others, is requisite in that species of literature which you have cultivated.—As I was desirous to be of some use to you, I kept a watchful eye all along over your style; but it is really so correct, and so good English, that I found not any thing worth the remarking. There is only one passage in this chapter, where you make use of the phrase *hinder to do*, instead of *hinder from doing*, which is the English one; but I could not find

Reid. find the passage when I sought for it. You may judge how unexceptionable the whole appeared to me, when I could remark so small a blemish."

The impression made on the minds of speculative men by the publication of Dr Reid's Inquiry was as great as could reasonably be expected from the nature of his undertaking. It was not level to the comprehension of the multitude, nor even addressed to them; and as it examined opinions with the utmost freedom which had obtained the sanction of the highest authorities, it had little prospect of conciliating the favour of the learned. Some, however, there were, who perceived the extent of his views, and beheld in his pages the true spirit and language of inductive investigation, which made proselytes of many, and was, by them, warmly recommended to the attention of others. The *Inquiry* of Dr Reid was so much esteemed by the learned body of teachers then in the university of Glasgow, that they gave him an invitation to the vacant professorship of moral philosophy, in the year 1763. It was no doubt with a considerable degree of reluctance that he resolved to leave Aberdeen; yet so numerous were the allurements which Glasgow presented to a man of his extensive erudition and deep research, that he gave it the preference. That seminary of learning could then boast of a Moor, a Simson, a Black, a Leechman, the two Wilsons, father and son, and an acute, discriminating Millar, with all of whom he was more or less intimate, and whose fascinating conversation made him in some measure forget that he was long acquainted with men of genius in the university of Aberdeen.

Dr Reid's merit as a public teacher arose principally from that fund of original philosophy which is characteristic of his writings; and from his invincible patience and perseverance in recommending such principles as he conceived to be of the last importance to human happiness. His style, too, was simple and perspicuous; his character grave and possessed of authority; and his students felt such an interest in the doctrines which he inculcated, that he never failed to be heard with the most profound attention.

In the year 1773 his remarks on Aristotle's logic appeared in Lord Kames's Sketches of the History of Man, of which he himself has favoured us with the following account. "In attempting to give some account of the Analytics, and of the Topics of Aristotle, ingenuity obliges me to confess, that though I have often purposed to read the whole with care, and to understand what is intelligible, yet my courage and patience always failed before I had done. Why should I throw away so much time and painful attention upon a thing of so little use? If I had lived in those ages when the knowledge of Aristotle's Organon entitled a man to the highest rank in philosophy, ambition might have induced me to employ upon it some years of painful study; and less, I conceive, would not be sufficient. Such reflections as these always got the better of my resolution when the first ardour began to cool. All I can say is, that I have read some part of the different books with care, some slightly, and some perhaps not at all. I have glanced over the whole often; and when any thing attracted my attention have dipped into it till my appetite was satisfied."

But in spite of his modest declarations, it is matter of doubt with some, whether any of his publications does him more honour than his perspicuous view of this complicated system. It is unquestionably superior to any other analysis of these writings we have yet seen, an opinion amply confirmed by the sentiments of different literary characters who were intimately acquainted with the works of Aristotle. Reid.

Dr Reid declined reading lectures in the university for some years before his death; and he devoted this period to the task of preparing for the press his great work, which was published in two volumes 4to, the first in 1785, entitled, "Essays on the Intellectual Powers of Man;" and the second in 1788, entitled, "Essays on the Active Powers of Man." His *Essay on Quantity, occasioned by reading a Treatise, in which Simple and Compound Ratios are applied to Virtue and Merit*, was composed previous to the year 1748, and was published in the Philosophical Transactions of London for that year. This paper affords some light with regard to the progress of his speculations about this time. The Inquiry into the Human Mind, of which we have already taken notice appeared in 1764; and at this time he was complimented with the degree of Doctor in Divinity.

In the year 1796 (the last of his mortal existence), he was prevailed upon to spend with his friends at Edinburgh a few weeks during the summer. From that visit he returned to Glasgow in his usual health and spirits, and for some time continued to devote a portion of his time to the exercise both of body and mind. About the end of September the same year, he was seized with a violent disorder, with which he maintained a severe struggle; and this, together with repeated strokes of the palsy, put a final period to his long and useful life on the 7th of October, and in the 87th year of his age.

As to his bodily constitution, few men have been more indebted to nature than Dr Reid. In this respect he was athletic and vigorous, and his muscular strength was uncommonly great; advantages which were powerfully seconded by his temperance, exercise, and the unclouded serenity of his temper. Deep and collected thought was very conspicuous in his countenance, and all his looks were expressive of kindness and good will.

With respect to his character, his rectitude was inflexible and intrepid; his attachment to truth was pure; and he had an entire command over all his passions, which he acquired by the unwearied exertions of a long life. When, therefore, he found it necessary to dispute the conclusions of others in any of his writings, he never employed any expressions to irritate those whom he was anxious to convince, and the asperity of his opponents could not provoke him to repress his spirit of liberality and good-humour; for he considered the intemperance with which controversy is usually carried on, as an enemy to the progress of useful knowledge, and as having done more harm to the practice than service to the theory of morality. He uniformly maintained the dignity of philosophy in private life, and he united in his character the most amiable modesty and gentleness, with the noblest spirit of independence. He never solicited any favours from the great, and all his academical or other preferments were conferred upon him by those who were real judges of his merit, and thought he deserved them. To a sound, cautious, and discriminating judgement, a singular patience and perseverance of thought,

thought, and fixed attention to the operations of his own mind, he added the curioſity of a naturaliſt and the eyes of an obſerver, and of courſe his information was accurate and extenſive. His ſenſibility was of an active and lively nature, and wherever he could command the means of relieving the diſtreſſed, he always employed them with the utmoſt ſecrecy poſſible.

His works are now in the hands of the public, and we believe we may venture to aſſert, that they will always be much eſteemed, while ſound ſenſe continues to be preferred to unintelligible jargon, ſophiſtry, or impiety. He has diveſted metaphyſics of myſtery, and rendered intelligible the moſt profound ſpeculations, by the regular and conſtant uſe of words in one determined ſenſe. In the ſtate in which he found the philoſophical world, it was Dr Reid's opinion, that his talents could not be ſo uſefully employed, as in combating the ſchemes of thoſe who aimed at the complete ſubverſion of religion, both natural and revealed. He apprehended the operations of his own mind with a clearneſs which gave to his language a perſpicuity and preciſion that the language of Locke never poſſeſſed; and in this reſpect he is decidedly ſuperior to all his predeceſſors.

REIN-DEER, or *Tarandus*. See CERVUS, ENTOMOLOGY *Index*.

REINS, in *Anatomy*, the ſame with KIDNEYS. See ANATOMY *Index*.

REINS *of a Bridle*, are two long ſlips of leather, faſtened on each ſide of a curb or ſnaffle, which the rider holds in his hand, to keep the horſe in ſubjection.

There is alſo what is called *falſe reins;* which is a lath of leather, paſſed ſometimes through the arch of the banquet, to bend the horſe's neck.

REJOINDER, in *Law*, is the defendant's anſwer to the plaintiff's replication or reply. Thus, in the court of chancery, the defendant puts in an anſwer to the plaintiff's bill, which is ſometimes alſo called an *exception;* the plaintiff's anſwer to that is called a *replication*, and the defendant's anſwer to that a *rejoindre*.

REISKE, JOHN JAMES, a profound ſcholar and eminent critic, was born in 1706 at a ſmall town in the duchy of Anhalt in Germany. His connections, it would appear, were in a humble ſituation of life; and in conſequence of the narrow circumſtances in which he was placed, he had many difficulties to ſtruggle with during the early part of his education. Theſe, however, by unabating perſeverance he ſurmounted, and in 1733 went to Leipſic, where he remained for five years in the ardent purſuit of his ſtudies. Here he acquired an extenſive knowledge of the Arabic, and was engaged in the tranſlation of a book from that language, which was afterwards publiſhed. With the view of proſecuting with greater advantage the ſtudy of Arabic, which had become with him a favourite object of purſuit, he travelled on foot to Leyden, where new difficulties attended him. While he remained in Leyden he was employed in arranging the Arabic manuſcripts belonging to the univerſity; and for this labour he received a very ſmall remuneration. During his reſidence here, part of his time was occupied in the tranſlation of various eſſays from the German and French languages into Latin. Theſe eſſays afterwards appeared in the *Miſcellanea Critica*. About the ſame time alſo our learned author tranſlated into Latin the whole of the *Chariton* from the Greek, and the Geography of Abulfeda from the Arabic.

Having ſpent eight years at Leyden, Reiſke was driven from this place by jealouſy and calumny, which it is ſaid were excited againſt him chiefly by the younger Burman, in conſequence of his critical ſtrictures on the edition of Petronius publiſhed by that author; but before his departure from this learned ſeminary, he had obtained the degree of doctor of phyſic, which was conferred in a manner highly to his honour. He afterwards viſited different parts of Germany, and at laſt ſettled a ſecond time at Leipſic, where he remained for twelve years. But although he had received the appointment of profeſſor of Arabic, the emoluments of his office were ſo ſcanty, that he had yet to ſtruggle with all the difficulties attendant on poverty, and merely to procure a ſubſiſtence was obliged to engage in the humbler employments of literary labour, and ſubmit to the ſevere and ill-requited drudgery of editing works for bookſellers, or contributing detached papers to periodical publications. About this time the *Acta Eruditorum* were greatly indebted to the labours of our author. But in the midſt of all the difficulties and hardſhips now alluded to, he prepared and publiſhed a work of profound learning and great merit. This work, which extended to five volumes, appeared under the title of *Animadverſiones in Auctores Græcos*, and added much to our author's reputation.

In the year 1758, in conſequence of the death of Haltauſius, he obtained a ſituation, which was not only honourable but lucrative. This was the place of rector of the academy of Leipſic, in which he continued during the remainder of his life. He was now raiſed above want, and being free from the difficulties and embarraſſments which had hitherto conſtantly attended him, he was thus enabled in the midſt of learned eaſe to proſecute his favourite ſtudies.

In the year 1764 Reiſke married E. C. Muller, a woman of great learning, and of whom it is ſaid that her knowledge, eſpecially in Greek literature, was little inferior to that of her huſband. In all his literary labours ſhe was an uſeful aſſociate; but the aſſiſtance which ſhe contributed to his great work, the edition of the Greek Orators, was particularly valuable. Thus paſſed the latter period of the life of this learned man. He died in 1774, poſſeſſing a very diſtinguiſhed reputation as a ſcholar and a critic. The number of the works which he ſuperintended and publiſhed is very great. The moſt approved are the following. "Remarks upon Greek Authors." An "Edition of the Greek Orators," in 12 vols. 8vo, which was completed by his widow. "Dionyſius Halicarnaſſenſis," in 7 vols. "Plutarch's Works," in 9 vols. "Theocritus," &c.

RELAND, ADRIAN, an eminent Orientaliſt, born at Ryp, in North Holland, in 1676. During three years ſtudy under Surenhuſius, he made an uncommon progreſs in the Hebrew, Syriac, Chaldee, and Arabic languages; and theſe languages were always his favourite ſtudy. In 1701, he was, by the recommendation of King William, appointed profeſſor of Oriental languages and eccleſiaſtical antiquities in the univerſity of Utrecht, and died of the ſmall-pox in 1718. He was diſtinguiſhed by his modeſty, humanity, and learning; and carried on a correſpondence with the moſt eminent fcholars of his time. His principal works are, 1. An excellent defcription of Paleftine. 2. Five differtations on the Medals of the ancient Hebrews, and feveral other differtations on different fubjects. 3. An Introduction to the Hebrew Grammar. 4. The Antiquities of the ancient Hebrews. 5. On the Mahometan Religion. Thefe works are all written in Latin.

RELATION, the mutual refpect of two things, or what each is with regard to the other. See METAPHYSICS, n° 93, &c. and 128, &c.

RELATION, in *Geometry*. See RATIO.

RELATION, is alfo ufed for analogy. See ANALOGY, and METAPHYSICS.

RELATIVE, fomething relating to or refpecting another.

RELATIVE, in *Mufic*. See MODE.

RELATIVE Terms, in *Logic*, are words which imply relation; fuch are mafter and fervant, hufband and wife, &c.

In grammar, relative words are thofe which anfwer to fome other word foregoing, called the *antecedent*; fuch are the relative pronouns *qui*, *quæ*, *quod*, &c. and in Englifh, *who*, *whom*, *which*, &c. The word anfwering to thefe relatives is often underftood, as, "I know whom you mean;" for "I know the perfon whom you mean."

RELAXATION, in *Medicine*, the act of loofening or flackening; or the loofenefs or flacknefs of the fibres, nerves, mufcles, &c.

RELAY, a fupply of horfes placed on the road, and appointed to be ready for a traveller to change, in order to make the greater expedition.

RELEASE, in *Law*, is a difcharge or conveyance of a man's right in lands or tenements, to another that hath fome former eftate in poffeffion. The words generally ufed therein are "remifed, releafed, and for ever quitclaimed." And thefe releafes may enure, either, 1. By way of *enlarging an eftate*, or *enlarger l'eftate*: as, if there be tenant for life or years, remainder to another in fee, and he in remainder releafes all his right to the particular tenant and his heirs, this gives him the eftate in fee. But in this cafe the releffee muft be in *poffeffion* of of fome eftate, for the releafe to work upon; for if there be leffee for years, and, before he enters and is in poffeffion, the leffor releafes to him all his right in the reverfion, fuch releafe is void for want of poffeffion in the releffee. 2. By way of *paffing an eftate* or *mitter l'eftate*: as when one of two coparceners releafeth all his right to the other, this paffeth the fee-fimple of the whole. And, in both thefe cafes, there muft be a privity of eftate between the releffor and releffee; that is, one of their eftates muft be fo related to the other, as to make but one and the fame eftate in law. 3. By way of *paffing a right*, or *mitter le droit*: as if a man be diffeifed, and releafeth to his diffeifor all his right; hereby the diffeifor acquires a new right, which changes the quality of his eftate, and renders that lawful which before was tortius. 4. By way of *extinguifhment*: as if my tenant for life makes a leafe to A for life, remainder to B and his heirs, and I releafe to A; this extinguifhes my right to the reverfion, and fhall enure to the advantage of B's remainder as well as of A's particular eftate. 5. By way of *entry and feoffment*: as if there be two joint diffeifors, and the diffeifee releafes to one of them, he fhall be fole feifed,

Blackft. Comment.

and fhall keep out his former companion; which is the fame in effect as if the diffeifee had entered, and thereby put an end to the diffeifin, and afterwards had enfeoffed one of the diffeifors in fee. And hereupon we may obferve, that when a man has in himfelf the poffeffion of lands, he muft at the common law convey the freehold by feoffment and livery; which makes a notoriety in the country: but if a man has only a right or a future intereft, he may convey that right or intereft by a mere releafe to him that is in poffeffion of the land: for the occupancy of the releffee is a matter of fufficient notoriety already.

RELEVANCY, in *Scots Law*. See LAW, N° clxxxvi. 48.

RELICS, in the Romifh church, the remains of the bodies or clothes of faints or martyrs, and the inftruments by which they were put to death, devoutly preferved, in honour to their memory; kiffed, revered, and carried in proceffion.

The refpect which was juftly due to the martyrs and teachers of the Chriftian faith, in a few ages increafed almoft to adoration; and at length adoration was really paid both to departed faints and to relics of holy men or holy things. The abufes of the church of Rome, with refpect to relics, are very flagrant and notorious. For fuch was the rage for them at one time, that, as F. Mabillon a Benedictine juftly complains, the altars were loaded with fufpected relics; numerous fpurious ones being everywhere offered to the piety and devotion of the faithful. He adds, too, that bones are often confecrated, which, fo far from belonging to faints, probably do not belong to Chriftians. From the catacombs numerous relics have been taken, and yet it is not known who were the perfons interred therein. In the 11th century, relics were tried by fire, and thofe which did not confume were reckoned genuine, and the reft not. Relics were, and ftill are, preferved on the altars whereon mafs is celebrated; a fquare hole being made in the middle of the altar, big enough to receive the hand, and herein is the relic depofited, being firft wrapped in red filk, and inclofed in a leaden box.

The Romanifts plead antiquity in behalf of relics: For the Manichees, out of hatred to the flefh, which they confidered as an evil principle, refufed to honour the relics of faints; which is reckoned a kind of proof that the Catholics did it in the firft ages.

We know, indeed, that the touching of linen cloths on relics, from an opinion of fome extraordinary virtue derived therefrom, was as ancient as the firft ages, there being a hole made in the coffins of the 40 martyrs at Conftantinople exprefsly for this purpofe. The honouring the relics of faints, on which the church of Rome afterwards founded her fuperftitious and lucrative ufe of them, as objects of devotion, as a kind of charms or amulets, and as inftruments of pretended miracles, appears to have originated in a very ancient cuftom, that prevailed among Chriftians, of affembling at the cemeteries or burying-places of the martyrs, for the purpofe of commemorating them, and of performing divine worfhip When the profeffion of Chriftianity obtained the protection of the civil government, under Conftantine the Great, ftately churches were erected over their fepulchres, and their names and memories were treated with every poffible token of affection and refpect. This reverence, however, gradually exceeded all reafonable bounds;

bounds; and theſe prayers and religious ſervices were thought to have a peculiar ſanctity and virtue, which were performed over their tombs. Hence the practice, which afterwards obtained, of depoſiting relics of ſaints and martyrs under the altars in all churches. This practice was then thought of ſuch importance, that St Ambroſe would not conſecrate a church becauſe it had no relics; and the council of Conſtantinople in Trullo ordained, that thoſe altars ſhould be demoliſhed under which there were found no relics. The rage of procuring relics for this and other purpoſes of a ſimilar nature, became ſo exceſſive, that in 386 the emperor Theodoſius the Great was obliged to paſs a law, forbidding the people to dig up the bodies of the martyrs, and to traffic in their relics.

Such was the origin of that reſpect for ſacred relics, which afterwards was perverted into a formal worſhip of them, and became the occaſion of innumerable proceſſions, pilgrimages, and miracles, from which the church of Rome hath derived incredible advantage.—In the end of the ninth century, it was not ſufficient to reverence departed ſaints, and to confide in their interceſſions and ſuccours, to clothe them with an imaginary power of healing diſeaſes, working miracles, and delivering from all ſorts of calamities and dangers; their bones, their clothes, the apparel and furniture they had poſſeſſed during their lives, the very ground which they had touched, or in which their putrified carcaſes were laid, were treated with a ſtupid veneration, and ſuppoſed to retain the marvellous virtue of healing all diſorders both of body and mind, and of defending ſuch as poſſeſſed them againſt all the aſſaults and devices of the devil. The conſequence of all this was, that every one was eager to provide himſelf with theſe ſalutary remedies; conſequently, great numbers undertook fatiguing and perilous voyages, and ſubjected themſelves to all ſorts of hardſhips; while others made uſe of this deluſion to accumulate their riches, and to impoſe upon the miſerable multitude by the moſt impious and ſhocking inventions. As the demand for relics was prodigious and univerſal, the clergy employed the utmoſt dexterity to ſatisfy all demands, and were far from being nice in the methods they uſed for that end. The bodies of the ſaints were ſought by faſting and prayer, inſtituted by the prieſt in order to obtain a divine anſwer and an infallible direction, and this pretended direction never failed to accompliſh their deſires; the holy carcaſe was always found, and that always in conſequence, as they impiouſly gave out, of the ſuggeſtion and inſpiration of God himſelf. Each diſcovery of this kind was attended with exceſſive demonſtrations of joy, and animated the zeal of theſe devout ſeekers to enrich the church ſtill more and more with this new kind of treaſure. Many travelled with this view into the eaſtern provinces, and frequented the places which Chriſt and his diſciples had honoured with their preſence, that, with the bones and other ſacred remains of the firſt heralds of the goſpel, they might comfort dejected minds, calm trembling conſciences, ſave ſinking ſtates, and defend their inhabitants from all ſorts of calamities. Nor did theſe pious travellers return home empty; the craft, dexterity, and knavery of the Greeks, found a rich prey in the ſtupid credulity of the Latin relic-hunters, and made a profitable commerce of this new devotion. The latter paid conſiderable ſums for legs and arms, ſkulls and jaw-bones (ſeveral of which were Pagan, and ſome not human), and other things that were ſuppoſed to have belonged to the primitive worthies of the Chriſtian church; and thus the Latin churches came to the poſſeſſion of thoſe celebrated relics of St Mark, St James, St Bartholomew, Cyprian, Pantaleon, and others, which they ſhow at this day with ſo much oſtentation. But there were many who, unable to procure for themſelves theſe ſpiritual treaſures by voyages and prayers, had recourſe to violence and theft; for all ſorts of means, and all ſorts of attempts in a cauſe of this nature, were conſidered, when ſucceſsful, as pious and acceptable to the Supreme Being.—Beſides the arguments from antiquity to which the Papiſts refer, in vindication of their worſhip of relics, of which the reader may form ſome judgement from this article, Bellarmine appeals to Scripture in ſupport of it, and cites the following paſſages, viz. Exod. xiii. 19.; Deut. xxxiv. 6.; 2 Kings xiii. 21.; 2 Kings xxiii. 16, 17, 18.; Iſaiah xi. 10.; Matthew xi. 20, 21, 22.; Acts v. 12—15.; Acts xix. 11, 12. See Popery.

The Roman Catholics in Great Britain do not acknowledge any worſhip to be due to relics, but merely a high veneration and reſpect, by which means they think they honour God, who, they ſay, has often wrought very extraordinary miracles by them. But, however proper this veneration and reſpect may be, its abuſe has been ſo great and ſo general, as fully to warrant the rejection of them altogether.

Relics are forbidden to be uſed or brought into England by ſeveral ſtatutes; and juſtices of peace are empowered to ſearch houſes for popiſh books and relics, which, when found, are to be defaced and burnt, &c. 3 Jac. I. cap. 26.

RELICT, in *Law*, the ſame with Widow.

RELIEF (*Relevamen*; but, in Domeſday, *Relevatio*, *Relevium*), ſignifies a certain ſum of money, which the tenant, holding by knight's ſervice, grand ſerjeanty, or other tenure, (for which homage or legal ſervice is due), and being at full age at the death of his anceſtor, paid unto his lord at his entrance. See Primer.

Though reliefs had their original while feuds were only life eſtates, yet they continued after feuds became hereditary; and were therefore looked upon, very juſtly, as one of the greateſt grievances of tenure: eſpecially when, at the firſt, they were merely arbitrary and at the will of the lord; ſo that, if he pleaſed to demand an exorbitant relief, it was in effect to diſinherit the heir. The Engliſh ill brooked this conſequence of their newly adopted policy; and therefore William the Conqueror by his laws *aſcertained* the relief, by directing (in imitation of the Daniſh heriots), that a certain quantity of arms, and habiliments of war, ſhould be paid by the earls, barons, and vavaſours reſpectively; and, if the latter had no arms, they ſhould pay 100 ſhillings. William Rufus broke through this compoſition, and again demanded arbitrary uncertain reliefs, as due by the feodal laws; thereby in effect obliging every heir to new-purchaſe or *redeem* his land: but his brother Henry I. by the charter before mentioned, reſtored his father's law; and ordained, that the relief to be paid ſhould be according to the law ſo eſtabliſhed, and not an arbitrary redemption.—But afterwards, when, by an ordinance in 27 Hen. II. called the *aſſiſe of arms*, it was provided, that every man's armour ſhould deſcend to his heir, for defence of the realm, and it thereby became impracticable

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cable to pay these acknowledgements in arms according to the laws of the Conqueror, the composition was universally accepted of 100 shillings for every knight's fee, as we find it ever after established. But it must be remembered, that this relief was only then payable, if the heir at the death of his ancestor had attained his full age of 21 years.

To RELIEVE *the* GUARD, is to put fresh men upon guard, which is generally every 24 hours.

To RELIEVE *the Trenches*, is to relieve the guard of the trenches, by appointing those for that duty who have been there before.

To RELIEVE *the Sentries*, is to put fresh men upon that duty from the guard, which is generally done every two hours, by a corporal who attends the relief, to see that the proper orders are delivered to the soldier who relieves.

RELIEVO, or RELIEF, in *Sculpture*, &c. is the projecture or standing out of a figure which arises prominent from the ground or plane on which it is formed; whether that figure be cut with the chisel, moulded, or cast.

There are three kinds or degrees of relievo, viz. alto, basso, and demi-relievo. The alto-relievo, called also *haut-relief*, or *high-relievo*, is when the figure is formed after nature, and projects as much as the life. Basso-relievo, bass-relief, or low-relievo, is when the work is raised a little from the ground, as in medals, and the frontispieces of buildings; and particularly in the histories, festoons, foliages, and other ornaments of friezes. Demi-relievo is when one half of the figure rises from the plane. When, in a basso-relievo, there are parts that stand clear out, detached from the rest, the work is called a *demi basso*.

In architecture, the relievo or projecture of the ornaments ought always to be proportioned to the magnitude of the building it adorns, and to the distance at which it is to be viewed.

RELIEVO, or *Relief*, in *Painting*, is the degree of boldness with which the figures seem, at a due distance, to stand out from the ground of the painting.

The relievo depends much upon the depth of the shadow, and the strength of the light; or on the height of the different colours, bordering on one another; and particularly on the difference of the colour of the figure from that of the ground: thus, when the light is so disposed as to make the nearest parts of the figure advance, and is well diffused on the masses, yet insensibly diminishing, and terminating in a large spacious shadow, brought off insensibly, the relievo is said to be bold, and the clair obscure well understood.

RELIGION (RELIGIO), is a Latin word derived, according to Cicero *, from *relegere*, "to re-consider;" but according to Servius and most modern grammarians, from *religare*, "to bind fast." The reason assigned by the Roman orator for deducing *religio* from *relego*, is in these words, "qui autem omnia, quæ ad cultum deorum pertinerent, diligenter retractarent, et tanquam relegerent, sunt dicti *religiosi* ex relegendo." The reason given by Servius for his derivation of the word is, "quod mentem religio religet." If the Ciceronian etymology be the true one, the word *religion* will denote the diligent study of whatever pertains to the worship of the gods; but according to the other derivation, which we are inclined to prefer, it denotes that obligation which we feel on our minds from the relation in which we stand to some superior power. In either case, the import of the word *religion* is different from that of *theology*, as the former signifies a number of practical duties, and the latter a system of speculative truths. *Theology* is therefore the foundation of *religion*, or the science from which it springs; for no man can study what pertains to the worship of superior powers till he believe that such powers exist, or feel any obligation on his mind from a relation of which he knows nothing.

* *De Natura Deorum*, lib. ii. § 28.

1 Religion defined;

2 and distinguished from theology.

This idea of religion, as distinguished from theology, comprehends the duties not only of those more refined and complicated systems of theism or polytheism which have prevailed among civilized and enlightened nations, such as the polytheism of the Greeks and Romans, and the theism of the Jews, the Mahometans, and the Christians; it comprehends every sentiment of obligation which human beings have ever conceived themselves under to superior powers, as well as all the forms of worship which have ever been practised through the world, however fantastic, immoral, or absurd.

3 It is an important subject of speculation.

When we turn our eyes to this feature of the human character, we find it peculiarly interesting. Mankind are distinguished from the brutal tribes, and elevated to a higher rank, by the rational and moral faculties with which they are endowed; but they are still more widely distinguished from the inferior creation, and more highly exalted above them, by being made capable of religious notions and religious sentiments. The slightest knowledge of history is sufficient to inform us, that religion has ever had a powerful influence in moulding the sentiments and manners of men. It has sometimes dignified, and sometimes degraded, the human character. In one region or age it has been favourable to civilization and refinement; in another, it has occasionally cramped the genius, depraved the morals, and deformed the manners of men. The varieties of religion are innumerable; and the members of every distinct sect must view all who differ from them as more or less mistaken with respect to the most important concerns of man. Religion seems to be congenial to the heart of man; for wherever human society subsists, there we are certain of finding religious opinions and sentiments.

4 Three questions concerning religion.

It must, therefore, be an important subject of speculation to the man and the philosopher to consider the origin of religion; to inquire, How far religion in general has a tendency to promote or to injure the order and happiness of society? and, above all, to examine, What particular religion is best calculated to produce a happy influence on human life?

We shall endeavour to give a satisfactory answer to each of these questions; reserving to the article THEOLOGY the consideration of the dogmas of that particular religion which, from our present inquiries, shall appear to be true, and to have the happiest influence on human life and manners.

5 Of the source or foundation of religion.

I. The foundation of all religion rests on the belief of the existence of one or more superior beings, who govern the world, and upon whom the happiness or misery of mankind ultimately depends. Of this belief, as it may be said to have been universal, there seem to be but three sources that can be conceived. Either the image of Deity must be stamped on the mind of every human being, the savage as well as the sage; or the founders of societies, and other eminent persons, tracing, by the efforts

efforts of their own reason visible effects to invisible causes, must have discovered the existence of superior powers, and communicated the discovery to their associates and followers; or, lastly, the universal belief in such powers must have been derived by tradition from a primæval revelation, communicated to the progenitors of the human race.

6
It does not arise from an original stamp on the mind;

One or other of these hypotheses must be true, because a fourth cannot be framed. But we have elsewhere (POLYTHEISM, N° 2.) examined the reasoning which has been employed to establish the first, and shewn that it proceeds upon false notions of human nature. We should likewise pronounce it contrary to fact, could we believe, on the authority of some of its patrons, who are not ashamed to contradict one another, that the Kamtschatkans, and other tribes, in the lowest state of reasoning and morals, have no ideas whatever of Deity. We proceed, therefore, to consider the second hypothesis, which is much more plausible, and will bear a stricter scrutiny.

7
nor from reasoning;

That the existence and many of the attributes of the Deity are capable of rigid demonstration, is a truth which cannot be controverted either by the philosopher or the Christian; for "the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and Godhead," (see METAPHYSICS, Part III. chap. vi. and THEOLOGY, N° 8, 9.). But surely it would be rash to infer, either that every truth for which, when it is known, the ingenuity of man can frame a demonstration, is therefore *discoverable* by human sagacity, or that all the truths which have been discovered by a *Newton* or a *Locke* might therefore have been discovered by untaught barbarians. In mathematical science, there are few demonstrations of easier comprehension than that given by Euclid, of the theorem of which Pythagoras is the reputed author; yet no man ever dreamed that a boy capable of being made to understand that theorem, must therefore have sagacity equal to the sage of Samos; or that such a boy, having never heard of the relation between the hypothenuse and other two sides of a right-angled triangle, would be likely to *discover* that the square of the former is precisely equal to the sum of the squares of the latter. Just so it seems to be with the fundamental truths of theology. There can hardly be conceived a demonstration less intricate, or more conclusive, than that which the man of science employs to prove the existence of at least one God, possessed of boundless power and perfect wisdom. And could we suppose that the human race had remained without any knowledge of God in the world, till certain lucky individuals had by some means or other made themselves masters of the rules of logic, and the philosophy of causes, there can be no doubt but that these individuals might have discovered the existence of superior powers, and communicated their discovery to their associates and followers. But this supposition cannot be admitted, as it is contradicted by the evidence of all history. No nation or tribe has ever been found, in which there is not reason to believe that some notions were entertained of superior and invisible powers, upon which depends the happiness or misery of mankind: and from the most authentic records of antiquity, it is apparent that very pure principles of theism prevailed in some nations long before the rules of logic, and the philosophy of causes, were thought of by any people under heaven.

The supposition before us is inadmissible upon other accounts. Some modern philosophers have fancied that the original progenitors of mankind were left entirely to themselves from the moment of their creation; that they wandered about for ages without the use of speech and in the lowest state of savagism; but that they gradually civilized themselves, and at last stumbled upon the contrivance of making articulate sounds significant of ideas, which was followed by the invention of arts and sciences, with all the blessings of religion and legislation in their train. But this is a wild reverie, inconsistent with the phenomena of human nature.

It is a well known fact, that a man blind from his birth, and suddenly made to see, would not by means of his newly acquired sense discern either the magnitude or figure or distance of objects, but would conceive every thing which communicated to him visible sensations as inseparably united to his eye or his mind (See METAPHYSICS, N° 49—53). How long his sense of sight would remain in such an imperfect state, we cannot positively say; but from attending to the visible sensations of infants, we are confident that weeks, if not months, elapse before they can distinguish one thing from another. We have indeed been told, that Cheselden's famous patient, though he was at first in the state which we have described, learned to distinguish objects by sight in the course of a few hours, or at the most of a few days: but admitting this to a certain extent to be true, it may easily be accounted for. The disease called a *cataract* does not always occasion total blindness; but let us suppose the eyes of this man to have been so completely dimmed as to communicate no sensation whatever upon being exposed to the rays of light; still we must remember that he had long possessed the power of loco-motion and all his other senses in perfection. He was therefore well acquainted with the real, *i. e.* the tangible magnitude, figure, and distance of many objects; and having been often told that the things which he touched would, upon his acquisition of sight, communicate new sensations to his mind, differing from each other according to the distance, figure, and magnitude of the objects by which they were occasioned, he would soon learn to infer the one from the other, and to distinguish near objects by means of his sight.

The progenitors of the human race, however, if left to themselves from the moment of their creation, had not the same advantages. When they first opened their eyes, they had neither moved, nor handled, nor heard, nor smelled, nor tasted, nor had a single idea or notion treasured up in their memories; but were in all these respects in the state of new-born infants. Now we should be glad to be informed by those sages who have conducted mankind through many generations in which they were *mutum et turpe pecus* to that happy period when they invented language, how the first men were taught to distinguish objects by their sense of sight, and how they contrived to *live* till this most necessary faculty was acquired? It does not appear that men are like brutes, provided with a number of instincts which guide them blindfold and without experience to whatever is necessary for their own preservation (see INSTINCT): On the contrary, all voyagers tell us that, in in ſtrange and uninhabited countries, they dare not venture to taſte unknown fruits unleſs they perceive that theſe fruits are eaten by the fowls of the air. But without the aid of inſtinct, or of ſome other guide equally to be depended upon, it is not in our power to conceive how men dropt from the hands of their Creator, and left from that inſtant wholly to themſelves, could move a ſingle ſtep without the moſt imminent danger, or even ſtretch out their hands to lay hold of that food which we may ſuppoſe to have been placed within their reach. They could not, for many days, diſtinguiſh a precipice from a plane, a rock from a pit, or a river from the meadows through which it rolled. And in ſuch circumſtances, how could they poſſibly exiſt, till their ſenſe of ſight had acquired ſuch perfection as to be a ſufficient guide to all their neceſſary motions? Can any conſiſtent theiſt ſuppoſe that the God whoſe goodneſs is ſo conſpicuouſly diſplayed in all his works, would leave his nobleſt creature on earth, a creature for whoſe comfort alone many other creatures ſeem to have been formed, in a ſituation ſo forlorn as this, where his immediate deſtruction appears to be inevitable? No! This ſuppoſition cannot be formed, becauſe mankind ſtill exiſt.

8
But from an original revelation.

Will it then be ſaid, that when God formed the firſt men, he not only gave them organs of ſenſation, and ſouls capable of arriving by diſcipline at the exerciſe of reaſon, but that he alſo impreſſed upon their minds adequate ideas and notions of every object in which they were intereſted; brought all their organs, external and internal, at once to their utmoſt poſſible ſtate of perfection; taught them inſtantaneouſly the laws of reaſoning; and, in one word, ſtored their minds with every branch of uſeful knowledge? This is indeed our own opinion; and it is perfectly agreeable to what we are taught by the Hebrew lawgiver.

9
This opinion agreeable to the writings of Moſes.

When God had formed Adam and Eve, Moſes does not ſay that he left them to acquire by ſlow degrees the uſe of their ſenſes and reaſoning powers, and to diſtinguiſh as they could fruits that were ſalutary from thoſe that were poiſonous. No: he placed them in a garden where every tree but one bore fruit fit for food; he warned them particularly againſt the fruit of that tree; he brought before them the various animals which roamed through the garden; he arranged theſe animals into their proper genera and ſpecies; and by teaching Adam to give them names, he communicated to the firſt pair the elements of language. This condeſcenſion appears in every reſpect worthy of perfect benevolence; and indeed without it the helpleſs man and woman could not have lived one whole week. But it cannot be ſuppoſed, that amidſt ſo much uſeful inſtruction the gracious Creator would neglect to communicate to his rational creatures the knowledge of himſelf; to inform them of their own origin, and the relation in which they ſtood to him; and to ſtate in the plaineſt terms the duties incumbent on them in return for ſo much goodneſs.

10
The mode of communication not certainly known.

In what manner all this knowledge was communicated, cannot be certainly known. It may have been in either of the following ways conceivable by us, or in others of which we can form no conception. God may have miraculouſly ſtored the minds of the firſt pair with adequate ideas and notions of ſenſible and intellectual objects; and then by an internal operation of his own Spirit have enabled them to exert at once their rational faculties ſo as to diſcover his exiſtence and attributes, together with the relation in which as creatures they ſtood to him their Almighty Creator. Or, after rendering them capable of diſtinguiſhing objects by means of their ſenſes, of comparing their ideas, and underſtanding a language, he may have exhibited himſelf under ſome ſenſible emblem, and conducted them by degrees from one branch of knowledge to another, as a ſchoolmaſter conducts his pupils, till they were ſufficiently acquainted with every thing relating to their own happineſs, and duty, as rational, moral, and religious creatures. In determining the queſtion before us, it is of no importance whether infinite wiſdom adopted either of theſe methods, or ſome other different from them, both which we cannot conceive. The ordinary proceſs in which men acquire knowledge is, by the laws of their nature, extremely tedious. They cannot reaſon before their minds be ſtored with ideas and notions; and they cannot acquire theſe but through the medium of their ſenſes long exerciſed on external objects.

11
But whether internal or external, it was equally a revelation.

The progenitors of the human race, left to inform themſelves by this proceſs, muſt have inevitably periſhed before they had acquired one diſtinct notion; and it is the ſame thing with reſpect to the origin of religion, whether God preſerved them from deſtruction by an *internal* or *external* revelation. If he ſtored their minds at once with the rudiments of all uſeful knowledge, and rendered them capable of exerting their rational faculties, ſo as, by tracing effects to their cauſes, to diſcover his being and attributes, he *revealed* himſelf to them as certainly as he did afterwards to Moſes, when to him he condeſcended to ſpeak face to face.

12
Such a revelation muſt naturally be handed to poſterity.

If this reaſoning be admitted as fair and concluſive, and we apprehend that the principles on which it proceeds cannot be conſidered as ill-founded, we have advanced ſo far as to prove that mankind muſt have been originally enlightened by a revelation. But it is ſcarce neceſſary to obſerve, that this revelation muſt have been handed down through ſucceeding generations. It could not fail to reach the era of the deluge. It is not abſurd to ſuppoſe, that he who ſpake from heaven to Adam, ſpake alſo to Noah. And both the revelation which had been handed down to the poſtdiluvian patriarch by tradition, and that which was communicated immediately to himſelf, would be by him made known to his deſcendants. Thus it appears almoſt impoſſible that ſome part of the religious ſentiments of mankind ſhould not have been derived from revelation; and that not of the religious ſentiments of one particular family or tribe, but of almoſt all the nations of the earth.

13
The authority of the Jewiſh and Chriſtian ſcriptures, &c.

This concluſion, which we have deduced by fair reaſoning from the benevolence of God and the nature of man, is confirmed by the authority of the Jewiſh and Chriſtian Scriptures, which are entitled to more implicit credit than all the other records of ancient hiſtory.

When we review the internal and external evidence of the authenticity of theſe ſacred books, we cannot for a moment heſitate to receive them as the genuine *word of God*. If we examine their internal character, they everywhere appear to be indeed the voice of Heaven. The creation of the world—the manner in which this globe was firſt peopled—the deluge which ſwept away its inhabitants—the ſucceeding views of the ſtate of mankind

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mankind in the next ages after the deluge—the calling of Abraham—the legiflation of Mofes—the whole feries of events which befel the Jewifh nation—the prophecies—the appearance of Jefus Chrift, and the promulgation of his gofpel, as explained to us in the Scriptures—form one feries, which is, in the higheft degree, illuftrative of the power, wifdom, and goodnefs of the Supreme Being.

While it muft be allowed that the human mind is ever prone to debafe the fublime principles of true religion by enthufiafm and fuperftition, reafon and candour will not for a moment hefitate to acknowledge, that the whole fyftem of revelation reprefents the Supreme Being in the moft fublime and amiable light: that, in it, religion appears effentially connected with morality: that the legiflative code of Mofes was fuch as no legiflator ever formed and eftablifhed among a people equally rude and uncultivated: that the manners and morals of the Jews, vicious and favage as they may in fome inftances appear, yet merit a much higher character than thofe either of their neighbours, or of almoft any other nation, whofe circumftances and character were in other refpects fimilar to theirs: that there is an infinite difference between the Scripture prophecies and the oracles and predictions which prevailed among heathen nations: and that the miracles recorded in thofe writings which we efteem facred were attended with circumftances which entitle them to be ranked in a very different clafs from thofe which enthufiafm and impofture have fabricated among other nations. See MIRACLE and PROPHECY.

14 The five books of Mofes proved to be divine:

But as the evidence of the divine origin of the primæval religion refts particularly on the authority of the firft five books of the Old Teftament, it may be thought incumbent on us to fupport our reafoning on this fubject, by proving, that the author of thofe books was indeed infpired by God. This we fhall endeavour to do by one decifive argument; for the nature of the article, and the limits prefcribed us, admit not of our entering into a minute detail of all that has been written on the divine legation of Mofes.

If the miracles recorded in the book of Exodus, and the other writings of the Hebrew lawgiver, were really performed; if the firft-born of the Egyptians were all cut off in one night, as is there related; and if the children of Ifrael paffed through the Red fea, the waters being divided, and forming a wall on their right hand and on their left—it muft neceffarily be granted, that Mofes was fent by God; becaufe nothing lefs than a divine power was fufficient to perform fuch wonderful works. But he who fuppofes that thofe works were never performed, muft affirm that the books recording them were *forged*, either at the era in which the miracles are faid to have been wrought, or at fome fubfequent era: There is no other alternative.

15 for it was otherwife impoffible to impofe them on the Jews in the era to which they relate, or

That they could not be *forged* at the era in which they affirm the miracles to have been wrought, a very few reflections will make incontrovertibly evident. Thefe books inform the people for whofe ufe they were written, that their author, after having inflicted various plagues upon Pharaoh and his fubjects, brought them, to the number of 600,000, out of Egypt with a high hand; that they were led by a pillar of cloud through the day, and by a pillar of fire through the night, to the brink of the Red fea, where they were almoft overtaken by the Egyptians, who had purfued them with chariots and horfes; that, to make a way for their efcape, Mofes ftretched out his rod over the fea, which was immediately divided, and permitted them to pafs through on dry ground, between two walls of water; and that the Egyptians, purfuing and going in after them to the midft of the fea, were all drowned by the return of the waters to their ufual ftate, as foon as the Hebrews arrived at the further fhore. Is it poffible now that Mofes or any other man could have perfuaded 600,000 perfons, however barbarous and illiterate we fuppofe them, that they had been witneffes of all thefe wonderful works, if no fuch works had been performed? Could any art or eloquence perfuade all the inhabitants of Edinburgh and Leith, that they had yefterday walked on dry ground through the Frith to Kinghorn, the waters being divided and forming a wall on their right hand and on their left? If this queftion muft be anfwered in the negative, it is abfolutely impoffible that the books of Mofes, fuppofing them to have been forged, could have been received by the people who were alive when thofe wonders are faid to have been wrought.

16 in any after period.

Let us now inquire, whether, if they be forgeries, they could have been received as authentic at any fubfequent period; and we fhall foon find this fuppofition as impoffible as the former. The books claiming Mofes for their author fpeak of themfelves as delivered by him, and from his days kept in the ark of the covenant *; an ark which, upon this fuppofition, had no exiftence prior to the forgery. They fpeak of themfelves likewife, not only as a hiftory of miracles wrought by their author, but as the ftatutes or municipal law of the nation, of which a copy was to be always in the poffeffion of the priefts, and another in that of the fupreme magiftrate †. Now, in whatever age we fuppofe thefe books to have been forged, they could not poffibly be received as authentic; becaufe no copy of them could then be found either with the king, with the priefts, or in the ark, though, as they contain the ftatute law of the land, it is not conceiveable that, if they had exifted, they could have been kept fecret. Could any man, at this day, forge a book of ftatutes for England or Scotland, and make it pafs upon thefe nations for the only book of ftatutes which they had ever known? Was there ever fince the world began a book of fham ftatutes, and thefe, too, multifarious and burdenfome, impofed upon any people as the only ftatutes by which they and their fathers had been governed for ages? Such a forgery is evidently impoffible.

* Deut. xxxi. 24—27.

† Deut. xviii. 19.

But the books of Mofes have internal proofs of authenticity, which no other books of ancient ftatutes ever had. They not only contain the laws, but alfo give an hiftorical account of their enactment, and the reafons upon which they were founded. Thus they tell us ‡, that the rite of circumcifion was inftituted as a mark of the covenant between God and the founder of the Jewifh nation, and that the practice of it was enforced by the declaration of the Almighty, that every uncircumcifed man-child fhould be cut off from his people. They inform us that the annual folemnity of the paffover was inftituted in commemoration of their deliverance when God flew, in one night, all the firft-born of the Egyptians; that the firft-born of Ifrael, both of men and beaft, were on the fame occafion dedicated for ever to God, who took the Levites inftead of the firft-born of the

‡ Gen. xvii.

the men *; that this tribe was conſecrated as prieſts, by whoſe hands alone the ſacrifices of the people were to be offered; that it was death for any perſon of a different tribe to approach the altar, or even to touch the ark of the covenant; and that Aaron's budding rod was kept in the ark in memory of the wonderful deſtruction of Korah, Dathan, and Abiram, for their rebellion againſt the prieſthood.

* Exod. xii. and Numb. viii.

Is it poſſible now, if all theſe things had not been practiſed among the Hebrews from the era of Moſes, with a retroſpect to the ſignal mercies which they are ſaid to commemorate, that any man or body of men could have perſuaded a whole nation, by means of forged books, that they had always religiouſly obſerved ſuch inſtitutions? Could it have been poſſible, at any period poſterior to the Exodus, to perſuade the Iſraelites that they and their fathers had all been circumciſed on the eighth day from their birth, if they had been conſcious themſelves that they had never been circumciſed at all? or that the paſſover was kept in memory of their deliverance from Egyptian bondage, if no ſuch feſtival was known among them?

But let us ſuppoſe that circumciſion had been practiſed, and all their other rites and ceremonies obſerved from time immemorial, without their knowing any reaſon of ſuch inſtitutions: ſtill it muſt be confeſſed, that the forger of theſe books, if they *were* forged, conſtructed his narrative in ſuch a manner as that no man of common ſenſe could receive it as authentic. He ſays it was death to touch the ark! As ſuch an aſſertion was never heard of before, and as the ritual he was endeavouring to make them eſteem ſacred was oppreſſively multifarious; ſurely ſome daring ſpirit would have ventured to put his veracity to the teſt by moving the ark and even offering ſacrifices; and ſuch a teſt would at once have expoſed the impoſture. The budding rod, too, and the pot of manna, which, though long preſerved, were never before heard of, muſt have produced inquiries that could not fail to end in detection. Theſe books ſpeak likewiſe of weekly ſabbaths, daily ſacrifices, a yearly expiation, and monthly feſtivals, all to be kept in remembrance of great things, particularly ſpecified as done for the nation at an early period of its exiſtence. If this was not the caſe, could the forger of the books have perſuaded the people that it really was ſo? The enlightened reaſoners of this nation would be offended were we to compare them with the ancient Iſraelites; but ſurely they will not ſay that we are partial to that people, if we bring them to a level with the moſt ſavage tribes of the Ruſſian empire, who profeſs Chriſtianity? Now, were a book to be forged containing an account of many ſtrange things done a thouſand years ago in Siberia by an *Apollonius*, or any other philoſopher or hero, numbers of the barbarians inhabiting that country would, we doubt not, give implicit credit to the *legend:* But were the author, in confirmation of his narative, to affirm, that all the Siberians had from that day to this kept ſacred the firſt day of the week in memory of his hero; that they had all been baptized or circumciſed in his name; that in their public judicatories they had ſworn by his name, and upon that very book which they had never ſeen before; and that the very ſame book was their law and their goſpel, by which for a thouſand years back the actions of the whole people had been regulated—ſurely the groſſeſt ſavage among them would reject with contempt and indignation a forgery ſo palpable.

If this reaſoning be concluſive, the books of Moſes muſt indubitably be authentic, and he himſelf muſt have been inſpired by the ſpirit of God. But this point being eſtabliſhed, the queſtion reſpecting the origin of the primæval religion is completely anſwered. The writer of the book of Geneſis informs us, that Adam and Noah received many revelations from the Author of their being, and that their religion was founded on the principles of the pureſt theiſm. How it degenerated among the greater part of their deſcendants into the groſſeſt idolatry, has been ſhown at large in another place. See POLYTHEISM.

17 Of the influence of religion on ſociety.

II. Having thus anſwered the firſt queſtion propoſed for diſcuſſion in the preſent article, we now proceed to conſider the ſecond, and to inquire whether and how far religious ſentiments have a tendency to injure or to promote the welfare of ſociety? This is a ſubject of the utmoſt importance; and if we prove ſucceſsful in our inquiries, we ſhall be enabled to determine whether the governors of mankind ought carefully to ſupport religious eſtabliſhments, or whether the philoſopher who calls himſelf a citizen of the world, and profeſſes to feel the moſt eager deſire to promote the intereſts of his ſpecies, acts conſiſtently when he labours to exterminate religion from among men.

A celebrated French financier *, a man of abilities and virtue, who has publiſhed a book on the importance of religious opinions, labours to ſhow that religious eſtabliſhments are indiſpenſably neceſſary for the maintenance of civil order, and demonſtrates how weak the influence of political inſtitutions is on the morals of mankind; but he refuſes to review the hiſtory of paſt ages in order to diſcover how far religious opinions have actually been injurious or beneficial to the welfare of ſociety; chooſing rather to content himſelf with the reſult of a ſeries of metaphyſical diſquiſitions.

* *M. Necker.*

We admire the ſpirit which induced a man who had ſpent a conſiderable part of his life amid the hurry of public buſineſs, to become the ſtrenuous advocate of religion; but we cannot help thinking that, notwithſtanding the eloquence, the acuteneſs, and the knowledge of mankind which he has diſplayed, his refuſing to admit the evidence of facts, concerning the influence of religion on ſociety, may poſſibly be regarded by its enemies as a tacit acknowledgment that the evidence of facts would be unfavourable to the cauſe which he wiſhes to defend. The fallacy of general reaſonings, and the inutility of metaphyſics for the purpoſes of life, are ſo univerſally acknowledged, that they have long been the theme of declamation. Though the abuſes of religion, as well as the abuſes of reaſon, the perverſion of any of the principles of the human mind, and the miſapplication of the gifts of Providence, may have often produced effects hurtful to the virtue and the happineſs of mankind; yet, after tracing religion to a divine origin, we cannot, for a moment, allow ourſelves to think that the primary tendency of religion muſt be hoſtile to the intereſt of ſociety, or that it is neceſſary to view it abſtractly in order that we may not behold it in an odious light. Often has the ſceptic attacked religion with artful malice; but perhaps none of his attacks has been ſo ſkilfully directed as that which has firſt ridiculed the abſurdity of the moſt abſurd ſuperſtitions, and

18 Triumphs of the ſceptic on account of the abuſes of religion.

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and afterwards laboured to prove that the moſt abſurd ſyſtem of polytheiſm is more favourable to the intereſts of ſociety than the pureſt and moſt ſublime theiſm. Inſtances in which the abuſe of religion had tended to deprave the human heart, and had led to the moſt ſhocking crimes, have been aſſiduouſly collected, and diſplayed in all the aggravating colours in which eloquence could array them, till at length even the friends of true religion have been abaſhed; and it has become a faſhionable opinion, that nothing but ſelf-intereſt or bigotry can prompt men to repreſent religion as the friend of civil order. But let us try if, by a candid conſideration of what effects have reſulted to ſociety from religious principles, in general, without comparing theſe with regard to truth or falſehood, we can advance any thing to vindicate the character of religion.

Notions of Deity in general, of various orders of divinities, of their moral character, of their influence on human life, of a future ſtate, and of the immortality of the human ſoul, conſtitute the leading articles of religion. Let us view theſe together with the rites to which they have given riſe; and we may perhaps be enabled to form ſome well-grounded notions on this important point.

19 The firſt religious opinions entertained by men could not poſſibly be injurious to ſociety.

1. Having proved that the firſt religious principles entertained by men were derived from revelation, it is impoſſible to ſuppoſe that they could produce effects injurious to ſociety. If religion of any kind has ever leſſened the virtue or diſturbed the peace of men, it muſt have been that religion which ſprings from a belief in a multitude of ſuperior powers actuated by paſſions, and of whom ſome were conceived as benevolent and others as malicious beings. That ſuch ſentiments ſhould have produced vices unknown in ſocieties where pure theiſm is profeſſed, will be readily admitted. Even the few *atheiſts* who live in Chriſtian or Mahometan countries are reſtrained by the laws, by a deſire to promote the honour of the ſect, and by many other conſiderations, from indulging in practices which the example of the falſe gods of antiquity ſanctioned in their votaries. But in determining the preſent queſtion, we muſt not compare the virtues of the pagan world with thoſe of individual atheiſts in modern Europe, but with thoſe of *nations* profeſſing atheiſm; and ſuch nations are nowhere to be found. We can however eaſily conceive, that in a ſociety unawed by any notions of God or a future ſtate, no ſuch laws would be enacted as thoſe which reſtrain the ſenſual appetites; of which the criminal indulgence was one of the greateſt ſtigmas on the pagan worſhip of antiquity. In ſuch ſocieties, therefore, thoſe vices would be practiſed conſtantly to which paganiſm gave only an occaſional ſanction; and many others, in ſpite of the utmoſt vigilance of human laws, would be perpetrated in ſecret, which the moſt profligate pagans viewed with horror. Conſcience, though acting with all her energy, would not be able to command any regard to the laws of morality: No virtue would be known; ſocial order would be nowhere obſerved; the midnight aſſaſſin would everywhere be found; and in the general ſcramble mankind would be exterminated from the face of the earth.

20 The effect of atheiſm on the manners of nations

The worſt ſpecies of paganiſm, even that which prevails among ſavages who worſhip evil ſpirits, affords greater ſecurity than this. It is indeed ſhocking to think that demons ſhould be worſhipped, while deities, who are regarded as being all benevolence, are treated with contempt: And it has been aſked, If the influence of ſuch religious ſentiments on the moral practice of the idolaters muſt not naturally be, to cauſe them to treat their friends and benefactors with ingratitude, and to humble themſelves with mean ſubmiſſion before a powerful enemy?

21 would be more malignant than that of the moſt abſurd paganiſm.

They do not appear to have produced ſuch effects on the morality of the ſavages by whom they were entertained. The benevolent deities were neglected, only becauſe their benevolence was neceſſary. A voluntary favour merits a grateful return: a deſigned injury provokes reſentment. But when you become, by accident, the inſtrument of any man's good fortune, the world will ſcarce conſider him as owing you any obligation: the ſtone which bruiſes your foot excites only a momentary emotion of reſentment. Thoſe gods who could not avoid doing good to men might not receive a profuſion of thanks for their ſervices; and yet a favour conferred by a human benefactor commands the warmeſt gratitude. But thoſe rude tribes appear to have had ſo much wiſdom as to confer a leſs abſolute malice on their malevolent deities, than the benevolence which they attributed to their more amiable order of ſuperior beings: though the latter could not poſſibly do them any thing but good, and that conſtantly; yet the former were not under an equally indiſpenſable neceſſity of perſevering in depreſſing them under calamities. On their malevolent deities they conferred a freedom of agency which they denied to the benevolent. No wonder, then, that they were more aſſiduous in paying their court to the one than to the other. They might with as much propriety have thought of being grateful to the boar or ſtag whoſe fleſh ſupported them, as to deities who were always benevolent, becauſe they could not poſſibly be otherwiſe. Though negligent of ſuch deities, this can ſcarce be thought to have had any tendency to render them ungrateful to benefactors like themſelves. And yet, it muſt not be diſſembled, that the American Indians, among whom ſuch religious ſentiments have been found to prevail, are ſaid to be very little ſenſible to the emotions of gratitude. An Indian receives a preſent without thinking of making any grateful acknowledgments to the beſtower. He pleaſes his fancy or gratifies his appetite with what you have given, without ſeeming to conſider himſelf as under the ſmalleſt obligation to you for the gift.

It may be doubted, however, whether this ſpirit of ingratitude originates from, or is only collateral with, that indifference which refuſes adoration and worſhip to the benevolent divinities. If the former be actually the caſe, we muſt acknowledge that thoſe religious notions which we now conſider, though preferable to general atheiſm, are in this reſpect unfriendly to virtue. But if the Indians may be thought to owe the ingratitude for which they are diſtinguiſhed to the opinion which they entertain of the exiſtence of a benevolent order of deities, whoſe benevolence is neceſſary and involuntary, their ideas of the nature of their malevolent demons do not appear to have produced equal effects on their moral ſentiments. However ſubmiſſive to thoſe dreaded beings, they are far from ſhowing the ſame tame and cowardly ſubmiſſion to their human enemies: towards them

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them they seem rather to adopt the sentiments of their demons. Inveterate rancour and brutal fury, inhuman cruelty and inconceivable cunning, are displayed in the hostilities of tribes at war; and we know not, after all, if even these sentiments do not owe somewhat of their force to the influence of religion.

Yet let us remember that these same Indians have not been always represented in so unamiable a light; or, at least, other qualities have been ascribed to them which seem to be inconsistent with those barbarous dispositions. They have been described as peculiarly susceptible of conjugal and parental love; and he who is so cannot be destitute of virtue.

21 The influence of Greek and Roman polytheism

2. But leaving the religion of savages, of which very little is known with certainty, let us proceed to examine what is the natural influence of that mixed system of theology which represents to the imagination of men a number of superior and inferior divinities, actuated by the same passions and feelings with themselves, and often making use of their superior power and knowledge for no other purpose but to enable them to violate the laws of moral order with impunity. This is the celebrated polytheism of the Greeks and Romans, and most other nations of antiquity (see POLYTHEISM). Could its influence be favourable to virtue?

22 apparently friendly to profligacy;

At a first view every person will readily declare, that such a system must have been friendly to profligacy. If you commit the government of the universe, and the inspection of human society, to a set of beings who are often disposed to regard vice with a no less favourable eye than virtue, and who, though there be an established order by which virtue is discriminated from vice, and right from wrong, yet scruple not to violate that order in their own conduct; you cannot expect them to require in you a degree of rectitude of which they themselves appear incapable. A Mercury will not discourage the thievish arts of the trader; a Bacchus and a Venus cannot frown upon debauchery; Mars will behold with savage delight all the cruelties of war. The Thracians indeed, one of the most barbarous nations of antiquity, whose ferocity was little if at all inferior to that of the Indians who have been distinguished as canibals, was the favourite nation of Mars; among whom stood his palace, to which he repaired when about to mount his chariot, and arm himself for battle. Even Jupiter, who had been guilty of so many acts of tyrannical caprice, had been engaged in such a multitude of amorous intrigues, and seemed to owe his elevated station as monarch of the sky, not to superior goodness or wisdom, but merely to a superior degree of brutal force, could not be feared as the avenger of crimes, or revered as the impartial rewarder of virtues.

23 but when contrasted with atheism its effects were favourable:

That this system had a pernicious effect on morals, and that, as compared with pure theism, it was injurious to society, cannot be denied; but yet, when contrasted with atheism, it was not without its favourable effects. It was so connected with the order of society, that, without its support, that order could scarce have been maintained. The young rake might perhaps justify himself by the example of Jupiter, or Apollo, or some other amorous divinity; the frail virgin or matron might complain of Cupid, or boast of imitating Venus; and the thief might practise his craft under the patronage of Mercury: But if we take the whole system together, if we consider with what views those deities were publicly worshipped, what temples were raised, what rites instituted, what sacrifices offered, and what *feriæ* consecrated; we shall perhaps find it necessary to acknowledge that the general effects even of that mixed and incoherent system of polytheism which prevailed among the Greeks and Romans were favourable to society. To state a particular instance; the *ancilia* of Mars and the fire of Vesta were thought to secure the perpetuity of the Roman empire. As long as the sacred *ancile*, which had been dropped from heaven for that benevolent purpose, was safely preserved in those holy archives in which it had been deposited; and as long as the sacred fire of Vesta was kept burning, without being once extinguished, or at least suffered to remain for an instant in that state; so long was Rome to subsist and flourish. And, however, simple and absurd the idea which connected the prosperity of a nation with the preservation of a piece of wood in a certain place, or with the constant blazing of a flame upon an hearth; yet no fact can be more certain, than that the patriotism and enthusiastic valour of the Romans, which we so much extol and admire, were, in many instances, owing in no inconsiderable degree to the veneration which they entertained for the *ancilia* and the vestal fire.

24 as is proved by a numerous series of facts, &c.

A numerous series of facts occur in the Roman history, which show the happy effects of their religious opinions and ceremonies on their sentiments concerning social order and the public welfare. How powerful was the influence of the *sacramentum* administered to the soldiers when they enlisted in the service of their country? The promises made, the idea of the powers invoked, and the rites performed on that occasion, produced so deep and so awful an impression on their minds, that no danger, nor distress, nor discontent, could prompt them to violate their engagements. The responses of the oracles, too, though the dictates of deceit and imposture, were often of singular service to those to whom they were uttered; when they inspired the warrior, as he marched out to battle, with the confidence of success, they communicated to him new vigour, and more heroic valour, by which he was actually enabled to gain, or at least to deserve, the success which they promised. Again, when in times of public distress, the augur and the priest directed some games to be celebrated, certain sacrifices to be offered, or some other solemnities to be performed, in order to appease the wrath of the offended deities; it is plain that the means were not at all suited to accomplish the end proposed by them; yet still they were highly beneficial. When the attention of the whole people was turned entirely to those solemnities by which the wrath of heaven was to be averted, they were roused from that despondency under which the sense of the public distress or danger might have otherwise caused them to sink: the public union was at the same time more closely cemented, and the hearts of the people knit together; and when persuaded, that by propitiating the gods they had removed the cause of their distress, they acquired such calmness and strength of mind as enabled them to take more direct and proper measures for the safety of the state.

Could we view the ancient Greeks and Romans acting in public or in private life under the influence of that system of superstition which prevailed among them; could

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could we perceive how much it contributed to the maintenance of civil order; could we behold Numa and Lycurgus establishing their laws, which would otherwise have met with a very different reception under the sanction of divinities; could we observe all the beneficial effects which arose to communities from the celebration of religious ceremonies, we should no longer hesitate to acknowledge, that those principles in the human heart by which we are susceptible of religious sentiments, are so eminently calculated to promote the happiness of mankind, that even when perverted and abused, their influence is still favourable.

25 Their notion of a future state of retribution incorrect;

The ideas which prevailed among the nations of the heathen world concerning a future state of retribution were, it must be confessed, not very correct. Some of the poets, we believe, have represented them in no unfair light: both Homer and Virgil have conducted their heroes through the realms of Pluto, and have taken occasion to unfold to us the secrets of those dreary abodes. The scenes are wild and fanciful; the rewards of the just and virtuous are of no very refined or dignified nature: and of the punishments inflicted on the guilty, it is often hard to say for what ends they could be inflicted; whether to correct and improve, or for the gratification of revenge or whim: they are often so whimsical and unsuitable, that they cannot with any degree of propriety be ascribed to any cause but blind chance or wanton caprice. A great dog with three tongues, a peevish old boat-man with a leaky ferry boat, demanding his freight in a surly tone, and an uxorious monarch, are objects too familiar and ludicrous not to degrade the dignity of those awful scenes which are represented as the mansions of the dead, and to prevent them from making a deep enough impression on the imagination. The actions and qualities too, for which departed spirits were admitted into Elysium, or doomed to the regions of suffering, were not always of such a nature as under a well-regulated government on earth would have been thought to merit reward, or to be worthy of punishment. It was not always virtue or wisdom which conducted to the Elysian fields, or gained admission into the society of the immortal gods.—Ganimede was for a very different reason promoted to be the cup-bearer of Jove; and Hercules and Bacchus could not surely plead that any merits of that kind entitled them to seats in the council, and at the banquets of the immortals. That doctrine, likewise, which represented mortals as hurried by fate to the commission of crimes, which they could no more abstain from committing than the sword can avoid to obey the impulse of a powerful and furious arm plunging it into the breast of an unresisting antagonist, could not but produce effects unfavourable to virtue; and it afforded a ready excuse for the most extravagant crimes.

26 but nevertheless favourable to virtue and moral order.

Yet, after all, he who attentively considers the ideas of the Greeks and Romans concerning the moral government of the world and a future state of rewards and punishments, will probably acknowledge, that their general influence must have been favourable to virtue and moral order. Allow them to have been incorrect and dashed with absurdity; still they represent punishments prepared for such qualities and actions as were injurious to the welfare of society; whilst, for those qualities which rendered men eminently useful in the world, they hold forth a reward. Though incorrect, their ideas concerning a future state were exceedingly distinct; they were not vague or general, but such as might be readily conceived by the imagination, in all their circumstances, as really existing. When a man is told that for such a deed he will be put to death, he may shudder and be alarmed, and think of the deed as what he must by no means commit; but place before him the scene and the apparatus for his execution, call him to behold some other criminal mounting the scaffold, addressing his last words in a wild scream of despair to the surrounding spectators, and then launching into eternity—his horror of the crime, and his dread of the punishment, will now be much more powerfully excited. In the same manner, to encourage the soldier marching out to battle, or the mariner setting sail under the prospect of a storm, promise not, merely in general terms, a liberal reward; be sure to specify the nature of the reward which you mean to bestow; describe it so as that it may take hold on the imagination, and may rise in opposition to the images of death and danger with which his courage is to be assailed.

If these phenomena of the human mind are fairly stated, if it be true that general ideas produce no very powerful effects on the sentiments and dispositions of the human heart, it must then be granted, that though the scenes of future reward and punishment, which the heathens considered as prepared for the righteous and the wicked, were of a somewhat motley complexion; yet still, as they were distinct and even minute draughts, they must have been favourable to virtue, and contributed in no inconsiderable degree to the support of civil order.

27 The notion of deities peopling all nature of a useful tendency when compared with atheism.

Another thing of which we may take notice under this head, is the vast multiplicity of deities with which the Greek and Roman mythology peopled all the regions of nature. Flocks and fields, and woods and oaks, and flowers, and many much more minute objects, had all their guardian deities. These were somewhat capricious at times, it is true, and expected to have attention paid them. But yet the faithful shepherd, and the industrious farmer, knew generally how to acquire their friendship; and in the idea of deities enjoying the same simple pleasures, partaking in the same labours, protecting their possessions, and bringing forward the fruits of the year, there could not but be something of a very pleasing nature, highly favourable to industry, which would animate the labours, and cheer the festivals, of the good people who entertained such a notion; nay, would diffuse a new charm over all the scenes of the country, even in the gayest months of the year.

From all of these particular observations, we think ourselves warranted to conclude, that notwithstanding the mixed characters of the deities who were adored by the celebrated nations of antiquity; though they are in many instances represented as conspicuous for vices and frolics; however vain, absurd, and morally criminal, some of the rites by which they were worshipped may have been, and however incorrect the notions of the heathens concerning the moral government of the universe and a future state of retribution; yet still, after making a just allowance for all these imperfections, the general influence of their religious system was rather favourable than unfavourable to virtue and to the order and happiness of society.

It

Religion.

28
The advantage of eſtabliſhing law, &c. on the baſis of religion.

It was not without good reaſon that the earlieſt legiſlators generally endeavoured to eſtabliſh their laws and conſtitutions on the baſis of religion; government needs the ſupport of opinion; the governed muſt be impreſſed with a belief that the particular eſtabliſhment to which they are required to ſubmit, is the beſt calculated for their ſecurity and happineſs, or is ſupported on ſome ſuch ſolid foundation, that it muſt prove impoſſible for them to overturn it, or is connected with ſome awful ſanction, which it would be the moſt heinous impiety to oppoſe. Of theſe ſeveral notions, the laſt will ever operate on moſt men with the moſt ſteady influence. We are frequently blind to our own intereſt; even when eager for the attainment of happineſs, we often refuſe to take the wiſeſt meaſures for that end. The great bulk of the people in every community are ſo little capable of reaſoning and foreſight, that the public miniſter who ſhall moſt ſteadily direct his views to the public good will often be the moſt unpopular. Thoſe laws, and that ſyſtem of government, which are the moſt beneficial, will often excite the ſtrongeſt popular diſcontents. Again, it is not always eaſy to perſuade people that your power is ſuperior to theirs, when it is not really ſo. No one man will ever be able to perſuade a thouſand that he is ſtronger than they all together: and therefore, in order to perſuade one part of his ſubjects or army that it is abſolutely neceſſary for them to ſubmit to him, becauſe any attempts to reſiſt his power would prove ineffectual, a monarch or general muſt take care firſt to perſuade another part that it is for their intereſt to ſubmit to him; or to impreſs the whole with a belief that, weak and pitiful as he himſelf may appear, when viewed ſingly in oppoſition to them all, yet by the aſſiſtance of ſome awful inviſible beings, his friends and protectors, he is ſo powerful, that any attempts to reſiſt his authority muſt prove preſumptuous folly. Here, then, the aid of religion becomes requiſite. Religious ſentiments are the moſt happily calculated to ſerve this purpoſe. Scarce ever was there a ſociety formed, a mode of government eſtabliſhed, or a code of laws framed and enacted, without having the religious ſentiments of mankind, their notions of the exiſtence of ſuperior inviſible beings, and their hopes and fears from thoſe beings, as its fundamental principle. Now, we believe, it is almoſt univerſally agreed, that even the rudeſt form of ſociety is more favourable to the happineſs of mankind, and the dignity of the human character, than a ſolitary and ſavage ſtate. And if this, with what we have aſſerted concerning religion as the baſis of civil government, be both granted, it will follow, that even the moſt imperfect religious notions, the moſt fooliſh and abſurd rites, and the wildeſt ideas that have been entertained concerning the moral government of the univerſe by ſuperior beings, and a future ſtate of retribution, have been more advantageous than atheiſm to the happineſs and virtue of human life. We have already granted, nor can it be denied, indeed, that many of the religious opinions which prevailed among the ancient heathens, did contribute, in ſome degree, to the depravation of their morals: and all that we argue for is, that on a comparative view of the evil and the good which reſulted from them, the latter muſt appear more than adequate to counterbalance the effects of the former.

29
The infinite advantage of a pure, rational, and true religion.

But if ſuch be the natural tendency of thoſe principles by which the human heart is made ſuſceptible of religious ſentiments, that even enthuſiaſm and abſurd ſuperſtition are productive of beneficial effects more than ſufficient to counterbalance whatever is malignant in their influence on ſociety—ſurely a pure rational religion, the doctrines of which are founded in undeniable truth, and all the obſervances which it enjoins calculated to promote by their direct and immediate effects ſome uſeful purpoſes, muſt be in a very high degree conducive to the dignity and the happineſs of human nature. Indeed one collateral proof of the truth of any religion, which muſt have very conſiderable weight with all who are not of opinion that the ſyſtem of the univerſe has been produced and hitherto maintained in order and exiſtence by blind chance, will be its having a ſtronger and more direct tendency than others to promote the intereſts of moral virtue and the happineſs of mankind in the preſent life. Even the teſtimony of thouſands, even miracles, prophecies, and the ſanction of remote antiquity, will ſcarce have ſufficient weight to perſuade us, that a religion is of divine origin, if its general tendency appear to be rather unfavourable than advantageous to moral virtue.

30
Comparative view of the effects of different religious ſyſtems.

III. We ſhall therefore, in the next place, endeavour to determine, from a comparative view of the effects produced on the character and circumſtances of ſociety by the moſt eminent of theſe various ſyſtems of religion which have been in different ages or in different countries eſtabliſhed in the world, how far any one of them has in this reſpect the advantage over the reſt; and, if the utility of a ſyſtem of religion were to be received as a teſt of its truth, what particular ſyſtem might, with the beſt reaſon, be received as true, while the reſt were rejected.

1ſt, The principle upon which we here ſet out is, that all, or almoſt all, ſyſtems of religion with which we are acquainted, whether true or falſe, contribute more or leſs to the welfare of ſociety. But as one field is more fruitful, and one garden leſs overgrown with weeds than another; ſo, in the ſame manner, one ſyſtem of religious opinions and ceremonies may be more happily calculated than others to promote the trueſt intereſts of mankind. In oppoſition to thoſe philoſophers who are ſo vehement in their declamations againſt the inequality of ranks, we have ever been of opinion, that refinement and civilization contribute to the happineſs of human life. The character of the ſolitary ſavage is, we are told, more dignified and reſpectable than that of the philoſopher and the hero, in proportion as he is more independent. He is indeed more independent; but his independence is that of a ſtone, which receives no nouriſhment from the earth or air, and communicates none to animals or vegetables around it. In point of happineſs, and in point of reſpectability, we cannot heſitate a moment, let philoſophers ſay what they will, to prefer a virtuous, enlightened, and poliſhed Briton, to any of the rudeſt ſavages, the leaſt acquainted with the reſtraints and the ſympathies of ſocial life, that wander through the wild foreſts of the weſtern world. But if we prefer civilization to barbariſm, we muſt admit, that in this view Chriſtianity has the advantage over every other religious ſyſtem which has in any age or country prevailed

31
Advantage of civilization;

32
and therefore of Chriſtianity.

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prevailed among men; for nowhere has civilization and useful science been carried to such a height as among Christians.

33
View of the various religious notions of Pagan nations.

It is not, indeed, in any considerable degree that the absurd superstitions of those rude tribes, who can scarce be said to be formed into any regular society, can contribute to their happiness. Among them the faculty of reason is but in a very low state; and the moral principle usually follows the improvement or the depression of the reasoning faculty. Their appetites and merely animal passions are almost their only principles of action: their first religious notions, if we suppose them not to be derived from revelation or tradition, are produced by the operation of gratitude, or grief, or hope, or fear, upon their imaginations. And to these, however wild and fanciful, it is not improbable that they may owe some of their earliest moral notions. The idea of superior powers naturally leads to the thought that those powers have some influence on human life. From this they will most probably proceed to fancy one set of actions agreeable, another offensive, to those beings to whom they believe themselves subject. And this, perhaps, is the first distinction that savages can be supposed to form between actions, as right or wrong, to be performed or to be avoided. But if this be the case, we must acknowledge, that the religious notions of the savage, however absurd, contribute to elevate his character, and to improve his happiness, when they call forth the moral principle implanted in his breast.

But if the social state be preferable to a state of wild and solitary independence, even the rude superstitions of unenlightened tribes of savages are in another respect beneficial to those among whom they prevail. They usually form, as has been already observed under this article, the basis of civil order. Religious opinions may lead the great body of the community to reverence some particular set of institutions, some individual, or some family, which are represented to them as peculiarly connected with the gods whom they adore. Under this sanction some form of government is established; they are taught to perform social duties, and rendered capable of social enjoyments. Not only Numa and Lycurgus, but almost every legislator who has sought to civilize a rude people, and reduce them under the restraints of legal government, have endeavoured to impress their people with an idea that they acted with the approbation, and under the immediate direction of superior powers. We cannot but allow that the rude superstitions of early ages are productive of these advantages to society; but we have already acknowledged, and it cannot be denied, that they are also attended with many unhappy effects. When we view the absurdities intermixed with the systems of religion which prevailed among most of the nations of antiquity, we cannot help lamenting that so noble a principle of human nature as our religious sentiments should be liable to such gross perversion; and when we view the effects which they produce on the morals of mankind, and the forms of society, though we allow them to have been upon the whole rather beneficial than hurtful, yet we cannot but observe, that their unfavourable effects are by far more numerous than if they had been better directed. What unhappy effects, for instance, have been produced by false notions concerning the condition of human souls in a future state. Various nations have imagined that the scenes and objects of the world of spirits are only a shadowy representation of the things of the present world. Not only the souls of men, according to them, inhabit those regions; all the inferior animals and vegetables, and even inanimate bodies that are killed or destroyed here, are supposed to pass into that visionary world; and, existing there in unsubstantial forms, to execute the same functions, or serve the same purposes, as on earth. Such are the ideas of futurity that were entertained by the inhabitants of Guinea. And by these ideas they were induced, when a king or great man died among them, to provide for his comfortable accommodation in the world of spirits, by burying with him meat and drink for his subsistence, slaves to attend and serve him, and wives with whom he might still enjoy the pleasures of love. His faithful subjects vied with each other in offering, one a servant, another a wife, a third a son or daughter, to be sent to the other world in company with the monarch, that they might there be employed in his service. In New Spain, in the island of Java, in the kingdom of Benin, and among the inhabitants of Indostan, similar practices on the same occasion, owing no doubt to similar notions of futurity, have been prevalent. But such practices as these cannot be viewed with greater contempt on account of the opinions which have given rise to them, than horror on account of their unhappy effects on the condition of those among whom they prevail. A lively impression of the enjoyments to be obtained in a future state, together with some very false or incorrect notions concerning the qualities or actions which were to entitle the departing soul to admission into the scene of those enjoyments, is said to have produced equally unhappy effects among the Japanese. They not only bribe their priests to solicit for them; but looking upon the enjoyments of the present life with disgust or contempt, they used to dash themselves from precipices, or cut their throats, in order to get to paradise as soon as possible. Various other superstitions subsisting among rude nations might here be enumerated, as instances of the perversion of the religious principles of the human heart, which render them injurious to virtue and happiness. The austerities which have been practised, chiefly among rude nations, as means of propitiating superior powers, are especially worthy of notice.—When the favourite idol of the Banians is carried in solemn procession, some devotees prostrate themselves on the ground, that the chariot in which the idol is carried may run over them; others, with equal enthusiasm, dash themselves on spikes fastened on purpose to the car. Innumerable are the ways of torture which have been invented and practised on themselves by men ignorantly striving to recommend themselves to the favour of heaven. These we lament as instances in which religious sentiments have been so ill directed by the influence of imagination, and unenlightened erring reason, as to produce unfavourable effects on the human character, and oppose the happiness of social life.—Though we have argued, that even the most absurd systems of religion that have prevailed in the world, have been upon the whole rather beneficial than injurious to the dignity and happiness of human nature; yet if it shall not appear, as we proceed farther in our comparative view of the effects of religion on society, that others have been attended with happier effects than these superstitions which belong to the rude ages of society, we may scarce venture to brand the infidel with the appellation of *fool*, for refusing to give his assent to religious doctrines, or to act under their influence.

2d, The polytheism of the Greeks and Romans, and other heathen nations in a similar state of civilization, we have already considered as being, upon the whole, rather favourable than unfavourable to virtue; but we must not partially conceal its defects. The vicious characters of the deities which they worshipped, the incorrect notions which they entertained concerning the moral government of the universe and a future retribution, the absurdity of their rites and ceremonies, and the criminal practices which were intermixed with them, must have altogether had a tendency to pervert both the reasoning and the moral principles of the human mind. The debaucheries of the monarch of the gods, and the fidelity with which his example in that respect was followed by the whole crowd of the inferior deities, did, we know, dispose the devout heathen, when he felt the same passions which had asserted their power over the gods, to gratify them without scruple. It is a truth, however, and we will not attempt to deny or conceal it, that the genius of the polytheism of the Greeks and Romans was friendly to the arts; to such of them especially as are raised to excellence by the vigorous exertion of a fine imagination; music, poetry, sculpture, architecture, and painting, all of these arts appear to have been considerably indebted for that perfection to which they attained, especially among the Greeks, to the splendid and fanciful system of mythology which was received among that ingenious people.—But we cannot give an equally favourable account of its influence on the sciences. There was little in that system that could contribute to call forth reason. We may grant indeed, that if reason can be so shocked with absurdity as to be roused to a more vigorous exertion of her powers, and a more determined assertion of her rights in consequence of surveying it; in that case, this system of mythology might be favourable to the exercise and improvement of reason; not otherwise.

The connection of paganism with morality was too imperfect for it to produce any very important effects on the morals of its votaries. Sacrifices and prayers, and temples and festivals, not purity of heart and integrity of life, were the means prescribed for propitiating the favour of the deities adored by the Pagans. There were other means, too, besides true heroism and patriotism, of gaining admission into the Elysian fields, or obtaining a seat in the council of the gods. Xenophon, in one of the most beautiful parts of his Memoirs of Socrates, represents Hercules wooed by Virtue and Pleasure in two fair female forms, and deliberating with much anxiety which of the two he should prefer. But this is the fiction of a philosopher desirous to improve the fables of antiquity in such a way as to render them truly useful. Hercules does not appear, from the tales which are told us of his adventures, to have been at any such pains in choosing his way of life. He was received into the palace of Jove, without having occasion to plead that he had through life been the faithful follower of that goddess to whom the philosopher makes him give the preference; his being the son of Jove, and his wild adventures, were sufficient without any other merits to gain him that honour. The same may be said concerning many of the other demi-gods and heroes who were advanced to heaven, or conveyed to the blissful fields of Elysium. And whatever might be the good effects of the religion of Greece and Rome in general upon the civil and political establishments, and in some few instances on the manners of the people, yet still it must be acknowledged to have been but ill calculated to impress the heart with such principles as might in all circumstances direct to a firm, uniform tenor of virtuous conduct.

But after what has been said on the character of this religion elsewhere (see POLYTHEISM), and in the second part of this article, we cannot without repetition enlarge farther on it here. Of the Jewish religion, however, we have as yet said little, having on purpose reserved to this place whatever we mean to introduce under the article, concerning its influence on society.

34 View of Judaism.

3d, When we take a general view of the circumstances in which the Jewish religion was established, the effects which it produced on the character and fortune of the nation, the rites and ceremonies which it enjoined, and the singular political institutions to which it gave a sanction, it may perhaps appear hard to determine, whether it were upon the whole more or less beneficial to society than the polytheism of the Egyptians, Greeks, and Romans. But if such be the judgement which preconceived prejudices, or a hasty and careless view, have induced some to form of this celebrated system; there are others who, with equal keenness, and sounder reasoning, maintain, that it was happily calculated, not only to accomplish the great design of preparing the way for the promulgation of the Gospel, but likewise to render the Jews a more refined and virtuous people, and a better regulated community, than any neighbouring nation. In the first place, the attributes of the Deity were very clearly exhibited to the Jews in the establishment of their religion. The miracles by which he delivered them from servitude, and conducted them out of Egypt, were striking demonstrations of his power; that condescension with which he forgave their repeated acts of perverseness and rebellion, was a most convincing proof of his benevolence; and the impartiality with which the observance and the violation of his laws were rewarded and punished, even in the present life, might well convince them of his justice. A part of the laws which he dictated to Moses are of eternal and universal obligation; others of them were local and particular, suited to the character of the Jews, and their circumstances in the land of Canaan. The Jewish code, taken altogether, is not to be considered as a complete system of religion, or laws calculated for all countries and all ages of society. When we consider the expediency of this system, we must take care not to overlook the design for which the Jews are said to have been separated from other nations, the circumstances in which they had lived in Egypt, the customs and manners which they had contracted by their intercourse with the natives of that country, the manner in which they were to acquire to themselves settlements by extirpating the nations of Canaan, the rank which they were to hold among the nations of Syria and the adjacent countries, together with the difficulty of

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35 The ſabbath, Although in every religion or ſuperſtition that has prevailed through the world, we find one part of its inſtitutions to conſiſt in the enjoining of certain feſtivals to be celebrated by relaxation from labour, and the performance of certain ceremonies in honour of the gods; yet in none, or almoſt none beſides the Jewiſh, do we find every ſeventh day ordained to be regularly kept holy. One great end which the legiſlator of the Jews had in view in the inſtitution of the Sabbath was, to impreſs them with a belief that God was the maker of the univerſe. In the early ages of the world a great part of mankind imagined the ſtars, the ſun, the moon, and the other planets, to be eternal, and conſequently objects highly worthy of adoration. To convince the Iſraelites of the abſurdity of this belief, and prevent them from adopting that idolatry, Moſes taught them, that thoſe conſpicuous objects which the Gentile nations regarded as eternal, and endowed with divine power and intelligence, were created by the hand of God; who, after bringing all things out of nothing, and giving them form, order, and harmony, in the ſpace of ſix days, reſted on the ſeventh from all his works. Various paſſages in the Old Teſtament concur to ſhow, that this was one great end of the inſtitution of the Sabbath. The obſervance of the Sabbath, and deteſtation of idolatrous worſhip, are frequently inculcated together; and again, the breach of the Sabbath, and the worſhip of idols, are uſually reprobated at the ſame time. Another good reaſon for the inſtitution of a Sabbath might be, to remind the Jews of their deliverance from bondage, to inſpire them with humanity to ſtrangers and domeſtics, and to mitigate the rigours of ſervitude.

36 and other feſtivals. The purpoſes for which the other feſtivals of the Jewiſh religion were inſtituted appear alſo of ſufficient importance. The great miracle, which, after a ſeries of other miracles, all directed to the ſame end, finally effected the deliverance of the Jews out of Egypt, and their actual departure from that land of ſervitude, might well be commemorated in the feaſt of the paſſover. To recal to the minds of poſterity the hiſtory of their anceſtors, to impreſs them with an awful and grateful ſenſe of the goodneſs and greatneſs of God, and to make them think of the purpoſes for which his almighty power had been ſo ſignally exerted, were ſurely good reaſons for the inſtitution of ſuch a feſtival. The feaſt of Pentecoſt celebrated the firſt declaration of the law by Moſes, in the ſpace of fifty days after the feaſt of the paſſover. It ſerved alſo as a day of ſolemn thankſgiving for the bleſſings of a plenteous harveſt. On the feaſt of tabernacles, they remembered the wanderings of their anceſtors through the wilderneſs, and expreſſed their gratitude to heaven for the more comfortable circumſtances in which they found themſelves placed. The feaſt of new moons ſerved to fix their kalendar, and determine the times at which the other feſtivals were to be celebrated; on it trumpets were ſounded, to give public notice of the event which was the cauſe of the feſtival; no ſervile works were performed, divine ſervice was carefully attended, and the firſt fruits of the month were offered to the Lord. The Jewiſh legiſlator limited his feſtivals to a very ſmall number, while the heathens devoted a conſiderable part of the year to the celebration of theirs. But we perceive the occaſions upon which the Jewiſh feſtivals were celebrated to have been of ſuitable importance; whereas thoſe of the heathens were often celebrated on trifling or ridiculous occaſions. Piety and innocent recreation ſhared the Jewiſh feſtival; the feſtivals of the heathens were chiefly devoted to debauchery and idleneſs.

37 The ſabbatical year, jubilee, and laws of uſury. The Hebrews had other ſolemn ſeaſons of devotion beſides the weekly Sabbath and theſe annual feſtivals. Every ſeventh year they reſted from labour: they were then neither to plough, to ſow, nor to prune; and whatever the earth produced ſpontaneouſly that year belonged rather to ſtrangers, orphans, and the poor, than to the proprietors of the ground. On this year inſolvent debtors were diſcharged from all debts contracted by purchaſing the neceſſaries of life: and the great end of this releaſe from debts contracted during the preceding ſix years, appears to have been to prevent the Hebrew from flying to the Gentiles and forſaking his religion when embarraſſed in his circumſtances. None but native Iſraelites and proſelytes of righteouſneſs were admitted to this privilege; it was refuſed to ſtrangers, and even to proſelytes of the gate. The jubilee was a feſtival to be celebrated every fiftieth year. It produced the ſame effect with the ſabbatical year as to reſt from labour and the diſcharge of debts; with this addition, that on the year of the jubilee ſlaves obtained their freedom, and the lands reverted to the old proprietors. On the year of the jubilee, as on the ſabbatical year, the lands were to reſt uncultivated, and lawſuits were now to terminate. The chief deſign of this inſtitution appears to have been, to preſerve the order of ranks and property originally eſtabliſhed in the Hebrew ſtate. None but Iſraelites or circumciſed converts could enjoy the benefit of this inſtitution; nor could even theſe hope to regain their eſtates on the year of the jubilee, if they ſold them for any other purpoſe but to ſupply their neceſſities. The law relative to uſury was evidently founded on the ſame plan of polity with reſpect to property. To almoſt any other nation ſuch a law, it muſt be confeſſed, would have been unſuitable and unjuſt: but as the Jews were not deſigned for a trading nation, they could have little occaſion to borrow, unleſs to relieve diſtreſs; and as an indulgence to people in ſuch circumſtances, the Jew was forbidden to exact uſury from his brother to whom he had lent money.

38 Of clean and unclean beaſts, and the place of worſhip. The Jewiſh legiſlator, we may well think, would be diſpoſed to adopt every proper method to prevent his nation from falling away into the idolatry of heathen nations. Probably one reaſon of the diſtinctions between *clean* beaſts which they were permitted to eat, and *unclean* beaſts, the eating of which they were taught to conſider as pollution, was to prevent them from convivial intercourſe with profane nations, by which they might be ſeduced to idolatry. We do not readily ſit down at table with people who are fond of diſhes which

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we regard with abhorence. And if the Jews were taught to loathe the flesh of some of those animals which were among the greatest delicacies of the Gentiles, they would naturally of consequence avoid sitting down at meat with them, either at their ordinary meals or at those entertainments which they prepared in honour of their deities; and this we may with good reason consider as one happy mean to preserve them from idolatry. Besides, the Jews were permitted, or rather enjoined, to eat animals which the Gentiles reverenced as sacred, and from which they religiously withheld all violence. Goats, sheep, and oxen, were worshipped in Egypt (see POLYTHEISM and PAN); and several learned writers are of opinion, that Moses directed his people to sacrifice and eat certain of the favourite animals of the Egyptians, in order to remove from their minds any opinions which they might have otherwise entertained of the sanctity of those pretended deities. Many of the observances which Moses enjoined with regard to food, appear to have been intended to inspire the Israelites with contempt for the superstitions of the people among whom they had so long sojourned. They were to kill the animal which the Egyptians worshipped; to roast the flesh which that people ate raw; to eat the head, which they never ate; and to dress the entrails, which they set apart for divination. These distinctions concurred with the peculiarities of their dress, language, government, customs, places and times of worship, and even the natural situation of their country, by which they were in a manner confined and fortified on all sides, to separate them in such a manner from neighbouring nations, that they might escape the infection of their idolatry. And if we reflect both on the design for which Providence separated the Israelites from other nations, and on the probability that, in the state of society in which mankind were during the earlier period of the Jewish history, the Jews, by mixing with other nations, would rather have been themselves converted to idolatry than have converted idolatrous nations to the worship of the true God; we cannot but be satisfied, that even this, however it may at first appear, was a benefit, not a disadvantage; and in the author of their legislation wisdom, not caprice.

39 Other distinguishing particulars in the Jewish ritual.

But not only in the distinctions of meats, and between clean and unclean animals, does the legislator of the Jews appear to have laboured to fix a barrier between them and other nations which might preserve them from the contagion of idolatry—we shall not err, perhaps, if we ascribe many particulars of their worship to this design in the institutor. The heathens had gods who presided over woods, rivers, mountains, and valleys, and to each of these they offered sacrifices, and performed other rites of worship in a suitable place. Sometimes the grove, sometimes the mountain top, at other times the bank of the river or the brink of the spring, was the scene of their devotions. But as the unity of the divine nature was the truth the most earnestly inculcated on the children of Israel; so in order to impress that truth on their minds with the more powerful efficacy, they were taught to offer their sacrifices and other offerings only in one place, the place chosen by the Lord; and death was threatened to those who dared to disobey the command. To confirm this idea, one of the prophets intimates, that when idolatry should be abolished, the worship of God should not be confined to Jerusalem, but it would then be lawful to worship him anywhere.

40 Effects of these institutions, &c. in impressing a respect for the Deity.

The whole institutions and observances of the Jewish religion appear to have been designed and happily calculated to impress the minds of the people with veneration and respect for the Deity. All the festivals which either commemorated some gracious dispensation of his providence towards their ancestors, or served as days of thanksgiving for the constant returns of his goodness to those who celebrated them, and all the other rites designed to fortify them against idolatry, served at the same time to impress their hearts with awful reverence for the God of Jacob. Various other particulars in the institutions of the Jewish economy appear to have been directed solely to that end. Into the most sacred place, the Holy of Holies, none but the high priest was admitted, and he only once a-year. No fire was used in sacrifice but what was taken from the altar. Severe punishments were on various occasions inflicted on such as presumed to intermeddle in the service of the sanctuary in a manner contrary to what the law had directed. All the laws respecting the character, the circumstances, and the services, of the priests and the Levites, appear plainly to have a similar tendency.

In compliance with the notions of Deity which naturally prevailed among a gross and rude people, though no visible object of worship was granted to the Jews, yet they were allowed in their wanderings through the wilderness to have a tabernacle or portable temple, in which the sovereign of the universe sometimes deigned to display some rays of his glory. Incapable as they were of conceiving aright concerning the spiritual nature and the omnipresence of the Deity, they might possibly have thought Jehovah careless and indifferent about them, had they been at no time favoured with a visible demonstration of his presence.

41 Sacrifices and lustrations.

The sacrifices in use among the Gentiles in their worship of idols were permitted by the Jewish legislator; but he directed them to be offered with views very different from those with which the Gentiles sacrificed to their idols. Some of the sacrifices of the Jewish ritual were designed to avert the indignation of the Deity; some to expiate offences and purify the heart; and all of them to abolish or remove idolatry. Lustrations or ablutions entered likewise into the Jewish ritual; but these were recommended and enjoined by Moses for purposes widely different from those which induced the heathens to place so high a value upon them. The heathens practised them with magical and superstitious ceremonies; but in the Jewish ritual they were intended simply for the cleansing away of impurities and pollutions.

42 Tendency of the theocracy and temporal sanctions.

The theocratical form of government to which the Jews were subject, the rewards which they were sure of receiving, and the punishments which they were equally liable to suffer in the present life, had a powerful effect to remove superstition and preserve them from idolatry, as well as to support all the social virtues among them. They were promised a numerous offspring, a land flowing with milk and honey, long life, and victory over their enemies, on the condition of their paying a faithful obedience to the will of their heavenly Sovereign; plague, famine, disease, defeats, and death, were threatened as the punishments to be inflicted on those who violated

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violated his laws; and these sanctions, it must be allowed, were happily accommodated to the genius of a rude and carnal-minded people, attentive only to present objects, and not likely to be influenced by remote and spiritual considerations.

43
Rites and prohibitions of less apparent utility.

There were other rites and prohibitions in the Mosaic law, which appear to have had but little connection with religion, morals, or policy. These may be more liable to be objected against, as adding an unnecessary weight to a burden which, though heavy, might yet have been otherwise borne in consideration of the advantages connected with it. Even these, however, may perhaps admit of being viewed in a light in which they shall appear to have been in no way unfavourable to the happiness of those to whom they were enjoined. They appear to have had none of them an immoral tendency: all of them had, in all probability, a tendency to remove or prevent idolatry, or to support, in some way or other, the religious and the civil establishment to which they belonged.

44
The whole admirably calculated for the purposes intended.

From these views of the spirit and tendency of the Jewish religion, we may fairly conclude it to have been happily calculated to promote the welfare of society. In comparing it with other religions, it is necessary to reflect on the peculiar purposes for which it was given; that its two principal objects were to preserve the Jews a separate people, and to guard them against the contagion of the surrounding idolatry. When these things are taken into consideration, every candid mind acquainted with the history of ancient nations will readily acknowledge that the whole system, though calculated indeed in a peculiar manner for them, was as happily adapted for the purposes for which it had been wisely and graciously intended, as it is possible to imagine any such system to be. It would be unhappy, indeed, if, on a comparison of pure theism with polytheism, the latter, with all its absurdities, should be found more beneficial to mankind than the former. The theism of the Jews was not formed to be disseminated through the earth; that would have been inconsistent with the purposes for which it is said to have been designed. But while the Jews were separated by their religion from all other nations, and perhaps, in some degree, fixed and rendered stationary in their progress towards refinement, they were placed in circumstances, in respect to laws, and government, and religion, and moral light, which might with good reason render them the envy of every other nation in the ancient world.

45
View of Christianity.

IV. The Christian religion next demands our attention. It is to be considered as an improvement of the Jewish, or a new superstructure raised on the same basis. If the effects of the Jewish religion were beneficial to those among whom it was established, they were confined almost to them alone. But is the spirit of Christianity equally pure and benignant? Is its influence equally beneficial and more diffusive than that of Judaism? Does it really merit to have triumphed over both the theism of the Jews and the polytheism of the heathens?

46
The doctrines pure and rites simple.

If we consider the doctrines and precepts of the Christian religion, nothing can be more happily calculated to raise the dignity of human nature, and promote the happiness of mankind. The happiness of the individual is best promoted by the exercise of love and gratitude towards God, and resignation to his providence; of humanity, integrity, and good will towards men; and by the due government of our appetites and passions. Social happiness again proceeds from the members of society entertaining a disinterested regard for the public welfare; being actively industrious each in his proper sphere of exertion; and being strictly just and faithful, and generously benevolent in their mutual intercourse. The tenor of the gospel inculcates these virtues; it seems everywhere through the whole of the Christian code to have been the great design of its Author to inspire mankind with mild, benevolent, and peaceable dispositions, and to form them to courteous manners. Christianity again represents the Deity and his attributes in the fairest light; even so as to render our ideas of his nature, and the manner in which he exerts his power, consistent with the most correct principles of morality that can be collected from all the other religions that have prevailed in the earth, and from the writings of the most admired philosophers. The ritual observances which Christianity enjoins are few in number, easy to perform, decent, expressive, and edifying. It inculcates no duties but what are founded on the principles of human nature, and on the relation in which men stand to God, their Creator, Redeemer, and Sanctifier; and it prescribes accurate rules for the regulation of the conduct. The assistance of the spirit of God is promised in this sacred volume to those who assiduously labour to discharge the duties which it enjoins; and it exhibits a striking example of spotless purity, which we may safely venture to imitate. The gospel teaches that worldly afflictions are incident to both good and bad men; a doctrine highly conducive to virtue, which consoles us in distress, prevents despair, and encourages us to persist firmly in our integrity under every difficulty and trial. Christianity represents all men as children of the same God, and heirs of the same salvation, and levels all distinctions of rich and poor, as accidental and insignificant in the sight of him who rewards or punishes with impartiality according to the merits or demerits of his creatures. This doctrine is highly favourable to virtue, as it tends to humble the proud, and to communicate dignity of sentiment to the lowly; to render princes and inferior magistrates moderate and just, gentle and condescending, to their inferiors. It farther requires husbands to be affectionate and indulgent to their wives, wives to be faithful and respectful to their husbands, and both to be true and constant to each other. Such is the purity of the gospel, that it forbids us even to harbour impure thoughts; it requires us to abandon our vices, however dear to us; and to the cautious wisdom of the serpent it directs us to join the innocent simplicity of the dove. The Christian dispensation, to prevent a perseverance in immorality, offers pardon for the past, provided the offender forsake his vicious practices, with a firm resolution to act differently in future. The sanctions of the gospel have a natural tendency to exalt the mind above the paltry pursuits of this world, and to render the Christian incorruptible by wealth, honours, or pleasures. The true Christian not only abstains from injustice towards others, but even forgives those injuries which he himself suffers, knowing that he cannot otherwise hope for forgiveness from God. Such are the precepts, such the spirit, and such the general tendency of the gospel. Even those who refused to give credit to its doctrines and history have yet acknowledged the excellence

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cellence of its precepts. They have acknowledged, that "no religion ever yet appeared in the world of which the natural tendency was ſo much directed to promote the peace and happineſs of mankind as the Chriſtian; and that the goſpel of Chriſt is one continued leſſon of the ſtricteſt morality, of juſtice, benevolence, and univerſal charity." Theſe are the words of Bolingbroke, one of its keeneſt and moſt inſidious opponents. Without examining the effects of this religion on ſociety, we might almoſt venture to pronounce with confidence, that a religion, the precepts of which are ſo happily formed to promote all that is juſt and excellent, cannot but be in the higheſt degree beneficial to mankind. By reviewing the effects which it has actually produced, the favourable opinion which we naturally conceive of it, after conſidering its precepts, cannot but be confirmed.

47
The virtues it recommends unoſtentatious.

One circumſtance we muſt take notice of as rather unfavourable to this review. It is really impoſſible to do juſtice to Chriſtianity by ſuch a diſcuſſion of its merits. The virtues which it has a natural tendency to produce and cheriſh in the human heart, are not of a noiſy oſtentatious kind; they often eſcape the obſervation of the world. Temperance, gentleneſs, patience, benevolence, juſtice, and general purity of manners, are not the qualities which moſt readily attract the admiration and obtain the applauſe of men. The man of Roſs, whom Mr Pope has ſo juſtly celebrated, was a private character; his name is now likely to live, and his virtues to be known to the lateſt poſterity: and yet, however diſintereſted his virtues, however beneficial his influence to all around him, had his character not attracted the notice of that eminent poet, his name would perhaps ere this time have been loſt in oblivion. Individuals in private life ſeldom engage the attention of the hiſtorian; his object is to record the actions of princes, warriors, and ſtateſmen. Had not the profeſſors of Chriſtianity in the earlier ages of its exiſtence been expoſed to perſecutions, and unjuſt accuſations from which they were called on to vindicate themſelves, we ſhould be ſtrangers to the names and virtues of ſaints and martyrs, and to the learning and endowments of the firſt apologiſts for Chriſtianity. We can therefore only trace the general influence of the inſtitutions of Chriſtianity on ſociety. We cannot hope to make an accurate enumeration of particulars. In many of the countries in which it has been eſtabliſhed, it has produced a very favourable change on the circumſtances of domeſtic life. Polygamy, a practice repugnant to the will of our Creator (ſee POLYGAMY), who has declared his intentions in this inſtance in the plaineſt manner, by cauſing nearly equal numbers of males and females to be brought into the world, was never completely aboliſhed but by Chriſtianity.

48
Its effects on the manners of nations.

The practice of divorce, too, though in ſome caſes proper and even neceſſary, had been ſo much abuſed at the time of our Saviour's appearance in the world, that he found reaſon to declare it unlawful, unleſs in the caſe of adultery. The propriety and reaſonableneſs of this prohibition will ſufficiently appear, if we conſider, that when divorces are eaſily obtained, both parties will often have nothing elſe in view at the period of marriage than the diſſolution of their nuptial engagements after a ſhort cohabitation; the intereſts of the huſband and the wife will almoſt always be ſeparate; and the children of ſuch a marriage are ſcarce likely to enjoy the cordial affection and tender watchful care of either parent. The huſband in ſuch a caſe will naturally be to his wife, not a friend and protector, but a tyrant; fear and deceit, not love, gratitude, or a ſenſe of duty, will be the principles of the wife's obedience.

In another inſtance, likewiſe, Chriſtianity has produced an happy change on the circumſtances of domeſtic life; it muſt be acknowledged to have contributed greatly to the abolition of ſlavery, or at leaſt to the mitigation of the rigour of ſervitude. The cuſtoms and laws of the Romans in relation to ſlaves were cruel and ſevere. Maſters were often ſo inhuman as to remove aged, ſick, or infirm ſlaves, into an iſland in the Tiber, where they ſuffered them to periſh without pity or aſſiſtance. The greater part of the ſubjects of many of thoſe republics which enjoyed the moſt liberty, groaned under tyrannical oppreſſion; they were condemned to drag out a miſerable exiſtence in hard labour, under inhuman uſage, and to be transferred like beaſts from one maſter to another. The hardſhips of ſlavery were eaſed, not by any particular precept of the Goſpel, but by the gentle and humane ſpirit which breathed through the general tenor of the whole ſyſtem of doctrines and precepts of which the Goſpel conſiſts. It muſt indeed be allowed, that a trade in ſlaves is at preſent carried on by people who preſume to call themſelves Chriſtians, and protected by the legiſlature of Chriſtian ſtates: but the ſpirit of the Chriſtian code condemns the practice, and the true Chriſtian will not engage in it.

Partly by the direct and conſpicuous, partly by the ſecret and unſeen, influence of Chriſtianity ſince its promulgation in the world, the hearts of men have been gradually ſoftened; even barbarians have been formed to mildneſs and humanity; the influence of ſelfiſhneſs has been checked and reſtrained; and even war, amid all the pernicious improvements by which men have ſought to render it more terrible, has aſſumed much more of the ſpirit of mildneſs and peace than ever entered into it during the reign of heatheniſm.

If we review the hiſtory of mankind with a view to their political circumſtances, we ſhall find, that by ſome means or other, it has happened, ſince the time when the Goſpel was firſt preached, that both ſyſtems of legiſlature and forms of government have been raiſed to much greater perfection, at leaſt in thoſe parts of the world into which the religion of Jeſus has made its way, and obtained an eſtabliſhment.

The popular government of the Romans, notwithſtanding the multiplicity of their laws, and the imperfections of their political conſtitution, was, no doubt, happily enough adapted to promote the increaſe of the power and the extenſion of the empire of Rome. In Greece there were various republics, the wiſdom and impartiality of whoſe laws have been highly celebrated. But we apprehend that there is a ſufficient number of well authenticated facts to warrant us to affirm, that ſince Chriſtianity has been propagated, and has had ſufficient time to produce its full effect on arts, manners, and literature, even under governments the form of which might appear leſs favourable than the celebrated models of antiquity to the liberty and happineſs of the people in general, theſe actually have been much better provided for than under the laws of Athens or Sparta, or even of Rome in the days of the conſuls. It is a

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Religion. just and happy observation of Montesquieu, who has attributed so much to the influence of climate and local circumstances, that "the mildness so frequently recommended in the Gospel is incompatible with the despotic rage with which an arbitrary tyrant punishes his subjects, and exercises himself in cruelty. It is the Christian religion (says he) which, in spite of the extent of empire, and the influence of climate, has hindered despotism from being established in Ethiopia, and has carried into Africa the manners of Europe. The heir to the empire of Ethiopia enjoys a principality, and gives to other subjects an example of love and obedience.—Not far from hence may be seen the Mahometan shutting up the children of the king of Sennaar, at whose death the council sends to murder them in favour of the prince who ascends the throne. Let us set before our eyes (continues that eloquent writer), in the third chapter of the 24th book of his spirit of Laws, on one hand the continual massacres of the kings and generals of the Greeks and Romans, and on the other the destruction of people and cities by the famous conquerors Timur Beg and Jenghiz Khan, who ravaged Asia; and we shall perceive, that we owe to Christianity in government a certain political law, and in war a certain law of nations, which allows to the conquered the great advantages of liberty, laws, wealth, and always religion, when the conqueror is not blind to his own interest."

These are the reflections of no common judge in this matter, but one who had long studied the history of nations, and observed the phenomena of the various forms of society, with such success as few others have attained.

49
Its effects in softening and humanizing barbarians.

But on no occasion has the mild influence of Christianity been more eminently displayed, or more happily exerted, than in softening and humanizing the barbarians who overturned the Roman empire. The idolatrous religion which prevailed among those tribes before their conversion to Christianity, instead of disposing them to cultivate humanity and mildness of manners, contributed strongly to render them fierce and bloodthirsty, and eager to distinguish themselves by deeds of savage valour. But no sooner had they settled in the dominions of Rome, and embraced the principles of Christianity, than they became a mild and generous people.

We are informed by Mosheim, who was at pains to collect his materials from the most authentic sources, that in the 10th century Christian princes exerted themselves in the conversion of nations whose fierceness they had experienced, in order to soften and render them more gentle. The mutual humanity with which nations at war treat each other in modern times, is certainly owing, in a great measure, to the influence of the mild precepts of the Gospel. It is a fact worthy of notice, too, that during the barbarous ages, the spiritual courts of justice were more rational and impartial in their decisions than civil tribunals.

How many criminal practices which prevailed among heathen nations have been abolished by their conversion to Christianity! Christians of all nations have been observed to retain the virtues and reject the vicious practices of their respective countries. In Parthia, where polygamy prevailed, they are not polygamists; in Persia, the Christian father does not marry his own daughter. By the laws of Zoroaster the Persians committed incest until they embraced the Gospel; after which period they abstained from that crime, and observed the duties of chastity and temperance, as enjoined by its precepts. Even the polished and enlightened Romans were cruel and blood-thirsty before the propagation of the Gospel. The breaking of a glass, or some such trifling offence, was sufficient to provoke Vidius Pollio to cast his slaves into fish-ponds to be devoured by lampreys. The effusion of human blood was their favourite entertainment; they delighted to see men combating with beasts, or with one another; and we are informed on respectable authority, that no wars ever made such havock on mankind as the fights of gladiators, which sometimes deprived Europe of 20,000 lives in one month. Not the humanity of Titus, nor the wisdom and virtue of Trajan, could abolish the barbarous spectacle. However humane and wise in other instances, in this practice those princes complied with the custom of their country, and exhibited splendid shows of gladiators, in which the combatants were matched by pairs; who, though they had never injured nor offended each other, yet were obliged to maim and murder one another in cold blood. Christian divines soon exercised their pens against these horrid practices; the Christian emperor Constantine restrained them by edicts, and Honorius finally abolished them. It would be tedious to proceed through an enumeration of particulars; but wherever Christianity has been propagated, it has constantly operated to the civilization of the manners of mankind, and to the abolition of absurd and criminal practices. The Irish, the Scotch, and all the ancient inhabitants of the British isles, were, notwithstanding their intercourse with the Romans, rude barbarians, till such time as they were converted to Christianity. The inhuman practice of exposing infants, which once prevailed so generally over the world, and still prevails among some Pagan nations, even under very humane and enlightened legislatures, yielded to the influence of Christianty.

50
Learning is much indebted to Christianity.

Let us likewise remember, in honour of Christianity, that it has contributed eminently to the diffusion of knowledge, the preservation and the advancement of learning. When the barbarians overspread Europe, what must have become of the precious remains of polished, enlightened antiquity, had there been no other depositaries to preserve them but the heathen priests? We allow that even the Romish clergy during the dark ages did not study the celebrated models of ancient times with much advantage themselves, and did not labour with much assiduity to make the laity acquainted with them. It must even be acknowledged, that they did not always preserve those monuments of genius with sufficient care, as they were often ignorant of their real value. Yet, after all, it will be granted, it cannot be denied, that had it not been for the clergy of the Christian church, the lamp of learning would, in all probability, have been entirely extinguished, during that night of ignorance and barbarity in which all Europe was buried for a long series of centuries, after the irruption of the barbarians into the Roman empire.

51
The beneficial influence of Christianity has extended even to those who have not embraced it.

Such is the excellence of the Christian system, and such its tendency to meliorate the human character, that its beneficial influence has not been confined to those who have received its doctrines and precepts, and have professed themselves Christians; it has even produced many

Religion. many happy effects on the circumſtances and the characters of Pagans and infidels, who have had opportunities of beholding the virtues of Chriſtians, and learning the excellence of the morality of the goſpel. Thoſe virtues which diſtinguiſhed the character of the apoſtate Julian were ſurely owing in no inconſiderable degree to his acquaintance with Chriſtianity; and it is an undeniable fact, that after the propagation of Chriſtianity through the Roman empire, even while the purity of that holy religion was gradually debaſed, the manners of thoſe Pagans who remained unconverted became more pure, and their religious doctrines and worſhip leſs immoral and abſurd.—We might here adduce a tedious ſeries of facts to the ſame purpoſe. Whenever Chriſtians have had any intercourſe with Pagan idolaters, and have not concealed the laws of the goſpel, nor ſhewn by their conduct that they diſregarded them, even thoſe who have not been converted to Chriſtianity have, however, been improved in their diſpoſitions and manners by its influence. The emperor, whoſe virtues we have mentioned as ariſing, in a certain degree, from his acquaintance with Chriſtianity, in a letter to an Heathen pontiff, deſires him to turn his eyes to the means by which the ſuperſtition of Chriſtians was propagated; by kindneſs to ſtrangers, by ſanctity of life, and by the attention which they paid to the burial of the dead. He recommends an imitation of their virtues, exhorts him to cauſe the prieſts of Galatia to be attentive to the worſhip of their gods, and authoriſes him to ſtrip them of the ſacerdotal function, unleſs they obliged their wives, children, and ſervants, to pay attention to the ſame duties. He likewiſe enjoins works of beneficence, deſires the prieſt to relieve the diſtreſſed, and to build houſes for the accommodation of ſtrangers of whatever religion; and ſays it is a diſgrace for Pagans to diſregard thoſe of their own religion, while Chriſtians do kind offices to ſtrangers and enemies. This is indeed an eminent inſtance of the happy influence of Chriſtianity even on the ſentiments and manners of thoſe who regarded the Chriſtian name with abhorrence.

52 Chriſtianity to be preferred to all other religions.

Upon the whole, then, may we not, from the particulars here exhibited concerning the influence of this religion on the manners and happineſs of men in ſociety, conclude that Chriſtianity is infinitely ſuperior to the ſuperſtitions of Paganiſm? as being in its tendency uniformly favourable to the virtue and the happineſs of mankind, and even to the ſyſtem of religion and laws delivered by Moſes to the children of Iſrael: becauſe, while the religion of the Jews was calculated only for one particular nation, and it may almoſt be ſaid for one particular ſtage in the progreſs of ſociety, Chriſtianity is an univerſal religion, formed to exert its happy influence in all ages and among all nations; and has a tendency to diſpel the ſhades of barbariſm and ignorance, to promote the cultivation of the powers of the human underſtanding, and to encourage every virtuous refinement of manners.

53 View of Mahometaniſm.

V. Another religion, which has made and ſtill makes a conſpicuous figure in the world, remains yet to be examined. The religion of Mahomet is that which we here alluded to. Whether we conſider through what an extenſive part of the globe that religion prevails, the political importance of the nations among whom it is profeſſed, or the ſtriking peculiarity of character by which it is diſtinguiſhed from all other religious ſyſtems—it is for all theſe reaſons well worthy of particular notice. Like the Jewiſh religion, it is not barely a ſyſtem of religious doctrines and general moral precepts; it forms both the civil legiſlature and the religious ſyſtem of thoſe nations among whom it is profeſſed; and, like it too, it would appear to be calculated rather for one particular period in the progreſs of mankind from rudeneſs to refinement, than for all ages and all ſtates of ſociety.

The hiſtory of its origin is pretty well known, and we have had occaſion to enlarge upon it under a former article (ſee Mahomet and Mahometanism). We are not here to trace the impoſtures of the prophet, or to conſider the arts by which he ſo ſucceſsfully accompliſhed his deſigns; but merely to conſider the morality of his religion, and its influence on civil order and the happineſs of ſociety.

54 It is friendly to ignorance, deſpotiſm, and impurity.

If we view the ſtate of the nations among whom it is eſtabliſhed, we cannot heſitate a moment to declare it friendly to ignorance, to deſpotiſm, and to impurity of manners. The Turks, the Perſians, and the Malays, are all Mahometans; and in reviewing their hiſtory and conſidering their preſent ſtate, we might find a ſufficient number of facts to juſtify the above aſſertion: and we muſt not neglect to obſerve, that, as thoſe nations are not known to have ever been ſince their converſion to Mahometaniſm under a much happier government, or in a much more civilized ſtate than at preſent, it cannot be, with any degree of fairneſs, argued, with reſpect to Mahometaniſm as with reſpect to Chriſtianity, that it is only when its influence is ſo oppoſed by other cauſes as to prevent it from producing its full effects, that it does not conduct thoſe ſocieties among which it is eſtabliſhed to a high ſtate of civilization and refinement.

55 Remarks on the Koran, &c.

One, and that by no means an inconſiderable, part of the Koran, was occaſionally invented to ſolve ſome difficulty with which the prophet found himſelf at the time perplexed, or to help him to the gratification of his ruling paſſions, luſt and ambition. When he and his followers were, at any time, unſucceſsful in thoſe wars by which he ſought to propagate his religion, to prevent them from falling away into unbelief, or ſinking into deſpondency, he took care to inform them that God ſuffered ſuch misfortunes to befal believers, as a puniſhment for their ſins, and to try their faith. The doctrine of predeſtination, which he aſſiduouſly inculcated, had a happy effect to perſuade his followers to ruſh boldly into the midſt of death and danger at his command. He prevailed with Zeyd to put away his wife, married her himſelf, and pretended that his crime had the approbation of heaven; and, in the Koran, he introduces the Deity approving of this marriage. Being repulſed from the ſiege of Mecca, he made a league with the inhabitants; but on the very next year, finding it convenient to ſurpriſe the city, by violating this treaty, he juſtified his perfidy by teaching his followers to diſregard promiſes or leagues made with infidels. In ſome inſtances again, we find abſurd prohibitions enjoined for ſimilar reaſons: his officers, having on ſome occaſion drunk to exceſs, excited much riot and confuſion in the camp, he prohibited the uſe of wine and other inebriating liquors among his followers in future. Now, though it muſt be acknowledged that many evils ariſe from the uſe of theſe liquors, yet we cannot but think that,

that, when used in moderation, they are in many cases beneficial to men; and certainly as much allowed by God as opium, which the Mahometans have substituted in their place.

56 Mahometanism a mixture of Christianity, Judaism, and the superstitions of Arabia.

Mahomet is allowed to have copied from the Christian and the Jewish religions, as well as from the idolatrous superstitions which prevailed through Arabia, and thus to have formed a motley mixture of reason and absurdity, of pure theism and wild superstition. He considered also the circumstances of his country, and the prejudices of his countrymen. When he attended to the former, he was generally judicious enough to suit his doctrines and decisions to them with sufficient skill; the latter he also managed with the greatest art: but he entered into accommodation with them in instances when a true prophet or a wise and upright legislator would surely have opposed them with decisive vigour. Where the prophet indulges his own fancy, or borrows from the superstitions of his countrymen, nothing can be more ridiculous than that rhapsody of lies, contradictions, and extravagant fables, which he delivers to his followers. Amazing are the absurdities which he relates concerning the patriarchs, concerning Solomon, and concerning the animals that were assembled in Noah's ark.

57 Notion of heaven and hell.

But in the whole tissue of absurdities of which his system consists, there is nothing more absurd, or more happily calculated to promote impurity of manners, than his descriptions of heaven and hell; the ideas of future rewards and punishments which he sought to impress on the minds of his followers. Paradise was to abound with rivers, trees, fruits, and shady groves; wine which would not intoxicate was to be there plentifully served up to believers; the inhabitants of that happy region were all to enjoy perpetual youth; and their powers of enjoyment were to be enlarged and invigorated, in order that so many fine things might not be thrown away upon them. "Instead of inspiring the blessed inhabitants of paradise with a liberal taste for harmony and science, conversation and friendship (says Mr Gibbon), Mahomet idly celebrates the pearls and diamonds, the robes of silk, palaces of marble, dishes of gold, rich wines, artificial dainties, numerous attendants, and the whole train of sensual luxury.—Seventy two houris, or black-eyed girls of resplendent beauty, blooming youth, virgin purity, and exquisite sensibility, will be created for the use of the meanest believer; a moment of pleasure will be prolonged for 1000 years, and his faculties will be increased 100 fold, to render him worthy of his felicity." It must be acknowledged that he allows believers other more refined enjoyments than these; thus they are to see the face of God morning and evening; a pleasure which is far to exceed all the other pleasures of paradise. The following is his description of the punishments of hell: The wicked are there to drink nothing but boiling stinking water; breathe nothing but hot winds; dwell for ever in continual burning fire and smoke; eat nothing but briars and thorns, and the fruit of a tree that riseth out of the bottom of hell, whose branches resemble the heads of devils, and whose fruits shall be in their bellies like burning pitch.

All that we can conclude from a general view of the religion of Mahomet, from considering the character of the prophet, or from reviewing the history of the nations among whom it has been established, is, that it is one tissue of absurdities, with a few truths, however, and valuable precepts incongruously intermixed; that a great part of it is unfavourable to virtuous manners, to wise and equal laws, and to the progress of knowledge and refinement. It often inculcates in a direct manner sentiments that are highly immoral; it substitutes trifling superstitious observances in the room of genuine piety and moral virtue; and it gives such views of futurity as render purity of heart no necessary qualification for seeing God.

58 Mahometanism to be preferred to paganism.

Surely, therefore, even the deist, who rejects all but natural religion, would not hesitate to prefer Christianity, and even Judaism, to the religion of Mahomet. Judaism, calculated for a peculiar people, was undoubtedly much more sublime and much more happily framed to render that people virtuous and happy in the circumstances in which they were placed; and Christianity we find to be an universal religion, suited to all circumstances and to all the stages of society, and acting, wherever it is received, with more or less force to the support of civil order, virtuous manners, improvement of arts, and the advancement of science. However, as Mahometanism forms in some measure a regular system, as it has borrowed many of the precepts and doctrines of Judaism and Christianity, not indeed without corrupting and degrading them; and as it has contributed considerably to the support of civil government, although in a very imperfect form, in those countries in which it has obtained an establishment; for all these reasons we cannot but give it the preference to the superstitions of Paganism.

59 Conclusion.

The whole result of our inquiries under this article, therefore, is, 1. That as man, by the constitution of his mind, is naturally fitted for acquiring certain notions concerning the existence of invisible, superior beings, and their influence on human life; so the religious ideas which we find to have in all ages of the world, and in all the different stages of the progress of society, prevailed among mankind, appear to have originated partly from the natural exertions of the human imagination, understanding, and passions, in various circumstances, and partly from supernatural revelation.

2. That though religious opinions, together with the moral precepts, and the rites of worship connected with them, may appear to have been in numerous instances injurious to the virtue and happiness of society; yet, as they have often contributed to lead the mind to form moral distinctions, when it would otherwise in all probability have been an entire stranger to such distinctions; and as they have always contributed in an essential manner to the establishment and the support of civil government—it must therefore be acknowledged that they have always, even in their humblest state, been more beneficial than hurtful to mankind.

3. That when the different systems of religion that have prevailed in the world are comparatively viewed with respect to their influence on the welfare of society, we find reason to prefer the polytheism of the Greeks and Romans to the ruder, wilder, religious ideas and ceremonies that have prevailed among savages; Mahometanism, perhaps in some respects, to the polytheism of the Greeks and Romans; Judaism, however, to Mahometanism; and Christianity to all of them.

RELIGIOUS, in a general sense, something that relates to religion.—We say, a religious life, religious society,

society, &c.—Churches and churchyards are religious places.—A religious war is also called a *croisade*. See Croisade.

Religious, is also used substantially for a person engaged by solemn vows to the monastic life; or a person shut up in a monastery to lead a life of devotion and austerity, under some rule or institution. The male religious we popularly call *monks* and *friars*; the female, *nuns* and *canonesses*.

REMBRANDT Van Rhin, a Flemish painter and engraver of great eminence, was born in 1606, in a mill upon the banks of the Rhine, from whence he derived his name of *Van Rhin*. This master was born with a creative genius, which never attained perfection. It was said of him, that he would have invented painting, if he had not found it already discovered. Without study, without the assistance of any master, but by his own instinct, he formed rules, and a certain practical method for colouring; and the mixture produced the designed effect. Nature is not set off to the greatest advantage in his pictures; but there is such a striking truth and simplicity in them, that his heads, particularly his portraits, seem animated, and rising from the canvas. He was fond of strong contrasts of light and shade. The light entered in his working-room only by a hole, in the manner of a camera obscura, by which he judged with greater certainty of his productions. This artist considered painting like the stage, where the characters do not strike unless they are exaggerated. He did not pursue the method of the Flemish painters of finishing his pieces. He sometimes gave his light such thick touches, that it seemed more like modelling than painting. A head of his has been shown, the nose of which was so thick of paint, as that which he copied from nature. He was told one day, that by his peculiar method of employing colours, his pieces appeared rugged and uneven—he replied, he was a painter, and not a dyer. He took a pleasure in dressing his figures in an extraordinary manner: with this view he had collected a great number of eastern caps, ancient armour, and drapery long since out of fashion. When he was advised to consult antiquity to attain a better taste in drawing, as his was usually heavy and uneven, he took his counsellor to the closet where these old vestments were deposited, saying, by way of derision, those were his antiques.

Rembrandt, like most men of genius, had many caprices. Being one day at work, painting a whole family in a single picture, word being brought him that his monkey was dead, he was so affected at the loss of this animal, that, without paying any attention to the persons who were sitting for their pictures, he painted the monkey upon the same canvas. This whim could not fail of displeasing those for whom the piece was designed; but he would not efface it, choosing rather to lose the sale of his picture.

This freak will appear still more extraordinary in Rembrandt, when it is considered that he was extremely avaricious; which vice daily grew upon him. He practised various stratagems to sell his prints at a high price. The public were very desirous of purchasing them, and not without reason. In his prints the same taste prevails as in his pictures; they are rough and irregular, but picturesque. In order to heighten the value of his prints, and increase their price, he made his son sell them as if he had purloined them from his father; others he exposed at public sales, and went thither himself in disguise to bid for them; sometimes he gave out that he was going to leave Holland, and settle in another country. These stratagems were successful, and he got his own price for his prints. At other times he would print his plates half finished, and expose them to sale; he afterwards finished them, and they became fresh plates. When they wanted retouching, he made some alterations in them, which promoted the sale of his prints a third time, though they differed but little from the first impressions.

His pupils, who were not ignorant of his avarice, one day painted some pieces of money upon cards; and Rembrandt no sooner saw them, than he was going to take them up. He was not angry at the pleasantry; but it had no effect in checking his avarice. He died in 1674.

REMEMBRANCE, is when the idea of something formerly known recurs again to the mind without the operation of a like object on the external sensory. See Memory and Reminiscence.

REMEMBRANCERS, anciently called *clerks of the remembrance*, certain officers in the exchequer, whereof three are distinguished by the names of the *king's remembrancer*, the *lord treasurer's remembrancer*, and the *remembrancer of the first fruits*. The king's remembrancer enters in his office all recognizances taken before the barons for any of the king's debts, for appearances or observing of orders; he also takes all bonds for the king's debts, &c. and makes out processes thereon. He likewise issues processes against the collectors of the customs, excise, and others, for their accounts; and informations upon penal statutes are entered and sued in his office, where all proceedings in matters upon English bills in the exchequer-chamber remain. His duty farther is to make out the bills of compositions upon penal laws, to take the statement of debts; and into his office are delivered all kinds of indentures and other evidences which concern the assuring any lands to the crown. He every year *in crastino animarum*, reads in open court the statute for election of sheriffs; and likewise openly reads in court the oaths of all the officers, when they are admitted.

The lord treasurer's remembrancer is charged to make out process against all sheriffs, escheators, receivers, and bailiffs, for their accounts. He also makes out writs of *fieri facias*, and extent for debts due to the king, either in the pipe or with the auditors; and process for all such revenue as is due to the king on account of his tenures. He takes the account of sheriffs; and also keeps a record, by which it appears whether the sheriffs or other accountants pay their proffers due at Easter and Michaelmas; and at the same time he makes a record, whereby the sheriffs or other accountants keep their prefixed days: there are likewise brought into his office all the accounts of customers, comptrollers, and accountants, in order to make entry thereof on record; also all estreats and amercements are certified here, &c.

The remembrancer of the first-fruits takes all compositions and bonds for the payment of first-fruits and tenths; and makes out process against such as do not pay the same.

REMINISCENCE, that power of the human mind, whereby it recollects itself, or calls again into its remembrance,

brance, ſuch ideas or notions as it had really forgot: in which it differs from memory, which is a treaſuring up of things in the mind, and keeping them there, without forgetting them.

REMISSION, in *Phyſics*, the abatement of the power or efficacy of any quality; in oppoſition to the *increaſe* of the ſame, which is called *intenſion*.

Remission, in *Law*, &c. denotes the pardon of a crime, or giving up the puniſhment due thereto.

Remission, in *Medicine*, is when a diſtemper abates for a time, but does not go quite off.

REMITTANCE, in *Commerce*, the traffick or return of money from one place to another, by bills of exchange, orders, or the like.

REMONSTRANCE, an expoſtulation or humble ſupplication, addreſſed to a king, or other ſuperior, beſeeching him to reflect on the inconveniences or ill conſequences of ſome order, edict, or the like. This word is alſo uſed for an expoſtulatory counſel, or advice; or a gentle and handſome reproof, made either in general, or particular, to apprize of or correct ſome fault, &c.

REMONSTRANTS, in church-hiſtory, a title which was given to the Arminians in conſequence of the remonſtrance made by them in the year 1610 to the ſtates of Holland, againſt the ſentence of the ſynod of Dort, which pronounced them to be heretics. The chief leaders of the Remonſtrants were Epiſcopius and Grotius; and their principles were firſt openly countenanced in England by Archbiſhop Laud. In oppoſition to the repreſentation or remonſtrance of the Arminians, the Dutch Calviniſts preſented an addreſs, which was called a counter-remonſtrance; and hence they obtained the denomination of *Counter-remonſtrants*. A great deal of keen controverſy was agitated in this affair, by theſe rival ſects. See Arminians.

REMORA, or Sucking-fish, a ſpecies of Echeneis. See Echeneis, Ichthyology *Index*.—Many incredible things are related of this animal by the ancients; as that it had the power of ſtopping the largeſt and ſwifteſt veſſel in its courſe; and even to this day it is aſſerted by the fiſhermen in the Mediterranean, that it has a power of retarding the motion of their boats by attaching itſelf to them; for which reaſon they kill it whenever they fancied this retardation took place.

REMORSE, in its worſt ſenſe, means that pain or anguiſh which one feels after having committed ſome bad action. It alſo means tenderneſs, pity, or ſympathetic ſorrow. It is moſt generally uſed in a bad ſenſe, and is applied to perſons who feel compunction for ſome great crime, as murder and ſuch like. Murders which have been committed with the utmoſt circumſpection and ſecrecy, and the authors of which could never have been diſcovered by any human inveſtigation, have been frequently unfolded by the remorſe and confeſſion of the perpetrators, and that too many years afterwards. Of this there are numerous inſtances, which are well authenticated, and which are ſo generally known that it is needleſs to relate them here. See Repentance.

REMPHAN, an idol or Pagan god whom St Stephen ſays the Iſraelites worſhipped in the wilderneſs as they paſſed from Egypt to the land of Promiſe: "Yea, ye took up the tabernacle of Moloch, and the ſtar of your god Remphan; figures which ye made to worſhip them." That the martyr here quotes the following words of the prophet Amos, all commentators are agreed: "Ye have borne the tabernacle of your Moloch, and Chiun your images, the ſtar of your god, which ye made to yourſelves." But if this coincidence between the Chriſtian preacher and the Jewiſh prophet be admitted, it follows, that *Chiun* and *Remphan* are two names of one and the ſame deity. This is indeed farther evident from the LXX tranſlators having ſubſtituted in their verſion the word Ραιφαν, inſtead of *Chiun*, which we read in the Hebrew and Engliſh Bibles. But the queſtion which ſtill remains to be anſwered is, what god was worſhipped by the name of *Remphan*, *Raiphan*, or *Chiun?* for about the other divinity here mentioned there is no diſpute. See Moloch.

That *Chiun* or *Remphan* was an Egyptian divinity, cannot be queſtioned; for at the era of the *Exodus* the Hebrews muſt have been ſtrangers to the idolatrous worſhip of all other nations; nor are they ever accuſed of any other than Egyptian idolatries during their 40 years wanderings in the wilderneſs, till towards the end of that period that they became infected by the Moabites with the worſhip of *Baal-peor*. That *Moloch*, *Moleck*, *Molek*, or *Milcom*, in its original acceptation, denotes a *king* or *chief*, is known to every oriental ſcholar; and therefore when it is uſed as the name of a god, it undoubtedly ſignifies the *ſun*, and is the ſame divinity with the *Egyptian Oſiris*. Reaſoning in this way, many critics, and we believe Selden is in the number, have concluded that *Chiun*, and of courſe *Remphan*, is the planet *Saturn;* becauſe *Chiun* is written *Ciun*, *Cevan*, *Ceuan*, *Chevvin;* all of which are modern oriental names of that planet.

But againſt this hypotheſis inſurmountable objections preſent themſelves to our minds. It is univerſally allowed (ſee Polytheism), that the firſt objects of idolatrous worſhip were the *ſun* and *moon*, conſidered as the king and queen of heaven. The fixed ſtars, indeed, and the planets, were afterwards gradually admitted into the Pagan rubric; but we may be ſure that thoſe would be firſt aſſociated with the two prime luminaries which moſt reſembled them in brightneſs, and were ſuppoſed to be moſt benignant to man. But the planet Saturn appears to the naked eye with ſo feeble a luſtre, that, in the infancy of aſtronomy, it could not make ſuch an impreſſion on the mind as to excite that admiration which we muſt conceive to have always preceded planetary worſhip. It is to be obſerved, too, that by the Pagan writers of antiquity Saturn is conſtantly repreſented as a ſtar of baleful influence. He is termed the *leaden planet;* the *planet of malevolent aſpect;* the *diſmal*, the *inhumane ſtar*. That the Egyptians, at ſo early a period as that under conſideration, ſhould have adored as one of their greateſt gods a planet obſcure in its appearance, diſtant in its ſituation, and baleful in its influence, is wholly incredible.

There is, however, another ſtar which they might naturally adore, and which we know they actually did adore, as one of their moſt beneficent gods, at a very early period. This is the *αστροκυων* or *σειριος* of the Greeks, the *canis* or *ſtella canicularis* of the Romans, and the *dog-ſtar* of modern Europe. By the Egyptians it was called *Sothis* or *Soth*, which ſignifies *ſafety*, *beneficence*, *fecundity;* and it received this name, becauſe making its appearance in the heavens at the very time when the Nile overflowed the country, it was ſuppoſed to to regulate the inundation. On this account Plutarch (*Is. et Osir.*) tells us, they believed the soul of their illustrious benefactress *Isis* to have transmigrated into the star *Sothis*, which they therefore worshipped as the divinity which rendered their country fruitful. It made its appearance, too, on the first day of the month *Thoth* (A), which was the beginning of the Egyptian year, and as such celebrated with feasting and festivity; and being by much the brightest star in the heavens, Horopollo (cap. 3.) informs us it was considered as sovereign over the rest. A combination of so many important circumstances might have induced a people less superstitious than the Egyptians to pay divine homage to that glorious luminary, which was confounded with *Isis*, who had been long regarded with the highest veneration; and as Isis was the wife and sister of Osiris, and always associated with him, the star of Isis or *Remphan* was naturally associated with *Moloch*, the same with Osiris.

But it will be asked, how the star which by the Egyptians was called *Soth* or *Sothis* came to be worshipped by the Hebrews under the appellation of *Chiun* or *Remphan?* This is a very pertinent question, and we shall endeavour to answer it.

Every one knows that the pronunciation of oriental words is very uncertain; and that as the vowels were often omitted in writing, it is of very little importance to the meaning how they be supplied, provided we retain the radical consonants. The word *Chiun* may with equal propriety be written *Kiun*, *Kion*, or even *Kyon*, the Hebrew *jod* being convertible into the Greek υ or the Roman *y*; but the words *Cane*, *Chan*, *Kan*, or *Khan*, which are often diversified into *Ken*, *Kyn*, *Cohen*, *Cahan*, signifying *Head*, *Chief*, *Prince*, *King*, &c. are diffused through a great part of Asia and Europe. In the Chinese language *Quin*, which signifies a *King*, is so similar to the word *Chiun* or *Khiun* under consideration, that no etymologist will hesitate to pronounce them of the same original and the same import. The word *Kan* or *Khan* is universally known to be an honorary title in Tartary; and *Kaian* or *Kain*, which is manifestly cognate of the word *Chiun* or *Kiun*, is, in the *Plhevi* or old Persian language, the epithet applied to the dynasty of princes which succeeded Cyrus the Great. Among the Scythians or ancient Tartars, *Ghiun* signifies the *Sun* and likewise the *day*; and *Kung*, *Kinung*, *Kun*, runs through all the dialects of the Gothic tongue, everywhere denoting a *chief* or *sovereign*. In the Syrian dialect, *Kon* signifies a prince; and hence the Almighty is styled (Gen. xiv. 19.) *Konah*, which is translated *possessor*, but might have, with perhaps more propriety, been rendered *Sovereign* of heaven and earth. In Hebrew, the word *Kahan* or *Kahen*, which is the very same with *Khan* or *Kan*, signifies either a *priest* or a *prince*; and in Egypt *Kon* was the name of the first Hercules or the *sun*. Hence the same word in composition denotes greatness, as *Can-obus* the great serpent; *Can athoth*, the great *Thoth* or Mercury; *Can-osiris*, the great *Osiris*.

From this deduction we would conclude, that the word, which is found in so many tongues, and always denotes *Chief*, *Prince*, *Sovereign*, is the very word *Chiun* which the Egyptians and Hebrews applied to *Sothis*, as being, in their conceptions, the chief or sovereign of all the stars. This will appear still more probable, when we have ascertained the import of the word *Remphan*, or, as the LXX have it, *Raiphan*.

Phan, the latter part of this word, is unquestionably the same with *Pan*, the most ancient of the Egyptian gods (see Pan). It is likewise a cognate of the Hebrew *Phanah*, conspexit, spectavit, vidit; and the radical word seems to be PHAH, which signifies sometimes the countenance and sometimes *light*. Hence *Phaethon*, which is compounded of *pha*, "light," *eth* or *esh*, "fire," and *on*, "strength," came to be one of the names of the sun. *Rai*, which we commonly write *Rajah*, has long signified, among the Indians, a subordinate prince; and we know, that between India and Egypt there was a very early intercourse. *Raiphan*, therefore, may be either the *royal light* or the *bright prince*, subordinate to Osiris; and in either sense, it was a very proper epithet of *Sothis* in the Egyptian kalendar. The word *Rem* or *Rom*, again (for it is sometimes written Remphan, and sometimes Rompha), is no other than the Hebrew רום, *Rum*, "high, exalted." Hence Remphan is the *high* or *exalted light*, which Sothis certainly was.

For this etymological disquisition we are indebted to Dr Doig, the learned author of *Letters on the Savage State*, who has written a dissertation on *Chiun* and *Remphan*, of such value that we hope it will not be much longer withheld from the public. The ascertaining the identity of those names, and the god to which they belonged, is the least of its merit; for it will be found to throw much light upon many passages in the Old Testament. What confirms his interpretation is, that the idol consecrated by the Egyptians to *Sothis* or the dog-star, was a female figure with a star on her head; and hence the prophet upbraids his countrymen with having borne the *Star* of their deity.

Action of REMOVING, in *Scots Law*. See Law, N° clxvii. 18.

REMURIA, festivals established at Rome by Romulus to appease the manes of his brother Remus. They were afterwards called *Lemuria*, and celebrated yearly.

REMUS, the brother of Romulus, was exposed together with his brother by the cruelty of his grandfather. In the contest which happened between the two brothers about building a city, Romulus obtained the preference, and Remus, for ridiculing the rising walls, was put to death by his brother's orders, or by Romulus himself (see Romulus). The Romans were afflicted with a plague after this murder; upon which the oracle was consulted, and the manes of Remus appeased by the institution of the Remuria.

RENAL, something belonging to the reins or Kidneys.

RENCOUNTER, in the military art, the encounter of two little bodies or parties of forces. In which sense *rencounter* is used in opposition to a pitched battle.

Rencounter, in single combats, is used by way of contradistinction

(A) This was the case at a very remote period; but it is otherwise at present, owing to the *Precession of the Equinoxes*. See that article.

contradistinction to DUEL.—When two persons fall out and fight on the spot without having premeditated the combat, it is called a *rencounter*.

RENDEZVOUS, or RENDEVOUS, a place appointed to meet in at a certain day and hour.

RENDSBURG, the frontier town in Holstein, is regularly built, and better fortified than any in the Danish dominions. It is situated on a canal which runs from the Baltic. This is a work of considerable commercial consequence, and deserves to be particularly noticed. It has its source three miles north of Keil, forming the boundary of Holstein and Sleswick, and by means of it ships of 140 tons can come up from the Baltic. This canal was begun in 1777, and it is intended to make it stretch across the whole peninsula, the utility of which will be clearly perceived by all those who are acquainted with the value of inland navigation. Rendsburg is a place of considerable trade, and contains about 2800 inhabitants, including the garrison which is usually stationed there.

RENEALMIA, a genus of plants belonging to the monandria class. See BOTANY *Index*.

RENEGADE, or RENEGADO, a person who has apostatized or renounced the Christian faith to embrace some other religion, particularly Mahometanism.

RENFREW, a royal borough, and the county town of Renfrewshire, situated not far from the south bank of the Clyde, about five miles west from Glasgow, and three north from Paisley. It has only one narrow street half a mile long, and its trade is inconsiderable, though favourably situated for commerce. The river Clyde having shifted its bed, a canal was formed in it, by which vessels of 200 tons burden can come up to the town during spring tides. The manufacture of thread has been long carried on here, and that of soap and candles to a great extent. Many looms are constantly employed in the fabrication of silk and muslin. In the year 1164 it became memorable for a battle between Somerled thane of Argyle and Gilchrist earl of Angus, in which the former was defeated. King Robert II. made it a royal borough; and charters were afterwards granted to it by James VI. and Queen Anne. Its political constitution consists of a provost, two bailies, and 16 counsellors, who have the management of about 360l. of annual revenue, arising from lands, salmon fishing, &c. In the year 1791 the population amounted to 1628. The soil consists of clay, sand, and rich loam, the latter of which is the most predominant. The whole of the land is enclosed and well cultivated. It is a place of very great antiquity, as we find mention made of it in the chartularies of the abbeys of Dunfermline and Paisley.

RENFREWSHIRE, a small but populous county of Scotland, bounded on the south-west by the hills which run along the northern part of Ayrshire; towards the west and north by the river Clyde, and on the east by Lanarkshire. It is rather level along the north east and north part of it; and it has few hills which rise to any considerable height. But the summits of Balagich and Dunware, in the parish of Eaglesham, are about 1000 feet above the level of the sea.

The waters of Renfrewshire are not extensive, but human industry has rendered them of considerable importance; and they are rather employed to turn some vast water wheel or other piece of machinery, than to give variety to the beauties of a park, or to please the eye with the romantic scenery which nature sometimes delights to display. The chief rivers are the White and Black Carts, and the Grief, which ultimately form a junction, and discharge themselves into the Clyde below Inchinnan bridge.

The number of lakes in this county is increased for the purpose of collecting water to give motion to the machinery of cotton mills, or to answer the demands of extensive bleachfields.

The general appearance of this county is favourable to agriculture, the population being very extensive, and the inclosures numerous, while manure in abundance is obtained from the neighbouring towns. Commerce and manufactures have been so often successfully pursued, producing great and sudden riches, that in a greater or less degree they occupy the attention of almost every individual. Although a considerable part of it might be constantly kept with advantage under arable crops, yet so extensive is the demand for the products of the dairy, that a very large proportion of the soil is perpetually kept in grass. With respect to crops, potatoes generally constitute a part of every rotation. This is the usual arrangement: Oats from grass; potatoes or barley dunged; oats, with five pounds of red clover and 3 firlots of rye-grass; hay for two years; pasture.

The proprietors of land in this county have shewn a laudable zeal for the making of excellent roads, which are constantly kept in the best repair, and steelyards are fixed at every toll-bar to prevent carts from being overloaded; 15 cwt. being allowed in the vicinity of Paisley as the load for a cart with one horse.

The mineral productions are not very extensive, but they are very abundant in the vicinity of Paisley. No coal has been met with near Greenock or Port Glasgow; but what is called *osmund stone* is found in the parishes of Eaglesham and Kilbarchan, so very soft at first that it may be cut with a chisel, but it becomes much harder by exposure to the air. It is of various colours; breaks in every direction; readily absorbs water; and if recently heated in the fire, the absorption is accompanied with a hissing noise. There are two mineral springs in the same vicinity of Eaglesham; the one possessing a purgative quality, and the other is regarded as a remedy for what is called the *moor-ill* in black cattle.

The most remarkable field of minerals is in the vicinity of Paisley; the most singular being the coal at Quarreltown, upwards of 50 feet thick, consisting of five strata in contact with each other (A). The Hurlet coal, belonging to Lord Glasgow, about three miles south-east of Paisley, is five feet three inches thick, and supposed to have been wrought for more than two centuries. Inflammable air and fixed air are met with in this mine, but from the precautions adopted accidents are not so frequent as might otherwise be apprehended. The coal-mines of Hurlet have for a long time afforded the materials for a copperas manufactory on a small scale; and one

(A) For a detailed account of this singular mass of coal, the reader is referred to the Appendix to Williams's Mineral Kingdom, by Dr Millar, 2 vols. 8vo, 1809.

Renfrew-ſhire.

one of the moſt extenſive manufactories of alum in Britain has been eſtabliſhed and ſucceſsfully carried on by a ſpirited and enterpriſing company, for ſeveral years paſt, at the ſame place. Coal is alſo found in the upper part of the county, as in the pariſh of Cathcart, and alſo not far from Renfrew. Limeſtone is abundant in many part of the county, as in the pariſh of Cathcart; and at Lord Glaſgow's coal work at Hurlet, it forms a very conſiderable ſtrata covering the coal. But one of the moſt remarkable maſſes of limeſtone is found at the entrance to a romantic glen called Glenniffer, three miles to the ſouth of Paiſley. The limeſtone is in a maſs of about 10 feet thick, dips to the centre, and is wrought by driving mines under a thick maſs of whinſtone which covers it. Ironſtone is alſo abundant along with the coal ſtrata in ſome parts of the county.

The ruins of an old caſtle, called the Peel, to which the lairds of Semple retreated in times of imminent danger, are ſtill to be ſeen in an iſland of Caſtle Semple loch; and the ruins of the caſtle of Newark, lower down the country, are even at this day deſerving of attention. They are lofty, and have ſtill an air of magnificence, and ſome parts of it were inhabited about half a century ago. It is ſituated on the eaſtern part of the bay containing the town and harbour of Port Glaſgow and Newark. This caſtle is very ancient, is the property of Lord Belhaven, but when it was erected cannot be fully aſcertained. Mearns Caſtle, another ruin, ſtands in the ſouth-eaſt part of the county near the village and church of the ſame name. Crookſtone Caſtle is ſituated about three miles to the ſouth-eaſt of Paiſley. The ſtrong poſition and commanding proſpect of this magnificent ruin muſt have rendered it a favourite reſidence of the powerful family of Lennox, to whom it originally belonged. Near the caſtle there is a yew tree, venerable from its antiquity, but ſtill more ſo, according to the legendary lore of the country, as having afforded its ſhade to the unfortunate Queen Mary and her equally unfortunate huſband Darnley. If this be true, the ſaid tree is not leſs than three centuries old.

There are four cups in the pariſh of Kilmacolm which were uſed by the celebrated reformer John Knox at the diſpenſation of the Lord's ſupper. They are formed of the pureſt ſilver, and ſeem to have been originally intended for candleſticks, although neceſſity converted them into communion cups. This ſacred uſe of them, joined to their antiquity, makes them much eſteemed by the people at large.

Renfrew is the only royal borough in this county, a privilege which was conferred upon it by Robert Bruce. It elects a member of parliament along with Glaſgow, Dunbarton, and Rutherglen.

The other towns are Paiſley, Greenock, Port Glaſgow; and ſome of ſmaller note, as Kilbarchan, Lochwinnoch, Neilſton, Gourock, and Auldkirk. Among theſe deſerves alſo to be mentioned Johnſton, which within a period of little more than 20 years has become a large town, owing to the progreſs and proſperity of the cotton manufacture.

The manufacture of ſilk gauze was introduced into Paiſley about the year 1760, in imitation of that of Spittalfields in London; experiencing at firſt many difficulties to which new inventions are very frequently expoſed. Patterns and deſigns of fancy works were originally compoſed at Paris; but the manufacturers at Paiſley eſtabliſhed draughtſmen of their own, and the patterns thus executed were ſent to London and Paris in order to be approved of. By means of induſtry and genius properly encouraged, the moſt curious fabrics came to be deviſed; and the vaſt variety of elegant and highly ornamented gauze manufactured here is allowed to be ſuperior to every thing of the kind which had formerly made its appearance. Even London itſelf was obliged to relinquiſh this manufacture; merchants from the metropolis came to carry it on at Paiſley; and warehouſes were opened in London, in Dublin, and Paris for vending their commodities. We formerly ſaid that Paiſley muſt contain upwards of 25,000 inhabitants (ſee PAISLEY); but we have ſince ſeen a more recent computation, by which they are ſtated at upwards of 31,000.

Renfrewſhire, Rennes.

The whole population of Renfrewſhire amounted to 78,000 in 1801, of which Paiſley alone contains much more than a third. In the year 1755 the population of this county was 26,645, ſo that in the courſe of half a century it has been nearly tripled. The following table exhibits a view of the population of each pariſh according to the reports communicated to the Statiſtical Hiſtory of Scotland.

	Pariſhes.	Population in 1755.	Population in 1790—1798.
1	Cathcart	499	697
	Eagleſham	1103	1000
	Eaſtwood	1142	2642
	Erſkine	829	808
5	Greenock	3858	15,000
	Houſton	947	1034
	Inchinnan	347	306
	Innerkip	1590	1280
	Kilbarchan	1485	2506
10	Kilmacolm	1495	951
	Lochwinnoch	1530	2613
	Mearns	886	1430
	Neilſton	1299	2330
	Paiſley, town	4290	13,800
15	Ditto, Abbey pariſh	2509	10,792
	Port Glaſgow	1695	4036
17	Renfrew	1091	1628
		26,645	62,853
			26,645
		Increaſe	36,208

RENNES, a town of France, in Bretagne, and capital of that province. Before the revolution it had a biſhop's ſee, two abbeys, a parliament, and a mint. It is very populous; the houſes are ſix or ſeven ſtories high, and the ſuburbs of larger extent than the town itſelf. The cathedral church is large, and the parliament-houſe a handſome ſtructure. The great ſquare belonging to it is ſurrounded with handſome houſes. There is a tower, formerly a pagan temple, which now contains the town-clock. It is ſeated on the river Vilaine, which divides it into two parts, and was anciently fortified, but the walls are now in ruins, and the ditch nearly filled up. The ſiege of the city by Edward III. king of England is very celebrated in hiſtory. The Engliſh and Breton army conſiſted of 40,000 men; and nevertheleſs, after having remained before it ſix months, were

were obliged to retire without success. E. Long. 0. 23. N. Lat. 48. 7.

RENNET. See RUNNET.

RENT, in *Law*, a sum of money, or other consideration, issuing yearly out of lands or tenements.

RENTERING, in the manufactories, the same with fine-drawing. It consists in sewing two pieces of cloth edge to edge, without doubling them, so that the seam scarce appears; and hence it is denominated *fine-drawing*. It is a French word meaning the same thing, and is derived from the Latin *retrahere*, of *re*, *in*, and *trahere*, because the seam is drawn in or covered. We are told *, that in the East Indies, if a piece of fine muslin be torn and afterwards mended by the fine-drawers, it will be impossible to discover where the rent was. In this country the dexterity of the fine-drawers is not so great as that of those in the east; but it is still such as to enable them to defraud the revenue, by sewing a head or slip of English cloth on a piece of Dutch, Spanish, or other foreign cloth; or a slip of foreign cloth on a piece of English, so as to pass the whole as of a piece, and by that means avoid the duties, penalties, &c. The trick was discovered in France by M. Savary.

* *Lettres Edifiantes et Curieuses.*

RENTERING, in tapestry, is the working new warp into a piece of damaged tapestry, whether eaten by the rats or otherwise destroyed, and on this warp to restore the ancient pattern or design. The warp is to be of woollen, not linen. Among the titles of the French tapestry-makers is included that of renterers. Fine-drawing is particularly used for a rent or hole, which happens in dressing or preparing a piece of cloth artfully sewed up or mended with silk. All fine-drawings are reckoned defects or blemishes, and should be allowed for in the price of the piece.

RENVERSE, INVERTED, in *Heraldry*, is when any thing is set with the head downwards, or contrary to its natural way of standing. Thus, a chevron renverse is a chevron with the point downwards. They use also the same term when a beast is laid on its back.

RENUNCIATION, the act of renouncing, abdicating, or relinquishing, any right, real or pretended.

REPARTEE, a smart, ready reply, especially in matters of wit, humour, or raillery. See RAILLERY.

REPEALING, in *Law*, the revoking or annulling of a statute or the like.

No act of parliament shall be repealed the same session in which it was made. A deed or will may be repealed in part, and stand good for the rest. Is is held that a pardon of felony may be repealed on disproving the suggestion thereof.

REPELLENTS, in *Medicine*, remedies which are supposed to drive back a morbid humour into the mass of blood, from whence it was unduly secreted.

REPENTANCE, in general, means sorrow for any thing past. In theology it means such a sorrow for sin as produces newness of life, or such a conviction of the evil and danger of a sinful course as is sufficient to produce shame and sorrow in the review of it, and effectual resolutions of amendment. In this sense the evangelical writers use μεταμελεια and μετανοια. See PENITENCE and THEOLOGY.

REPERCUSSION, in *Music*, a frequent repetition of the same sound.

REPERTORY, a place wherein things are orderly disposed, so as to be easily found when wanted. The indices of books are repertories, showing where the matters sought for are treated of. Common-place books are also kinds of repertories.

REPETEND, in *Arithmetic*, signifies that part of an infinite decimal fraction, which is continually repeated *ad infinitum*. Thus in the numbers 2. 13 13 13 &c. the figures 13 are the repetend and marked thus $\dot{1}\dot{3}$. These repetends chiefly arise in the reduction of vulgar fractions to decimals. Thus, $\frac{1}{3}=0.333$ &c.$=0.\dot{3}$.

REPETITION, the reiterating of an action.

REPETITION, in *Music*, denotes a reiterating or playing over again the same part of a composition, whether it be a whole strain, part of a strain, or double strain, &c.

When the song ends with a repetition of the first strain, or part of it, the repetition is denoted by *da capo*, or D. C. *i. e.* "from the beginning."

REPETITION, in *Rhetoric*, a figure which gracefully and emphatically repeats either the same word, or the same sense in different words. See ORATORY, N° 67—80.

The nature and design of this figure is to make deep impressions on those we address. It expresses anger and indignation, full assurance of what we affirm, and a vehement concern for what we have espoused.

REPHIDIM, in *Ancient Geography*, a station of the Israelites near Mount Horeb, where they murmured for want of water; when Moses was ordered to smite the rock Horeb, upon which it yielded water. Here Joshua discomfited the Amalekites. This rock, out of which Moses brought water, is a stone of a prodigious height and thickness, rising out of the ground; on two sides of which are several holes, by which the water ran. (Thevenot).

REPLEGIARE, in *Law*, signifies to redeem a thing taken or detained by another, by putting in legal sureties.

DE HOMINE REPLEGIANDO. See HOMINE.

REPLEVIN, in *Law*, a remedy granted on a distress, by which the first possessor has his goods restored to him again, on his giving security to the sheriff that he will pursue his action against the party distraining, and return the goods or cattle if the taking them shall be adjudged lawful.

In a replevin the person distrained becomes plaintiff; and the person distraining is called the *defendant* or *avowant*, and his justification an *avowery*.

At the common law replevins are by writ, either out of the king's-bench or common-pleas; but by statute, they are by plaint in the sheriff's court, and court-baron, for a person's more speedily obtaining the goods distrained.

If a plaint in replevin be removed into the court of king's bench, &c. and the plaintiff makes default and becomes non-suited, or judgement is given against him, the defendant in replevin shall have the writ of *retorno habendo* of the goods taken in distress. See the next article.

REPLEVY, in *Law*, is a tenant's bringing a writ of replevin, or *replegiari facias*, where his goods are taken by distress for rent; which must be done within five days after the distress, otherwise at the five days end they are to be appraised and sold.

This word is also used for bailing a person, as in the case of a *homine replegando*.

REPORT,

Report || Reprieve.

REPORT, the relation made upon oath, by officers or perfons appointed to vifit, examine, or eftimate the ftate, expences, &c. of any thing.

REPORT, in *Law*, is a public relation of cafes judicially argued, debated, refolved, or adjudged in any of the king's courts of juftice, with the caufes and reafons of the fame, as delivered by the judges. Alfo when the court of chancery, or any other court, refers the ftating of a cafe, or the comparing of an account, to a mafter of chancery, or other referee, his certificate thereon is called a *report*.

REPOSE, in *Poetry*, &c. the fame with reft and paufe. See REST, &c.

REPOSE, in *Painting*, certain maffes or large affemblages of light and fhade, which being well conducted, prevented the confufion of objects and figures, by engaging and fixing the eye fo as it cannot attend to the other parts of the painting for fome time; and thus leading it to confider the feveral groups gradually, proceeding as it were from ftage to ftage.

REPRESENTATION, in the drama, the exhibition of a theatrical piece, together with the fcenes, machinery, &c.

REPRESENTATIVE, one who perfonates or fupplies the place of another, and is invefted with his right and authority. Thus the houfe of commons are the reprefentatives of the people in parliament. See COMMONS and PARLIAMENT.

REPRIEVE, in *Criminal Law*, (from *reprendre*, "to take back"), is the withdrawing of a fentence for an interval of time; whereby the execution is fufpended. See JUDGEMENT.

Blackft. Comment.

This may be, firft, *ex arbitrio judicis*, either before or after judgement: as, where the judge is not fatisfied with the verdict, or the evidence is fufpicious, or the indictment is infufficient, or he is doubtful whether the offence be within clergy; or fometimes if it be a fmall felony, or any favourable circumftances appear in the criminal's character, in order to give room to apply to the crown for either an abfolute or conditional pardon. Thefe arbitrary reprieves may be granted or taken off by the juftices of gaol-delievery, although their feffion be finifhed, and their commiffion expired: but this rather by common ufage than of ftrict right.

Reprieves may alfo be *ex neceffitate legis*: as where a woman is capitally convicted, and pleads her pregnancy. Though this is no caufe to ftay judgement, yet it is to refpite the execution till fhe be delivered. This is a mercy dictated by the law of nature, *in favorem prolis;* and therefore no part of the bloody proceedings in the reign of Queen Mary hath been more juftly detefted, than the cruelty that was exercifed in the ifland of Guernfey, of burning a woman big with child; and, when through the violence of the flame the infant fprang forth at the ftake, and was preferved by the byftanders, after fome deliberations of the priefts who affifted at the facrifice, they caft it into the fire as a young heretic. A barbarity which they never learned from the laws of ancient Rome; which direct, with the fame humanity as our own, *quod prægnantis mulieris damnatæ pœne differatur, quoad pariat:* which doctrine has alfo prevailed in England, as early as the firft memorials of our laws will reach. In cafe this plea be made in ftay of execution, the judge muft direct a jury of twelve matrons or difcreet women to inquire into the fact: and if they bring in their verdict *quick with child* (for barely *with child*, unlefs it be alive in the womb, is not fufficient), execution fhall be ftaid generally till the next feffion; and fo from feffion to feffion, till either fhe is delivered, or proves by the courfe of nature not to have been with child at all. But if fhe once hath had the benefit of this reprieve, and been delivered, and afterwards becomes pregnant again, fhe fhall not be intitled to the benefit of a farther refpite for that caufe. For fhe may now be executed before the child is quick in the womb; and fhall not, by her own incontinence, evade the fentence of juftice.

Reprieve. Reprifals.

Another caufe of regular reprieve is, if the offender become *non compos* between the judgement and the award of execution: for regularly, though a man be *compos* when he commits a capital crime, yet if he becomes *non compos* after, he fhall not be indicted; if after indictment, he fhall not be convicted; if after conviction, he fhall not receive judgement; if after judgement, he fhall not be ordered for execution: for *furiofus folo furore punitur;* and the law knows not but he might have offered fome reafon, if in his fenfes, to have ftayed thefe refpective proceedings. It is therefore an invariable rule, when any time intervenes between the attainder and the award of execution, to demand of the prifoner what he hath to allege why execution fhould not be awarded againft him; and, if he appears to be infane, the judge in his difcretion may and ought to reprieve him. Or, the party may plead in bar of execution; which plea may be either pregnancy, the king's pardon, an act of grace, or diverfity of perfon, viz. that he is not the fame that was attainted, and the like. In this cafe a jury fhall be impanelled to try this collateral iffue, namely, the identity of his perfon; and not whether guilty or innocent, for that has been decided before. And in thefe collateral iffues the trial fhall be *inftanter;* and no time allowed the prifoner to make his defence or produce his witneffes, unlefs he will make oath that he is not the perfon attainted: neither fhall any peremptory challenges of the jury be allowed the prifoner, though formerly fuch challenges were held to be allowable whenever a man's life was in queftion. If neither pregnancy, infanity, non-identity, nor other plea, will avail to avoid the judgement, and ftay the execution confequent thereupon, the laft and fureft refort is in the king's moft gracious pardon; the granting of which is the moft amiable prerogative of the crown. See the article PARDON.

REPRISALS, a right which princes claim of taking from their enemies any thing equivalent to what they unjuftly detain from them or their fubjects. For as the delay of making war may fometimes be detrimental to individuals who have fuffered by depredations from foreign potentates, our laws have in fome refpects armed the fubject with powers to impel the prerogative; by directing the minifters of the crown to iffue letters of marque and reprifal upon due demand: the prerogative of granting which is nearly related to, and plainly derived from, that other of making war; this being indeed only an incomplete ftate of hoftilities, and generally ending in a formal denunciation of war. Thefe letters are grantable by the law of nations, whenever the fubjects of one ftate are oppreffed and injured by thofe of another; and juftice is denied by that ftate to which the oppreffor belongs. In this cafe letters of marque and

and reprisal (words used as synonymous; and signifying, the latter a taking in return, the former the passing the frontiers in order to such taking) may be obtained, in order to seize the bodies or goods of the subjects of the offending state, until satisfaction be made, wherever they happen to be found. And indeed this custom of reprisals seems dictated by nature herself; for which reason we find in the most ancient times very notable instances of it. But here the necessity is obvious of calling in the sovereign power, to determine when reprisals may be made; else every private sufferer would be a judge in his own cause. In pursuance of which principle, it is with us declared by the stat. 4 Hen. V. c. 7. that, if any subjects of the realm are oppressed in time of truce by any foreigners, the king will grant marque in due form, to all that feel themselves grieved. Which form is thus directed to be observed: the sufferer must first apply to the lord privy-seal, and he shall make out letters of request under the privy-seal; and if after such request of satisfaction made, the party required do not within convenient time make due satisfaction or restitution to the party grieved, the lord chancellor shall make him out letters of marque under the great seal; and by virtue of these he may attack and seize the property of the aggressor nation, without hazard of being condemned as a robber or pirate.

Reprisal, or *Recaption*, is a species of remedy allowed to an injured person. This happens when any one has deprived another of his property in goods or chattels personal, or wrongfully detains one's wife, child, or servant: in which case the owner of the goods, and the husband, parent, or master, may lawfully claim and retake them, wherever he happens to find them; so it be not in a riotous manner, or attended with a breach of the peace. The reason for this is obvious; since it may frequently happen that the owner may have this only opportunity of doing himself justice: his goods may be afterwards conveyed away or destroyed; and his wife, children, or servants, concealed or carried out of his reach; if he had no speedier remedy than the ordinary process of law. If therefore he can so contrive it as to gain possession of his property again, without force or terror, the law favours and will justify his proceeding. But, as the public peace is a superior consideration to any one man's private property; and as, if individuals were once allowed to use private force as a remedy for private injuries, all social justice must cease, the strong would give law to the weak, and every man would revert to a state of nature; for these reasons it is provided, that this natural right of recaption shall never be exerted, where such exertion must occasion strife and bodily contention, or endanger the peace of society. If, for instance, my horse is taken away, and I find him in a common, a fair, or a public inn, I may lawfully seize him to my own use; but I cannot justify breaking open a private stable, or entering on the grounds of a third person, to take him, except he be feloniously stolen; but must have recourse to an action at law.

REPROBATION, in *Theology*, means the act of abandoning, or state of being abandoned, to eternal destruction; and is applied to that decree or resolve which God has taken from all eternity to punish sinners who shall die in impenitence; in which sense it is directly opposed to election. When a sinner is so hardened as to feel no remorse or misgiving of conscience, it is considered as a sign of reprobation; which by the casuists has been distinguished into positive and negative. The first is that whereby God is supposed to create men with a positive and absolute resolution to damn them eternally. This opinion is countenanced by St Augustine and other Christian fathers, and is a peculiar tenet of Calvin and most of his followers. The church of England, in *The thirty-nine Articles*, teaches something like it; and the church of Scotland, in the *Confession of Faith*, maintains it in the strongest terms. But the notion is generally exploded, and is believed by no rational divine in either church, being totally injurious to the justice of the Deity. Negative or conditional reprobation is that whereby God, though he has a sincere desire to save men, and furnishes them with the necessary means, so that all if they will may be saved, yet sees that there are many who will not be saved by the means, however powerful, that are afforded them; though by other means which the Deity sees, but will not afford them, they might be saved. Reprobation respects angels as well as men, and respects the latter either fallen or unfallen. See PREDESTINATION.

REPRODUCTION is usually understood to mean the restoration of a thing before existing, and since destroyed. It is very well known that trees and plants may be raised from slips and cuttings; and some late observations have shown, that there are some animals which have the same property. The polype * was the first instance we had of this; but we had scarce time to wonder at the discovery Mr Trembley had made, when Mr Bonnet discovered the same property in a species of water-worm. Amongst the plants which may be raised from cuttings, there are some which seem to possess this quality in so eminent a degree, that the smallest portion of them will become a complete tree again.

* See *Polypus*.

It deserves inquiry, whether or not the great Author of nature, when he ordained that certain insects, as these polypes and worms, should resemble those plants in that particular, allowed them this power of being reproduced in the same degree? or, which is the same thing, whether this reproduction will or will not take place in whatever part the worm is cut? In order to try this, Mr Bonnet entered on a course of many experiments on the water-worms which have this property. These are, at their common growth, from two to three inches long, and of a brownish colour, with a cast of reddish. From one of these worms he cut off the head and tail, taking from each extremity only a small piece of a twelth of an inch in length; but neither of these pieces were able to reproduce what was wanting. They both perished in about 24 hours; the tail first, and afterwards the head. As to the body of the worm from which these pieces were separated, it lived as well as before, and seemed indeed to suffer nothing by the loss, the head-part being immediately used as if the head was thereon, boring the creature's way into the mud. There are, besides this, two other points in which the reproduction will not take place; the one of these is about the fifth or sixth ring from the head, and the other at the same distance from the tail; and in all probability the condition of the great artery in these parts is the cause of this.

What is said of the want of the reproductive power of these parts relates only to the head and tail ends; for as to the body, it feels very little inconvenience from the

Reproduction.

the loſs of what is taken off, and very ſpeedily reproduces thoſe parts. Where then does the principle of life reſide in ſuch worms, which, after having their heads cut off, will have not only the ſame motions, but even the inclinations, that they had before? and yet this difficulty is very ſmall, compared to ſeveral others which at the ſame time offer themſelves to our reaſon. Is this wonderful reproduction of parts only a natural conſequence of the laws of motion? or is there lodged in the body of the creature a chain of minute buds or ſhoots, a ſort of little embryos, already formed and placed in ſuch parts where the reproductions are to begin? Are theſe worms only mere machines? or are they, like more perfect animals, a ſort of compound, the ſprings of whoſe motions are actuated or regulated by a ſort of ſoul? And if they have themſelves ſuch a principle, how is it that this principle is multiplied, and is found in every ſeparate piece? Is it to be granted, that there are in theſe worms, not a ſingle ſoul (if it is to be ſo called) in each, but that each contains as many ſouls as there are pieces capable of reproducing perfect animals? Are we to believe with Malpighi, that theſe ſorts of worms are all heart and brain from one end to the other! This may be; but yet if we knew that it was ſo, we ſhould know in reality but very little the more for knowing it: and it ſeems, after all, that in caſes of this kind we are only to admire the works of the great Creator, and ſit down in ſilence.

The nice ſenſe of feeling in ſpiders has been much talked of by naturaliſts; but it appears that theſe worms have yet ſomewhat more ſurpriſing in them in regard to this particular. If a piece of ſtick, or any other ſubſtance, be brought near them, they do not ſtay for its touching them, but begin to leap and friſk about as ſoon as it comes towards them. There want, however, ſome farther experiments to aſcertain whether this be really owing to feeling or to ſight; for though we can diſcover no diſtinct organs of ſight in theſe creatures, yet they ſeem affected by the light of the ſun or a candle, and always friſk about in the ſame manner at the approach of either; nay, even the moon-light has ſome effect upon them.

A twig of willow, poplar, or many other trees, being planted in the earth, takes root, and becomes a tree, every piece of which will in the ſame manner produce other trees. The caſe is the ſame with theſe worms: they are cut to pieces, and theſe ſeveral pieces become perfect animals; and each of theſe may be again cut into a number of pieces, each of which will in the ſame manner produce an animal. It had been ſuppoſed by ſome that theſe worms were oviparous: but Mr Bonnet, on cutting one of them to pieces, having obſerved a ſlender ſubſtance, reſembling a ſmall filament, to move at the end of one of theſe pieces, ſeparated it; and on examining it with glaſſes, found it to be a perfect worm, of the ſame form with its parent, which lived and grew larger in a veſſel of water into which he put it. Theſe ſmall bodies are eaſily divided, and very readily complete themſelves again, a day uſually ſerving for the production of a head to the part that wants one; and, in general, the ſmaller and ſlenderer the worms are, the ſooner they complete themſelves after this operation. When the bodies of the large worms are examined by the microſcope, it is very eaſy to ſee the appearance of the young worms alive, and moving about within them: but it requires greater preciſion and exactneſs to be certain of this; ſince the ramifications of the great artery have very much the appearance of young worms, and they are kept in a ſort of continual motion by the ſyſtoles and diaſtoles of the ſeveral portions of the artery, which ſerve as ſo many hearts. It is very certain, that what we force in regard to theſe animals by our operations, is done alſo naturally every day in the brooks and ditches where they live. A curious obſerver will find in theſe places many of them without heads or tails, and ſome without either; as alſo other fragments of various kinds, all which are then in the act of completing themſelves: but whether accidents have reduced them to this ſtate, or they thus purpoſely throw off parts of their own body for the reproduction of more animals, it is not eaſy to determine. They are plainly liable to many accidents, by which they loſe the ſeveral parts of their body, and muſt periſh very early if they had not a power of reproducing what was loſt: they often are broken into two pieces, by the reſiſtance of ſome hard pieces of mud which they enter; and they are ſubject to a diſeaſe, a kind of gangrene, rotting off the ſeveral parts of their bodies, and muſt inevitably periſh by it, had they not this ſurpriſing property.

This worm was a ſecond inſtance, after the polype, of the ſurpriſing power in an animal of recovering its moſt eſſential parts when loſt. But Nature does not ſeem to have limited her beneficence in this reſpect to theſe two creatures. Mr Bonnet tried the ſame experiments on another ſpecies of water-worm, differing from the former in being much thicker. This kind of worm, when divided in the ſummer ſeaſon, very often ſhows the ſame property: for if it be cut into two or three pieces, the pieces will lie like dead for a long time, but afterwards will move about again; and will be found in this ſtate of reſt to have recovered a head, or a tail, or both. After recovering their parts, they move very little; and, according to this gentleman's experiments, ſeldom live more than a month.

It ſhould ſeem, that the more difficult ſucceſs of this laſt kind of worm, after cutting, and the long time it takes to recover the loſt parts, if it do recover them at all, is owing to its thickneſs; ſince we always find in that ſpecies of worms which ſucceeds beſt of all, that thoſe which are thinneſt always recover their parts much ſooner than the others.

The water-inſects alſo are not the only creatures which have this power of recovering their loſt parts. The earth affords us ſome already diſcovered to grow in this manner from their cuttings, and theſe not leſs deſerving our admiration than thoſe of the water: the common earth-worms are of this kind. Some of theſe worms have been divided into two, others into three or four pieces; and ſome of theſe pieces, after having paſſed two or three months without any appearance of life or motion, have then begun to reproduce a head or tail, or both. The reproduction of the anus, after ſuch a ſtate of reſt, is no long work; a few days do it: but it is otherwiſe with the head, that does not ſeem to perform its functions in the divided pieces till about ſeven months after the ſeparation. It is to be obſerved, that in all theſe operations both on earth and water-worms, the hinder part ſuffers greatly more than the fore part in the cutting; for it always twiſts itſelf about a long time, as if actuated by ſtrong convulſions; whereas the head

head usually crawls away without the appearance of any great uneasiness.

The reproduction of several parts of lobsters, crabs, &c. makes also one of the great curiosities in natural history. That, in lieu of an organical part of an animal broken off, another shall rise perfectly like it, may seem inconsistent with the modern system of generation, where the animal is supposed to be wholly formed in the egg. Yet has the matter of fact been well attested by the fishermen, and even by several virtuosos who have taken the point into examination, particularly M. de Reaumur and M. Perrault, whose skill and accuracy in things of this nature will hardly be questioned. The legs of lobsters, &c. consist each of five articulations: now, when any of the legs happen to break by any accident, as in walking, &c. which frequently happens, the fracture is always found to be in a part near the fourth articulation; and what they thus lose is precisely reproduced some time afterwards; that is, a part of a leg shoots out, consisting of four articulations, the first whereof has two claws as before; so that the loss is entirely repaired.

If a lobster's leg be broken off by design at the fourth or fifth articulation, what is thus broken off always comes again; but it is not so if the fracture be made in the first, second, or third articulation. In those cases, the reproduction is very rare if things continue as they are. But what is exceedingly surprising is, that they do not; for, upon visiting the lobster maimed in these barren and unhappy articulations, at the end of two or three days, all the other articulations are found broken off to the fourth; and it is suspected they have performed the operation on themselves, to make the reproduction of a leg certain.

The part reproduced is not only perfectly like that retrenched, but also, in a certain space of time, grows equal to it. Hence it is that we frequently see lobsters, which have their two big legs unequal, and that in all proportions. This shows the smaller leg to be a new one.

A part thus reproduced being broken, there is a second reproduction. The summer, which is the only season of the year when the lobsters eat, is the most favourable time for the reproduction. It is then performed in four or five weeks; whereas it takes up eight or nine months in any other season. The small legs are sometimes reproduced, but more rarely, as well as more slowly, than the great ones: the horns do the same. The experiment is most easily tried on the common crab.

REPTILES, in *Natural History*, a kind of animals denominated from their creeping or advancing on the belly. Or reptiles are those animals, which, instead of feet, rest on one part of the body, while they advance forward with the rest. Such are earthworms, snakes, caterpillars, &c. Indeed, most of the reptiles have feet; only those very small, and the legs short in proportion to the bulk of the body.

Naturalists observe a world of artful contrivance for the motion of reptiles. Thus, particularly in the earthworm, Dr Willis tells us, the whole body is only a chain of annular muscles; or, as Dr Derham says, it is only one continued spiral muscle, the orbicular fibres whereof being contracted, render each ring narrower and longer than before; by which means it is enabled, like the worm of an augre, to bore its passage into the earth. Its reptile motion might also be explained by a wire wound on a cylinder, which when slipped off, and one end extended and held fast, will bring the other near to it. So the earthworm having shot out or extended his body (which is with a wreathing), it takes hold by these small feet it hath, and so contracts the hinder part of its body. Dr Tyson adds, that when the forepart of the body is stretched out, and applied to a plane at a distance, the hind part relaxing and shortening is easily drawn towards it as a centre.

Its feet are disposed in a quadruple row the whole length of the worm, with which, as with so many hooks, it fastens down sometimes this and sometimes that part of the body to the plane, and at the same time stretches out or drags after it another.

The creeping of serpents is effected after a somewhat different manner; there being a difference in their structure, in that these last have a compages of bones articulated together.

The body here is not drawn together, but as it were complicated; part of it being applied on the rough ground, and the rest ejaculated and shot from it, which being set on the ground in its turn, brings the other after it. The spine of the back variously wreathed has the same effect in leaping, as the joints in the feet of other animals; they make their leaps by means of muscles, and extend the plicæ or folds. See ERPETOLOGY and OPHIOLOGY.

REPTILIA, the name of one of the orders of the class amphibia, including tortoises, frogs, lizards. See ERPETOLOGY.

REPUBLIC, or COMMONWEALTH, a popular state or government; or a nation where the people have the government in their own hands. See GOVERNMENT, ARISTOCRACY, DEMOCRACY, and MONARCHY.

REPUBLIC of Letters, a phrase used collectively of the whole body of the studious and learned people.

REPUDIATION, in the *Civil Law*, the act of divorcing. See DIVORCE.

REPULSION, in *Physics*, that property of bodies whereby they recede from each other, and, on certain occasions, mutually avoid coming into contact.

REPULSION, as well as attraction, has of late been considered as one of the primary qualities of all matter, and has been much used in explaining the phenomena of nature: thus the particles of air, fire, steam, electric fluid, &c. are all said to have a repulsive power with respect to one another.—That this is the case with the air, and vapour of all kinds, is certain; because when they are compressed into a small space, they expand with great force: but as to fire, light, and electricity, our experiments fail; nay, the supposition of a repulsive power among the particles of the electric fluid is inconsistent with the phenomena, as has been demonstrated under the article ELECTRICITY. Even in those fluids, air and steam, where a repulsive power most manifestly exists, it is demonstrable that the repulsion cannot be a *primary* quality, since it can be increased to a great degree by heat, and diminished by cold: but it is impossible that a *primary* quality of matter can be increased or diminished by any external circumstances whatever; for whatever property depends upon external circumstances, is not a primary but a secondary one.—The repulsion

pulſion of electrified bodies is explained under the article ELECTRICITY: that of others is leſs ſubject to inveſtigation; and the moſt that can be ſaid concerning it is, that in many caſes it ſeems to be the conſequence of a modification of fire, and in others of electricity.

REPUTATION means credit, honour, or the character of good; and ſince we are deſtined to live in ſociety, is neceſſary and uſeful more or leſs to every human being. There is no man, except one who is overgrown with pride and ſelf-conceit, or whoſe actions are bad, but pays attention to his reputation, and wiſhes to poſſeſs the good opinion of his neighbours or the world. The love of reputation and of fame are moſt powerful ſprings of action; but though they proceed from the ſame principle, the means of attaining them, and the effects of them, are not altogether the ſame.

Many means indeed ſerve equally to ſupport the reputation and to increaſe the fame, differing only in degrees; others, however, belong peculiarly either to the one or to the other. An honeſt reputation is within the reach of the bulk of mankind; it is obtained by the ſocial virtues and the conſtant practice of the common duties of life. This kind of reputation indeed is neither extenſive nor brilliant, but it is often the moſt uſeful in point of happineſs. Wit, talents, and genius, are the neceſſary requiſites for fame; but thoſe advantages are perhaps leſs real in their conſequences than thoſe ariſing from a good reputation. What is of real uſe coſts little; things rare and ſplendid require the greateſt labour to procure, and yield perhaps a more ideal happineſs.

Fame can be poſſeſſed, comparatively ſpeaking, but by few individuals; as it requires either very ſuperior abilities, ſupported by great efforts, or very fortunate circumſtances. It is conſtituted by the applauſe of mankind, or at leaſt by that of a ſingle nation; whilſt reputation is of much leſs extent, and ariſes from different circumſtances. That reputation which is founded on deceit and artifice is never ſolid; and the moſt honourable will always be found to be the moſt uſeful. Every one may ſafely, and indeed ought to, aſpire to the conſideration and praiſe due to his condition and merit; but he who aſpires to more, or who ſeeks it by diſhoneſt means, will at length meet with contempt.

REQUEST, in *Law*, a ſupplication or petition preferred to a prince, or to a court of juſtice; begging relief in ſome conſcionable caſes where the common law grants no immediate redreſs.

Court of REQUESTS (*curia requiſitionum*) was a court of equity, of the ſame nature with the court of chancery, but inferior to it; principally inſtituted for the relief of ſuch petitioners as in conſcionable caſes addreſſed themſelves by ſupplication to his majeſty. Of this court the lord privy-ſeal was chief judge, aſſiſted by the maſters of requeſts; and it had beginning about the 9 Hen. VII. according to Sir Julius Cæſar's tractate upon this ſubject: though Mr Gwyn, in his preface to his Readings, ſaith it began from a commiſſion firſt granted by King Henry VIII. This court, having aſſumed great power to itſelf, ſo that it became burthenſome, *Mich.* anno 40 and 41 *Eliz.* in the court of common-pleas it was adjudged upon ſolemn argument, that the court of requeſts was no court of judicature, &c. and by ſtat. 16 and 17 Car. I. cap. 10. it was taken away.

Blackſt. Comment.

There are ſtill courts of requeſts, or courts of conſcience, conſtituted in London and other trading and populous diſtricts for the recovery of ſmall debts. The firſt of theſe was eſtabliſhed in London ſo early as the reign of Henry VIII. by an act of their common council; which however was certainly inſufficient for that purpoſe, and illegal, till confirmed by ſtatute 3 Jac. I. c. 15. which has ſince been explained and amended by ſtatute 14 Geo. II. c. 10. The conſtitution is this: two aldermen and four commoners ſit twice a week to hear all cauſes of debt not exceeding the value of forty ſhillings; which they examine in a ſummary way, by the oath of the parties or other witneſſes, and make ſuch order therein as is conſonant to equity and good conſcience. The time and expence of obtaining this ſummary redreſs are very inconſiderable, which make it a great benefit to trade; and thereupon divers trading towns and other diſtricts have obtained acts of parliament for eſtabliſhing in them courts of conſcience upon nearly the ſame plan as that in the city of London.

By 25 Geo. III. c. 45. (which is confined to proſecutions in courts of conſcience in London, Middleſex, and the borough of Southwark), and by 26 Geo. III. c. 38. (which extends the proviſions of the former act to all other courts inſtituted for the recovery of ſmall debts), it is enacted, that after the firſt day of September 1786, no perſon whatſoever, being a debtor or defendant, and who has been or ſhall be committed to any gaol or priſon, by order of any court or commiſſioners authoriſed by any act or acts of parliament for conſtituting or regulating any court or courts for the recovery of ſmall debts, where the debt does not exceed twenty ſhillings, ſhall be kept or continued in cuſtody, on any pretence whatſoever, more than twenty days from the commencement of the laſt mentioned act; or from the time of his, her, or their commitment to priſon: and where the original debt does not amount to or exceed the ſum of forty ſhillings, more than forty days from the commencement of the ſaid act, or from the time of his, her, or their commitment as aforeſaid; and all gaolers are thereby required to diſcharge ſuch perſons accordingly. And by ſect. 2. if it ſhall be proved to the ſatisfaction of the court, that any ſuch debtor has money or goods which he has wilfully and fraudulently concealed: in that caſe the court ſhall have power to enlarge the aforeſaid times of impriſonment for debts under twenty ſhillings, to any time not exceeding thirty days, and for debts under forty ſhillings, to any time not exceeding ſixty days; which ſaid ground of farther detention ſhall be ſpecified in the ſaid commitment. And that (by ſect. 3.) at the expiration of the ſaid reſpective times of impriſonment, every ſuch perſon ſhall immediately be diſcharged, without paying any ſum of money, or other reward or gratuity whatſoever, to the gaoler of ſuch gaol on any pretence whatſoever; and every gaoler demanding or receiving any fee for the diſcharge of any ſuch perſon, or keeping any ſuch perſon priſoner after the ſaid reſpective times limited by the ſaid act, ſhall forfeit five pounds, to be recovered in a ſummary way before two juſtices of the peace, one moiety thereof to be paid to the overſeers of the poor of the pariſh where the offence ſhall be committed, and the other to the informer.

REQUIEM, in the Romiſh hiſtory, a maſs ſung for the reſt of the ſoul of a perſon deceaſed.

RESCISSION,

Refciffion || Refemblance.

RESCISSION, in the *Civil Law*, an action intended for the annulling or fetting afide any contract, deed, &c.

RESCRIPT, an anfwer delivered by an emperor, or a pope, when confulted by particular perfons on fome difficult queftion or point of law, to ferve as a decifion thereof.

RESEDA, a genus of plants belonging to the dodecandria clafs; and in the natural method ranking under the 54th order, *Mifcellaneæ*. See BOTANY *Index*. The *Luteola* or *Dyer's-weed*, *Yellow-weed*, *Weld*, or *Wild-woad*, is one of the moft valuable of the fpecies, on account of its extenfive ufe in dyeing. See DYEING. The *odorata* or mignionette is well known for the fweetnefs of its fragrance, and as an ornament of the flower-garden.

RESEMBLANCE *and* DISSIMILITUDE, the relations of likenefs and difference among objects. See COMPARISON.

Elem. of Criticifm.

The connection that man hath with the beings around him, requires fome acquaintance with their nature, their powers, and their qualities, for regulating his conduct. For acquiring a branch of knowledge fo effential to our well-being, motives alone of reafon and intereft are not fufficient: nature hath providentially fuperadded curiofity, a vigorous propenfity, which never is at reft. This propenfity alone attaches us to every new object †; and incites us to compare objects, in order to difcover their differences and refemblances.

† See *Novelty.*

Refemblance among objects of the fame kind, and diffimilitude among objects of different kinds, are too obvious and familiar to gratify our curiofity in any degree: its gratification lies in difcovering differences among things where refemblance prevails, and refemblances where difference prevails. Thus a difference in individuals of the fame kind of plants or animals, is deemed a difcovery, while the many particulars in which they agree are neglected; and in different kinds, any refemblance is greedily remarked, without attending to the many particulars in which they differ.

A comparifon of the former neither tends to gratify our curiofity, nor to fet the objects compared in a ftronger light: two apartments in a palace, fimilar in fhape, fize, and furniture, make feparately as good a figure as when compared; and the fame obfervation is applicable to two fimilar compartments in a garden: on the other hand, oppofe a regular building to a fall of water, or a good picture to a towering hill, or even a little dog to a large horfe, and the contraft will produce no effect. But a refemblance between objects of the fame kind, have remarkably an enlivening effect. The poets, fuch of them as have a juft tafte, draw all their fimilies from things that in the main differ widely from the principal fubject; and they never attempt a contraft, but where the things have a common genus, and a refemblance in the capital circumftances: place together a large and a fmall fized animal of the fame fpecies, the one will appear greater, the other lefs, than when viewed feparately: when we oppofe beauty to deformity, each makes a greater figure by the comparifon. We compare the drefs of different nations with curiofity, but without furprife; becaufe they have no fuch refemblance in the capital parts as to pleafe us by contrafting the fmaller parts. But a new cut of a fleeve, or of a pocket, enchants by its novelty; and, in oppofition to the former fafhion, raifes fome degree of furprife.

Refemblance.

That refemblance and diffimilitude have an enlivening effect upon objects of fight, is made fufficiently evident; and that they have the fame effect upon objects of the other fenfes, is alfo certain. Nor is that law confined to the external fenfes; for characters contrafted make a greater figure by the oppofition: Iago, in the tragedy of Othello, fays,

> He hath a daily beauty in his life
> That makes me ugly.

The character of a fop, and of a rough warrior, are nowhere more fuccefsfully contrafted than in Shakefpeare:

> *Hotfpur*. My liege, I did deny no prifoners:
> But I remember, when the fight was done,
> When I was dry with rage, and extreme toil,
> Breathlefs and faint, leaning upon my fword,
> Came there a certain lord, neat, trimly drefs'd,
> Frefh as a bridegroom; and his chin, new-reap'd,
> Show'd like a ftubble-land at harveft-home.
> He was perfumed like a milliner;
> And 'twixt his finger and his thumb he held
> A pouncet-box, which ever and anon
> He gave his nofe:—and ftill he fmil'd and talk'd;
> And as the foldiers bare dead bodies by,
> He call'd them untaught knaves, unmannerly,
> To bring a flovenly, unhandfome corfe
> Betwixt the wind and his nobility.
> With many holiday and lady terms
> He queftion'd me: among the reft, demanded
> My pris'ners, in your Majefty's behalf.
> I then, all fmarting with my wounds; being gall'd
> To be fo pefter'd with a popinjay,
> Out of my grief, and my impatience,
> Anfwer'd, neglectingly, I know not what:
> He fhould, or fhould not; for he made me mad,
> To fee him fhine fo brifk, and fmell fo fweet,
> And talk fo like a waiting gentlewoman,
> Of guns, and drums, and wounds, (God fave the mark!)
> And telling me, the fovereign'ft thing on earth
> Was parmacity for an inward bruife;
> And that it was great pity, fo it was,
> This villanous faltpetre fhould be digg'd
> Out of the bowels of the harmlefs earth,
> Which many a good, tall fellow had deftroy'd
> So cowardly: and but for thefe vile guns,
> He would himfelf have been a foldier.——
>
> *Firft part, Henry* IV. act i. fc. 4.

Paffions and emotions are alfo inflamed by comparifon. A man of high rank humbles the byftanders even to annihilate them in their own opinion: Cæfar, beholding the ftatue of Alexander, was greatly mortified, that now, at the age of 32, when Alexander died, he had not performed one memorable action.

Our opinions alfo are much influenced by comparifon. A man whofe opulence exceeds the ordinary ftandard is reputed richer than he is in reality; and wifdom or weaknefs, if at all remarkable in an individual, is generally carried beyond the truth.

The opinion a man forms of his prefent diftrefs is

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is heightened by contrasting it with his former happiness:

——————————Could I forget
What I have been, I might the better bear
What I'm destin'd to. I'm not the first
That have been wretched: but to think how much
I have been happier.

Southern's Innocent Adultery, act ii.

The distress of a long journey makes even an indifferent inn agreeable: and, in travelling, when the road is good, and the horseman well covered, a bad day may be agreeable, by making him sensible how snug he is.

The same effect is equally remarkable, when a man opposes his condition to that of others. A ship tossed about in a storm, makes the spectator reflect upon his own ease and security, and puts these in the strongest light.

A man in grief cannot bear mirth; it gives him a more lively notion of his unhappiness, and of course makes him more unhappy. Satan, contemplating the beauties of the terrestrial paradise, has the following exclamation:

With what delight could I have walk'd thee round,
If I could joy in ought, sweet interchange
Of hill and valley, rivers, woods, and plains,
Now land, now sea, and shores with forest crown'd,
Rocks, dens, and caves! but I in none of these
Find place or refuge; and the more I see
Pleasures about me, so much more I feel
Torment within me, as from the hateful siege
Of contraries: all good to me becomes
Bane, and in heav'n much worse would be my state.

Paradise Lost, book ix. l. 114.

The appearance of danger gives sometimes pleasure, sometimes pain. A timorous person upon the battlements of a high tower, is seized with fear, which even the consciousness of security cannot dissipate. But upon one of a firm head, this situation has a contrary effect: the appearance of danger heightens, by opposition, the consciousness of security, and consequently the satisfaction that arises from security: here the feeling resembles that above-mentioned, occasioned by a ship labouring in a storm.

The effect of magnifying or lessening objects by means of comparison is to be attributed to the influence of passion over our opinions. This will evidently appear by reflecting in what manner a spectator is affected, when a very large animal is for the first time placed beside a very small one of the same species. The first thing that strikes the mind is the difference between the two animals, which is so great as to occasion surprise; and this, like other emotions, magnifying its object, makes us conceive the difference to be the greatest that can be: we see, or seem to see, the one animal extremely little, and the other extremely large. The emotion of surprise arising from any unusual resemblance, serves equally to explain, why at first view we are apt to think such resemblance more entire than it is in reality. And it must be observed, that the circumstances of more and less, which are the proper subjects of comparison, raise a perception so indistinct and vague as to facilitate the effect described; we have no mental standard of great and little, nor of the several degrees of any attribute; and the mind, thus unrestrained, is naturally disposed to indulge its surprise to the utmost extent.

In exploring the operations of the mind, some of which are extremely nice and slippery, it is necessary to proceed with the utmost circumspection: and after all, seldom it happens that speculations of that kind afford any satisfaction. Luckily, in the present case, our speculations are supported by facts and solid argument. First, a small object of one species opposed to a great object of another, produces not, in any degree, that deception which is so remarkable when both objects are of the same species. The greatest disparity between objects of different kinds, is so common as to be observed with perfect indifference; but such disparity between the objects of the same kind being uncommon, never fails to produce surprise: and may we not fairly conclude, that surprise, in the latter case, is what occasions the deception, when we find no deception in the former? In the next place, if surprise be the sole cause of the deception, it follows necessarily that the deception will vanish as soon as the objects compared become familiar. This holds so unerringly, as to leave no reasonable doubt that surprise is the prime mover: our surprise is great, the first time a small lapdog is seen with a large mastiff; but when two such animals are constantly together, there is no surprise, and it makes no difference whether they be viewed separately or in company. We set no bounds to the riches of a man who has recently made his fortune; the surprising disproportion between his present and his past situation being carried to an extreme: but with regard to a family that for many generations hath enjoyed great wealth, the same false reckoning is not made. It is equally remarkable, that a trite simile has no effect: a lover compared to a moth scorching itself at the flame of a candle, originally a sprightly simile, has by frequent use lost all force; love cannot now be compared to fire, without some degree of disgust. It has been justly observed against Homer, that the lion is too often introduced into his similes; all the variety he is able to throw into them not being sufficient to keep alive the reader's surprise.

To explain the influence of comparison upon the mind, we have chosen the simplest case, viz. the first sight of two animals of the same kind, differing in size only; but to complete the theory, other circumstances must be taken in. And the next supposition we make, is where both animals, separately familiar to the spectator, are brought together for the first time. In that case, the effect of magnifying and diminishing is found remarkably greater than in that first mentioned; and the reason will appear upon analysing the operation: the first feeling we have is of surprise at the uncommon difference of two creatures of the same species; we are next sensible, that the one appears less, the other larger, than they did formerly; and that new circumstance increasing our surprise, makes us imagine a still greater opposition between the animals, than if we had formed no notion of them beforehand.

Let us make one other supposition, that the spectator was acquainted beforehand with one of the animals only; the lapdog, for example. This new circumstance will vary the effect; for, instead of widening the natural

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ral difference, by enlarging in appearance the one animal, and diminishing the other in proportion, the whole apparent alteration will rest upon the lapdog: the surprise to find it less than it appeared formerly, directs to it our whole attention, and makes us conceive it to be a most diminutive creature: the mastiff in the mean time is quite overlooked. To illustrate this effect by a familiar example. Take a piece of paper or of linen tolerably white, and compare it with a pure white of the same kind; the judgment we formed of the first object is instantly varied; and the surprise occasioned by finding it less white than was thought, produceth a hasty conviction that it is much less white than it is in reality: withdrawing now the pure white, and putting in its place a deep black, the surprise occasioned by that new circumstance carries us to the other extreme, and makes us conceive the object first mentioned to be a pure white; and thus experience compels us to acknowledge, that our emotions have an influence even upon our eye-sight. This experiment leads to a general observation, that whatever is found more strange and beautiful than was expected, is judged to be more strange and beautiful than it is in reality. Hence a common artifice, to depreciate beforehand what we wish to make a figure in the opinion of others.

The comparisons employed by poets and orators are of the kind last mentioned; for it is always a known object that is to be magnified or lessened. The former is effected by likening it to some grand object, or by contrasting it with one of an opposite character. To effectuate the latter, the method must be reversed: the object must be contrasted with something superior to it, or likened to something inferior. The whole effect is produced upon the principal object; which by that means is elevated above its rank, or depressed below it.

In accounting for the effect that any unusual resemblance or dissimilitude hath upon the mind, no cause has been mentioned but surprise; and to prevent confusion, it was proper to discuss that cause first. But surprise is not the only cause of the effect described: another occurs, which operates perhaps not less powerfully, viz. a principle in human nature that lies still in obscurity, not having been unfolded by any writer, though its effects are extensive: and as it is not distinguished by a proper name, the reader must be satisfied with the following description. Every man who studies himself or others, must be sensible of a tendency or propensity in the mind to complete every work that is begun, and to carry things to their full perfection. There is little opportunity to display that propensity upon natural operations, which are seldom left imperfect; but in the operations of art it hath great scope: it impels us to persevere in our own work, and to wish for the completion of what another is doing: we feel a sensible pleasure when the work is brought to perfection; and our pain is not less sensible when we are disappointed. Hence our uneasiness when an interesting story is broke off in the middle, when a piece of music ends without a close, or when a building or garden is left unfinished. The same propensity operates in making collections; such as the whole works, good and bad, of any author. A certain person attempted to collect prints of all the capital paintings, and succeeded except as to a few. La Bruyere remarks, that an anxious search was made for these; not for their value, but to complete the set.

The final cause of the propensity is an additional proof of its existence. Human works are of no significancy till they be completed; and reason is not always a sufficient counterbalance to indolence: some principle over and above is necessary to excite our industry, and to prevent our stopping short in the middle of the course.

We need not lose time to describe the co-operation of the foregoing propensity with surprise, in producing the effect that follows any unusual resemblance or dissimilitude. Surprise first operates, and carries our opinion of the resemblance or dissimilitude beyond truth. The propensity we have been describing carries us still farther; for it forces upon the mind a conviction, that the resemblance or dissimilitude is complete. We need no better illustration, than the resemblance that is fancied in some pebbles to a tree or an insect; which resemblance, however faint in reality, is conceived to be wonderfully perfect. The tendency to complete a resemblance acting jointly with surprise, carries the mind sometimes so far, as even to presume upon future events. In the Greek tragedy entitled *Phineides*, those unhappy women seeing the place where it was intended they should be slain, cried out with anguish, "They now saw their cruel destiny had condemned them to die in that place, being the same where they had been exposed in their infancy." *Arist. Poet. cap. 17.*

The propensity to advance every thing to its perfection, not only co-operates with surprise to deceive the mind, but of itself is able to produce that effect. Of this we see many instances where there is no place for surprise; and the first we shall give is of resemblance. *Unumquodque eodem modo dissolvitur quo colligatum est*, is a maxim in the Roman law that has no foundation in truth; for tying and loosing, building and demolishing, are acts opposite to each other, and are performed by opposite means: but when these acts are connected by their relation to the same subject, their connection leads us to imagine a sort of resemblance between them, which by the foregoing propensity is conceived to be as complete as possible. The next instance shall be of contrast. Addison observes, "That the palest features look the most agreeable in white; that a face which is overflushed appears to advantage in the deepest scarlet; and that a dark complexion is not a little alleviated by a black hood." *Spectator, N° 265.* The foregoing propensity serves to account for these appearances: to make this evident, one of the cases shall suffice. A complexion, however dark, never approaches to black: when these colours appear together, their opposition strikes us; and the propensity we have to complete the opposition, makes the darkness of complexion vanish out of sight.

The operation of this propensity, even where there is no ground for surprise, is not confined to opinion or conviction: so powerful it is, as to make us sometimes proceed to action, in order to complete a resemblance or dissimilitude. If this appear obscure, it will be made clear by the following instance. Upon what principle is the *lex talionis* founded, other than to make the punishment resemble the mischief? Reason dictates, that there ought to be a conformity or resemblance between

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tween a crime and its punishment; and the foregoing propensity impels us to make the resemblance as complete as possible. Titus Livius *, under the influence of that propensity, accounts for a certain punishment, by a resemblance between it and the crime too subtile for common apprehension. Speaking of Mettus Fuffetius, the Alban general, who, for treachery to the Romans his allies, was sentenced to be torn to pieces by horses, he puts the following speech in the mouth of Tullus Hostilius, who decreed the punishment. "*Mette Fuffeti, inquit, si ipse discere posses fidem ac fœdera servare, vivo tibi ea disciplina à me adhibita esset. Nunc, quoniam tuum insanabile ingenium est, at tu tuo supplicio doce humanum genus ea sancta credere, quæ à te violata sunt. Ut igitur paulo ante animum inter Fidenatem Romanamque rem ancipitem gessisti, ita jam corpus passim distrahendum dabis.*" By the same influence, the sentence is often executed upon the very spot where the crime was committed. In the *Electra* of Sophocles, Egistheus is dragged from the theatre into an inner room of the supposed palace, to suffer death where he murdered Agamemnon. Shakespeare, whose knowledge of nature is not less profound than extensive, has not overlooked this propensity:

* Lib. i. § 28.

"*Othello.* Get me some poison, Iago, this night. I'll not expostulate with her, lest her body and her beauty unprovide my mind again. This night, Iago."

"*Iago.* Do it not with poison; strangle her in her bed, even in the bed she hath contaminated."

"*Othello.* Good, good: the justice of it pleases: very good." *Othello*, act iv. sc. 5.

Persons in their last moments are generally seized with an anxiety to be buried with their relations. In the *Amynta* of Tasso, the lover, hearing that his mistress was torn to pieces by a wolf, expresses a desire to die the same death.

Upon the subject in general we have two remarks to add. The first concerns resemblance, which, when too entire, hath no effect, however different in kind the things compared may be. The remark is applicable to works of art only; for natural objects of different kinds have scarce ever an entire resemblance. To give an example in a work of art: Marble is a sort of matter very different from what composes an animal; and marble cut into a human figure, produces great pleasure by the resemblance: but if a marble statue be coloured like a picture, the resemblance is so entire as at a distance to make the statue appear a real person: we discover the mistake when we approach; and no other emotion is raised, but surprise occasioned by the deception: the figure still appears a real person, rather than an imitation; and we must use reflection to correct the mistake. This cannot happen in a picture; for the resemblance can never be so entire as to disguise the imitation.

The other remark belongs to contrast. Emotions make the greatest figure when contrasted in succession; but then the succession ought neither to be rapid, nor immoderately slow: if too slow, the effect of contrast becomes faint by the distance of the emotions; and if rapid, no single emotion has room to expand itself to its full size, but is stifled, as it were, in the birth by a succeeding emotion. The funeral oration of the bishop of Meaux upon the duchess of Orleans, is a perfect hodge-podge of cheerful and melancholy representations, following each other in the quickest succession: opposite emotions are best felt in succession; but each emotion separately should be raised to its due pitch, before another be introduced.

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What is above laid down, will enable us to determine a very important question concerning emotions raised by the fine arts, viz. Whether ought similar emotions to succeed each other, or dissimilar? The emotions raised by the fine arts are for the most part too nearly related to make a figure by resemblance; and for that reason their succession ought to be regulated as much as possible by contrast. This holds confessedly in epic and dramatic compositions; and the best writers, led perhaps by taste more than by reasoning, have generally aimed at that beauty. It holds equally in music: in the same cantata all the variety of emotions that are within the power of music, may not only be indulged, but, to make the greatest figure, ought to be contrasted. In gardening, there is an additional reason for the rule: the emotions raised by that art, are at best so faint, that every artifice should be employed to give them their utmost vigour: a field may be laid out in grand, sweet, gay, neat, wild, melancholy scenes; and when these are viewed in succession, grandeur ought to be contrasted with neatness, regularity with wildness, and gaiety with melancholy, so as that each emotion may succeed its opposite: nay, it is an improvement to intermix in the succession rude uncultivated spots as well as unbounded views, which in themselves are disagreeable, but in succession heighten the feeling of the agreeable object; and we have nature for our guide, which in her most beautiful landscapes often intermixes rugged rocks, dirty marshes, and barren stony heaths. The greatest masters of music have the same view in their compositions: the second part of an Italian song seldom conveys any sentiment: and, by its harshness, seems purposely contrived to give a greater relish for the interesting parts of the composition.

A small garden, comprehended under a single view, affords little opportunity for that embellishment. Dissimilar emotions require different tones of mind; and therefore in conjunction can never be pleasant: gaiety and sweetness may be combined, or wildness and gloominess; but a composition of gaiety and gloominess is distasteful. The rude uncultivated compartment of furze and broom in Richmond garden, hath a good effect in the succession of objects; but a spot of that nature would be insufferable in the midst of a polished parterre or flower-plot. A garden, therefore, if not of great extent, admits not dissimilar emotions; and in ornamenting a small garden, the safest course is to confine it to a single expression. For the same reason, a landscape ought also to be confined to a single expression; and accordingly it is a rule in painting, that if the subject be gay, every figure ought to contribute to that emotion.

It follows from the foregoing train of reasoning, that a garden near a great city ought to have an air of solitude. The solitariness, again, of a waste country ought to be contrasted in forming a garden; no temples, no obscure walks; but *jets d'eau*, cascades, objects active, gay, and splendid. Nay, such a garden should in some measure avoid imitating nature, by taking on an extraordinary

traordinary appearance of regularity and art, to ſhow the buſy hand of man, which in a waſte country has a fine effect by contraſt.

Wit and ridicule make not an agreeable mixture with grandeur. Diſſimilar emotions have a fine effect in a ſlow ſucceſſion; but in a rapid ſucceſſion, which approaches to co-exiſtence, they will not be reliſhed. In the midſt of a laboured and elevated deſcription of battle, Virgil introduces a ludicrous image, which is certainly out of its place:

> Obvius ambuſtum torrem Chorinæus ab ara
> Corripit, et venienti Ebuſo plagamque ferenti
> Occupat os flammis: illi ingens barba reluxit,
> Nidoremque ambuſta dedit. *Æn.* xii. 298.

> E qual tauro ferito, il ſuo dolore
> Verſo mugghiando e ſoſpirando fuore.
> *Gieruſal.* cant. iv. ſt. 1.

It would however be too auſtere to baniſh altogether ludicrous images from an epic poem. This poem doth not always ſoar above the clouds: it admits great variety; and upon occaſion can deſcend even to the ground without ſinking. In its more familiar tones, a ludicrous ſcene may be introduced without impropriety. This is done by Virgil * in a foot-race: the circumſtances of which, not excepting the ludicrous part, are copied from Homer †. After a fit of merriment, we are, it is true, the leſs diſpoſed to the ſerious and ſublime: but then, a ludicrous ſcene, by unbending the mind from ſevere application to more intereſting ſubjects, may prevent fatigue, and preſerve our reliſh entire.

* *Eneid*, lib. v.

† *Iliad*, xxiii. 879.

RESEN, (Moſes); a town on the Tigris, built by Nimrod; thought to be the *Lariſſa* of Xenophon; which ſee. But as *Lariſſa* is a name in imitation of a Greek city; and as there were no Greek cities, conſequently no *Lariſſa*, in Aſſyria, before Alexander the Great; it is probable that the Greeks aſking of what city thoſe were the ruins they ſaw, the Aſſyrians might anſwer, *Lareſen*, "Of *Reſen*;" which word Xenophon expreſſed by *Lariſſa*, a more familiar ſound to a Greek ear, (Wells).

RESENTMENT, means a ſtrong perception of good or ill, generally a deep ſenſe of injury, and may be diſtinguiſhed into *anger* and *revenge*. "By anger (ſays Archdeacon Paley), I mean the pain we ſuffer upon the receipt of an injury or affront, with the uſual effects of that pain upon ourſelves. By revenge, the inflicting of pain upon the perſon who has injured or offended us, farther than the juſt ends of puniſhment or reparation require. Anger prompts to revenge; but it is poſſible to ſuſpend the effect when we cannot altogether quell the principle. We are bound alſo to endeavour to qualify and correct the principle itſelf. So that our duty requires two different applications of the mind: and for that reaſon anger and revenge ſhould be conſidered ſeparately." See REVENGE.

RESERVATION, in *Law*, an action or clauſe whereby ſomething is reſerved, or ſecured to one's ſelf.

Mental RESERVATION, a propoſition which, ſtrictly taken, and according to the natural import of the terms, is falſe; but, if qualified by ſomething concealed in the mind, becomes true.

Mental reſervations are the great refuge of religious hypocrites, who uſe them to accommodate their conſciences with their intereſts: the Jeſuits are zealous advocates for mental reſervations; yet are they real lies, as including an intention to deceive.

RESERVE, in *Law*, the ſame with reſervation. See RESERVATION.

Body of RESERVE, or *Corps de RESERVE*, in military affairs, the third or laſt line of an army, drawn up for battle; ſo called becauſe they are reſerved to ſuſtain the reſt as occaſion requires, and not to engage but in caſe of neceſſity.

RESERVOIR, a place where water is collected and reſerved, in order to be conveyed to diſtant places through pipes, or ſupply a fountain or jet d'eau.

RESET, in *Law*, the receiving or harbouring an outlawed perſon. See OUTLAWRY.

RESET of Theft, in *Scots Law*. See LAW, N° clxxxvi. 29.

RESIDENCE, in the *Canon* and *Common Law*, the abode of a perſon or incumbent upon his benefice; and his aſſiduity in attending on the ſame.

RESIDENT, a public miniſter, who manages the affairs of a kingdom or ſtate, at a foreign court.

They are a claſs of public miniſters, inferior to ambaſſadors or envoys; but, like them, are under the protection of the law of nations.

RESIDUAL ANALYSIS, a calculus invented by Mr Landen, and propoſed as a ſubſtitute for the method of fluxions. The deſign of it was to avoid introducing the idea of motion, and of quantities infinitely ſmall, into mathematical inveſtigation. The reſidual analyſis accordingly proceeds, by taking the difference of the ſame function of a variable quantity in two different ſtates of that quantity, and denoting the relation of this difference to the difference between the two ſtates of the ſaid variable quantity. This relation being firſt generally expreſſed, is next conſidered in the caſe when the difference of the two ſtates of the variable quantity is $=0$; and by that means it is obvious, that the ſame thing is done as when the function of a variable quantity is aſſigned by the ordinary methods.

The evolutions of the functions, conſidered in this very general view, requires the aid of a new theorem, diſcovered by Mr Landen, and remarkable for its ſimplicity and great extent. It is, that

if x and v are any two variable quantities $\frac{x^{\frac{m}{n}}-v^{\frac{m}{n}}}{x-v}$

$$=x^{\frac{m}{n}-1}\times\frac{1+\frac{v}{x}+\frac{v^2}{x^2}+\frac{v^3}{x^3}+\cdots(m)}{1+\left(\frac{v}{x}\right)^{\frac{m}{n}}+\left(\frac{v}{x}\right)^{\frac{2m}{n}}+\left(\frac{v}{x}\right)^{\frac{3m}{n}}\cdots(n)}$$

where m and n are any integer numbers.

This theorem is the baſis of the calculus, and from the expreſſions $x^{\frac{m}{n}}-v^{\frac{m}{n}}$, and $x-v$ having the form of what algebraiſts denominate *reſiduals*, the inventor gave to his method the name of the *reſidual analyſis*.

Mr Landen publiſhed the firſt account of this method in 1758, which he denominated *A Diſcourſe concerning* the

Residual ‖ Resin.

the Residual Analysis. The first book of the analysis appeared in 1764, which contained an explanation of the principles of the new calculus, with its application to problems of the direct method of fluxions, and the second book solved several problems of the inverse method, but it was never published.

If we estimate the value of this analysis by its practical utility, it may be said to possess no great merit. Its principles are much less easily apprehended than the fluxionary calculus; they are not so luminous, and less direct in their application, as well as inferior to it for enlarging the boundaries of mathematical science.

RESIDUAL Figure, in *Geometry*, the figure remaining after the subtraction of the less from the greater.

RESIDUAL Root, is a root composed of two members only connected by the sign — or minus. Thus, $a-b$, or $5-3$, is a residual root; and is so called, because its true value is no more than the residue, or difference between the parts a and b or 5 and 3, which in this case is 2.

RESIDUE, the remainder or balance of an account, debt, or obligation.

RESIGNATION, in general, signifies the implicit submission of ourselves, or of something we possess, to the will of another. In a religious sense it signifies a perfect submission, without discontent, to the will of God. See MORAL PHILOSOPHY, N° 119.

RESIN, in *Natural History*, a viscid juice oozing either spontanoously, or by incision, from several trees, as the pine, fir, &c.—A premium for several years has been offered by the London Society for Encouraging Arts, &c. for discovering a mode of reducing the inflammable quality of resin, so as to adapt it to the purposes of making candles; but no such discovery has yet been made.

Elastic RESIN. See CAOUTCHOUC, CHEMISTRY *Index*.

Gum RESIN, a mixture of gum and resin. See CHEMISTRY and MATERIA MEDICA *Index*.

Red Gum RESIN, is procured from the red gum tree, or eucalyptus resinifera; a tree so large and lofty as to exceed in size the English oak. The wood of the tree is brittle, and of little use but for firewood, from the large quantity of resinous gum it contains. The tree is distinguished by having pedunculated flowers, and an acute or pointed conical calyptra. To obtain the juice from this tree incisions are made in the trunk of it, and sometimes upwards of 60 gallons of red resinous juice have been obtained from one of them. "When this juice is dried, it becomes a very powerful astringent gum-resin, of a red colour, much resembling that known in the shops by the name of *kino*, and, for all medical purposes, fully as efficacious. Mr White administered it to a great number of patients in the dysentery, which prevailed much soon after the landing of the convicts, and in no one instance found it to fail. This gum-resin dissolves almost entirely in spirit of wine, to which it gives a blood-red tincture. Water dissolves about one-sixth part only, and the watery solution is of a bright red. Both these solutions are powerfully astringent." *White's Voyage, Appendix.*

Yellow Gum RESIN, is procured from the yellow resin tree, which is as large as the English walnut tree. The properties of this resin are equal to those of the most fragrant balsams. It exudes from the bark spontaneously, but more readily if incisions are made. The colour of it is yellow, and at first it is fluid; but after being inspissated in the sun, it becomes solid. When burnt on hot coals, it smells like a mixture of balsam of Tolu and benzoin, approaching somewhat to storax. "It is perfectly soluble in spirit of wine, but not in water, nor even in essential oil of turpentine, unless it be digested in a strong heat. The varnish which it makes with either is very weak, and of little use. With respect to its medicinal qualities, Mr White has found it, in many cases, a good pectoral medicine, and very balsamic. It is not obtainable in so great abundance as the red gum produced by the eucalyptus resinifera. The plant which produces the yellow gum seems to be perfectly unknown to botanists, but Mr White has communicated no specimens by which its genus or even class could be determined." *White's Voyage, Appendix.*

Resin, ‖ Resistance.

RESINOUS ELECTRICITY, is that kind of electricity which is produced by exciting bodies of the resinous kind, and which is generally negative. See ELECTRICITY *passim*.

RESISTANCE, or *RESISTING Force*, in *Philosophy*, denotes, in general, any power which acts in an opposite direction to another, so as to destroy or diminish its effect. See MECHANICS, HYDRODYNAMICS, and PNEUMATICS.

1 Importance of the subject.

Of all the resistances of bodies to each, there is undoubtedly none of greater importance than the resistance or reaction of fluids. It is here that we must look for a theory of naval architecture, for the impulse of the air is our moving power, and this must be modified so as to produce every motion we want by the form and disposition of our sails; and it is the resistance of the water which must be overcome, that the ship may proceed in her course; and this must also be modified to our purpose, that the ship may not drive like a log to leeward, but on the contrary may ply to windward, that she may answer her helm briskly, and that she may be easy in all her motions on the surface of the troubled ocean. The impulse of wind and water makes them ready and indefatigable servants in a thousand shapes for driving our machines; and we should lose much of their service did we remain ignorant of the laws of their action: they would sometimes become terrible masters, if we did not fall upon methods of eluding or softening their attacks.

2 The ancients were tolerably well acquainted with it.

We cannot refuse the ancients a considerable knowledge of this subject. It was equally interesting to them as to us; and we cannot read the accounts of the naval exertions of Phœnicia, Carthage, and of Rome, exertions which have not been surpassed by any thing of modern date, without believing that they possessed much practical and experimental knowledge of this subject. It was not, perhaps, possessed by them in a strict and systematic form, as it is now taught by our mathematicians; but the master-builders, in their dockyards, did undoubtedly exercise their genius in comparing the forms of their finest ships, and in marking those circumstances of form and dimension which were *in fact* accompanied with the desirable properties of a ship, and thus framing to themselves maxims of naval architecture in the same manner as we do now. For we believe that our naval architects are not disposed to grant

Reſiſtance.

grant that they have profited much by all the labours of the mathematicians. But the ancients had not made any great progreſs in the phyſicomathematical ſciences, which conſiſt chiefly in the application of calculus to the phenomena of nature. In this branch they could make none, becauſe they had not the means of inveſtigation. A knowledge of the motions and actions of fluids is acceſſible only to thoſe who are familiarly acquainted with the fluxionary mathematics; and without this key there is no admittance. Even when poſſeſſed of this guide, our progreſs has been very ſlow, heſitating, and devious; and we have not yet been able to eſtabliſh any ſet of doctrines which are ſuſceptible of an eaſy and confident application to the arts of life. If we have advanced farther than the ancients, it is becauſe we have come after them, and have profited by their labours, and even by their miſtakes.

3 But even now it is not perfectly underſtood.

4 Sir I. Newton firſt applied mathematics to it.

Sir Iſaac Newton was the firſt (as far as we can recollect) who attempted to make the motions and actions of fluids the ſubject of mathematical diſcuſſion. He had invented the method of fluxions long before he engaged in his phyſical reſearches; and he proceeded in theſe *ſuâ matheſi facem præferente.* Yet even with this guide he was often obliged to grope his way, and to try various bye-paths, in the hopes of obtaining a legitimate theory. Having exerted all his powers in eſtabliſhing a theory of the lunar motions, he was obliged to reſt contented with an approximation inſtead of a perfect ſolution of the problem which aſcertains the motions of three bodies mutually acting on each other. This convinced him that it was in vain to expect an accurate inveſtigation of the motions and actions of fluids, where millions of unſeen particles combine their influence. He therefore caſt about to find ſome particular caſe of the problem which would admit of an accurate determination, and at the ſame time furniſh circumſtances of analogy or reſemblance ſufficiently numerous for giving limiting caſes, which ſhould include between them thoſe other caſes that did not admit of this accurate inveſtigation. And thus, by knowing the limit to which the caſe propoſed did approximate, and the circumſtance which regulated the approximation, many uſeful propoſitions might be deduced for directing us in the application of theſe doctrines to the arts of life.

5 Difficulties he met with in it.

6 He propoſed a theory,

He therefore figured to himſelf a hypothetical collection of matter which poſſeſſed the characteriſtic property of fluidity, viz. the *quâquâverſum* propagation of preſſure, and the moſt perfect intermobility (pardon the uncouth term) of parts, and which formed a phyſical whole or aggregate, whoſe parts were connected by mechanical forces, determined both in degree and in direction, and ſuch as rendered the determination of certain important circumſtances of their motion ſuſceptible of preciſe inveſtigation. And he concluded, that the laws which he ſhould diſcover in theſe motions muſt have a great analogy with the laws of the motions of real fluids: And from this hypotheſis he deduced a ſeries of propoſitions, which form the baſis of almoſt all the theories of the impulſe and reſiſtance of fluids which have been offered to the public ſince his time.

7 which does not, however, agree with experiment.

It muſt be acknowledged, that the reſults of this theory agree but ill with experiment, and that, *in the way in which it has been zealouſly proſecuted by ſubſequent mathematicians,* it proceeds on principles or aſſumptions which are not only gratuitous, but even falſe. But it affords ſuch a beautiful application of geometry and calculus, that mathematicians have been as it were faſcinated by it, and have publiſhed ſyſtems ſo elegant and ſo extenſively applicable, that one cannot help lamenting that the foundation is ſo flimſy. John Bernoulli's theory, in his diſſertation on the communication of motion, and Bouguer's in his *Traité du Navire*, and in his *Theorie du Manœuvre et de la Mâture des Vaiſſeaux*, muſt ever be conſidered as among the fineſt ſpecimens of phyſicomathematical ſcience which the world has ſeen. And, with all its imperfections, this theory ſtill furniſhes (as was expected by its illuſtrious author) many propoſitions of immenſe practical uſe, they being the limits to which the real phenomena of the impulſe and reſiſtance of fluids really approximate. So that when the law by which the phenomena deviate from the theory is once determined by a well choſen ſeries of experiments, this hypothetical theory becomes almoſt as valuable as a true one. And we may add, that although Mr d'Alembert, by treading warily in the ſteps of Sir Iſaac Newton in another route, has diſcovered a genuine and unexceptionable theory, the proceſs of inveſtigation is ſo intricate, requiring every fineſſe of the moſt abſtruſe analyſis, and the final equations are ſo complicated, that even their moſt expert author has not been able to deduce more than one ſimple propoſition (which too was diſcovered by Daniel Bernoulli by a more ſimple proceſs) which can be applied to any uſe. The hypothetical theory of Newton, therefore, continues to be the groundwork of all our practical knowledge of the ſubject.

8 But its utility is ſtill very conſiderable.

We ſhall therefore lay before our readers a very ſhort view of the theory, and the manner of applying it. We ſhall then ſhow its defects (all of which were pointed out by its great author), and give a hiſtorical account of the many attempts which have been made to amend it or to ſubſtitute another: in all which we think it our duty to ſhow, that Sir Iſaac Newton took the lead, and pointed out every path which others have taken, if we except Daniel Bernoulli and d'Alembert; and we ſhall give an account of the chief ſets of experiments which have been made on this important ſubject, in the hopes of eſtabliſhing an empirical theory, which may be employed with confidence in the arts of life.

9 The term reſiſtance, as here applied, explained.

We know by experience that force muſt be applied to a body in order that it may move through a fluid, ſuch as air or water; and that a body projected with any velocity is gradually retarded in its motion, and generally brought to reſt. The analogy of nature makes us imagine that there is a force acting in the oppoſite direction, or oppoſing the motion, and that this force reſides in, or is exerted by, the fluid. And the phenomena reſemble thoſe which accompany the known reſiſtance of active beings, ſuch as animals. Therefore we give to this ſuppoſed force the metaphorical name of RESISTANCE. We alſo know that a fluid in motion will hurry a ſolid body along with the ſtream, and that it requires force to maintain it in its place. A ſimilar analogy makes us ſuppoſe that the fluid exerts force, in the ſame manner as when an active being impels the body before him; therefore we call this the *IMPULSION of a Fluid.* And as our knowledge of nature

Resistance.

ture informs us that the mutual actions of bodies are in every case equal and opposite, and that the observed change of motion is the only indication, characteristic, and measure, of the changing force, the forces are the same (whether we call them impulsions or resistances) when the relative motions are the same, and therefore depend entirely on these relative motions. The force, therefore, which is necessary for keeping a body immoveable in a stream of water, flowing with a certain velocity, is the same with what is required for moving this body with this velocity through stagnant water. To any one who admits the motion of the earth round the sun, it is evident that we can neither observe nor reason from a case of a body moving through still water, nor of a stream of water pressing upon or impelling a quiescent body.

A body in motion appears to be resisted by a stagnant fluid, because it is a law of mechanical nature that force must be employed in order to put any body in motion. Now the body cannot move forward without putting the contiguous fluid in motion, and force must be employed for producing this motion. In like manner, a quiescent body is impelled by a stream of fluid, because the motion of the contiguous fluid is diminished by this solid obstacle; the resistance, therefore, or impulse, no way differs from the ordinary communications of motion among solid bodies.

10 Sir Isaac Newton supposes two systems similar in their parts, and each part having a constant ratio to each.

Sir Isaac Newton, therefore, begins his theory of the resistance and impulse of fluids, by selecting a case where, although he cannot pretend to ascertain the motions themselves which are produced in the particles of a contiguous fluid, he can tell precisely their mutual ratios.

He supposes two systems of bodies such, that each body of the first is similar to a corresponding body of the second, and that each is to each in a constant ratio. He also supposes them to be similarly situated, that is, at the angles of similar figures, and that the homologous lines of these figures are in the same ratio with the diameters of the bodies. He farther supposes, that they attract or repel each other in similar directions, and that the accelerating connecting forces are also proportional; that is, the forces in the one system are to the corresponding forces in the other system in a constant ratio, and that, in each system taken apart, the forces are as the squares of the velocities directly, and as the diameters of the corresponding bodies, or their distances, inversely.

11 Effect of the similar parts being put in motion.

This being the case, it legitimately follows, that if similar parts of the two systems are put into similar motions, in any given instant, they will *continue* to move similarly, each correspondent body describing similar curves, with proportional velocities: For the bodies being similarly situated, the forces which act on a body in one system, arising from the combination of any number of adjoining particles, will have the same direction with the force acting on the corresponding body in the other system, arising from the combined action of the similar and similarly directed forces of the adjoining correspondent bodies of the other system; and these compound forces will have the same ratio with the simple forces which constitute them, and will be as the squares of the velocities directly, and as the distances, or any homologous lines inversely; and therefore the chords of curvature, having the direction of the centripetal or centrifugal forces, and similarly inclined to the tangents of the curves described by the corresponding bodies, will have the same ratio with the distances of the particles. The curves described by the corresponding bodies will therefore be similar, the velocities will be proportional, and the bodies will be similarly situated at the end of the first moment, and exposed to the action of similar and similarly situated centripetal or centrifugal forces; and this will again produce similar motions during the next moment, and so on for ever. All this is evident to any person acquainted with the elementary doctrines of curvilinear motions, as delivered in the theory of physical astronomy.

12 Consequence deduced from it.

From this fundamental proposition, it clearly follows, that if two similar bodies, having their homologous lines proportional to those of the two systems, be similarly projected among the bodies of those two systems with any velocities, they will produce similar motions in the two systems, and will themselves continue to move similarly; and therefore will, in every subsequent moment, suffer similar diminutions or retardations. If the initial velocities of projection be the same, but the densities of the two systems, that is, the quantities of matter contained in an equal bulk or extent, be different, it is evident that the quantities of motion produced in the two systems in the same time will be proportional to the densities; and if the densities are the same, and uniform in each system, the quantities of motion produced will be as the squares of the velocities, because the motion communicated to each corresponding body will be proportional to the velocity communicated, that is, to the velocity of the impelling body; and the number of similarly situated particles which will be agitated will also be proportional to this velocity. Therefore, the whole quantities of motion produced in the same moment of time will be proportional to the squares of the velocities. And lastly, if the densities of the two systems are uniform, or the same through the whole extent of the systems, the number of particles impelled by similar bodies will be as the surfaces of these bodies.

Now the diminutions of the motions of the projected bodies are (by Newton's third law of motion) equal to the motions produced in the systems; and these diminutions are the measures of what are called the resistances opposed to the motions of the projected bodies. Therefore, combining all these circumstances, the resistances are proportional to the similar surfaces of the moving bodies, to the densities of the systems through which the motions are performed, and to the squares of the velocities, jointly.

13 A fluid considered as a system of small bodies similarly arranged.

We cannot form to ourselves any distinct notion of a fluid, otherwise than as a system of small bodies, or a collection of particles, similarly or symmetrically arranged, the centres of each being situated in the angles of regular solids. We must form this notion of it, whether we suppose, with the vulgar, that the particles are little globules in mutual contact, or, with the partisans of corpuscular attractions and repulsions, we suppose the particles kept at a distance from each other by means of these attractions and repulsions mutually balancing each other. In this last case, no other arrangement is consistent with a quiescent equilibrium; and in this case, it is evident, from the theory of curvilinear motions, that the agitations

Resistance. tations of the particles will always be such, that the connecting forces, in actual exertion, will be proportional to the squares of the velocities directly, and to the chords of the curvature having the direction of the forces inversely.

14 First law of the resistance, &c. of fluids. PROP. I. The resistances, and (by the third law of motion), the impulsions of fluids on similar bodies, are proportional to the surfaces of the solid bodies, to the densities of the fluids, and to the squares of the velocities, jointly.

We must now observe, that when we suppose the particles of the fluid to be in mutual contact, we may either suppose them elastic or unelastic. The motion communicated to the collection of elastic particles must be double of what the same body, moving in the same manner, would communicate to the particles of an elastic fluid. The impulse and resistance of elastic fluids must therefore be double of those of unelastic fluids.—But we must caution our readers not to judge of the elasticity of fluids by their sensible compressibility. A diamond is incomparably more elastic than the finest foot ball, though not compressible in any sensible degree.—It remains to be decided, by well chosen experiments, whether water be not as elastic as air. If we suppose, with Boscovich, the particles of perfect fluids to be at a distance from each other, we shall find it difficult to conceive a fluid void of elasticity. We hope that the theory of their impulse and resistance will suggest experiments which will decide this question, by pointing out what ought to be the absolute impulse or resistance in either case. And thus the fundamental proposition of the impulse and resistance of fluids, taken in its proper meaning, is susceptible of a rigid demonstration, relative to the only distinct notion that we can form of the internal constitution of a fluid. We say, *taken in its proper meaning*; namely, that the impulse or resistance of fluids is a pressure, opposed and measured by another pressure, such as a pound weight, the force of a spring, the pressure of the atmosphere, and the like. And we apprehend that it would be very difficult to find any legitimate demonstration of this leading proposition different from this, which we have now borrowed from Sir Isaac Newton, Prop. 23. B. II. *Princip.* We acknowledge that it is prolix and even circuitous: but in all the attempts made by his commentators and their copyists to simplify it, we see great defects of logical argument, or assumption of principles, which are not only gratuitous, but inadmissible. We shall have occasion, as we proceed, to point out some of these defects; and doubt not but the illustrious author of this demonstration had exercised his uncommon patience and sagacity in similar attempts, and was dissatisfied with them all.

15 Elasticity of water.

Before we proceed farther, it will be proper to make a general remark, which will save a great deal of discussion. Since it is a matter of universal experience, that every action of a body on others is accompanied by an equal and contrary re action; and since all that we can demonstrate concerning the resistance of bodies during their motions through fluids proceeds on this supposition, (the resistance of the body being *assumed* as equal and opposite to the sum of motions communicated to the particles of the fluid, estimated in the direction of the bodies motion), we are intitled to proceed in the contrary order, and to consider the impulsions which each of the particles of fluid exerts on the body at rest, as equal and opposite to the motion which the body would communicate to that particle if the fluid were at rest, and the body were moving equally swift in the opposite direction. And therefore the whole impulsion of the fluid must be conceived as the measure of the whole motion which the body would thus communicate to the fluid. It must therefore be also considered as the measure of the resistance which the body, moving with the same velocity, would sustain from the fluid. When, therefore, we shall demonstrate any thing concerning the impulsion of a fluid, estimated in the direction of its motion, we must consider it as demonstrated concerning the resistance of a quiescent fluid to the motion of that body, having the same velocity in the opposite direction. The determination of these impulsions being much easier than the determination of the motions communicated by the body to the particles of the fluid, this method will be followed in most of the subsequent discussions.

The general proposition already delivered is by means sufficient for explaining the various important phenomena observed in the mutual actions of solids and fluids. In particular, it gives us no assistance in ascertaining the modifications of this resistance or impulse, which depend on the shape of the body and the inclination of its impelled or resisted surface to the direction of the motion. Sir Isaac Newton found another hypothesis necessary; namely, that the fluid should be so extremely rare that the distance of the particles may be incomparably greater than their diameters. This additional condition is necessary for considering their actions as so many separate collisions or impulsions on a solid body. Each particle must be supposed to have abundant room to rebound, or otherwise escape, after having made its stroke, without sensibly affecting the situations and motions of the particles which have not yet made their stroke: and the motion must be so swift as not to give time for the sensible exertion of their mutual forces of attractions and repulsions.

Keeping these conditions in mind, we may proceed to determine the impulsions made by a fluid on surfaces of every kind: And the most convenient method to pursue in this determination, is to compare them all either with the impulse which the *same surface* would receive from the fluid impinging on it perpendicularly, or with the impulse which the *same stream of fluid* would make when coming perpendicularly on a surface of such extent as to occupy the whole stream.

It will greatly abbreviate language, if we make use of a few terms in an appropriated sense. 16 Terms explained.

By a *stream*, we shall mean a quantity of fluid moving in one direction, that is, each particle moving in parallel lines; and the *breadth* of the stream is a line perpendicular to all these parallels.

A *filament* means a portion of this stream of very small breadth, and it consists of an indefinite number of particles following one another in the same direction, and successively impinging on, or gliding along, the surface of the solid body.

The *base* of any surface exposed to a stream of fluid, is that portion of a plane perpendicular to the stream, which is covered or protected from the action of the stream

Resistance. Plate CCCCLXI. Fig. 1.

ſtream by the ſurface expoſed to its impulſe. Thus the baſe of a ſphere expoſed to a ſtream of fluid is its great circle, whoſe plane is perpendicular to the ſtream. If BC (fig. 1.) be a plane ſurface expoſed to the action of a ſtream of fluid, moving in the direction DC, then BR, or SE, perpendicular to DC, is its baſe.

Direct impulſe ſhall expreſs the energy or action of the particle or filament, or ſtream of fluid, when meeting the ſurface perpendicularly, or when the ſurface is perpendicular to the direction of the ſtream.

Abſolute impulſe means the actual preſſure on the impelled ſurface, ariſing from the action of the fluid, whether ſtriking the ſurface perpendicularly or obliquely; or it is the force impreſſed on the ſurface, or tendency to motion which it acquires, and which muſt be oppoſed by an equal force in the oppoſite direction, in order that the ſurface may be maintained in its place. It is of importance to keep in mind, that this preſſure is always perpendicular to the ſurface. It is a propoſition founded on univerſal and uncontradicted experience, that the mutual actions of bodies on each other are always exerted in a direction perpendicular to the touching ſurfaces. Thus, it is obſerved, that when a billiard ball A is ſtruck by another B, moving in any direction whatever, the ball A always moves off in the direction perpendicular to the plane which touches the two balls in the point of mutual contact, or point of impulſe. This inductive propoſition is ſupported by every argument which can be drawn from what we know concerning the forces which connect the particles of matter together, and are the immediate cauſes of the communication of motion. It would employ much time and room to ſtate them here; and we apprehend that it is unneceſſary: for no reaſon can be aſſigned why the preſſure ſhould be in *any particular* oblique direction. If any one ſhould ſay that the impulſe will be in the direction of the ſtream, we have only to deſire him to take notice of the effect of the rudder of a ſhip. This ſhows that the impulſe *is not in the direction of the ſtream*, and is therefore in ſome direction tranſverſe to the ſtream.—He will alſo find, that when a plane ſurface is impelled obliquely by a fluid, there is no direction in which it can be ſupported but the direction perpendicular to itſelf. It is quite ſafe, in the mean time, to take it as an experimental truth. We may, perhaps, in ſome other part of this work, give what will be received as a rigorous demonſtration.

Relative or effective impulſe means the preſſure on the ſurface eſtimated in ſome particular direction. Thus BC (fig. 1.) may repreſent the ſail of a ſhip, impelled by the wind blowing in the direction DC. GO may be the direction of the ſhip's keel, or the line of her courſe. The wind ſtrikes the ſail in the direction GH parallel to DC; the ſail is urged or preſſed in the direction GI, perpendicular to BC. But we are intereſted to know what tendency this will give the ſhip to move in the direction GO. This is the effective or relative impulſe. Or BC may be the tranſverſe ſection of the ſail of a common wind-mill. This, by the conſtruction of the machine, can move only in the direction GP, perpendicular to the direction of the wind; and it is only in this direction that the impulſe produces the deſired effect. Or BC may be half of the prow of a punt or lighter, riding at anchor by means of the cable DC, attached to the prow C. In this caſe, GQ, parallel to DC, is that part of the abſolute impulſe which is employed in ſtraining the cable.

The *angle of incidence* is the angle FGC contained between the direction of the ſtream FG and the plane BC.

The *angle of obliquity* is the angle OGC contained between the plane and the direction GO, in which we wiſh to eſtimate the impulſe.

17 Second law of reſiſtance.

PROP. II. The direct impulſe of a fluid on a plane ſurface, is to its abſolute oblique impulſe on the ſame ſurface, as the ſquare of the radius to the ſquare of the ſine of the angle of incidence.

Let a ſtream of fluid, moving in the direction DC, (fig. 1.), act on the plane BC. With the radius CB deſcribe the quadrant ABE; draw CA perpendicular to CE, and draw MNBS parallel to CE. Let the particle F, moving in the direction FG, meet the plane in G, and in FG produced take GH to repreſent the magnitude of the direct impulſe, or the impulſe which the particle would exert on the plane AC, by meeting it in V. Draw GI and HK perpendicular to BC, and HI perpendicular to GI. Alſo draw BR perpendicular to DC. (Fig. 1.)

The force GH is equivalent to the two forces GI and GK; and GK being in the direction of the plane has no ſhare in the impulſe. The abſolute impulſe, therefore, is repreſented by GI; the angle GHI is equal to FGC, the angle of incidence; and therefore GH is to GI as radius to the ſine of the angle of incidence: Therefore the direct impulſe of each particle or filament is to its abſolute oblique impulſe as radius to the ſine of the angle of incidence. But further, the number of particles or filaments which ſtrike the ſurface AC, is to the number of thoſe which ſtrike the ſurface BC as AC to NC: for all the filaments between LA and MB go paſt the oblique ſurface BC without ſtriking it. But BC : NC = rad. : ſin. NBC, = rad. : ſin. FGC, = rad. : ſin. incidence. Now the whole impulſe is as the impulſe of each filament, and as the number of filaments exerting equal impulſes jointly; therefore the whole direct impulſe on AC is to the whole abſolute impulſe on BC, as the ſquare of radius to the ſquare of the ſine of the angle of incidence.

Let S expreſs the extent of the ſurface, i the angle of incidence, o the angle of obliquity, v the velocity of the fluid, and d its denſity. Let F repreſent the direct impulſe, f the abſolute oblique impulſe, and φ the relative or effective impulſe: And let the tabular ſines and coſines be conſidered as decimal fractions of the radius unity.

This propoſition gives us $F : f = R^2 : \text{Sin.}^2\, i, = 1 : \text{Sin.}^2\, i$, and therefore $f = F \times \text{Sin.}^2\, i$. Alſo, becauſe impulſes are in the proportion of the extent of ſurface ſimilarly impelled, we have, in general, $f = FS \times \text{Sin.}^2, i$.

The firſt who publiſhed this theorem was Pardies, in his *Oeuvres de Mathematique*, in 1673. We know that Newton had inveſtigated the chief propoſitions of the Principia before 1670.

18 Third law.

PROP. III. The direct impulſe on any ſurface is to the effective oblique impulſe on the ſame ſurface, as the cube of radius to the ſolid, which has for its baſe the ſquare of the ſine of incidence, and the ſine of obliquity for its height.

For,

For, when GH repreſents the direct impulſe of a particle, GI is the abſolute oblique impulſe, and GO is the effective impulſe in the direction GO: Now GI is to GO as radius to the ſine of GIO, and GIO is the complement of IGO, and is therefore equal to CGO, the angle of obliquity.

$$\text{Therefore } f : \varphi = \text{R} : \text{Sin. O.}$$
$$\text{But } \quad \text{F} : f = \text{R}^2 : \text{Sin.}^2 i$$
$$\text{Therefore F} : \varphi = \text{R}^3 : \text{Sin.}^2 i \times \text{Sin. O. and}$$
$$\varphi = \text{F} \times \text{Sin.}^2 i \times \text{Sin. O.}$$

19 Proportion of the direct impulſe to the effective oblique impulſe.

Cor.—The direct impulſe on any ſurface is to the effective oblique impulſe in the direction of the ſtream, as the cube of radius to the cube of the ſine of incidence. For draw IQ and GP perpendicular to GH, and IP perpendicular to GP; then the abſolute impulſe GI is equivalent to the impulſe GQ in the direction of the ſtream, and GP, which may be called the tranſverſe impulſe. The angle GIQ is evidently equal to the angle GHI, or FGC, the angle of incidence.

$$\text{Therefore } f : \varphi = \text{GI} : \text{GQ}, = \text{R} : \text{Sin. } i.$$
$$\text{But } \quad \text{F} : f = \quad \text{R}^2 : \text{Sin.}^2 i.$$
$$\text{Therefore F} : \varphi = \quad \text{R}^3 : \text{Sin.}^3 i.$$
$$\text{And } \varphi = \text{F} \times \text{Sin.}^3 i.$$

10 Impulſe on a ſurface in motion.

Before we proceed further, we ſhall conſider the impulſe on a ſurface which is alſo in motion. This is evidently a frequent and an important caſe. It is perhaps the moſt frequent and important: It is the caſe of a ſhip under ſail, and of a wind or water-mill at work.

Fig. 2.

Therefore, let a ſtream of fluid, moving with the direction and velocity DE, meet a plane BC, (fig. 2.) which is moving parallel to itſelf in the direction and with the velocity DF: It is required to determine the impulſe?

Nothing is more eaſy: The mutual actions of bodies depend on their relative motions only. The motion, DE of the fluid relative to BC, which is alſo in motion, is compounded of the real motion of the fluid and the oppoſite to the real motion of the body. Therefore produce FD till Df=DF, and complete the parallelogram DfeE, and draw the diagonal De. The impulſe on the plane is the ſame as if the plane were at reſt, and every particle of the fluid impelled it in the direction and with the velocity De; and may therefore be determined by the foregoing propoſition. This propoſition applies to every poſſible caſe; and we ſhall not beſtow more time on it, but reſerve the important modification of the general propoſition for the caſes which ſhall occur in the practical applications of the whole doctrine of the impulſe and reſiſtance of fluids.

21 Proportion of the direct impulſe of a given ſtream to the effective oblique impulſe in the ſame direction.

Prop. IV. The direct impulſe of a ſtream of fluid, whoſe breadth is given, is to its oblique effective impulſe in the direction of the ſtream, as the ſquare of radius to the ſquare of the ſine of the angle of incidence.

For the number of filaments which occupy the oblique plane BC, would occupy the portion NC of a perpendicular plane, and therefore we have only to compare the perpendicular impulſe on any point V with the effective impulſe made by the ſame filament FV on the oblique plane at G. Now GH repreſents the impulſe which this filament would make at V; and GQ is the effective impulſe of the ſame filament at G, eſtimated in the direction GH of the ſtream; and GH is to GQ as GH^2 to GI^2, that is, as rad.^2 to $\text{ſin.}^2 i$.

Cor. 1. The effective impulſe in the direction of the ſtream on any plane ſurface BC, is to the direct impulſe on its baſe BR or SE, as the ſquare of the ſine of the angle of incidence to the ſquare of the radius.

Fig. 3.

2. If an iſoſceles wedge ACB (fig. 3.) be expoſed to a ſtream of fluid moving in the direction of its height CD, the impulſe on the ſides is to the direct impulſe on the baſe as the ſquare of half the baſe AD to the ſquare of the ſide AC, or as the ſquare of the ſine of half the angle of the wedge to the ſquare of the radius. For it is evident, that in this caſe the two tranſverſe impulſes, ſuch as GP in fig. 1. balance each other, and the only impulſe which can be obſerved is the ſum of the two impulſes, ſuch as GQ of fig. 1. which are to be compared with the impulſes on the two halves AD, DB of the baſe, Now AC : AB = rad. : ſin. ACD, and ACD is equal to the angle of incidence.

Therefore, if the angle ACB is a right angle, and ACD is half a right angle, the ſquare of AC is twice the ſquare of AD, and the impulſe on the ſides of a rectangular wedge is half the impulſe on its baſe.

Fig. 4.

Alſo, if a cube ACBE (fig. 4.) be expoſed to a ſtream moving in a direction perpendicular to one of its ſides, and then to a ſtream moving in a direction perpendicular to one of its diagonal planes, the impulſe in the firſt caſe will be to the impulſe in the ſecond as $\sqrt{2}$ to 1. Call the perpendicular impulſe on a ſide F, and the perpendicular impulſe on its diagonal plane f, and the effective oblique impulſe on its ſides φ;—we have

$$\text{F} : f = \text{AC} : \text{AB} = 1 : \sqrt{2}, \text{ and}$$
$$f : \varphi = \text{AC}^2 : \text{AD}^2 = 2 : 1. \text{ Therefore}$$
$$\text{F} : \varphi = \quad 2 : \sqrt{2}, = \sqrt{2} : 1, \text{ or}$$

very nearly as 10 to 7.

The ſame reaſoning will apply to a pyramid whoſe baſe is a regular polygon, and whoſe axis is perpendicular to the baſe. If ſuch a pyramid is expoſed to a ſtream of fluid moving in the direction of the axis, the direct impulſe on the baſe is to the effective impulſe on the pyramid, as the ſquare of the radius to the ſquare of the ſine of the angle which the axis makes with the ſides of the pyramid.

And, in like manner, the direct impulſion on the baſe of a right cone is to the effective impulſion on the conical ſurface, as the ſquare of the radius to the ſquare of the ſine of half the angle at the vertex of the cone. This is demonſtrated, by ſuppoſing the cone to be a pyramid of an infinite number of ſides.

We may in this manner compare the impulſe on any polygonal ſurface with the impulſe on its baſe, by comparing apart the impulſes on each plane with thoſe in their correſponding baſes, and taking their ſum.

And we may compare the impulſe on a curved ſurface with that on its baſe, by reſolving the curved ſurface into elementary planes, each of which is impelled by an elementary filament of the ſtream.

The following beautiful propoſition, given by Le Seur and Jaquier, in their Commentary on the ſecond book of Newton's Principia, with a few examples of its application, will ſuffice for any further account of this theory.

Reſiſtance.

22 The impulſe on a curved ſurface compared with that on his baſe Fig. 5.

Prop. V. Let ADB (fig. 5.) be the ſection of a ſurface of ſimple curvature, ſuch as is the ſurface of a cylinder. Let this be expoſed to the action of a fluid moving in the direction AC. Let BC be the ſection of the plane (which we have called its baſe), perpendicular to the direction of the ſtream. In AC produced, take any length CG; and on CG deſcribe the ſemicircle CHG, and complete the rectangle BCGO. Through any point D of the curve draw ED parallel to AC, and meeting BC and OG in Q and P. Let DF touch the curve in D, and draw the chord GH parallel to DF, and HKM perpendicular to CG, meeting ED in M. Suppoſe this to be done for every point of the curve ADB, and let LMN be the curve which paſſes through all the points of interſection of the parallels EDP and the correſponding perpendiculars HKM.

The effective impulſe on the curve ſurface ADB in the direction of the ſtream, is to its direct impulſe on the baſe BC as the area BCNL is to the rectangle BCGO.

Draw *edqmp* parallel to EP and extremely near it. The arch D*d* of the curve may be conceived as the ſection of an elementary plane, having the poſition of the tangent DF. The angle EDF is the angle of incidence of the filament ED*de*. This is equal to CGH, becauſe ED, DF, are parallel to CG, GH; and (becauſe CHG is a ſemicircle) CH is perpendicular to GH. Alſo $CG : CH = CH : CK$, and $CG : CK = CG^2 : CH^2, = \text{rad.}^2 : \text{ſin.}^2, CGH, = \text{rad.}^2 : \text{ſin.}^2$ incid. Therefore if CG, or its equal DP, repreſent the direct impulſe on the point Q of the baſe, CK, or its equal QM, will repreſent the effective impulſe on the point D of the curve. And thus, Q*qp*P will repreſent the direct impulſe of the filament on the element Q*q* of the baſe, and Q*qm*M will repreſent the effective impulſe of the ſame filament on the element D*d* of the curve. And, as this is true of the whole curve ADB, the effective impulſe on the whole curve will be repreſented by the area BCNML; and the direct impulſe on the baſe will be repreſented by the rectangle BCGO; and therefore the impulſe on the curve-ſurface is to the impulſe on the baſe as the area BLMNC is to the rectangle BOGC.

It is plain, from the conſtruction, that if the tangent to the curve at A is perpendicular to AC, the point N will coincide with G. Alſo, if the tangent to the curve at B is parallel to AC, the point L will coincide with B.

Whenever, therefore, the curve ADB is ſuch that an equation can be had to exhibit the general relation between the abſciſſa AR and the ordinate DR, we ſhall deduce an equation which exhibits the relation between the abſciſs CK and the ordinate KM of the curve LMN; and this will give us the ratio of BLNC to BOGC.

Fig 6.

Thus, if the ſurface is that of a cylinder, ſo that the curve BDA*b* (fig. 6.), which receives the impulſe of the fluid, is a ſemicircle, make CG equal to AC, and conſtruct the figure as before. The curve BMG is a parabola, whoſe axis is CG, whoſe vertex is G, and whoſe parameter is equal to CG. For it is plain, that $CG = DC$, and $GH = CQ, = MK$. And $CG \times GK = GH^2 = KM^2$. That is, the curve is ſuch, that the ſquare of the ordinate KM is equal to the rectangle of the abſciſſa GK and a conſtant line GC; and it is therefore a parabola whoſe vertex is G. Now, it is well known, that the parabolic area BMGC is two thirds of the parallelogram BCGO. Therefore the impulſe on the quadrant ADB is two thirds of the impulſe on the baſe BC. The ſame may be ſaid of the quadrant A*db* and its baſe *cb*. Therefore, *The impulſe on a cylinder or half cylinder is two thirds of the direct impulſe on its tranſverſe plane through the axis*; or it is two thirds of the direct impulſe on one ſide of a parallelopiped of the ſame breadth and height.

23 The impulſe on a cylinder,

Prop. VI. If the body be a ſolid generated by the revolution of the figure BDAC (fig. 5.) round the axis AC; and if it be expoſed to the action of a ſtream of fluid moving in the direction of the axis AC; then the effective impulſe in the direction of the ſtream is to the direct impulſe on its baſe, as the ſolid generated by the revolution of the figure BLMNC round the axis CN to the cylinder generated by the revolution of the rectangle BOGC.

This ſcarcely needs a demonſtration. The figure ADBLMNA is a ſection of theſe ſolids by a plane paſſing through the axis; and what has been demonſtrated of this ſection is true of every other, becauſe they are all equal and ſimilar. It is therefore true of the whole ſolids, and (their baſe) the circle generated by the revolution of BC round the axis AC.

24 on a ſphere, and

Hence we eaſily deduce, that *The impulſe on a ſphere is one half of the direct impulſe on its great circle, or on the baſe of a cylinder of equal diameter.*

For in this caſe the curve BMN (fig. 6.) which generates the ſolid expreſſing the impulſe on the ſphere is a parabola, and the ſolid is a parabolic conoid. Now this conoid is to the cylinder generated by the revolution of the rectangle BOGC round the axis CG, as the ſum of all the circles generated by the revolution of ordinates to the parabola ſuch as KM, to the ſum of as many circles generated by the ordinates to the rectangle ſuch as KT; or as the ſum of all the ſquares deſcribed on the ordinates KM to the ſum of as many ſquares deſcribed on the ordinates KT. Draw BG cutting MK in S. The ſquare on MK is to the ſquare on BC or TK as the abſciſſa GK to the abſciſſa GC (by the nature of the parabola), or as SK to BC; becauſe SK and BC are reſpectively equal to GK and GC. Therefore the ſum of all the ſquares on ordinates, ſuch as MK, is to the ſum of as many ſquares on ordinates, ſuch as TK, as the ſum of all the lines SK to the ſum of as many lines TK; that is, as the triangle BGC to the rectangle BOGC; that is, as one to two: and therefore the impulſe on the ſphere is one half of the direct impulſe on its great circle.

25 on the fruſtum of a cone.

From the ſame conſtruction we may very eaſily deduce a very curious and ſeemingly uſeful truth, that of all conical bodies having the circle whoſe diameter is AB (fig. 3.) for its baſe, and FD for its height, the one which ſuſtains the ſmalleſt impulſe or meets with the ſmalleſt reſiſtance is the fruſtum AGHB of a cone ACB ſo conſtructed, that EF being taken equal to ED, EA is equal to EC. This fruſtum, though more capacious than the cone AFB of the ſame height, will be leſs reſiſted.

Alſo, if the ſolid generated by the revolution of BDAC (fig. 5.) have its anterior part covered with a

Resistance. frustum of a cone generated by the lines D *a*, *a* A, forming the angle at *a* of 135 degrees; this solid, though more capacious than the included solid, will be less resisted.

And, from the same principles, Sir Isaac Newton determined the form of the curve ADB, which would generate the solid which, of all others of the same length and base, should have the least resistance.

These are curious and important deductions, but are not introduced here, for reasons which will soon appear.

The reader cannot fail to observe, that all that we have hitherto delivered on this subject, relates to the comparison of different impulses or resistances. We have always compared the oblique impulsions with the direct, and by their intervention we compare the oblique impulsions with each other. But it remains to give absolute measures of some individual impulsion; to which, as to an unit, we may refer every other. And as it is by their pressure that they become useful or hurtful, and they must be opposed by other pressures, it becomes extremely convenient to compare them all with that pressure with which we are most familiarly acquainted, the pressure of gravity.

26 Different impulsions compared with the pressure of gravity.

The manner in which the comparison is made, is this. When a body advances in a fluid with a known velocity, it puts a known quantity of the fluid into motion (as is supposed) with this velocity; and this is done in a known time. We have only to examine what weight will put this quantity of fluid into the same motion, by acting on it during the same time. This weight is conceived as equal to the resistance. Thus, let us suppose that a stream of water, moving at the rate of eight feet per second, is perpendicularly obstructed by a square foot of solid surface held fast in its place. Conceiving water to act in the manner of the hypothetical fluid now described, and to be without elasticity, the whole effect is the gradual annihilation of the motion of eight cubic feet of water moving eight feet in a second. And this is done in a second of time. It is equivalent to the gradually putting eight cubic feet of water into motion with this velocity; and doing this by acting uniformly during a second. What weight is able to produce this effect? The weight of eight feet of water, acting during a second on it, will, as is well known, give it the velocity of thirty-two feet per second; that is, four times greater. Therefore, the weight of the fourth part of eight cubic feet, that is, the weight of two cubic feet, acting during a second, will do the same thing, or the weight of a column of water whose base is a square foot, and whose height is two feet. This will not only produce this effect in the same time with the impulsion of the solid body, but it will also do it by the same degrees, as any one will clearly perceive, by attending to the gradual acceleration of the mass of water urged by one-fourth of its weight, and comparing this with the gradual production or extinction of motion in the fluid by the progress of the resisted surface.

Now it is well known that eight cubic feet of water, by falling one foot, which it will do in one-fourth of a second, will acquire the velocity of eight feet per second by its weight; therefore the force which produces the same effect in a whole second is one-fourth of this. This force is therefore equal to the weight of a column of water, whose base is a square foot, and whose height is two feet; that is, twice the height necessary for acquiring the velocity of the motion by gravity. The conclusion is the same whatever be the surface that is resisted, whatever be the fluid that resists, and whatever be the velocity of the motion. In this inductive and familiar manner we learn, that *the direct impulse or resistance of an unelastic fluid on any plane surface, is equal to the weight of a column of the fluid having the surface for its base, and twice the fall necessary for acquiring the velocity of the motion for its height*: and if the fluid is considered as elastic, the impulse or resistance is twice as great. See Newt. *Princip.* B. II. prop. 35. and 38.

27 This theory tried by different experiments.

It now remains to compare this theory with experiment. Many have been made, both by Sir Isaac Newton and by subsequent writers. It is much to be lamented, that in a matter of such importance, both to the philosopher and to the artist, there is such a disagreement in the results with each other. We shall mention the experiments which seem to have been made with the greatest judgement and care. Those of Sir Isaac Newton were chiefly made by the oscillations of pendulums in water, and by the descent of balls both in water and in air. Many have been made by Mariotte (*Traité de Mouvement des Eaux*). Gravesande has published, in his *System of Natural Philosophy*, experiments made on the resistance or impulsions on solids in the midst of a pipe or canal. They are extremely well contrived, but are on so small a scale that they are of very little use. Daniel Bernoulli, and his pupil Professor Krafft, have published, in the *Comment. Acad. Petropol.* experiments on the impulse of a stream or vein of water from an orifice or tube: These are of great value. The Abbé Bossut has published others of the same kind in his *Hydrodynamique*. Mr Robins has published, in his *New Principles of Gunnery*, many valuable experiments on the impulse and resistance of air. The Chev. de Borda, in the *Mem. Acad. Paris*, 1763 and 1767, has given experiments on the resistance of air and also of water, which are very interesting. The most complete collection of experiments on the resistance of water are those made at the public expence by a committee of the academy of sciences, consisting of the marquis de Condorcet, Mr d'Alembert, Abbé Bossut, and others. The Chev. de Buat, in his *Hydraulique*, has published some most curious and valuable experiments, where many important circumstances are taken notice of, which had never been attended to before, and which give a view of the subject totally different from what is usually taken of it. Don George d'Ulloa, in his *Examine Maritimo*, has also given some important experiments, similar to those adduced by Bouguer in his *Manœuvre des Vaisseaux*, but leading to very different conclusions. All these should be consulted by such as would acquire a practical knowledge of this subject. We must content ourselves with giving their most general and steady results. Such as,

1. It is very consonant to experiment that the resistances are proportional to the squares of the velocities. When the velocities of water do not exceed a few feet per second, no sensible deviation is observed. In very small velocities the resistances are sensibly greater than in this proportion, and this excess is plainly owing to the viscidity or imperfect fluidity of water. Sir Isaac Newton has shown that the resistance arising from this cause

Resistance. cause is constant, or the same in every velocity; and when he has taken off a certain part of the total resistance, he found the remainder was very exactly proportionable to the square of the velocity. His experiments to this purpose were made with balls a very little heavier than water, so as to descend very slowly; and they were made with his usual care and accuracy, and may be depended on.

28
Causes of its disagreement with them.
In the experiments made with bodies floating on the surface of water, there is an addition to the resistance arising from the inertia of the water. The water heaps up a little on the anterior surface of the floating body, and is depressed behind it. Hence arises a hydrostatical pressure, acting in concert with the true resistance. A similar thing is observed in the resistance of air, which is condensed before the body and rarefied behind it, and thus an additional resistance is produced by the unbalanced elasticity of the air; and also because the air, which is *actually* displaced, is denser than common air. These circumstances cause the resistances to increase faster than the squares of the velocities: but, even independent of this, there is an additional resistance arising from the tendency to rarefaction behind a very swift body; because the pressure of the surrounding fluid can only make the fluid fill the space left with a determined velocity.

We have had occasion to speak of this circumstance more particularly under Gunnery and Pneumatics, when considering very rapid motions. Mr Robins had remarked that the velocity at which the observed resistance of the air began to increase so prodigiously, was that of about 1100 or 1200 feet per second, and that this was the velocity with which air would rush into a void. He concluded, that when the velocity was greater than this, the ball was exposed to the additional resistance arising from the unbalanced statical pressure of the air, and that this constant quantity behoved to be added to the resistance arising from the air's inertia in all greater velocities. This is very reasonable: But he imagined that in smaller velocities there was no such unbalanced pressure. But this cannot be the case: for although in smaller velocities the air will still fill up the space behind the body, it will not fill it up with air of the same density. This would be to suppose the motion of the air into the deserted place to be instantaneous. There must therefore be a rarefaction behind the body, and a pressure backward; arising from unbalanced elasticity, independent of the condensation on the anterior part. The condensation and rarefaction are caused by the same thing, viz. the limited elasticity of the air. Were this infinitely great, the smallest condensation before the body would be instantly diffused over the whole air, and so would the rarefaction, so that no pressure of unbalanced elasticity would be observed; but the elasticity is such as to propagate the condensation with the velocity of sound only, *i. e.* the velocity of 1142 feet per second. Therefore this additional resistance does not commence precisely at this velocity, but is sensible in all smaller velocities, as is very justly observed by Euler. But we are not yet able to ascertain the law of its increase, although it is a problem which seems susceptible of a tolerably accurate solution.

Precisely similar to this is the resistance to the motion of floating bodies, arising from the accumulation or gorging up of the water on their anterior surface, and its depression behind them. Were the gravity of the water infinite, while its inertia remains the same, the wave raised up at the prow of a ship would be instantly diffused over the whole ocean, and it would therefore be infinitely small, as also the depression behind the poop. But this wave requires time for its diffusion; and while it is not diffused, it acts by hydrostatical pressure. We are equally unable to ascertain the law of variation of this part of the resistance, the mechanism of waves being but very imperfectly understood. The height of the wave in the experiments of the French academy could not be measured with sufficient precision (being only observed *en passant*) for ascertaining its relation to the velocity. The chev. Buat attempted it in his experiments, but without success. This must evidently make a part of the resistance in all velocities: and it still remains an undecided question, "What relation it bears to the velocities?" When the solid body is wholly buried in the fluid, this accumulation does not take place, or at least not in the same way: It may, however, be observed. Every person may recollect, that in a very swift running stream a large stone at the bottom will produce a small swell above it; unless it lies very deep, a nice eye may still observe it. The water, on arriving at the obstacle, glides past it in every direction, and is deflected on all hands; and therefore what passes over it is also deflected upwards, and causes the water over it to rise above its level. The nearer that the body is to the surface, the greater will be the perpendicular rise of the water, but it will be less diffused; and it is uncertain whether the *whole* elevation will be greater or less. By the whole elevation we mean the area of a perpendicular section of the elevation by a plane perpendicular to the direction of the stream. We are rather disposed to think that this area will be greatest when the body is near the surface. D'Ulloa has attempted to consider this subject scientifically; and is of a very different opinion, which he confirms by the single experiment to be mentioned by and by. Mean time, it is evident, that if the water which glides past the body cannot fall in behind it with sufficient velocity for filling up the space behind, there must be a void there; and thus a hydrostatical pressure must be superadded to the resistance arising from the inertia of the water. All must have observed, that if the end of a stick held in the hand be drawn slowly through the water, the water will fill the place left by the stick, and there will be no curled wave: but if the motion be very rapid, a hollow trough or gutter is left behind, and is not filled up till at some distance from the stick, and the wave which forms its sides is very much broken and curled. The writer of this article has often looked into the water from the poop of a second rate man of war when she was sailing 11 miles per hour, which is a velocity of 16 feet per second nearly; and he not only observed that the back of the rudder was naked for about two feet below the load water-line, but also that the trough or wake made by the ship was filled up with water which was broken and foaming to a considerable depth, and to a considerable distance from the vessel: There must therefore have been a void. He never saw the wake perfectly transparent (and therefore completely filled with water) when the velocity exceeded 9 or 10 feet per second. While this broken

broken water is obſerved, there can be no doubt that there is a void and an additional reſiſtance. But even when the ſpace left by the body, or the ſpace behind a ſtill body expoſed to a ſtream, is completely filled, it may not be filled ſufficiently faſt, and there may be (and certainly is, as we ſhall ſee afterwards) a quantity of water behind the body, which is moving more ſlowly away than the reſt, and therefore hangs in ſome ſhape by the body, and is dragged by it, increaſing the reſiſtance. The quantity of this muſt depend partly on the velocity of the body or ſtream, and partly on the rapidity with which the ſurrounding water comes in behind. This laſt muſt depend on the preſſure of the ſurrounding water. It would appear, that when this adjoining preſſure is very great, as muſt happen when the depth is great, the augmentation of reſiſtance now ſpoken of would be leſs. Accordingly this appears in Newton's experiments, where the balls were leſs retarded as they were deeper under water.

Theſe experiments are ſo ſimple in their nature, and were made with ſuch care, and by a perſon ſo able to detect and appreciate every circumſtance, that they deſerve great credit, and the concluſions *legitimately* drawn from them deſerve to be conſidered as phyſical laws. We think that the preſent deduction is unexceptionable: for in the motion of balls, which hardly deſcended, their preponderancy being hardly ſenſible, the effect of depth muſt have borne a very great proportion to the whole reſiſtance, and muſt have greatly influenced their motions; yet they were obſerved to fall as if the reſiſtance had no way depended on the depth.

The ſame thing appears in Borda's experiments, where a ſphere which was deeply immerſed in the water was leſs reſiſted than one that moved with the ſame velocity near the ſurface; and this was very conſtant and
29 Singularity of D'Ulloa's experiments. regular in a courſe of experiments. D'Ulloa, however, affirms the contrary: He ſays that the reſiſtance of a board, which was a foot broad, immerſed one foot in a ſtream moving two feet per ſecond, was $15\frac{1}{2}$ lbs. and the reſiſtance to the ſame board, when immerſed 2 feet in a ſtream moving $1\frac{1}{7}$ feet per ſecond (in which caſe the ſurface was 2 feet), was $26\frac{1}{4}$ pounds (A).

We are very ſorry that we cannot give a proper account of this theory of reſiſtance by Don George Juan D'Ulloa, an author of great mathematical reputation, and the inſpector of the marine academies in Spain. We have not been able to procure either the original or the French tranſlation, and judge of it only by an extract by Mr Prony in his *Architecture Hydralique*, § 868. &c. The theory is enveloped (according to Mr Prony's cuſtom) in the moſt complicated expreſſions, ſo that the phyſical principles are kept almoſt out of ſight. When accommodated to the ſimpleſt poſſible caſe, it is nearly as follows.

30 His theory of reſiſtance. Let o be an elementary orifice or portion of the ſurface of the ſide of a veſſel filled with a heavy fluid, and let h be its depth under the horizontal ſurface of the fluid. Let δ be the denſity of the fluid, and φ the accelerative power of gravity, $=$ 32 feet velocity acquired in a ſecond.

It is known, ſays he, that the water would flow out at this hole with the velocity $u = \sqrt{2\varphi h}$, and $u^2 = 2\varphi h$ and $h = \frac{u^2}{2\varphi}$. It is alſo known that the preſſure p on the orifice o is $\varphi o \delta h, = \varphi o \delta \frac{u^2}{2\varphi}, = \frac{1}{2} \delta o u^2$.

Now, let this little ſurface o be ſuppoſed to move with the velocity v. The fluid would meet it with the velocity $u + v$, or $u - v$, according as it moved in the oppoſite or in the ſame direction with the efflux. In the equation $p = \frac{1}{2} \delta o u^2$, ſubſtitute $u \pm v$ for u, and we have the preſſure on $o = p = \frac{\delta o}{2} (u \pm v)^2, = \frac{\delta o}{2} (\sqrt{2\varphi h} \pm v^2)$.

This preſſure is a weight, that is, a maſs of matter m actuated by gravity φ, or $p = \varphi m$, and $m = \delta o \left(\sqrt{h} \pm \frac{v}{\sqrt{2\varphi}}\right)^2$.

This elementary ſurface being immerſed in a ſtagnant fluid, and moved with the velocity v, will ſuſtain on one ſide a preſſure $\delta o \left(\sqrt{h} + \frac{v}{\sqrt{2\varphi}}\right)^2$, and on the other ſide a preſſure $\delta o \left(\sqrt{h} - \frac{v}{\sqrt{2\varphi}}\right)^2$; and the ſenſible reſiſtance will be the difference of theſe two preſſures, which is $\delta o 4 \sqrt{h} \frac{v}{\sqrt{2\varphi}}$, or $\delta o 4 \sqrt{h} \frac{v}{8}$, that is, $\frac{\delta o \sqrt{h} v}{2}$, becauſe $\sqrt{2\varphi} = 8$; a quantity which is in the ſubduplicate ratio of the depth under the ſurface of the fluid, and the ſimple ratio of the velocity of the reſiſted ſurface jointly.

There is nothing in experimental philoſophy more certain than that the reſiſtances are very nearly in the duplicate ratio of the velocities; and we cannot conceive by what experiments the ingenious author has ſupported this concluſion.

But there is, beſides, what appears to us to be an 31 Defect in his inveſtigation.
eſſential defect in this inveſtigation. The equation exhibits no reſiſtance in the caſe of a fluid without weight. Now a theory of the reſiſtance of fluids ſhould exhibit the retardation ariſing from inertia alone, and ſhould diſtinguiſh it from that ariſing from any other cauſe: and moreover, while it *aſſigns* an ultimate ſenſible reſiſtance proportional (*cæteris paribus*) to the ſimple velocity, it *aſſumes* as a firſt principle that the preſſure p is as $\overline{u \pm v}^2$. It alſo gives a falſe meaſure of the ſtatical preſſures: for theſe (in the caſe of bodies immerſed in our waters at leaſt) are made up of the preſſure of the incumbent water, which is meaſured by h, and the preſſure of the atmoſphere, a conſtant quantity.

Whatever reaſon can be given for ſetting out with the principle that the preſſure on the little ſurface o, moving with the velocity u, is equal to $\frac{1}{2} \delta o (u \pm v)^2$, makes it indiſpenſably neceſſary to take for the velocity u, not that with which water would iſſue from a hole whoſe depth under the ſurface is h, but the velocity with

(A) There is ſomething very unaccountable in theſe experiments. The reſiſtances are much greater than any other author has obſerved.

with which it will issue from a hole whose depth is $h+33$ feet. Because the pressure of the atmosphere is equal to that of a column of water 33 feet high: for this is the acknowledged velocity with which it would rush in to the void left by the body. If therefore this velocity (which does not exist) has any share in the effort, we must have for the fluxion of pressure not $\frac{4\sqrt{hv}}{\sqrt{2\varphi}}$, but $\frac{4\sqrt{\overline{h+33}|v}}{\sqrt{2\varphi}}$. This would not only give pressure or resistances many times exceeding those that have been observed in our experiments, but would also totally change the proportions which this theory determines. It was at any rate improper to embarrass an investigation, already very intricate, with the pressure of gravity, and with two motions of efflux, which do not exist, and are necessary for making the pressures in the ratio of $\overline{u+v}^2$ and $\overline{u-v}^2$.

Mr Prony has been at no pains to inform his readers of his reasons for adopting this theory of resistance, so contrary to all received opinions, and to the most distinct experiments. Those of the French academy, made under greater pressures, gave a much smaller resistance; and the very experiments adduced in support of this theory are extremely deficient, wanting fully one-third of what the theory requires. The resistances by experiment were $15\frac{1}{4}$ and $26\frac{1}{3}$, and the theory required $20\frac{1}{2}$ and 39. The equation, however, deduced from the theory is greatly deficient in the expression of the pressures caused by the accumulation and depression, stating the heights of them as $=\frac{v^2}{2\varphi}$. They can never be so high, because the heaped-up water flows off at the sides, and it also comes in behind by the sides; so that the pressure is much less than half the weight of a column whose height is $\frac{v^2}{2\varphi}$; both because the accumulation and depression are less at the sides than in the middle, and because, when the body is wholly immersed, the accumulation is greatly diminished. Indeed in this case, the final equation does not include their effects, though as real in this case as when part of the body is above water.

Upon the whole, we are somewhat surprised that an author of D'Ulloa's eminence should have adopted a theory so unnecessarily and so improperly embarrassed with foreign circumstances; and that Mr Prony should have inserted it with the explanation by which he was to abide, in a work destined for practical use.

This point, or the effect of deep immersion, is still much contested; and it is a received opinion, by many not accustomed to mathematical researches, that the resistance is greater in greater depths. This is assumed as an important principle by Mr Gordon, author of a *Theory of Naval Architecture;* but on very vague and slight grounds: and the author seems unacquainted with the manner of reasoning on such subjects. It shall be considered afterwards.

With these corrections it may be asserted that theory and experiment agree very well in this respect, and that the resistance may be asserted to be in the duplicate ratio of the velocity.

We have been more minute on this subject, because it is the leading proposition in the theory of the action of fluids. Newton's demonstration of it takes no notice of the manner in which the various particles of the fluid are put in motion, or the motion which each in particular acquires. He only shows, that if there be nothing concerned in the communication but pure inertia, the sum total of the motions of the particles, estimated in the direction of the bodies motion, or that of the stream, will be in the duplicate ratio of the velocity. It was therefore of importance to show that this part of the theory was just. To do this, we had to consider the effect of every circumstance which could be combined with the inertia of the fluid. All these had been foreseen by that great man, and are most briefly, though perspicuously, mentioned in the last scholium to prop. 36. B. II.

32 Impulse and resistances nearly in proportion of the surfaces.

2. It appears from a comparison of all the experiments, that the impulses and resistances are very nearly in the proportion of the surfaces. They appear, however, to increase somewhat faster than the surfaces. The chevalier Borda found that the resistance, with the same velocity, to a surface of

9 inches	was	9	instead of	9
16		17,535		16
36		42,750		36
81		104,737		81

The deviation in these experiments from the theory increases with the surface, and is probably much greater in the extensive surfaces of the sails of ships and windmills, and the hulls of ships.

3. The resistances do by no means vary in the duplicate ratio of the sines of the angles of incidence.

As this is the most interesting circumstance, having a chief influence on all the particular modifications of the resistance of fluids, and as on this depends the whole theory of the construction and working of ships, and the action of water on our most important machines, and seems most immediately connected with the mechanism of fluids, it merits a very particular consideration. We cannot do a greater service than by rendering more generally known the excellent experiments of the French academy.

33 Experiments of the French academy, Fig. 8.

Fifteen boxes or vessels were constructed, which were two feet wide, two feet deep, and four feet long. One of them was a parallelopiped of these dimensions; the others had prows of a wedge form, the angle ACB (fig. 8.) varying by 12° degrees from 12° to 180°; so that the angle of incidence increased by 6° from one to another. These boxes were dragged across a very large bason of smooth water (in which they were immersed two feet) by means of a line passing over a wheel connected with a cylinder, from which the actuating weight was suspended. The motion became perfectly uniform after a very little way; and the time of passing over 96 French feet with this uniform motion was very carefully noted. The resistance was measured by the weight employed, after deducting a certain quantity (properly estimated) for friction, and for the accumulation of the water against the anterior surface. The results of the many experiments are given in the following table; where column 1st contains the angle of the prow, column 2d contains the resistance as given by the preceding theory, column 3d contains the resistance exhibited in the experiments, and column 4th contains the deviation of the experiment from the theory.

Reſiſtance.

I.	II.	III.	IV.
180	10000	10000	0
168	9890	9893	+3
156	9568	9578	+10
144	9045	9084	+39
132	8346	8446	+100
120	7500	7710	+210
108	6545	6925	+380
96	5523	6148	+625
84	4478	5433	+955
72	3455	4800	+1345
60	2500	4404	+1904
48	1654	4240	+2586
36	955	4142	+3187
24	432	4063	+3631
12	109	3999	+3890

The reſiſtance to 1 ſquare foot, French meaſure, moving with the velocity of 2,56 feet per ſecond, was very nearly 7,625 pounds French.

Reducing theſe to Engliſh meaſures, we have the ſurface = 1,1363 feet, the velocity of the motion equal to 2,7263 feet per ſecond, and the reſiſtance equal to 8,234 pounds avoirdupois. The weight of a column of freſh water of this baſe, and having for its height the fall neceſſary for communicating this velocity, is 8,264 pounds avoirdupois. The reſiſtances to other velocities were accurately proportional to the ſquares of the velocities.

There is great diverſity in the value which different authors have deduced for the abſolute reſiſtance of water from their experiments. In the value now given nothing is taken into account but the inertia of the water. The accumulation againſt the forepart of the box was carefully noted, and the ſtatical preſſure backwards, ariſing from this cauſe, was ſubtracted from the whole reſiſtance to the drag. There had not been a ſufficient variety of experiments for diſcovering the ſhare which tenacity and friction produced; ſo that the number of pounds ſet down here may be conſidered as ſomewhat ſuperior to the mere effects of the inertia of the water. We think, upon the whole, that it is the moſt accurate determination yet given of the reſiſtance to a body in motion: but we ſhall afterwards ſee reaſon for believing, that the impulſe of a running ſtream having the ſame velocity is ſomewhat greater; and this is the form in which moſt of the experiments have been made.

Alſo obſerve, that the reſiſtance here given is that to a veſſel two feet broad and deep and four feet long. The reſiſtance to a plane of two feet broad and deep would probably have exceeded this in the proportion of 15,22 to 14,54, for reaſons we ſhall ſee afterwards.

34 and others. From the experiments of Chevalier Buat, it appears that a body of one foot ſquare, French meaſure, and two feet long, having its centre 15 inches under water, moving three French feet per ſecond, ſuſtained a preſſure of 1454 French pounds, or 15,63 Engliſh. This reduced in the proportion of 3^2 to $2{,}56^2$ gives 11,43 pounds, conſiderably exceeding the 8,24.

Mr Bouguer, in his *Manœuvre des Vaiſſeaux*, ſays, that he found the reſiſtance of ſea-water to a velocity of one foot to be 23 ounces *poids des Marc*.

The chevalier Borda found the reſiſtance of ſea-water to the face of a cubic foot, moving againſt the water one foot per ſecond, to be 21 ounces nearly. But this experiment is complicated: the wave was not deducted; and it was not a plane, but a cube.

Reſiſtance.

Don George d'Ulloa found the impulſe of a ſtream of ſea-water, running two feet per ſecond on a foot ſquare, to be $15\frac{1}{4}$ pounds Engliſh meaſure. This greatly exceeds all the values given by others.

From theſe experiments we learn, in the firſt place, that the direct reſiſtance to a motion of a plane ſurface through water, is very nearly equal to the weight of a column of water having that ſurface for its baſe, and for its height the fall producing the velocity of the motion. This is but one half of the reſiſtance determined by the preceding theory. It agrees, however, very well with the beſt experiments made by other philoſophers on bodies totally immerſed or ſurrounded by the fluid; and ſufficiently ſhows, that there muſt be ſome fallacy in the principles or reaſoning by which this reſult of the theory is ſuppoſed to be deduced. We ſhall have occaſion to return to this again. 35 Conſequences from them.

But we ſee that the effects of the obliquity of incidence deviate enormouſly from the theory, and that this deviation increaſes rapidly as the acuteneſs of the prow increaſes. In the prow of 60° the deviation is nearly equal to the whole reſiſtance pointed out by the theory, and in the prow of 12° it is nearly 40 times greater than the theoretical reſiſtance.

The reſiſtance of the prow of 90° ſhould be one half the reſiſtance of the baſe. We have not ſuch a prow; but the medium between the reſiſtance of the prow of 96 and 84 is 5790, inſtead of 500.

Theſe experiments are very conform to thoſe of other authors on plane ſurfaces. Mr Robins found the reſiſtance of the air to a pyramid of 45°, with its apex foremoſt, was to that of its baſe as 1000 to 1411, inſtead of one to two. Chevalier Borda found the reſiſtance of a cube, moving in water in the direction of the ſide, was to the oblique reſiſtance, when it was moved in the direction of the diagonal, in the proportion of $5\frac{1}{7}$ to 7; whereas it ſhould have been that of $\sqrt{2}$ to 1, or of 10 to 7 nearly. He alſo found, that a wedge whoſe angle was 90°, moving in air, gave for the proportion of the reſiſtances of the edge and baſe 7281 : 10000, inſtead of 5000 : 10000. Alſo, when the angle of the wedge was 60°, the reſiſtances of the edge and baſe were 52 and 100, inſtead of 25 and 100.

In ſhort, in all the caſes of oblique plane ſurfaces, the reſiſtances were greater than thoſe which are aſſigned by the theory. The theoretical law agrees tolerably with obſervation in large angles of incidence, that is, in incidences not differing very far from the perpendicular; but in more acute prows the reſiſtances are more nearly proportional to the ſines of incidence than to their ſquares.

The academicians deduced from theſe experiments an expreſſion of the general value of the reſiſtance, which correſponds tolerably well with obſervation. Thus let x be the complement of the half angle of the prow, and let P be the direct preſſure or reſiſtance, with an incidence of 90°, and p the effective oblique preſſure: then $p = \text{P} \times \text{coſine}^2\, x + 3{,}153 \left(\frac{x^0}{6^0}\right)^{3,25}$. This gives for a prow of 12° an error in defect about $\frac{1}{100}$, and in larger angles it is much nearer the truth; and this is exact enough for any practice.

This is an abundantly ſimple formula; but if we introduce

troduce

with which it will iſſue from a hole whoſe depth is $h+33$ feet. Becauſe the preſſure of the atmoſphere is equal to that of a column of water 33 feet high: for this is the acknowledged velocity with which it would ruſh in to the void left by the body. If therefore this velocity (which does not exiſt) has any ſhare in the effort, we muſt have for the fluxion of preſſure not $\frac{4\sqrt{hv}}{\sqrt{2\varphi}}$, but $\frac{4\sqrt{\overline{h+33}}\,v}{\sqrt{2\varphi}}$. This would not only give preſſure or reſiſtances many times exceeding thoſe that have been obſerved in our experiments, but would alſo totally change the proportions which this theory determines. It was at any rate improper to embarraſs an inveſtigation, already very intricate, with the preſſure of gravity, and with two motions of efflux, which do not exiſt, and are neceſſary for making the preſſures in the ratio of $\overline{u+v^2}$ and $\overline{u-v^2}$.

Mr Prony has been at no pains to inform his readers of his reaſons for adopting this theory of reſiſtance, ſo contrary to all received opinions, and to the moſt diſtinct experiments. Thoſe of the French academy, made under greater preſſures, gave a much ſmaller reſiſtance; and the very experiments adduced in ſupport of this theory are extremely deficient, wanting fully one-third of what the theory requires. The reſiſtances by experiment were $15\frac{1}{4}$ and $26\frac{1}{7}$, and the theory required $20\frac{1}{2}$ and 39. The equation, however, deduced from the theory is greatly deficient in the expreſſion of the preſſures cauſed by the accumulation and depreſſion, ſtating the heights of them as $=\frac{v^2}{2\varphi}$. They can never be ſo high, becauſe the heaped-up water flows off at the ſides, and it alſo comes in behind by the ſides; ſo that the preſſure is much leſs than half the weight of a column whoſe height is $\frac{v^2}{2\varphi}$; both becauſe the accumulation and depreſſion are leſs at the ſides than in the middle, and becauſe, when the body is wholly immerſed, the accumulation is greatly diminiſhed. Indeed in this caſe, the final equation does not include their effects, though as real in this caſe as when part of the body is above water.

Upon the whole, we are ſomewhat ſurpriſed that an author of D'Ulloa's eminence ſhould have adopted a theory ſo unneceſſarily and ſo improperly embarraſſed with foreign circumſtances; and that Mr Prony ſhould have inſerted it with the explanation by which he was to abide, in a work deſtined for practical uſe.

This point, or the effect of deep immerſion, is ſtill much conteſted; and it is a received opinion, by many not accuſtomed to mathematical reſearches, that the reſiſtance is greater in greater depths. This is aſſumed as an important principle by Mr Gordon, author of a *Theory of Naval Architecture;* but on very vague and ſlight grounds: and the author ſeems unacquainted with the manner of reaſoning on ſuch ſubjects. It ſhall be conſidered afterwards.

With theſe corrections it may be aſſerted that theory and experiment agree very well in this reſpect, and that the reſiſtance may be aſſerted to be in the duplicate ratio of the velocity.

We have been more minute on this ſubject, becauſe it is the leading propoſition in the theory of the action of fluids. Newton's demonſtration of it takes no notice of the manner in which the various particles of the fluid are put in motion, or the motion which each in particular acquires. He only ſhows, that if there be nothing concerned in the communication but pure inertia, the ſum total of the motions of the particles, eſtimated in the direction of the bodies motion, or that of the ſtream, will be in the duplicate ratio of the velocity. It was therefore of importance to ſhow that this part of the theory was juſt. To do this, we had to conſider the effect of every circumſtance which could be combined with the inertia of the fluid. All theſe had been foreſeen by that great man, and are moſt briefly, though perſpicuouſly, mentioned in the laſt ſcholium to prop. 36. B. II.

32 Impulſe and reſiſtances nearly in proportion of the ſurfaces.

2. It appears from a compariſon of all the experiments, that the impulſes and reſiſtances are very nearly in the proportion of the ſurfaces. They appear, however, to increaſe ſomewhat faſter than the ſurfaces. The chevalier Borda found that the reſiſtance, with the ſame velocity, to a ſurface of

9 inches	was	9	inſtead of	9
16		17,535		16
36		42,750		36
81		104,737		81

The deviation in theſe experiments from the theory increaſes with the ſurface, and is probably much greater in the extenſive ſurfaces of the ſails of ſhips and windmills, and the hulls of ſhips.

3. The reſiſtances do by no means vary in the duplicate ratio of the ſines of the angles of incidence.

As this is the moſt intereſting circumſtance, having a chief influence on all the particular modifications of the reſiſtance of fluids, and as on this depends the whole theory of the conſtruction and working of ſhips, and the action of water on our moſt important machines, and ſeems moſt immediately connected with the mechaniſm of fluids, it merits a very particular conſideration. We cannot do a greater ſervice than by rendering more generally known the excellent experiments of the French academy.

33 Experiments of the French academy, Fig. 8.

Fifteen boxes or veſſels were conſtructed, which were two feet wide, two feet deep, and four feet long. One of them was a parallelopiped of theſe dimenſions; the others had prows of a wedge form, the angle ACB (fig. 8.) varying by 12° degrees from 12° to 180°; ſo that the angle of incidence increaſed by 6° from one to another. Theſe boxes were dragged acroſs a very large baſon of ſmooth water (in which they were immerſed two feet) by means of a line paſſing over a wheel connected with a cylinder, from which the actuating weight was ſuſpended. The motion became perfectly uniform after a very little way; and the time of paſſing over 96 French feet with this uniform motion was very carefully noted. The reſiſtance was meaſured by the weight employed, after deducting a certain quantity (properly eſtimated) for friction, and for the accumulation of the water againſt the anterior ſurface. The reſults of the many experiments are given in the following table; where column 1ſt contains the angle of the prow, column 2d contains the reſiſtance as given by the preceding theory, column 3d contains the reſiſtance exhibite in the experiments, and column 4th contains the deviation of the experiment from the theory.

Reſiſtance.

I.	II.	III.	IV.
180	10000	10000	0
168	9890	9893	+3
156	9568	9578	+10
144	9045	9084	+39
132	8346	8446	+100
120	7500	7710	+210
108	6545	6925	+380
96	5523	6148	+625
84	4478	5433	+955
72	3455	4800	+1345
60	2500	4404	+1904
48	1654	4240	+2586
36	955	4142	+3187
24	432	4063	+3631
12	109	3999	+3890

The reſiſtance to 1 ſquare foot, French meaſure, moving with the velocity of 2,56 feet per ſecond, was very nearly 7,625 pounds French.

Reducing theſe to Engliſh meaſures, we have the ſurface = 1,1363 feet, the velocity of the motion equal to 2,7263 feet per ſecond, and the reſiſtance equal to 8,234 pounds avoirdupois. The weight of a column of freſh water of this baſe, and having for its height the fall neceſſary for communicating this velocity, is 8,264 pounds avoirdupois. The reſiſtances to other velocities were accurately proportional to the ſquares of the velocities.

There is great diverſity in the value which different authors have deduced for the abſolute reſiſtance of water from their experiments. In the value now given nothing is taken into account but the inertia of the water. The accumulation againſt the forepart of the box was carefully noted, and the ſtatical preſſure backwards, ariſing from this cauſe, was ſubtracted from the whole reſiſtance to the drag. There had not been a ſufficient variety of experiments for diſcovering the ſhare which tenacity and friction produced; ſo that the number of pounds ſet down here may be conſidered as ſomewhat ſuperior to the mere effects of the inertia of the water. We think, upon the whole, that it is the moſt accurate determination yet given of the reſiſtance to a body in motion: but we ſhall afterwards ſee reaſon for believing, that the impulſe of a running ſtream having the ſame velocity is ſomewhat greater; and this is the form in which moſt of the experiments have been made.

Alſo obſerve, that the reſiſtance here given is that to a veſſel two feet broad and deep and four feet long. The reſiſtance to a plane of two feet broad and deep would probably have exceeded this in the proportion of 15,22 to 14,54, for reaſons we ſhall ſee afterwards.

34 and others. From the experiments of Chevalier Buat, it appears that a body of one foot ſquare, French meaſure, and two feet long, having its centre 15 inches under water, moving three French feet per ſecond, ſuſtained a preſſure of 1454 French pounds, or 15,63 Engliſh. This reduced in the proportion of 3^2 to $2,56^2$ gives 11,43 pounds, conſiderably exceeding the 8,24.

Mr Bouguer, in his *Manœuvre des Vaiſſeaux*, ſays, that he found the reſiſtance of ſea-water to a velocity of one foot to be 23 ounces *poids des Marc*.

The chevalier Borda found the reſiſtance of ſea-water to the face of a cubic foot, moving againſt the water one foot per ſecond, to be 21 ounces nearly. But this experiment is complicated: the wave was not deducted; and it was not a plane, but a cube.

Don George d'Ulloa found the impulſe of a ſtream of ſea-water, running two feet per ſecond on a foot ſquare, to be $15\frac{1}{4}$ pounds Engliſh meaſure. This greatly exceeds all the values given by others.

35 Conſequences from them. From theſe experiments we learn, in the firſt place, that the direct reſiſtance to a motion of a plane ſurface through water, is very nearly equal to the weight of a column of water having that ſurface for its baſe, and for its height the fall producing the velocity of the motion. This is but one half of the reſiſtance determined by the preceding theory. It agrees, however, very well with the beſt experiments made by other philoſophers on bodies totally immerſed or ſurrounded by the fluid; and ſufficiently ſhows, that there muſt be ſome fallacy in the principles or reaſoning by which this reſult of the theory is ſuppoſed to be deduced. We ſhall have occaſion to return to this again.

But we ſee that the effects of the obliquity of incidence deviate enormouſly from the theory, and that this deviation increaſes rapidly as the acuteneſs of the prow increaſes. In the prow of 60° the deviation is nearly equal to the whole reſiſtance pointed out by the theory, and in the prow of 12° it is nearly 40 times greater than the theoretical reſiſtance.

The reſiſtance of the prow of 90° ſhould be one half the reſiſtance of the baſe. We have not ſuch a prow; but the medium between the reſiſtance of the prow of 96 and 84 is 5790, inſtead of 500.

Theſe experiments are very conform to thoſe of other authors on plane ſurfaces. Mr Robins found the reſiſtance of the air to a pyramid of 45°, with its apex foremoſt, was to that of its baſe as 1000 to 1411, inſtead of one to two. Chevalier Borda found the reſiſtance of a cube, moving in water in the direction of the ſide, was to the oblique reſiſtance, when it was moved in the direction of the diagonal, in the proportion of $5\frac{1}{2}$ to 7; whereas it ſhould have been that of $\sqrt{2}$ to 1, or of 10 to 7 nearly. He alſo found, that a wedge whoſe angle was 90°, moving in air, gave for the proportion of the reſiſtances of the edge and baſe 7281 : 10000, inſtead of 5000 : 10000. Alſo, when the angle of the wedge was 60°, the reſiſtances of the edge and baſe were 52 and 100, inſtead of 25 and 100.

In ſhort, in all the caſes of oblique plane ſurfaces, the reſiſtances were greater than thoſe which are aſſigned by the theory. The theoretical law agrees tolerably with obſervation in large angles of incidence, that is, in incidences not differing very far from the perpendicular; but in more acute prows the reſiſtances are more nearly proportional to the ſines of incidence than to their ſquares.

The academicians deduced from theſe experiments an expreſſion of the general value of the reſiſtance, which correſponds tolerably well with obſervation. Thus let x be the complement of the half angle of the prow, and let P be the direct preſſure or reſiſtance, with an incidence of 90°, and p the effective oblique preſſure: then $p = P \times \text{coſine}^2 x + 3{,}153 \left(\frac{x^{0}}{6^{0}}\right)^{3,25}$. This gives for a prow of 12° an error in defect about $\frac{1}{100}$, and in larger angles it is much nearer the truth; and this is exact enough for any practice.

This is an abundantly ſimple formula; but if we introduce

Resistance

troduce it in our calculations of the resistances of curvilineal prows, it renders them so complicated as to be almost useless; and what is worse, when the calculation is completed for a curvilineal prow, the resistance which results is found to differ widely from experiment. This shows that the motion of the fluid is so modified by the action of the most prominent part of the prow, that its impulse on what succeeds is greatly affected, so that we are not allowed to consider the prow as composed of a number of parts, each of which is affected as if it were detached from all the rest.

As the very nature of naval architecture seems to require curvilineal forms, in order to give the necessary strength, it seemed of importance to examine more particularly the deviations of the resistances of such prows from the resistances assigned by the theory. The academicians therefore made vessels with prows of a cylindrical shape; one of these was a half cylinder, and the other was one-third of a cylinder, both having the same breadth, viz. two feet, the same depth, also two feet, and the same length, four feet. The resistance of the half cylinder was to the resistance of the perpendicular prow in the proportion of 13 to 25, instead of being as 13 to 19.5. The chevalier Borda found nearly the same ratio of the resistances of the half cylinder, and its diametrical plane when moved in air. He also compared the resistances of two prisms or wedges, of the same breadth and height. The first had its sides plane, inclined to the base in angles of 60°: the second had its sides portions of cylinders, of which the planes were the chords, that is, their sections were arches of circles of 60°. Their resistances were as 133 to 100, instead of being as 133 to 220, as required by the theory; and as the resistance of the first was greater in proportion to that of the base than the theory allows, the resistance of the last was less.

Mr Robins found the resistance of a sphere moving in air to be to the resistance of its great circle as 1 to 2.27; whereas theory requires them to be as 1 to 2. He found, at the same time, that the absolute resistance was greater than the weight of a cylinder of air of the same diameter, and having the height necessary for acquiring the velocity. It was greater in the proportion of 49 to 40 nearly.

Borda found the resistance of the sphere moving in water to be to that of its great circle as 1000 to 2508, and it was one-ninth greater than the weight of the column of water whose height was that necessary for producing the velocity. He also found the resistance of air to the sphere was to its resistance to its great circle as 1 to 2.45.

36 The theory gives some resistances too small and others too great.

It appears, on the whole, that the theory gives the resistance of oblique plane surfaces too small, and that of curved surfaces too great; and that it is quite unfit for ascertaining the modifications of resistance arising from the figure of the body. The most prominent part of the prow changes the action of the fluid on the succeeding parts, rendering it totally different from what it would be were that part detached from the rest, and exposed to the stream with the same obliquity. It is of no consequence, therefore, to deduce any formula from the valuable experiments of the French academy. The experiments themselves are of great importance, because they give us the impulses on plane surfaces with every obliquity. They therefore put it in our power to select the most proper obliquity in a thousand important cases. By appealing to them, we can tell what is the proper angle of the sail for producing the greatest impulse in the direction of the ship's course; or the best inclination of the sail of a wind-mill, or the best inclination of the float of a water-wheel, &c. &c. These deductions will be made in their proper places in the course of this work. We see also, that the deviation from the simple theory is not very considerable till the obliquity is great; and that, in the inclinations which other circumstances would induce us to give to the floats of water-wheels, the sails of wind-mills, and the like, the results of the theory are sufficiently agreeable to experiment, for rendering this theory of very great use in the construction of machines. Its great defect is in the impulsions on curved surfaces, which puts a stop to our improvement of the science of naval architecture, and the working of ships.

But it is not enough to detect the faults of the theory: we should try to amend it, or to substitute another. It is a pity that so much ingenuity should have been thrown away in the application of a theory so defective. Mathematicians were seduced, as has been already observed, by the opportunity which it gave for exercising their calculus, which was a new thing at the time of publishing this theory. Newton saw clearly the defects of it, and makes no use of any part of it in his subsequent discussions, and plainly has used it merely as an introduction, in order to give some general notions in a subject quite new, and to give a demonstration of one leading truth, viz. the proportionality of the impulsions to the squares of the velocities. While we profess the highest respect for the talents and labours of the great mathematicians who have followed Newton in this most difficult research, we cannot help being sorry that some of the greatest of them continued to attach themselves to a theory which he neglected, merely because it afforded an opportunity of displaying their profound knowledge of the new calculus, of which they were willing to ascribe the discovery to Leibnitz. It has been in a great measure owing to this that we have been so late in discovering our ignorance of the subject. Newton had himself pointed out all the defects of this theory; and he set himself to work to discover another which should be more conformable to the nature of things, retaining only such deductions from the other as his great sagacity assured him would stand the test of experiment. Even in this he seems to have been mistaken by his followers. He retained the proportionality of the resistance to the square of the velocity. This they have endeavoured to demonstrate in a manner conformable to Newton's determination of the oblique impulses of fluids; and under the cover of the agreement of this proposition with experiment, they introduced into mechanics a mode of expression, and even of conception, which is inconsistent with all accurate notions of these subjects. Newton's proposition was, that the motions communicated to the fluid, and therefore the motions lost by the body, in equal times, were as the squares of the velocities; and he conceived these as proper measures of the resistances. It is a matter of experience, that the forces or pressures by which a body must be supported in opposition to the impulses of fluids, are in this very proportion. In determining the *proportion* of the direct and oblique resistances of plane surfaces,

37 Its defects pointed out by Newton.

Resistance. surfaces, he considers the resistances to arise from mutual collisions of the surface and fluid, repeated at intervals of time too small to be perceived. But in making this comparison, he has no occasion whatever to consider this *repetition;* and when he assigns the proportion between the resistance of a cone and of its base, he, in fact, assigns the proportion between two *simultaneous* and instantaneous impulses. But the mathematicians who followed him have considered this repetition as equivalent to an augmentation of the initial or first impulse; and in this way have attempted to demonstrate that the resistances are as the squares of the velocities. When the velocity is double, each impulse is double, and the number in a given time is double; therefore, say they, the resistance, and the force which will withstand it, is quadruple; and observation confirms their deduction: yet nothing is more gratuitous and illogical. It is very true that the resistance, conceived as Newton conceives it, the loss of motion sustained by a body moving in the fluid, is quadruple; but the instantaneous impulse, and the force which can withstand it, is, by all the laws of mechanics, only double. What is the force which can withstand a double impulse? Nothing but a double impulse. Nothing but impulse can be opposed to impulse; and it is a gross misconception to think of stating any kind of comparison between impulse and pressure. It is this which has given rise to much jargon and false reasoning about the force of percussion. This is stated as infinitely greater than any pressure, and as equivalent to a pressure infinitely repeated. It forced the abettors of these doctrines at last to deny the existence of all pressure whatever, and to assert that all motion, and tendency to motion, was the result of impulse. The celebrated Euler, perhaps the first mathematician, and the lowest philosopher, of this century, says, "since motion and impulse are seen to exist, and since we see that by means of motion pressure may be produced, as when a body in motion strikes another, or as when a body moved in a curved channel presses upon it, merely in consequence of its curvilineal motion, and the exertion of a centrifugal force; and since Nature is most wisely economical in all her operations; it is absurd to suppose that pressure, or tendency to motion, has any other origin; and it is the business of a philosopher to discover by what motion any observed pressure is produced." Whenever any pressure is observed, such as the pressure of gravity, of magnetism, of electricity, condensed air, nay, of a spring, and of elasticity and cohesion themselves, however disparate, nay, opposite, the philosopher must immediately cast about, and contrive a set of motions (creating *pro re natâ* the movers) which will produce a pressure like the one observed. Having pleased his fancy with this, he cries out εὕρηκα "this *will produce* the pressure;" *et frustra fit per plura quod fieri potest per pauciora*, "therefore in this way the pressure *is* produced." Thus the vortices of Descartes are brought back in triumph, and have produced vortices without number, which fill the universe with motion and pressure.

38
No comparison between impulse and pressure.

Such bold attempts to overturn long-received doctrines in mechanics, could not be received without much criticism and opposition; and many able dissertations appeared from time to time in defence of the common doctrines. In consequence of the many objections to the comparison of pure pressure with pure percussion or impulse, John Bernoulli and others were at last obliged to assert that there were no perfectly hard bodies in nature, nor could be, but that all bodies were elastic; and that in the communication of motion by percussion, the velocities of both bodies were *gradually* changed by their mutual elasticity acting during the finite but imperceptible time of the collision. This was, in fact, giving up the whole argument, and banishing percussion, while their aim was to get rid of pressure. For what is elasticity but a pressure? and how shall *it* be produced? To act in this instance, must it arise from a still smaller impulse? But this will require another elasticity, and so on without end.

These are all legitimate consequences of this attempt to state a comparison betweeen percussion and pressure. Numberless experiments have been made to confirm the statement; and there is hardly an itinerant lecturing showman who does not exhibit among his apparatus Gravesande's machine (Vol. I. plate xxxv. fig. 4.). But nothing affords so specious an argument as the experimented proportionality of the impulse of fluids to the square of the velocity. Here is every appearance of the accumulation of an infinity of minute impulses, in the known ratio of the velocity, each to each, producing pressures which are in the ratio of the squares of the velocities.

The pressures are observed; but the impulses or percussions, whose accumulation produces these pressures, are only supposed. The rare fluid, introduced by Newton for the purpose already mentioned, either does not exist in nature, or does not act in the manner we have said, the particles making their impulse, and then escaping through among the rest without affecting their motion. We cannot indeed say what may be the proportion between the diameter and the distance of the particles. The first may be incomparably smaller than the second, even in mercury, the densest fluid which we are familiarly acquainted with: but although they do not touch each other, they act nearly as if they did, in consequence of their mutual attractions and repulsions. We have seen air a thousand times rarer in some experiments than in others, and therefore the distance of the particles at least ten times greater than their diameters; and yet, in this rare state, it propagates all pressures or impulses made on any part of it to a great distance, almost in an instant. It cannot be, therefore, that fluids act on bodies by impulse. It is very possible to conceive a fluid advancing with a flat surface against the flat surface of a solid. The very first and superficial particles may make an impulse; and if they were annihilated, the next might do the same: and if the velocity were double, these impulses would be double, and would be withstood by a double force, and not a quadruple, as is observed: and this very circumstance, that a quadruple force is necessary, should have made us conclude that it was not to impulse that this force was opposed. The first particles having made their stroke, and not being annihilated, must escape laterally. In their escaping they effectually prevent every farther impulse, because they come in the way of those filaments which would have struck the body. The whole process seems to be somewhat as follows:

39
But a very small part of a fluid can make any impulse on a surface.

When the flat surface of the fluid has come into contact with the plane surface AD (fig. 7.), perpendicular to the direction DC of their motion, they must deflect Fig. 7.

to

to both sides equally, and in equal portions, because no reason can be assigned why more should go to either side. By this means the filament EF, which would have struck the surface in G, is deflected *before it arrives at* the surface, and describes a curved path EFIHK, continuing its rectilineal motion to I, where it is intercepted by a filament immediately adjoining to EF, on the side of the middle filament DC. The different particles of DC may be supposed to impinge in succession at C, and to be deflected at right angles; and gliding along CB, to escape at B. Each filament in succession, outwards from DC, is deflected in its turn; and being hindered from even touching the surface CB, it glides off in a direction parallel to it; and thus EF is deflected in I, moves parallel to CB from I to H, and is again deflected at right angles, and describes HK parallel to DC. The same thing may be supposed to happen on the other side of DC.

And thus it would appear, that except two filaments immediately adjoining to the line DC, which bisects the surface at right angles, no part of the fluid makes any impulse on the surface AB. All the other filaments are merely pressed against it by the lateral filaments without them, which they turn aside, and prevent from striking the surface.

40 No impulse on the edge of a prism. Fig. 8.

In like manner, when the fluid strikes the edge of a prism or wedge ACB (fig. 8.), it cannot be said that any real impulse is made. Nothing hinders us from supposing C a mathematical angle or indivisible point, not susceptible of any impulse, and serving merely to divide the stream. Each filament EF is effectually prevented from impinging at G in the line of its direction, and with the obliquity of incidence EGC, by the filaments between EF and DC, which glide along the surface CA; and it may be supposed to be deflected when it comes to the line CF which bisects the angle DCA, and again deflected and rendered parallel to DC at I. The same thing happens on the other side of DC; and we cannot in that case assert that there is any impulse.

41 The ordinary theory of no use in naval architecture. Fig. 9.

We now see plainly how the ordinary theory must be totally unfit for furnishing principles of naval architecture, even although a formula could be deduced from such a series of experiments as those of the French Academy. Although we should know precisely the impulse, or, to speak now more cautiously, the action, of the fluid on a surface GL (fig. 9.) of any obliquity, when it is alone, detached from all others, we cannot in the smallest degree tell what will be the action of *part* of a stream or fluid advancing towards it, with the same obliquity, when it is preceded by an adjoining surface CG, having a different inclination; for the fluid will not glide along GL in the same manner as if it made part of a more extensive surface having the same inclination. The previous deflections are extremely different in these two cases; and the previous deflections are the only changes which we can observe in the motions of the fluid, and the only causes of that pressure which we observe the body to sustain, and which we call the impulse on it. This theory must, therefore, be quite unfit for ascertaining the action on a curved surface, which may be considered as made up of an indefinite number of successive planes.

We now see with equal evidence how it happens that the action of fluids on solid bodies may and must be opposed by pressures, and may be compared with and measured by the pressure of gravity. We are not comparing forces of different kinds, percussions with pressures, but pressures with each other. Let us see whether this view of the subject will afford us any method of comparison or absolute measurement.

42 Pressure, the action of fluids.

When a filament of fluid, that is, a row of corpuscles, are turned out of their course EF (fig. 7.), and forced to take another course IH, force is required to produce this change of direction. The filament is prevented from proceeding by other filaments which lie between it and the body, and which deflect it in the same manner as if it were contained in a bended tube, and it will press on the concave filament next to it as it would press on the concave side of the tube. Suppose such a bended tube ABE (fig. 10.), and that a ball A is projected along it with any velocity, and moves in it without friction: it is demonstrated, in elementary mechanics, that the ball will move with undiminished velocity, and will press on every point, such as B, of the concave side of the tube, in a direction BF perpendicular to the plane CBD, which touches the tube in the point B. This pressure on the adjoining filament, on the concave side of its path, must be withstood by that filament which deflects it; and it must be propagated across that filament to the next, and thus augment the pressure upon that next filament already pressed by the deflection of the intermediate filament; and thus there is a pressure towards the middle filament, and towards the body, arising from the deflection of all the outer filaments; and their accumulated sum must be conceived as immediately exerted on the middle filaments and on the body, because a perfect fluid transmits every pressure undiminished.

Fig. 7.

Fig. 10.

The pressure BF is equivalent to the two BH, BG, one of which is perpendicular, and the other parallel, to the direction of the original motion. By the first (taken in any point of the curvilineal motion of any filament), the two halves of the stream are pressed together; and in the case of fig. 7. and 8. exactly balance each other. But the pressures, such as BG, must be ultimately withstood by the surface ACB; and it is by these accumulated pressures that the solid body is urged down the stream; and it is these accumulated pressures which we observe and measure in our experiments. We shall anticipate a little, and say that it is most easily demonstrated, that when a ball A (fig. 10.) moves with undiminished velocity in a tube so incurvated that its axis at E is at right angles to its axis at A, the accumulated action of the pressures, such as BG, taken for every point of the path, is precisely equal to the force which would produce or extinguish the original motion.

43 Whether they be elastic or not.

This being the case, it follows most obviously, that if the two motions of the filaments are such as we have described and represented by fig. 7. the whole pressure in the direction of the stream, that is, the whole pressure which can be observed on the surface, is equal to the weight of a column of fluid having the surface for its base, and twice the fall productive of the velocity for its height, precisely as Newton deduced it from other considerations; and it seems to make no odds whether the fluid be elastic or unelastic, if the deflections and velocities are the same. Now it is a fact, that no difference in this respect can be observed in the actions of air and water; and this had always appeared a great defect in Newton's theory: but it was only a defect of the

Resistance.

the theory attributed to him. But it is also true, that the observed action is but one-half of what is just now deduced from this improved view of the subject. Whence arises this difference? The reason is this: We have given a very erroneous account of the motions of the filaments. A filament EF does not move as represented in fig. 7. with two rectangular inflections at I and at H, and a path IH between them parallel to CB. The process of nature is more like what is represented in fig. 11. *It is observed*, that at the anterior part of the body AB, there remains a quantity of fluid ADB, almost, if not altogether stagnant, of a singular shape, having two curved concave sides A *a* D, B *b* D, along which the middle filaments glide. This fluid is very slowly changed.—

Fig. 11.

44
Important experiments by Sir Charles Knowles.

The late Sir Charles Knowles, an officer of the British navy, equally eminent for his scientific professional knowledge and for his military talents, made many beautiful experiments for ascertaining the paths of the filaments of water. At a distance up the stream, he allowed small jets of a coloured fluid, which did not mix with water, to make part of the stream; and the experiments were made in troughs with sides and bottom of plate-glass. A small taper was placed at a considerable height above, by which the shadows of the coloured filaments were most distinctly projected on a white plane held below the trough, so that they were accurately drawn with a pencil. A few important particulars may be here mentioned.

The still water ADC, fig. 11. lasted for a long while before it was renewed; and it seemed to be gradually wasted by abrasion, by the adhesion of the surrounding water, which gradually licked away the outer parts from D to A and B; and it seemed to renew itself in the direction CD, opposite to the motion of the stream. There was, however, a considerable intricacy and eddy in this motion. Some (seemingly superficial) water was continually, but slowly, flowing outward from the line DC, while other water was seen within and below it, coming inwards and going backwards.

The coloured lateral filaments were most constant in their form, while the body was the same, although the velocity was in some cases quadrupled. Any change which this produced seemed confined to the superficial filaments.

As the filaments were deflected, they were also constipated, that is, the curved parts of the filaments were nearer each other than the parallel straight filaments up the stream; and this constipation was more considerable as the prow was more obtuse and the deflexion greater.

The inner filaments were ultimately more deflected than those without them; that is, if a line be drawn touching the curve EFIH in the point H of contrary flexure, where the concavity begins to be on the side next the body, the angle HKC, contained between the axis and the tangent line, is so much the greater as the filament is nearer the axis.

When the body exposed to the stream was a box of upright sides, flat bottom, and angular prow, like a wedge, having its edge also upright, the filaments were not all deflected laterally, as theory would make us expect; but the filaments near the bottom were also deflected downwards as well as laterally, and glided along at some distance under the bottom, forming lines of double curvature.

The breadth of the stream that was deflected was much greater than that of the body; and the sensible deflection began at a considerable distance up the stream, especially in the outer filaments.

Lastly, the form of the curves was greatly influenced by the proportion between the width of the trough and that of the body. The curvature was always less when the trough was very wide in proportion to the body.

Great varieties were also observed in the motion or velocity of the filaments. In general, the filaments increased in velocity outwards from the body to a certain small distance, which was nearly the same in all cases, and then diminished all the way outward. This was observed by inequalities in the colour of the filaments, by which one could be observed to outstrip another. The retardation of those next the body seemed to proceed from friction; and it was imagined that without this the velocity there would always have been greatest.

45
With inferences from them.

These observations give us considerable information respecting the mechanism of these motions, and the action of fluids upon solids. The pressure in the duplicate ratio of the velocities comes here again into view. We found, that although the velocities were very different, the curves were precisely the same. Now the observed pressures arise from the transverse forces by which each particle of a filament is retained in its curvilineal path; and we know that the force by which a body is retained in any curve is directly as the square of the velocity, and inversely as the radius of curvature. The curvature, therefore, remaining the same, the transverse forces, and consequently the pressure on the body, must be as the square of the velocity: and, on the other hand, we can see pretty clearly (indeed it is rigorously demonstrated by D'Alembert), that whatever be the velocities, the curves *will* be the same. For it is known in hydraulics, that it requires a fourfold or ninefold pressure to produce a double or triple velocity. And as all pressures are propagated through a perfect fluid without diminution, this fourfold pressure, while it produces a double velocity, produces also fourfold transverse pressures, which will retain the particles, moving twice as fast, in the same curvilineal paths. And thus we see that the impulses, as they are called, and resistances of fluids, have a certain relation to the weight of a column of fluid, whose height is the height necessary for producing the velocity. How it happens that a plane surface, immersed in an extended fluid, sustains just half the pressure which it would have sustained had the motions been such as are sketched in figure 7th, is a matter of more curious and difficult investigation. But we see evidently that the pressure must be less than what is there assigned; for the stagnant water a-head of the body greatly diminishes the ultimate deflections of the filaments: And it may be demonstrated, that when the part BE of the canal, fig. 10. is inclined to the part AB in an angle less than 90°, the pressures BG along the whole canal are as the versed sine of the ultimate angle of deflection, or the versed sine of the angle which the part BE makes with the part AB. Therefore, since the deflections resemble more the sketch given in fig. 11. the accumulated sum of all these forces BG of fig. 10. must be less than the similar sum corresponding to fig. 7. that is, less than the weight of the column of fluid, having twice the productive height for its height. How it is just one half, shall be our next inquiry.

And

And here we muft return to the labours of Sir Ifaac Newton. After many beautiful obfervations on the nature and mechanifm of continued fluids, he fays, that the refiftance which they occafion is but one half of that occafioned by the rare fluid which had been the fubject of his former propofition; "which truth," (fays he, with his ufual caution and modefty), "I fhall endeavour to fhow."

46 Inveftigations of Newton

He then enters into another, as novel and as difficult an inveftigation, viz. the laws of hydraulics, and endeavours to afcertain the motion of fluids through orifices when urged by preffures of any kind. He endeavours to afcertain the velocity with which a fluid efcapes through a horizontal orifice in the bottom of a veffel, by the action of its weight, and the preffure which this vein of fluid will exert on a little circle which occupies part of the orifice. To obtain this, he employs a kind of approximation and trial, of which it would be extremely difficult to give an extract; and then, by increafing the diameter of the veffel and of the hole to infinity, he accommodates his reafoning to the cafe of a plane furface expofed to an indefinitely extended ftream of fluid; and, laftly, giving to the little circular furface the motion which he had before afcribed to the fluid, he fays, that the refiftance to a plane furface moving through an unelaftic continuous fluid, is equal to the weight of a column of the fluid whofe height is one-half of that neceffary for acquiring the velocity; and he fays, that the refiftance of a globe is, in this cafe, the fame with that of a cylinder of the fame diameter. The refiftance, therefore, of the cylinder or circle is four times lefs, and that of the globe is twice lefs than their refiftances on a rare elaftic medium.

47 liable to great objections,

But this determination, though founded on principles or affumptions, which are much nearer to the real ftate of things, is liable to great objections. It depends on his method for afcertaining the velocity of the iffuing fluid; a method extremely ingenious, but defective. The cataract, which he fuppofes, cannot exift as he fuppofes, defcending by the full action of gravity, and furrounded by a funnel of ftagnant fluid. For, in fuch circumftances, there is nothing to balance the hydroftatical preffure of this furrounding fluid; becaufe the whole preffure of the central cataract is employed in producing its own defcent. In the next place, the preffure which he determines is beyond all doubt only half of what is obferved on a plane furface in all our experiments. And, in the third place, it is repugnant to all our experience, that the refiftance of a globe or of a pointed body is as great as that of its circular bafe. His reafons are by no means convincing. He fuppofes them placed in a tube or canal; and fince they are fuppofed of the fame diameter, and therefore leave equal fpaces at their fides, he concludes, that becaufe the water efcapes by their fides with the fame velocity, they will have the fame refiftance. But this is by no means a neceffary confequence. Even if the water fhould be allowed to exert equal preffures on them, the preffures being perpendicular to their furfaces, and thefe furfaces being inclined to the axis, while in the cafe of the bafe of a cylinder, it is in the direction of the axis, there muft be a difference in the accumulated or compound preffure in the direction of the axis. He indeed fays, that in the cafe of the cylinder or the circle obftructing the canal, a quantity of water remains ftagnant on its upper furface; viz. all the water whofe motion would not contribute to the moft ready paffage of the fluid between the cylinder and the fides of the canal or tube; and that this water may be confidered as frozen. If this be the cafe, it is indifferent what is the form of the body that is covered with this mafs of frozen or ftagnant water. It may be a hemifphere or a cone; the refiftance will be the fame.—But Newton by no means affigns, either with precifion or with diftinct evidence, the form and magnitude of this ftagnant water, fo as to give confidence in the refults. He contents himfelf with faying, that it is that water whofe motion is not neceffary or cannot contribute to the moft eafy paffage of the water.

48 though difplaying great fagacity.

There remains, therefore, many imperfections in this theory. But notwithftanding thefe defects, we cannot but admire the efforts and fagacity of this great philofopher, who, after having difcovered fo many fublime truths of mechanical nature, ventured to trace out a path for the folution of a problem which no perfon had yet attempted to bring within the range of mathematical inveftigation. And his folution, though inaccurate, fhines throughout with that inventive genius and that fertility of refource, which no man ever poffeffed in fo eminent a degree.

Thofe who have attacked the folution of Sir Ifaac Newton have not been more fuccefsful. Moft of them, inftead of principles, have given a great deal of calculus; and the chief merit which any of them can claim, is that of having deduced fome fingle propofition which happens to quadrate with fome fingle cafe of experiment, while their general theories are either inapplicable, from difficulty and obfcurity, or are difcordant with more general obfervation.

We muft, however, except from this number Daniel Bernoulli, who was not only a great geometer, but one of the firft philofophers of the age. He poffeffed all the talents, and was free from the faults of that celebrated family; and while he was the mathematician of Europe who penetrated fartheft in the inveftigation of this great problem, he was the only perfon who felt, or at leaft who acknowledged, its great difficulty.

49 Bernoulli's general formula founded on hypothefis.

In the 2d volume of the *Comment. Petropol.* 1727, he propofes a formula for the refiftance of fluids, deduced from confiderations quite different from thofe on which Newton founded his folution. But he delivers it with modeft diffidence; becaufe he found that it gave a refiftance four times greater than experiment. In the fame differtation he determines the refiftance of a fphere to be one half of that of its great circle. But in his fubfequent theory of Hydrodynamics (a work which muft ever rank among the firft productions of the age, and is equally eminent for refined and elegant mathematics, and ingenious and original thoughts in dynamics), he calls this determination in queftion. It is indeed founded on the fame hypothetical principles which have been unfkilfully detached from the reft of Newton's phyfics, and made the groundwork of all the fubfequent theories on this fubject.

50 He treats the fubject in a particular cafe with great precifion.

In 1741 Mr Daniel Bernoulli publifhed another differtation (in the 8th volume of the *Com. Petropol.*) on the action and refiftance of fluids, limited to a very particular cafe; namely, to the impulfe of a vein of fluid

Resistance. fluid falling perpendicularly on an infinitely extended plane surface. This he demonstrates to be equal to the weight of a column of the fluid whose base is the area of the vein, and whose height is twice the fall producing the velocity. This demonstration is drawn from the true principles of mechanics and the acknowledged laws of hydraulics, and may be received as a strict physical demonstration. As it is the only proposition in the whole theory that has as yet received a demonstration accessible to readers not versant in all the refinements of modern analysis; and as the principles on which it proceeds will undoubtedly lead to a solution of every problem which can be proposed, once that our mathematical knowledge shall enable us to apply them—we think it our duty to give it in this place, although we must acknowledge, that this problem is so very limited, that it will hardly bear an application to any case that differs but a little from the express conditions of the problem. There do occur cases however in practice, where it may be applied to very great advantage.

Daniel Bernoulli gives two demonstrations; one of which may be called a popular one, and the other is more scientific and introductory to further investigation. We shall give both.

51 Determines the action exerted in the efflux of a vein of fluid.

Bernoulli first determines the whole action exerted in the efflux of the vein of fluid. Suppose the velocity of efflux v is that which would be acquired by falling through the height h. It is well known that a body moving during the time of this fall with the velocity v would describe a space $2\ h$. The effect, therefore, of the hydraulic action is, that in the time t of the fall h, there issues a cylinder or prism of water whose base is the cross section f or area of the vein, and whose length is $2\ h$. And this quantity of matter is now moving with the velocity v. The quantity of motion, therefore, which is thus produced is $2\ s\ h\ v$; and this quantity of motion is produced in the time t. And this is the accumulated effect of all the expelling forces, estimated in the direction of the efflux. Now, to compare this with the exertion of some pressing power with which we are familiarly acquainted, let us suppose this pillar $2\ s\ h$ to be frozen, and, being held in the hand, to be dropped. It is well known, that in the time t it will fall through the height h, and will acquire the velocity v, and now possesses the quantity of motion $2\ s\ h\ v$—and all this is the effect of its weight. The weight, therefore, of the pillar $2\ s\ h$ produces the same effect, and in the same time, and (as may easily be seen) in the same gradual manner, with the expelling forces of the fluid in the vessel, which expelling forces arise from the pressure of all the fluid in the vessel. Therefore the accumulated hydraulic pressure, by which a vein of a heavy fluid is forced out through an orifice in the bottom or side of a vessel, is equal (when estimated in the direction of the efflux) to the weight of a column of the fluid, having for its base the section of the vein, and twice the fall productive of the velocity of efflux for its height.

Fig. 12.

Now let ABDC (fig. 12.) be a quadrangular vessel with upright plane sides, in one of which is an orifice EF. From every point of the circumference of this orifice, suppose horizontal lines E e, F f, &c. which will mark a similar surface on the opposite side of the vessel. Suppose the orifice EF to be shut. There can be no doubt but that the surfaces EF and $e\,f$ will be equally pressed in opposite directions. Now open the orifice EF; the water will rush out, and the pressure on EF is now removed. There will therefore be a tendency in the vessel to move back in the direction E e. And this tendency must be precisely equal and opposite to the whole effort of the expelling forces. This is a conclusion as evident as any proposition in mechanics. It is thus that a gun recoils and a rocket rises in the air; and on this is founded the operation of Mr Parents or Dr Barker's mill, described in all treatises of mechanics, and most learnedly treated by Euler in the Berlin Memoirs.

Now, let this stream of water be received on a circular plane MN, perpendicular to its axis, and let this circular plane be of such extent, that the vein escapes from its sides in an infinitely thin sheet, the water flowing off in a direction parallel to the plane. The vein by this means will expand into a trumpet-like shape, having curved sides, EKG, FLH fig. 13. We abstract at present the action of gravity which would cause the vein to bend downwards, and occasion a greater velocity at H than at G; and we suppose the velocity equal in every point of the circumference. It is plain, that if the action of gravity be neglected after the water has issued through the orifice EF, the velocity in every point of the circumference of the plane MN will be that of the efflux through EF.

Fig. 13.

Now, because EKG is the natural shape assumed by the vein, it is plain, that if the whole vein were covered by a tube or mouth-piece, fitted to its shape, and perfectly polished, so that the water shall glide along it, without any friction (a thing which we may always suppose), the water will exert no pressure whatever on this trumpet mouth-piece. Lastly, let us suppose that the plane MN is attached to the mouth-piece by some bits of wire, so as to allow the water to escape all round by the narrow chink between the mouth-piece and the plane: We have now a vessel consisting of the upright part ABDC, the trumpet GKEFLH, and the plane MN; and the water is escaping from every point of the circumference of the chink GHNM with the velocity v. If any part of this chink were shut up, there would be a pressure on that part equivalent to the force of efflux from the opposite part. Therefore, when all is open, these efforts of efflux balance each other all round. There is not therefore any tendency in this compound vessel to move to any side. But take away the plane MN, and there would immediately arise a pressure in the direction E e equal to the weight of the column $2\ s\ h$. This is therefore balanced by the pressure on the circular plane MN, which is therefore equal to this weight, and the proposition is demonstrated.

A number of experiments were made by Professor Kraft at St Petersburg, by receiving the vein on a plane MN (fig. 12.) which was fastened to the arm of a balance OPQ, having a scale R hanging on the opposite arm. The resistance or pressure on the plane was measured by weights put into the scale R; and the velocity of the jet was measured by means of the distance KH, to which it spouted on a horizontal plane.

52 Difference between this theory and experiments accounted for.

The results of these experiments were as conformable to the theory as could be wished. The resistance was always a little less than what the theory required, but greatly exceeded its half; the result of the generally received theories. This defect should be expected; for the

the demonſtration ſuppoſes the plane MN to be infinitely extended, ſo that the film of water which iſſues through the chink may be accurately parallel to the plane. This never can be completely effected. Alſo it was ſuppoſed, that the velocity was juſtly meaſured by the amplitude of the parabola EGK. But it is well known that the very putting the plane MN in the way of the jet, though at the diſtance of an inch from the orifice, will diminiſh the velocity of the efflux through this orifice. This is eaſily verified by experiment. Obſerve the time in which the veſſel will be emptied when there is no plane in the way. Repeat the experiment with the plane in its place; and more time will be neceſſary. The following is a note of a courſe of experiments, taken as they ſtand, without any ſelection.

	Nº 1	2	3	4	5	6
Reſiſt by theory	1701	1720	1651	1602	1528	1072
Reſiſt. by experiment	1403	1463	1486	1401	1403	1021
Difference	298	257	165	201	125	51

In order to demonſtrate this propoſition in ſuch a manner as to furniſh the means of inveſtigating the whole mechaniſm and action of moving fluids, it is neceſſary to premiſe an elementary theorem of curvilineal motions.

Fig. 14. If a particle of matter deſcribes a curve line ABCE (fig. 14.) by the continual action of deflecting forces, which vary in any manner, both with reſpect to intenſity and direction, and if the action of theſe forces, in every point of the curve, be reſolved into two directions, perpendicular and parallel to the initial direction AK; then,

1. The accumulated effect of the deflecting forces, eſtimated in a direction AD perpendicular to AK, is to the final quantity of motion as the ſine of the final change of direction is to radius.

53 His propoſition demonſtrated.

Let us firſt ſuppoſe that the accelerating forces act by ſtarts, at equal intervals of time, when the body is in the points A, B, C, E. And let AN be the deflecting force, which, acting at A, changes the original direction AK to AB. Produce AB till BH = AB, and complete the parallelogram BFCH. Then FB is the force which, by acting at B, changed the motion BH (the continuation of AB) to BC. In like manner make C*h* (in BC produced) equal to BC, and complete the parallelogram C*f*E*h*. C*f* is the deflecting force at C, &c. Draw BO parallel to AN, and GBK perpendicular to AK. Alſo draw lines through C and E perpendicular to AK, and draw through B and C lines parallel to AK. Draw alſo HL, *hl* perpendicular, and FG, HI, *hi*, parallel to AK.

It is plain that BK is BO or AN eſtimated in the direction perpendicular to AK, and that BG is BF eſtimated in the ſame way. And ſince BH=AB, HL or IM is equal to BK. Alſo CI is equal to BG. Therefore CM is equal to AP+BG. By ſimilar reaſoning it appears that $Em = Ei + hl, = Cg + CM, = Cg + BG, + AP$.

Therefore if CE be taken for the meaſure of the final velocity or quantity of motion, E*m* will be the accumulated effect of the deflecting forces eſtimated in the direction AD perpendicular to AK. But E*m* is to CE as the ſine of *m*CE is to radius; and the angle *m*CE is the angle contained between the initial and final directions, becauſe C*m* is parallel to AK. Now let the intervals of time diminiſh continually and the frequency of the impulſes increaſe. The deflection becomes ultimately continuous, and the motion curvilineal, and the propoſition is demonſtrated.

We ſee that the initial velocity and its ſubſequent changes do not affect the concluſion, which depends entirely on the final quantity of motion.

2. The accumulated effect of the accelerating forces, when eſtimated in the direction AK of the original motion, or in the oppoſite direction, is equal to the difference between the initial quantity of motion and the product of the final quantity of motion by the coſine of the change of direction.

$$\text{For } Cm = Cl - ml, = BM - fq$$
$$BM = BL - ML, = AK - FG$$
$$AK = AO - OK, = AO - PN.$$

Therefore PN+FG+*f*Q (the accumulated impulſe in the direction OA)=AO—CM,=AO—CE × coſine of ECM.

Cor. 1. The ſame action, in the direction oppoſite to that of the original motion, is neceſſary for cauſing a body to move at right angles to its former direction as for ſtopping its motion. For in this caſe, the coſine of the change of direction is = *o*, and AO—CE × coſine ECM = AO—*o*, = AO, = the original motion.

Cor. 2. If the initial and final velocities are the ſame, the accumulated action of the accelerating forces, eſtimated in the direction OA, is equal to the product of the original quantity of motion by the verſed ſine of the change of direction.

The application of theſe theorems, particularly the ſecond, to our preſent purpoſe is very obvious. All the filaments of the jet were originally moving in the direction of its axis, and they are finally moving along the reſiſting plane, or perpendicular to their former motion. Therefore their tranſverſe forces in the direction of the axis are (*in cumulo*) equal to the force which would ſtop the motion. For the aggregate of the ſimultaneous forces of every particle in the whole filament is the ſame with that of the ſucceſſive forces of one particle, as it arrives at different points of its curvilineal path. All the tranſverſe forces, eſtimated in a direction perpendicular to the axis of the vein, preciſely balance and ſuſtain each other; and the only forces which can produce a ſenſible effect are thoſe in a direction parallel to the axis. By theſe all the inner filaments are preſſed towards the plane MN, and muſt be withſtood by it. It is highly probable, nay certain, that there is a quantity of ſtagnant water in the middle of the vein which ſuſtains the preſſures of the moving filaments without it, and tranſmits it to the ſolid plane. But this does not alter the caſe. And, fortunately, it is of no conſequence what changes happen in the velocities of the particles while each is deſcribing its own curve. And it is from this circumſtance, peculiar to this particular caſe of perpendicular impulſe, that we are able to draw the concluſion. It is by no means difficult to demonſtrate that the velocity of the external ſurface of this jet is conſtant, and indeed of every jet which is not acted on by external forces after it has quitted the orifice: but this diſcuſſion is quite unneceſſary here. It is however extremely difficult to aſcertain, even in this moſt ſimple caſe, what is the velocity of the internal filaments in the different points of their progreſs.

Such

Such is the demonſtration which Mr Bernoulli has given of this propoſition. Limited as it is, it is highly valuable, becauſe derived from the true principles of hydraulics.

He hoped to render it more extenſive and applicable to oblique impulſes, when the axis AC of the vein

Fig. 15.

(fig. 15.) is inclined to the plane in an angle ACN. But here all the ſimplicity of the caſe is gone, and we are now obliged to aſcertain the motion of each filament.

54 His theory attempted in vain to be rendered general.

It might not perhaps be impoſſible to determine what muſt happen in the plane of the figure, that is, in a plane paſſing through the axis of the vein, and perpendicular to the plane MN. But even in this caſe it would be extremely difficult to determine how much of the fluid will go in the direction EKG, and what will go in the path FLH, and to aſcertain the form of each filament, and the velocity in its different points. But in the real ſtate of the caſe, the water will diſſipate from the centre C on every ſide; and we cannot tell in what proportions. Let us however conſider a little what happens in the plane of the figure, and ſuppoſe that all the water goes either in the courſe EKG or in the courſe FLH. Let the quantities of water which take theſe two courſes have the proportions of p and Π. Let $\sqrt{2a}$ be the velocity at A, $\sqrt{2b}$ be the velocity at G, and $\sqrt{2\beta}$ be the velocity at H. ACG and ACH are the two changes of direction, of which let c and $-c$ be the coſines. Then, adopting the former reaſoning, we have the preſſure of the watery plate GKEACM on the plane in the direction AC $= \frac{p}{p+\Pi} \times \overline{2a-2cb}$, and the preſſure of the plate HLFACN $= \frac{\Pi}{p+\Pi} \times \overline{2a+2c\beta}$, and their ſum $= \frac{p \times \overline{2a-2cb} + \Pi \times \overline{2a+2c\beta}}{p+\Pi}$; which being multiplied by the ſine of ACM or $\sqrt{1-c^2}$, gives the preſſure perpendicular to the plane MN $= \frac{p \times \overline{2a-2cb} + \Pi \times \overline{2a+2c\beta}}{p+\Pi} \sqrt{1-c^2}$.

But there remains a preſſure in the direction perpendicular to the axis of the vein, which is not balanced, as in the former caſe, by the equality on oppoſite ſides of the axis. The preſſure ariſing from the water which eſcapes at G has an effect oppoſite to that produced by the water which eſcapes at H. When this is taken into account, we ſhall find that their joint efforts perpendicular to AC are $\frac{p-\Pi}{p+\Pi} \times 2a\sqrt{1-c^2}$, which, being multiplied by the coſine of ACM, gives the action perpendicular to MN $= \frac{p-\Pi}{p+\Pi} \times 2ac\sqrt{1-c^2}$.

The ſum or joint effort of all theſe preſſures is

$$\frac{p \times \overline{2a-2cb} + \Pi \times \overline{2a+2c\beta}}{p+\Pi} \sqrt{1-c^2} + \frac{p-\Pi}{p+\Pi} \times 2ac\sqrt{1-c^2}.$$

Thus, from this caſe, which is much ſimpler than can happen in nature, ſeeing that there will always be a lateral efflux, the determination of the impulſe is as uncertain and vague as it was ſure and preciſe in the former caſe.

It is therefore without proper authority that the abſolute impulſe of a vein of fluid on a plane which receives it wholly, is aſſerted to be proportional to the ſine of incidence. If indeed we ſuppoſe the velocity in G and H are equal to that at A, then $b=\beta$, $=a$, and the whole impulſe is $2a\sqrt{1-c^2}$, as is commonly ſuppoſed. But this cannot be. Both the velocity and quantity at H are leſs than thoſe at G. Nay, frequently there is no efflux on the ſide H when the obliquity is very great. We may conclude in general, that the oblique impulſe will always bear to the direct impulſe a greater proportion than that of the ſine of incidence to radius. If the whole water eſcapes at G, and none goes off laterally, the preſſure will be $\overline{2a+2ac-2bc} \times \sqrt{1-c^2}$. The experiments of the Abbé Boſſut ſhow in the plaineſt manner that the preſſure of a vein, ſtriking obliquely on a plane which receives it wholly, diminiſhes faſter than in the ratio of the ſquare of the ſine of incidence; whereas, when the oblique plane is wholly immerſed in the ſtream, the impulſe is much greater than in this proportion, and in great obliquities is nearly as the ſine.

Nor will this propoſition determine the impulſe of a fluid on a plane wholly immerſed in it, even when the impulſe is perpendicular to the plane. The circumſtance is now wanting on which we can eſtabliſh a calculation, namely, the angle of final deflection. Could this be aſcertained for each filament, and the velocity of the filament, the principles are completely adequate to an accurate ſolution of the problem. In the experiments which we mentioned to have been made under the inſpection of Sir Charles Knowles, a cylinder of ſix inches diameter was expoſed to the action of a ſtream moving preciſely one foot per ſecond; and when certain deductions were made for the water which was held adhering to the poſterior baſe (as will be noticed afterwards), the impulſe was found equal to $3\frac{1}{8}$ ounces avoirdupois. There were 36 coloured filaments diſtributed on the ſtream, in ſuch ſituations as to give the moſt uſeful indications of their curvature. It was found neceſſary to have ſome which paſſed under the body and ſome above it; for the form of theſe filaments, at the ſame diſtance from the axis of the cylinder, was conſiderably different: and thoſe filaments which were ſituated in planes neither horizontal nor vertical took a double curvature. In ſhort, the curves were all traced with great care, and the deflecting forces were computed for each, and reduced to the direction of the axis; and they were ſummed up in ſuch a manner as to give the impulſe of the whole ſtream. The deflections were marked as far a-head of the cylinder as they could be aſſuredly obſerved. By this method the impulſe was computed to be $2\frac{15}{16}$ ounces, differing from obſervation $\frac{3}{16}$ of an ounce, or about $\frac{1}{16}$ of the whole; a difference which may moſt reaſonably be aſcribed to the adheſion of the water, which muſt be moſt ſenſible in ſuch ſmall velocities. Theſe experiments may therefore be conſidered as giving all the confirmation that can be deſired of the juſtneſs of the principles. This indeed hardly admits of a doubt: but, alas! it gives us but ſmall aſſiſtance; for all this is empirical, in as far as it leaves us in every caſe the taſk of obſerving the form of the curves and

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and the velocities in their different points. To derive service from this most judicious method of Daniel Bernoulli, we must discover some method of determining, *à priori*, what will be the motion of the fluid whose course is obstructed by a body of any form. And here we cannot omit taking notice of the casual observations of Sir Isaac Newton when attempting to determine the resistance of the plane surface or cylinder, or sphere exposed to a stream moving in a canal. He says, that the form of the resisting surface is of less consequence, because there is always a quantity of water stagnant upon it, and which may therefore be considered as frozen; and he therefore considers that water only whose motion is necessary for the most expeditious discharge of the water in the vessel. He endeavours to discriminate that water from the rest; and although it must be acknowledged that the principle which he assumes for this purpose is very gratuitous, because it only shows, that *if certain portions of the water*, which he determines very ingeniously, were really frozen, the rest will issue, as he says, and will exert the pressure which he assigns; still we must admire his fertility of resource, and his sagacity in thus foreseeing what subsequent observation has completely confirmed. We are even disposed to think, that in this casual observation Sir Isaac Newton has pointed out the only method of arriving at a solution of the problem; and that, if we could discover *what motions are not necessary for the most expeditious passage of the water*, and could thus determine the form and magnitude of the stagnant water which adheres to the body, we should much more easily ascertain the real motions which occasion the observed resistance. We are here disposed to have recourse to the economy of nature, the improper use of which we have sometimes taken the liberty of reprehending. Mr Maupertuis published as a great discovery his principle of smallest action, where he showed that in all the mutual actions of bodies the quantity of action was a minimum; and he applied this to the solution of many difficult problems with great success, imagining that he was really reasoning from a contingent law of nature, selected by its infinitely wise Author, viz. that in all occasions there is the smallest possible exertion of natural powers. Mr D'Alembert has, however, shown (vid. *Encyclopedié Françoise*, ACTION) that this was but a whim, and that the minimum observed by Maupertuis is merely a minimum of calculus, peculiar to a formula which happens to express a combination of mathematical quantities which frequently occurs in our way of considering the phenomena of nature, but which is no natural measure of action.

55 A method recommended for obtaining a general theory.

But the chevalier D'Arcy has shown, that in the trains of natural operations which terminate in the production of motion in a particular direction, the intermediate communications of motion are such that the smallest possible quantity of motion is produced. We seem obliged to conclude, that this law will be observed in the present instance; and it seems a problem not above our reach to determine the motions which result from it. We would recommend the problem to the eminent mathematicians in some simple case, such as the proposition already demonstrated by Daniel Bernoulli, or the perpendicular impulse on a cylinder included in a tubular canal; and if they succeed in this, great things may be expected. We think that experience gives great encouragement. We see that the resistance to a plane surface is a very small matter greater than the weight of a column of the fluid having the fall productive of the velocity for its height, and the small excess is most probably owing to adhesion, and the measure of the real resistance is probably precisely this weight. The velocity of a spouting fluid was found, in fact, to be that acquired by falling from the surface of the fluid; and it was by looking at this, as at a pole star, that Newton, Bernoulli, and others, have with great sagacity and ingenuity discovered much of the laws of hydraulics, by searching for principles which would give this result. We may hope for similar success.

In the mean time, we may receive this as a physical truth, that the perpendicular impulse or resistance of a plane surface, wholly immersed in the fluid, is equal to the weight of the column having the surface for its base, and the fall producing the velocity for its height.

This is the medium result of all experiments made in these precise circumstances. And it is confirmed by a set of experiments of a kind wholly different, and which seem to point it out more certainly as an immediate consequence of hydraulic principles.

56 Experiment by Mr Pitot's tube. Fig. 16.

If Mr Pitot's tube be exposed to a stream of fluid issuing from a reservoir or vessel, as represented in fig. 16. with the open mouth I pointed directly against this stream, the fluid is observed to stand at K in the upright tube, precisely on a level with the fluid AB in the reservoir. Here is a most unexceptionable experiment, in which the impulse of the stream is actually opposed to the hydrostatical pressure of the fluid on the tube. Pressure is in this case opposed to pressure, because the issuing fluid is deflected by what stays in the mouth of the tube, in the same way in which it would be deflected by a firm surface. We shall have occasion by and by to mention some most valuable and instructive experiments made with this tube.

57 Euler's theory.

It was this which suggested to the great mathematician Euler another theory of the impulse and resistance of fluids, which must not be omitted, as it is applied in his elaborate performance On the Theory of the Construction and Working of Ships, in two volumes 4to, which was afterwards abridged and used as a text-book in some marine academies. He supposes a stream of fluid ABCD (fig. 17.), moving with any velocity, to strike the plane BD perpendicularly, and that part of it goes through a hole EF, forming a jet EGHF. Mr Euler says, that the velocity of this jet will be the same with the velocity of the stream. Now compare this with an equal stream issuing from a hole in the side of a vessel with the same velocity. The one stream is urged out by the pressure occasioned by the impulse of the fluid; the other is urged out by the pressure of gravity. The effects are equal, and the modifying circumstances are the same. The causes are therefore equal, and the pressure occasioned by the impulse of a stream of fluid, moving with any velocity, is equal to the weight of a column of fluid whose height is productive of this velocity, &c. He then determines the oblique impulse by the resolution of motion, and deduces the common rules of resistance, &c.

Fig. 17.

But all this is without just grounds. This gentleman was always satisfied with the slightest analogies which would give him an opportunity of exhibiting his great

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great dexterity in algebraic analysis, and was not afterwards startled by any discordancy with observation. *Analysi magis fidendum* is a frequent assertion with him. Though he wrote a large volume, containing a theory of light and colours totally opposite to Newton's, he has published many dissertations on optical phenomena on the Newtonian principles, expressly because his own principles *non ideo facile ansam præbebat analysi instruendæ*.

58 Without foundation.

Not a shadow of argument is given for the leading principle in this theory, viz. that the velocity of the jet is the same with the velocity of the stream. None can be given, but saying, that the pressure is equivalent to its production; and this is assuming the very thing he labours to prove. The matter of fact is, that the velocity of the jet is greater than that of the stream, and may be greater almost in any proportion. Which curious circumstance was discovered and ingeniously explained long ago by Daniel Bernoulli in his *Hydrodynamica*. It is evident that the velocity must be greater. Were a stream of sand to come against the plane, what goes through would indeed preserve its velocity unchanged: but when a real fluid strikes the plane, all that does not pass through is deflected on all sides; and by these deflections forces are excited, by which the filaments which surround the cylinder immediately fronting the hole are made to press this cylinder on all sides, and as it were squeeze it between them: and thus the particles at the hole must of necessity be accelerated, and the velocity of the jet must be greater than that of the stream. We are disposed to think that, in a fluid perfectly incompressible, the velocity will be double, or at least increased in the proportion of 1 to $\sqrt{2}$. If the fluid is in the smallest degree compressible, even in the very small degree that water is, the velocity at the first impulse may be much greater. D. Bernoulli found that a column of water moving 5 feet per second, in a tube some hundred feet long, produced a velocity of 136 feet per second in the first moment.

There being this radical defect in the theory of Mr Euler, it is needless to take notice of its total insufficiency for explaining oblique impulses and the resistance of curvilineal prows.

59 Ingenious solution of d'Alembert.

We are extremely sorry that our readers are deriving so little advantage from all that we have said; and that having taken them by the hand, we are thus obliged to grope about, with only a few scattered rays of light to direct our steps. Let us see what assistance we can get from Mr d'Alembert, who has attempted a solution of that problem in a method entirely new and extremely ingenious. He saw clearly, that all the followers of Newton had forsaken the path which he had marked out for them in the second part of his investigation, and had merely amused themselves with the mathematical discussion with which his introductory hypothesis gave them an opportunity of occupying themselves. He paid the deserved tribute of applause to Daniel Bernoulli for having introduced the notion of pure pressure as the chief agent in this business; and he saw that he was in the right road, and that it was from hydrostatical principles alone that we had any chance of explaining the phenomena of hydraulics. Bernoulli had only considered the pressures which were excited in consequence of the curvilineal motions of the particles. Mr d'Alembert even thought that these pressures were not the consequences, but the causes, of these curvilineal motions. No internal motion can happen in a fluid but in consequence of an unbalanced pressure; and every such motion will produce an inequality of pressure, which will determine the succeeding motions. He therefore endeavoured to reduce all to the discovery of those disturbing pressures, and thus to the laws of hydrostatics. He had long before this hit on a very refined and ingenious view of the action of bodies on each other, which had enabled him to solve many of the most difficult problems concerning the motions of bodies, such as the centre of oscillation, of spontaneous conversion, the precession of the equinoxes, &c. &c. with great facility and elegance. He saw that the same principle would apply to the action of fluid bodies. The principle is this.

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"*In whatever manner any number of bodies are supposed to act on each other, and by these actions come to change their present motions, if we conceive that the motion which each body would have in the following instant (if it became free), is resolved into two other motions; one of which is the motion which it really takes in the following instant; the other will be such, that if each body had no other motion but this second, the whole bodies would have remained in equilibrio.*" We here observe, that "the motion which each body would have in the following instant, if it became free," is a continuation of the motion which it has in the first instant. It may therefore perhaps be better expressed thus:

If the motions of bodies, anyhow acting on each other, be considered in two consecutive instants, and if we conceive the motion which it has in the first instant as compounded of two others, one of which is the motion which it actually takes in the second instant, the other is such, that if each body had only those second motions, the whole system would have remained in equilibrio.

The proposition itself is evident. For if these second motions be not such as that an equilibrium of the whole system would result from them, the other component motions would not be those which the bodies really have after the change; for they would necessarily be altered by these unbalanced motions. See D'Alembert *Essai de Dynamique*.

Assisted by this incontestable principle, M. d'Alembert demonstrates, in a manner equally new and simple, those propositions which Newton had so cautiously deduced from his hypothetical fluid, showing that they were not limited to this hypothesis, viz. that the motions produced by similar bodies, similarly projected in them, would be similar; that whatever were the pressures, the curves described by the particles would be the same; and that the resistances would be proportional to the squares of the velocities. He then comes to consider the fluid as having its motions constrained by the form of the canal or by solid obstacles interposed.

We shall here give a summary account of his fundamental proposition.

60 Summary account of his fundamental proposition. Fig. 18.

It is evident, that if the body ADCE (fig. 18.) did not form an obstruction to the motion of the water, the particles would describe parallel lines TF, OK, PS, &c. But while yet at a distance from the body in F, K, S, they gradually change their directions, and describe the curves FM, K *m*, S *n*, so much more incurvated as they are nearer to the body. At a certain distance ZY this

curvature

Resistance. curvature will be insensible, and the fluid included in the space ZYHQ will move uniformly as if the solid body were not there. The motions on the other side of the axis AC will be the same; and we need only attend to one half, and we shall consider these as in a state of permanency.

No body changes either its direction or velocity otherwise than by insensible degrees: therefore the particle which is moving in the axis will not reach the vertex A of the body, where it behoved to deflect instantaneously at right angles. It will therefore begin to be deflected at some point F a-head of the body, and will describe a curve FM, touching the axis in F, and the body in M; and then, gliding along the body, will quit it at some point L, describing a tangent curve, which will join the axis again (touching it) in R; and thus there will be a quantity of stagnant water FAM before or a-head of the body, and another LCR behind or aftern of it.

Let a be the velocity of a particle of the fluid in any instant, and a' its velocity in the next instant. The velocity a may be considered as compounded of a' and a''. If the particles tended to move with the velocities a'' only, the whole fluid would be in equilibrio (general principle), and the pressure of the fluid would be the same as if all were stagnant, and each particle were urged by a force $\frac{a''}{\dot{t}}$, $\dot{t}$ expressing an indefinitely small moment of time. (N. B. $\frac{a''}{\dot{t}}$ is the proper expression of the accelerating force, which, by acting during the moment $\dot{t}$, would generate the velocity a''; and a'' is supposed an indeterminate quantity, different perhaps for each particle). Now let a be supposed constant, or $a=a'$. In this case $a''=o$. That is to say, no pressure whatever will be exerted on the solid body unless there happen changes in the velocities or directions of the particles.

Let a and a' then be the motions of the particles in two consecutive instants. They would be in equilibrio if urged only by the forces $\frac{a''}{\dot{t}}$. Therefore if γ be the point where the particles which describe the curve FM begin to change their velocity, the pressure in D would be equal to the pressure which the fluid contained in the canal γFMD would exert, if each particle were solicited by its force $\frac{a''}{\dot{t}}$. The question is therefore reduced to the finding the curvature in the canal γFMD, and the accelerating forces $\frac{a''}{\dot{t}}$ in its different parts.

Fig. 19. It appears, in the first place, that no pressure is exerted by any of the particles along the curve FM: for suppose that the particle a (fig. 19.) describes the indefinitely small straight line ab in the first instant, and bc in the second instant; produce ab till $bd=ab$, and joining dc, the motion ab or bd may be considered as composed of bc, which the particle really takes in the next instant, and a motion dc which should be destroyed. Draw bi parallel to dc, and ie perpendicular to bc. It is plain that the particle b, solicited by the forces be, ei (equivalent to dc) should be in equilibrio. This being established, be must be $=o$, that is, there will be no accelerating or retarding force at b; for if there be, draw bm (fig. 20.) perpendicular to bF, and the parallel nq infinitely near it. The part bn of the fluid contained in the canal $bnqm$ would sustain some pressure from b towards n, or from n towards b. Therefore since the fluid in this stagnant canal should be in equilibrio, there must also be some action, at least in one of the parts bm, mq, qn, to counterbalance the action on the part bn. But the fluid is stagnant in the space FAM (in consequence of the law of continuity). Therefore there is no force which can act on bm, mq, qn; and the pressure in the canal in the direction bn or nb is nothing, or the force $be=o$, and the force ie is perpendicular to the canal; and there is therefore no pressure in the canal FM, except what proceeds from the part γF, or from the force ei; which last being perpendicular to the canal, there can be no force exerted on the point M, but what is propagated from the part γF. Fig. 20.

The velocity therefore in the canal FM is constant if finite, or infinitely small if variable: for, in the first case, the force be would be absolutely nothing; and in the second case, it would be an infinitesimal of the second order, and may be considered as nothing in comparison with the velocity, which is of the first order. We shall see by and by that the last is the real state of the case. Therefore the fluid, before it begins to change its direction in F, begins to change its velocity in some point γ a-head of F, and by the time that it reaches F its velocity is as it were annihilated.

Cor. 1. Therefore the pressure in any point D arises both from the retardations in the part γF, and from the particles which are in the canal MD: as these last move along the surface of the body, the force $\frac{a''}{\dot{t}}$, destroyed in every particle, is compounded of two others, one in the direction of the surface, and the other perpendicular to it; call these p and p'. The point D is pressed perpendicularly to the surface MD; 1st, by all the forces p in the curve MD; 2d, by the force p' acting on the single point D. This may be neglected in comparison of the indefinite number of the others: therefore taking in the arch MD, an infinitely small portion Nm, $=\dot{s}$, the pressure on D, perpendicular to the surface of the body, will be $=\int p\dot{s}$; and this fluent must be so taken as to be $=o$ in the point M.

Cor. 2. Therefore, to find the pressure on D, we must find the force p on any point N. Let u be the velocity of the particle N, in the direction Nm in any instant, and $u+\dot{u}$ its velocity in the following instant; we must have $p=\frac{-\dot{u}}{\dot{t}}$. Therefore the whole question is reduced to finding the velocity u in every point N, in the direction Nm.

61 His final equation truly solves the problem, but, And this is the aim of a series of propositions which follow, in which the author displays the most accurate and precise conception of the subject, and great address and elegance in his mathematical analysis. He at length brings out an equation which expresses the pressure on the body in the most general and unexceptionable manner. We cannot give an abstract, because the train of reasoning is already concise in the extreme: nor can we even exhibit the final equation; for it is conceived in the

Resistance. the most refined and abstruse form of indeterminate functions, in order to embrace every possible circumstance. But we can assure our readers, that it truly expresses the solution of the problem. But, alas! it is of no use. So imperfect is our mathematical knowledge, that even Mr d'Alembert has not been able to exemplify the application of the equation to the simplest case which can be proposed, such as the direct impulse on a plane surface wholly immersed in the fluid. All that he is enabled to do, is to apply it (by some modifications and substitutions which take it out of its state of extreme generality) to the direct impulse of a vein of fluid on a plane which deflects it wholly, and thus to show its conformity to the solution given by Daniel Bernoulli, and to observation and experience. He shows, that this impulse (independent of the deficiency arising from the plane's not being of infinite extent) is somewhat less than the weight of a column whose base is the section of the vein, and whose height is twice the fall necessary for communicating the velocity. This great philosopher and geometer concludes by saying, that he does not believe that any method can be found for solving this problem that is more direct and simple; and imagines, that if the deductions from it shall be found not to agree with experiment, we must give up all hopes of determining the resistance of fluids by theory and analytical calculus. He says *analytical calculus;* for all the physical principles on which the calculus proceeds are rigorously demonstrated, and will not admit of a doubt. There is only one hypothesis introduced in his investigation, and this is not a physical hypothesis, but a hypothesis of calculation. It is, that the quantities which determine the ratios of the second fluxions of the velocities, estimated in the directions parallel and perpendicular to the axis AC (fig. 18.) are functions of the abscissa AP, and ordinate PM of the curve. Any person, in the least acquainted with mathematical analysis, will see, that without this supposition no analysis or calculus whatever can be instituted. But let us see what is the *physical* meaning of this hypothesis. It is simply this, that the motion of the particle M depends on its situation only. It appears impossible to form any other opinion; and if we could form such an opinion, it is as clear as day-light that the case is desperate, and that we must renounce all hopes.

62 From the imperfect state of mathematics, it is useless.

Fig. 18.

63 Mathematicians should apply to simple cases;

We are sorry to bring our labours to this conclusion; but we are of opinion, that the only thing that remains is, for mathematicians to attach themselves with firmness and vigour to some simple cases; and, without aiming at generality, to apply M. d'Alembert's or Bernoulli's mode of procedure to the particular circumstances of the case. It is not improbable but that, in the solutions which may be obtained of these particular cases, circumstances may occur which are of a more general nature. These will be so many laws of hydraulics to be added to our present very scanty stock; and these may have points of resemblance, which will give birth to laws of still greater generality. And we repeat our expression of hopes of some success, by endeavouring to determine, in some simple cases, the *minimum possibile* of motion. The attempts of the Jesuit commentators on the *Principia* to ascertain this on the Newtonian hypothesis do them honour, and have really given us great assistance in the particular case which came through their hands.

64 and multiply experiments.

And we should multiply experiments on the resistance of bodies. Those of the French academy are undoubtedly of inestimable value, and will always be appealed to. But there are circumstances in those experiments which render them more complicated than is proper for a general theory, and which therefore limit the conclusions which we wish to draw from them. The bodies were floating on the surface. This greatly modifies the deflections of the filaments of water, causing some to deflect laterally, which would otherwise have remained in one vertical plane; and this circumstance also necessarily produced what the academicians called the *remou*, or accumulation on the anterior part of the body, and depression behind it. This produced an additional resistance, which was measured with great difficulty and uncertainty. The effect of adhesion must also have been very considerable, and very different in the different cases; and it is of difficult calculation. It cannot perhaps be totally removed in any experiment, and it is necessary to consider it as making part of the resistance in the most important practical cases, viz. the motion of ships. Here we see that its effect is very great. Every seaman knows that the speed, even of a copper-sheathed ship, is *greatly* increased by greasing her bottom. The difference is too remarkable to admit of a doubt: nor should we be surprised at this, when we attend to the diminution of the motion of water in long pipes. A smooth pipe four and a half inches diameter, and 500 yards long, yields but one-fifth of the quantity which it ought to do independent of friction. But adhesion does a great deal which cannot be compared with friction. We see that water flowing through a hole in a thin plate will be increased in quantity fully one-third, by adding a little tube whose length is about twice the diameter of the hole. The adhesion therefore will greatly modify the action of the filaments both on the solid body and on each other, and will change both the forms of the curves and the velocities in different points; and this is a sort of objection to the only hypothesis introduced by d'Alembert. Yet it is only a sort of objection; for the effect of this adhesion, too, must undoubtedly depend on the situation of the particle.

65 The experiments of Robins and Borda susceptible of considerable accuracy.

The form of these experiments of the academy is ill-suited to the examination of the resistance of bodies wholly immersed in the fluid. The form of experiment adopted by Robins for the resistance of air, and afterwards by the Chevalier Borda for water, is free from these inconveniences, and is susceptible of equal accuracy. The great advantage of both is the exact knowledge which they give us of the velocity of the motion; a circumstance essentially necessary, and but imperfectly known in the experiments of Mariotte and others, who examined quiescent bodies exposed to the action of a stream. It is extremely difficult to measure the velocity of a stream. It is very different in its different parts. It is swiftest of all in the middle superficial filament, and diminishes as we recede from this towards the sides or bottom, and the rate of diminution is not precisely known. Could this be ascertained with the necessary precision, we should recommend the following form of experiment as the most simple, easy, economical, and accurate.

Let a, b, c, d, (fig. 21.) be four hooks placed in a horizontal plane at the corners of a rectangular parallelogram, Fig. 21.

Resistance.

66 Simple experiment for measuring the velocity of a stream.

lelogram, the sides *a b*, *c d* being parallel to the direction of the stream ABCD, and the sides *a b*, *c d* being perpendicular to it. Let the body G be fastered to an axis *e f* of stiff-tempered steel-wire, so that the surface on which the fluid is to act may be inclined to the stream in the precise angle we desire. Let this axis have hooks at its extremities, which are hitched into the loops of four equal threads, suspended from the hooks *a*, *b*, *c*, *d*; and let H *e* be a fifth thread, suspended from the middle of the line joining the points of suspension *a*, *b*. Let HIK be a graduated arch, whose centre is H, and whose plane is in the direction of the stream. It is evident that the impulse on the body G will be measured (by a process well known to every mathematician) by the deviation of the thread H *e* from the vertical line HI; and this will be done without any intricacy of calculation, or any attention to the centres of gravity, of oscillation, or of percussion. These must be accurately ascertained with respect to that form in which the pendulum has always been employed for measuring the impulse or velocity of a stream. These advantages arise from the circumstance, that the axis *e f* remains always parallel to the horizon. We may be allowed to observe, by the bye, that this would have been a great improvement of the beautiful experiments of Mr Robins and Dr Hutton on the velocities of cannon-shot, and would have saved much intricate calculation, and been attended with many important advantages.

The great difficulty is, as we have observed, to measure the velocity of the stream. Even this may be done in this way with some precision. Let two floating bodies be dragged along the surface, as in the experiments of the academy, at some distance from each other laterally, so that the water between them may not be sensibly disturbed. Let a horizontal bar be attached to them, transverse to the direction of their motion, at a proper height above the surface, and let a spherical pendulum be suspended from this, or let it be suspended from four points, as here described. Now let the deviation of this pendulum be noted in a variety of velocities. This will give us the law of relation between the velocity and the deviation of the pendulum. Now, in making experiments on the resistance of bodies, let the velocity of the stream, in the very filament in which the resistance is measured, be determined by the deviation of this pendulum.

It were greatly to be wished that some more palpable argument could be found for the existence of a quantity of stagnant fluid at the anterior and posterior parts of the body. The one already given, derived from the consideration that no motion changes either its velocity or direction by finite quantities in an instant, is unexceptionable. But it gives us little information. The

Fig. 18.

smallest conceivable extent of the curve FM in fig. 18. will answer this condition, provided only that it touches the axis in some point F, and the body in some point M, so as not to make a finite angle with either. But surely there are circumstances which rigorously determine the extent of this stagnant fluid. And it appears without doubt, that if there were no cohesion or friction, this space will have a determined ratio to the size of the body (the figures of the bodies being supposed

Fig. 11.

similar). Suppose a plane surface AB, as in fig. 11. there can be no doubt but that the figure A *a* D *b* B will in every case be similar. But if we suppose an adhesion or tenacity which is constant, this may make a change both in its extent and its form: for its constancy of form depends on the disturbing forces being always as the squares of the velocity; and this ratio of the disturbing forces is preserved, while the inertia of the fluid is the only agent and patient in the process. But when we add to this the constant (that is, invariable) disturbing force of tenacity, a change of form and dimensions must happen. In like manner, the friction, or something analogous to friction, which produces an effect proportional to the velocity, must alter this necessary ratio of the whole disturbing forces. We may conclude, that the effect of both these circumstances will be to diminish the quantity of this stagnant fluid, by licking it away externally; and to this we must ascribe the fact, that the part FAM is never perfectly stagnant, but is generally disturbed with a whirling motion. We may also conclude, that this stagnant fluid will be more incurvated between F and M than it would have been, independent of tenacity and friction; and that the arch LR will, on the contrary, be less incurvated.—And, lastly, we may conclude, that there will be something opposite to pressure, or something which we may call *abstraction*, exerted on the posterior part of the body which moves in a tenacious fluid, or is exposed to the stream of such a fluid: for the stagnant fluid LCR adheres to the surface LC; and the passing fluid tends to draw it away both by its tenacity and by its friction. This must augment the apparent impulse of the stream on such a body; and it must greatly augment the resistance, that is, the motion lost by this body in its progress through the tenacious fluid: for the body must drag along with it this stagnant fluid, and drag it in opposition to the tenacity and friction of the surrounding fluid. The effect of this is most remarkably seen in the resistances to the motion of pendulums; and the chevalier Buat, in his examination of Newton's experiments, clearly shows that this constitutes the greatest part of the resistance.

This most ingenious writer has paid great attention to this part of the process of nature, and has laid the foundation of a theory of resistance entirely different from all the preceding. We cannot abridge it; and it is too imperfect in its present condition to be offered as a body of doctrine: but we hope that the ingenious author will prosecute the subject.

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67 Account of the chevalier Buat's experiments,

We cannot conclude this dissertation (which we acknowledge to be very unsatisfactory and imperfect) better, than by giving an account of some experiments of the chevalier Buat, which seem of immense consequence, and tend to give us very new views of the subject. Mr Buat observed the motion of water issuing from a glass cylinder through a narrow ring formed by a bottom of smaller diameter; that is, the cylinder was open at both ends, and there was placed at its lower end a circle of smaller diameter, by way of bottom, which left a ring all around. He threw some powdered sealing wax into the water, and observed with great attention the motion of its small particles. He saw those which happened to be in the very axis of the cylinder descend along the axis with a motion pretty uniform, Resistance. uniform, till they came very near the bottom; from this they continued to descend very slowly, till they were almost in contact with the bottom; they then deviated from the centre, and approached the orifice in straight lines and with an accelerated motion, and at last darted into the orifice with great rapidity. He had observed a thing similar to this in a horizontal canal, in which he had set up a small board like a dam or bar, over which the water flowed. He had thrown a gooseberry into the water, in order to measure the velocity at the bottom, the gooseberry being a small matter heavier than water. It approached the dam uniformly till about three inches from it. Here it almost stood still, but it continued to advance till almost in contact. It then rose from the bottom along the inside of the dam with an accelerated motion, and quickly escaped over the top.

Hence he concluded, that the water which covers the anterior part of the body exposed to the stream is not perfectly stagnant, and that the filaments recede from the axis in curves, which converge to the surface of the body as different hyperbolas converge to the same assymptote, and that they move with a velocity continually increasing till they escape round the sides of the body.

He had established (by a pretty reasonable theory, confirmed by experiment) a proposition concerning the pressure which water in motion exerts on the surface along which it glides, viz. *that the pressure is equal to that which it would exert if at rest* minus *the weight of the column whose height would produce the velocity of the passing stream.* Consequently the pressure which the stream exerts on the surface perpendicularly exposed to it will depend on the velocity with which it glides along it, and will diminish from the centre to the circumference. This, says he, may be the reason why the impulse on a plane wholly immersed is but one half of that on a plane which deflects the whole stream.

68 and of the instrument he contrived for examining his theory. Fig. 22. Fig. 23.

He contrived a very ingenious instrument for examining this theory. A square brass plate ABGF (fig. 22.) was pierced with a great number of holes, and fixed in the front of a shallow box represented edgewise in fig. 23. The back of this box was pierced with a hole *c*, in which was inserted the tube of glass CDE, bent square at D. This instrument was exposed to a stream of water, which beat on the brass plate. The water having filled the box through the holes, stood at an equal height in the glass tube when the surrounding water was stagnant; but when it was in motion, it always stood in the tube above the level of the smooth water without, and thus indicated the pressure occasioned by the action of the stream.

When the instrument was not wholly immersed, there was always a considerable accumulation against the front of the box, and a depression behind it. The water before it was by no means stagnant: indeed it should not be, as Mr Buat observes; for it consists of the water which was escaping on all sides, and therefore upwards from the axis of the stream, which meets the plate perpendicularly in *c* considerably under the surface. It escapes upwards; and if the body were sufficiently immersed, it would escape in this direction almost as easily as laterally. But in the present circumstances, it heaps up, till the elevation occasions it to fall off sidewise as fast as it is renewed. When the instrument was immersed more than its semidiameter under the surface, the water still rose above the level, and there was a great depression immediately behind this elevation. In consequence of this difficulty of escaping upwards, the water flows off laterally; and if the horizontal dimensions of the surface is great, this lateral efflux becomes more difficult, and requires a greater accumulation. From this it happens, that the resistance of broad surfaces equally immersed is greater than in the proportion of the breadth. A plane of two feet wide and one foot deep, when it is not completely immersed, will be more resisted than a plane two feet deep and one foot wide; for there will be an accumulation against both: and even if these were equal in height, the additional surface will be greatest in the widest body; and the elevation will be greater, because the lateral escape is more difficult.

69 Circumstances chiefly to be attended to in using this instrument.

The circumstances chiefly to be attended to are these.

The pressure on the centre was much greater than towards the border, and, in general, the height of the water in the tube DE was more than $\frac{4}{3}$ of the height necessary for producing the velocity when only the central hole was open. When various holes were opened at different distances from the centre, the height of the water in DH continually diminished as the hole was nearer the border. At a certain distance from the border the water at E was level with the surrounding water, so that no pressure was exerted on that hole. But the most unexpected and remarkable circumstance was, that, in great velocities, the holes at the very border, and even to a small distance from it, not only sustained no pressure, but even gave out water; for the water in the tube was lower than the surrounding water. Mr Buat calls this a *non-pression*. In a case in which the velocity of the stream was three feet, and the pressure on the central hole caused the water in the vertical tube to stand 33 lines or $\frac{3}{1}\frac{1}{2}$ of an inch above the level of the surrounding smooth water, the action on a hole at the lower corner of the square caused it to stand 12 lines lower than the surrounding water. Now the velocity of the stream in this experiment was 36 inches per second. This requires $21\frac{1}{4}$ lines for its productive fall; whereas the pressure on the central hole was 33. This approaches to the pressure on a surface which deflects it wholly. The intermediate holes gave every variation of pressure, and the diminution was more rapid as the holes were nearer the edge; but the law of diminution could not be observed.

70 Remarkable circumstance.

71 not inconsistent with the principles of hydrostatics or hydraulics.

This is quite a new and most unexpected circumstance in the action of fluids on solid bodies, and renders the subject more intricate than ever; yet it is by no means inconsistent with the genuine principles of hydrostatics or hydraulics. In as far as M. Buat's proposition concerning the pressure of moving fluids is true, it is very reasonable to say, that when the lateral velocity with which the fluid tends to escape exceeds the velocity of percussion, the height necessary for producing this velocity must exceed that which would produce the other, and a non-pression must be observed. And if we consider the forms of the lateral filaments near the edge of the body, we see that the concavity of the curve is turned towards the body, and that the centrifugal forces tend to diminish their pressure on the body. If the middle alone were struck with a considerable velocity, the water might even

Resistance. even rebound, as is frequently observed. This *actual* rebounding is here prevented by the surrounding water, which is moving with the same velocity: but the pressure may be almost annihilated by the *tendency* to rebound of the inner filaments.

Part (and perhaps a considerable part) of this apparent non-pression is undoubtedly produced by the tenacity of the water, which licks off with it the water lying in the hole. But, at any rate, this is an important fact, and gives great value to these experiments.

72 Substance of Buat's theory.

It gives a key to many curious phenomena in the resistance of fluids; and the theory of Mr Buat deserves a very serious consideration. It is all contained in the two following propositions.

1. "*If, by any cause whatever, a column of fluid, whether making part of an indefinite fluid, or contained in solid canals, come to move with a given velocity, the pressure which it exerted laterally before its motion, either on the adjoining fluid or on the sides of the canal, is diminished by the weight of a column having the height necessary for communicating the velocity of the motion.*

2. "*The pressure on the centre of a plane surface perpendicular to the stream, and wholly immersed in it, is $\frac{3}{2}$ of the weight of a column having the height necessary for communicating the velocity. For 33 is $\frac{3}{2}$ of $21\frac{1}{2}$.*"

73 Experiments by which it is confirmed.

He attempted to ascertain the medium pressure on the whole surface, by opening 625 holes dispersed all over it. With the same velocity of current, he found the height in the tube to be 29 lines, or $7\frac{1}{2}$ more than the height necessary for producing the velocity. But he justly concluded this to be too great a measure, because the holes were $\frac{1}{4}$ of an inch from the edge: had there been holes at the very edge, they would have sustained a non-pression, which would have diminished the height in the tube very considerably. He exposed to the same stream a conical funnel, which raised the water to 34 lines. But this could not be considered as a measure of the pressure on a plane solid surface; for the central water was undoubtedly scooped out, as it were, and the filaments much more deflected than they would have been by a plane surface. Perhaps something of this happened even in every small hole in the former experiments. And this suggests some doubt as to the accuracy of the measurement of the pressure and of the velocity of a current by Mr Pitot's tube. It surely renders some corrections absolutely necessary. It is a fact, that when exposed to a vein of fluid coming through a short passage, the water in the tube stands on a level with that in the reservoir. Now we know that the velocity of this stream *does not* exceed what would be produced by a fall equal to $\frac{82}{100}$ of the head of water in the reservoir. Mr Buat made many valuable observations and improvements on this most useful instrument, which will be taken notice of in the articles RIVERS and *WATER-Works*.

Mr Buat, by a scrupulous attention to all the circumstances, concludes, that the medium of pressure on the whole surface is equal to $\frac{25.5}{21.5}$ of the weight of a column, having the surface for its base, and the productive fall for its height. But we think that there is an uncertainty in this conclusion; because the height of the water in the vertical tube was undoubtedly augmented by an hydrostatical pressure arising from the accumulation of water above the body which was exposed to the stream. Resistance.

Since the pressures are as the squares of the velocities, or as the heights h which produce the velocities, we may express this pressure by the symbol $\frac{25.5}{21.5}h$, or $1.186h$, or mh, the value of m being 1.186. This exceeds considerably the result of the experiments of the French academy. In these it does not appear that m sensibly exceeds unity. Note, that in these experiments the body was moved through still water; here it is exposed to a stream. These are generally supposed to be equivalent, on the authority of the third law of motion, which makes every action depend on the relative motions. We shall by and by see some causes of difference.

The writers on this subject seem to think their task completed when they have considered the action of the fluid on the anterior part of the body, or that part of it which is before the broadest section, and have paid little or no attention to the hinder part. Yet those who are most interested in the subject, the naval architects, seem convinced that it is of no less importance to attend to the form of the hinder part of a ship. And the universal practice of all nations has been to make the hinder part more acute than the fore-part. This has undoubtedly been deduced from experience; for it is in direct opposition to any notions which a person would naturally form on this subject. Mr Buat therefore thought it very necessary to examine the action of the water on the hinder part of a body by the same method. And, previous to this examination, in order to acquire some scientific notions of the subject, he made the following very curious and instructive experiment. 74 The action on the hinder part of a body or ship equally important with that on the fore-part.

75 Experiment on this subject by Buat, Fig. 24.

Two little conical pipes AB (fig. 24.) were inserted into the upright side of a prismatic vessel. They were an inch long, and their diameters at the inner and outer ends were five and four lines. A was 57 lines under the surface, and B was 73. A glass syphon was made of the shape represented in the figure, and its internal diameter was $1\frac{1}{4}$ lines. It was placed with its mouth in the axis, and even with the base of the conical pipe. The pipes being shut, the vessel was filled with water, and it was made to stand on a level in the two legs of the syphon, the upper part being full of air. When this syphon was applied to the pipe A, and the water running freely, it rose 32 lines in the short leg, and sunk as much in the other. When it was applied to the pipe B, the water rose 41 lines in the one leg of the syphon, and sunk as much in the other.

76 and his reasoning upon it.

He reasons in this manner from the experiment. The ring comprehended between the end of the syphon and the sides of the conical tube being the narrowest part of the orifice, the water issued with the velocity corresponding to the height of the water in the vessel above the orifice, diminished for the contraction. If therefore the cylinder of water immediately before the mouth of the syphon issued with the same velocity the tube would be emptied through a height equal to this HEAD OF WATER (*charge*). If, on the contrary, this cylinder of water, immediately before the mouth of the syphon, were stagnant, the water in it would exert its full pressure on the mouth of the syphon, and the water in the syphon would be level with the water in the vessel.

Between

Between theſe extremes we muſt find the real ſtate of the caſe, and we muſt meaſure the force of non-preſſure by the riſe of the water in the ſyphon.

We ſee that in both experiments it bears an accurate proportion to the depth under the ſurface. For 57 : 73=32 : 41 very nearly. He therefore eſtimates the non-preſſure to be $\frac{56}{100}$ of the height of the water above the orifice.

77 ſeemingly inaccurate.

We are diſpoſed to think that the ingenious author has not reaſoned accurately from the experiment. In the firſt place, the force indicated by the experiment, whatever be its origin, is certainly double of what he ſuppoſes; for it muſt be meaſured by the ſum of the riſe of the water in one leg, and its depreſſion in the other, the weight of the air in the bend of the ſyphon being neglected. It is preciſely analogous to the force acting on the water oſcillating in a ſyphon, which is acknowledged to be the ſum of the elevation and depreſſion. The force indicated by the experiment therefore is $\frac{112}{100}$ of the height of the water above the orifice. The force exhibited in this experiment bears a ſtill greater proportion to the productive height; for it is certain that the water *did not* iſſue with the velocity acquired by the fall from the ſurface, and probably did not exceed $\frac{2}{3}$ of it. The effect of contraction muſt have been conſiderable and uncertain. The velocity ſhould have been meaſured both by the amplitude of the jet and by the quantity of water diſcharged. In the next place, we apprehend that much of the effect is produced by the tenacity of the water, which drags along with it the water which would have ſlowly iſſued from the ſyphon, had the other end not dipped into the water of the veſſel. We know, that if the horizontal part of the ſyphon had been continued far enough, and if no retardation were occaſioned by friction, the column of water in the upright leg would have accelerated like any heavy body; and when the laſt of it had arrived at the bottom of that leg, the whole in the horizontal part would be moving with the velocity acquired by falling from the ſurface. The water of the veſſel which iſſues through the ſurrounding ring very quickly acquires a much greater velocity than what the water deſcending in the ſyphon would acquire in the ſame time, and it drags this laſt water along with it both by tenacity and friction, and it drags it out till its action is oppoſed by the want of equilibrium produced in the ſyphon, by the elevation in the one leg and the depreſſion in the other. We imagine that little can be concluded from the experiment with reſpect to the real non-preſſure. Nay, if the ſides of the ſyphon be ſuppoſed infinitely thin, ſo that there would be no curvature of the filaments of the ſurrounding water at the mouth of the ſyphon, we do not very diſtinctly ſee any ſource of non-preſſure: For we are not altogether ſatisfied with the proof which Mr Buat offers for this meaſure of the preſſure of a ſtream of fluid gliding along a ſurface, *and obſtructed by friction or any other cauſe*. We imagine that paſſing water in the preſent experiment would be a little retarded by accelerating continually the water deſcending in the ſyphon, and renewed a-top, ſuppoſing the upper end open; becauſe this water would not of itſelf acquire more than half this velocity. It however drags it out, till it not only reſiſts with a force equal to the weight of the whole vertical column, but even exceeds it by $\frac{12}{100}$. This it is able to do, becauſe the whole preſſure by which the water iſſues from an orifice has been ſhown (by Daniel Bernoulli) to be equal to twice this weight. We therefore conſider this beautifuly experiment as chiefly valuable, by giving us a meaſure of the tenacity of the water; and we wiſh that it were repeated in a variety of depths, in order to diſcover what relation the force exerted bears to the depth. It would ſeem that the tenacity, being a certain determinate thing, the proportion of 100 to 112 would not be conſtant; and that the obſerved ratio would be made up of two parts, one of them conſtant, and the other proportional to the depth under the ſurface.

But ſtill this experiment is intimately connected with the matter in hand; and this apparent non-preſſure on the hinder part of a body expoſed to a ſtream, from whatever cauſes it proceeds, does operate in the action of water on this hinder part, and muſt be taken into the account.

78 Further diſcuſſions of De Buat.

We muſt therefore follow the chevalier de Buat in his diſcuſſions on this ſubject. A priſmatic body, having its prow and poop equal and parallel ſurfaces, and plunged horizontally into a fluid, will require a force to keep it firm in the direction of its axis preciſely equal to the difference between the real preſſures exerted on its prow and poop. If the fluid is at reſt, this difference will be nothing, becauſe the oppoſite dead preſſures of the fluid will be equal: but in a ſtream, there is ſuperadded to the dead preſſure on the prow the active preſſure ariſing from the deflections of the filaments of this fluid.

If the dead preſſure on the poop remained in its full intenſity by the perfect ſtagnation of the water behind it, the whole ſenſible preſſure on the body would be the active preſſure only on the prow, repreſented by mh. If, on the other hand, we could ſuppoſe that the water behind the body moved continually away from it (being renewed laterally) with the velocity of the ſtream, the dead preſſure would be entirely removed from its poop, and the whole ſenſible preſſure, or what muſt be oppoſed by ſome external force, would be $mh+h$. Neither of theſe can happen; and the real ſtate of the caſe muſt be between theſe extremes.

79 Experiments.

The following experiments were tried: The perforated box with its vertical tube was expoſed to the ſtream, the braſs plate being turned down the ſtream. The velocity was again 36 inches per ſecond.

The central hole A alone being opened, gave a non-preſſure of	-	13 lines.
A hole B, $\frac{5}{6}$ of an inch from the edge, gave	- -	15
A hole C, near the ſurface	-	15·7
A hole D, at the lower angle	-	15·3

Here it appears that there is a very conſiderable non-preſſure, increaſing from the centre to the border. This increaſe undoubtedly proceeds from the greater lateral velocity with which the water is gliding in from the ſides. The water behind was by no means ſtagnant, although moving off with a much ſmaller velocity than that of the paſſing ſtream, and it was viſibly removed from the ſides, and gradually licked away at its further extremity.

Another box, having a great number of holes, all open, indicated a medium of non-preſſure equal to $13\frac{1}{8}$ lines.

Another

Resistance.

Another of larger dimensions, but having fewer holes, indicated a non-pressure of 12⅛.

But the most remarkable, and the most important phenomena, were the following:

The first box was fixed to the side of another box, so that, when all was made smooth, it made a perfect cube, of which the perforated brass plate made the poop.

The apparatus being now exposed on the stream, with the perforated plate looking down the stream,

The hole A indicated a non-pression -	=7.2
B - - -	8
C - - -	6

Here was a great diminution of the non-pressions produced by the distance between the prow and the poop.

This box was then fitted in the same manner, so as to make the poop of a box three feet long. In this situation the non-pressures were as follow:

Hole A - - -	1.5
B - - -	3.2

The non-pressions were still farther diminished by this increase of length.

The box was then exposed with all the holes open, in three different situations:

1st, Single, giving a non-pressure -	13.1
2d, Making the poop of a cube -	5.3
3d, Making the poop of a box three feet long	3.0
Another larger box:	
1st, Single - -	12.2
2d, Poop of a cube - -	5.
3d, Poop of the long box - -	3.2

80 Great utility of them in ship-building.

These are most valuable experiments. They plainly show how important it is to consider the action on the hinder part of the body. For the whole impulse or resistance, which must be withstood or overcome by the external force, is the sum of the active pressure on the fore-part, and of the non-pressure on the hinder part; and they show that this does not depend solely on the form of the prow and poop, but also, and perhaps chiefly, on the length of the body. We see that the non-pressure on the hinder-part was prodigiously diminished (reduced to one-fourth) by making the length of the body triple of the breadth. And hence it appears, that merely lengthening a ship, without making any change in the form either of her prow or her poop, will greatly diminish the resistance to her motion through the water; and this increase of length may be made by continuing the form of the midship frame in several timbers along the keel, by which the capacity of the ship, and her power of carrying sail, will be greatly increased, and her other qualities improved, while her speed is augmented.

81 Physical cause of it explained.

It is surely of importance to consider a little the physical cause of this change. The motions are extremely complicated, and we must be contented if we can but perceive a few leading circumstances.

The water is turned aside by the anterior part of the body, and the velocity of the filaments is increased, and they acquire a divergent motion, by which they also push aside the surrounding water. On each side of the body, therefore, they are moving in a divergent direction, and with an increased velocity. But as they are on all sides pressed by the fluid without them, their motions gradually approach parallelism, and their velocities to an equality with the stream. The progressive velocity, or that in the direction of the stream, is checked, at least at first. But since we observe the filaments constipated round the body, and that they are not deflected at right angles to their former direction, it is plain that the real velocity of a filament in its oblique path is augmented. We always observe, that a stone lying in the sand, and exposed to the wash of the sea, is laid bare at the bottom, and the sand is generally washed away to some distance all round. This is owing to the increased velocity of the water which comes into contact with the stone. It takes up more sand than it can keep floating, and it deposits it at a little distance all around, forming a little bank, which surrounds the stone at a small distance. When the filaments of water have passed the body, they are pressed by the ambient fluid into the place which it has quitted, and they glide round its stern, and fill up the space behind. The more divergent and the more rapid they are, when about to fall in behind, the more of the circumambient pressure must be employed to turn them into the trough behind the body, and less of it will remain to press them to the body itself. The extreme of this must obtain when the stream is obstructed by a thin plane only. But when there is some distance between the prow and the poop, the divergency of the filaments which had been turned aside by the prow, is diminished by the time that they have come abreast of the stern, and should turn in behind it. They are therefore more readily made to converge behind the body, and a more considerable part of the surrounding pressure remains unexpended, and therefore presses the water against the stern; and it is evident that this advantage must be so much the greater as the body is longer. But the advantage will soon be susceptible of no very considerable increase: for the lateral and divergent, and accelerated filaments, will soon become so nearly parallel and equally rapid with the rest of the stream, that a great increase of length will not make any considerable change in these particulars; and it must be accompanied with an increase of friction.

These are very obvious reflections. And if we attend minutely to the way in which the almost stagnant fluid behind the body is expended and renewed, we shall see all these effects confirmed and augmented. But as we cannot say any thing on this subject that is precise, or that can be made the subject of computation, it is needless to enter into a more minute discussion. The diminution of the non-pressure towards the centre most probably arises from the smaller force which is necessary to be expended in the inflection of the lateral filaments, already inflected in some degree, and having their velocity diminished. But it is a subject highly deserving the attention of the mathematicians; and we presume to invite them to the study of the motions of these lateral filaments, passing the body, and pressed into its wake by forces which are susceptible of no difficult investigation. It seems highly probable, that if a prismatic box, with a square stern, were fitted with an addition precisely shaped like the water which would (abstracting tenacity and friction) have been stagnant behind it, the quantity of non-pression would be the smallest possible. The mathematician would surely discover circumstances which would

would furniſh ſome maxims of conſtruction for the hinder part as well as for the prow. And as his ſpeculations on this laſt have not been wholly fruitleſs, we may expect advantages from his attention to this part, ſo much neglected.

82
Buat's deductions from his experiments.

In the mean time, let us attend to the deductions which Mr de Buat has made from his few experiments.

When the velocity is three feet per ſecond, requiring the productive height 21.5 lines, the heights correſponding to the non-preſſure on the poop of a thin plane is 14.41 lines (taking in ſeveral circumſtances of judicious correction, which we have not mentioned), that of a foot cube is 5.83, and that of a box of triple length is 3.31.

Let q expreſs the variable ratio of theſe to the height producing the velocity, ſo that $q\,h$ may expreſs the non-preſſure in every caſe; we have,

For a thin plane	- -	$q=0.67$
a cube	- - -	0.271
a box = 3 cubes	- - -	0.153

It is evident that the value of q has a dependence on the proportion of the length, and the tranſverſe ſection of the body. A ſeries of experiments on priſmatic bodies ſhowed Mr de Buat that the deviation of the filaments was ſimilar in ſimilar bodies, and that this obtained even in diſſimilar priſms, when the lengths were as the ſquare-roots of the tranſverſe ſections. Although therefore the experiments were not ſufficiently numerous for deducing the preciſe law, it ſeemed not impoſſible to derive from them a very uſeful approximation. By a dexterous compariſon he found, that if l expreſſes the length of the priſm, and s the area of the tranſverſe ſection, and L expreſſes the common logarithm of the quantity to which it is prefixed, we ſhall expreſs the non-preſſure pretty accurately by the formula $\frac{1}{q}=\mathrm{L}\left(1.42\frac{l}{\sqrt{s}}\right)$.

Hence ariſes an important remark, that when the height correſponding to the non-preſſion is greater than $\sqrt{s}$, and the body is little immerſed in the fluid, there will be a void behind it. Thus a ſurface of a ſquare inch, juſt immerſed in a current of three feet per ſecond, will have a void behind it. A foot ſquare will be in a ſimilar condition when the velocity is 12 feet.

We muſt be careful to diſtinguiſh this non-preſſure from the other cauſes of reſiſtance, which are always neceſſarily combined with it. It is ſuperadditive to the active impreſſion on the prow, to the ſtatical preſſure of the accumulation a-head of the body, the ſtatical preſſure ariſing from the depreſſion behind it, the effects of friction, and the effects of tenacity. It is indeed next to impoſſible to eſtimate them ſeparately, and many of them are actually combined in the meaſures now given. Nothing can determine the pure non-preſſures till we can aſcertain the motions of the filaments.

83
He controverts a maxim univerſally adopted,

M. de Buat here takes occaſion to controvert the univerſally adopted maxim, that the preſſure occaſioned by a ſtream of fluid on a fixed body is the ſame with that on a body moving with equal velocity in a quieſcent fluid. He repeated all theſe experiments with the perforated box in ſtill water. The general diſtinction was, that both the preſſures and the non-preſſure in this caſe were leſs, and that the odds were chiefly to be obſerved near the edges of the ſurface. The general factor of the preſſure of a ſtream on the anterior ſurface was $m=1.186$; but that on a moving body through a ſtill fluid is only $m=1$. He obſerved no non-preſſure even at the very edge of the prow, but even a ſenſible preſſure. The preſſure, therefore, or reſiſtance, is more equably diffuſed over the ſurface of the prow than the impulſe is.—He alſo found that the reſiſtances diminiſhed in a leſs ratio than the ſquares of the velocities, eſpecially in ſmall velocities.

The non-preſſures increaſed in a greater ratio than the ſquares of the velocities. The ratio of the velocities to a ſmall velocity of $2\frac{1}{5}$ inches per ſecond increaſed geometrically, the value of q increaſed arithmetically; and we may determine q for any velocity V by this proportion

$$\mathrm{L}\,\frac{55}{2.2} : \mathrm{L}\,\frac{\mathrm{V}}{22} = 0.5 : q, \text{ and } q=\frac{\mathrm{L}\frac{\mathrm{V}}{2.2}}{2.8}.$$

That is, let the common logarithm of the velocity, divided by $2\frac{1}{5}$, be conſidered as a common number; divide this common number by $2\frac{8}{10}$, the quotient is q, which muſt be multiplied by the productive height. The product is the preſſure.

When Pitot's tube was expoſed to the ſtream, we had $m=1$; but when it is carried through ſtill water, m is $=1.22$. When it was turned from the ſtream, we had $q=0.157$; but when carried through ſtill water, q is $=0.138$. A remarkable experiment.

84
and ſupports his opinion by a remarkable experiment.

When the tube was moved laterally through the water, ſo that the motion was in the direction of the plane of its mouth, the non-preſſure was $=1$. This is one of his chief arguments for his theory of non-preſſion. He does not give the detail of the experiment, and only inſerts the reſult in his table.

As a body expoſed to a ſtream deflects the fluid, heaps it up, and increaſes its velocity; ſo a body moved through a ſtill fluid turns it aſide, cauſes it to ſwell up before it, and gives it a real motion alongſide of it in the oppoſite direction. And as the body expoſed to a ſtream has a quantity of fluid almoſt ſtagnant both before and behind; ſo a body moved through a ſtill fluid carries before it and drags after it a quantity of fluid, which accompanies it with nearly an equal velocity. This addition to the quantity of matter in motion muſt make a diminution of its velocity; and this forms a very conſiderable part of the obſerved reſiſtance.

85
The objection not well founded.

We cannot, however, help remarking that it would require very diſtinct and ſtrong proof indeed to overturn the common opinion, which is founded on our moſt certain and ſimple conceptions of motion, and on a law of nature to which we have never obſerved an exception. M. de Buat's experiments, though moſt judiciouſly contrived, and executed with ſcrupulous care, are by no means of this kind. They were, of abſolute neceſſity, very complicated; and many circumſtances, impoſſible to avoid or to appreciate, rendered the obſervation, or at leaſt the compariſon, of the velocities, very uncertain.

86
Remarks and experiments on the motion of bodies in running or ſtill water.

We can ſee but two circumſtances which do not admit of an eaſy or immediate compariſon in the two ſtates of the problem. When a body is expoſed to a ſtream *in our experiments*, in order to have an impulſe made on it, there is a force tending to move the body backwards, independent of the real impulſe or preſſure occaſioned by the deflection of the ſtream. We cannot have

Resistance. have a stream except in consequence of a sloping surface. Suppose a body floating on this stream. It will not only sail down *along with the stream*, but it will sail *down the stream*, and will therefore go faster along the canal than the stream does: for it is floating on an inclined plane; and if we examine it by the laws of hydrostatics, we shall find, that besides its own tendency to *slide* down this inclined plane, there is an odds of hydrostatical pressure, which *pushes* it down this plane. It will therefore go along the canal faster than the stream. For this acceleration depends on the difference of pressure at the two ends, and will be more remarkable as the body is larger, and especially as it is longer. This may be distinctly observed. All floating bodies go into the stream of the river, because there they find the smallest obstruction to the acquisition of this motion along the inclined plane; and when a number of bodies are thus floating down the stream, the largest and longest outstrip the rest. A log of wood floating down in this manner may be observed to make its way very fast among the chips and saw-dust which float alongside of it.

Now when, in the course of our experiments, a body is supported against the action of the stream, and the impulse is measured by the force employed to support it, it is plain that part of this force is employed to act against that tendency which the body has to outstrip the stream. This does not appear in our experiment, when we move a body with the velocity of this stream through still water having a horizontal surface.

The other distinguishing circumstance is, that the retardations of a stream arising from friction are found to be nearly as the velocities. When, therefore, a stream moving in a limited canal is checked by a body put in its way, the diminution of velocity occasioned by the friction of the stream having already produced its effect, the impulse is not affected by it; but when the body puts the still water in motion, the friction of the bottom produces some effect, by retarding the recess of the water. This, however, must be next to nothing.

The chief difference will arise from its being almost impossible to make an exact comparison of the velocities: for when a body is moved against the stream, the relative velocity is the same in all the filaments. But when we expose a body to a stream, the velocity of the different filaments is not the same; because it decreases from the middle of the stream to the sides.

87 Mr Buat's calculation of resistance,

M. Buat found the total sensible resistance of a plate 12 inches square, and measured, not by the height of water in the tube of the perforated box, but by weights acting on the arm of a balance, having its centre 15 inches under the surface of a stream moving three feet per second, to be 19.46 pounds; that of a cube of the same dimensions was 15.22; and that of a prism three feet long was 13.87; that of a prism six feet long was 14.27. The three first agree extremely well with the determination of m and q, by the experiments with the perforated box. The total resistance of the last was undoubtedly much increased by friction, and by the retrograde force of so long a prism floating in an inclined stream. This last by computation is 0.223 pounds; this added to $h\,(m+q)$, which is 13.39, gives 13.81, leaving 0.46 for the effect of friction.

If the same resistances be computed on the supposition that the body moves in still water, in which case we have $m=1$, and q for a thin plate $=0.433$; and if q be computed for the lengths of the other two bodies by the formula $\frac{1}{q}=\text{L}\ 1.42+\frac{l}{\sqrt{s}}$; we shall get for the resistances 14.94; 12.22; and 11.49.

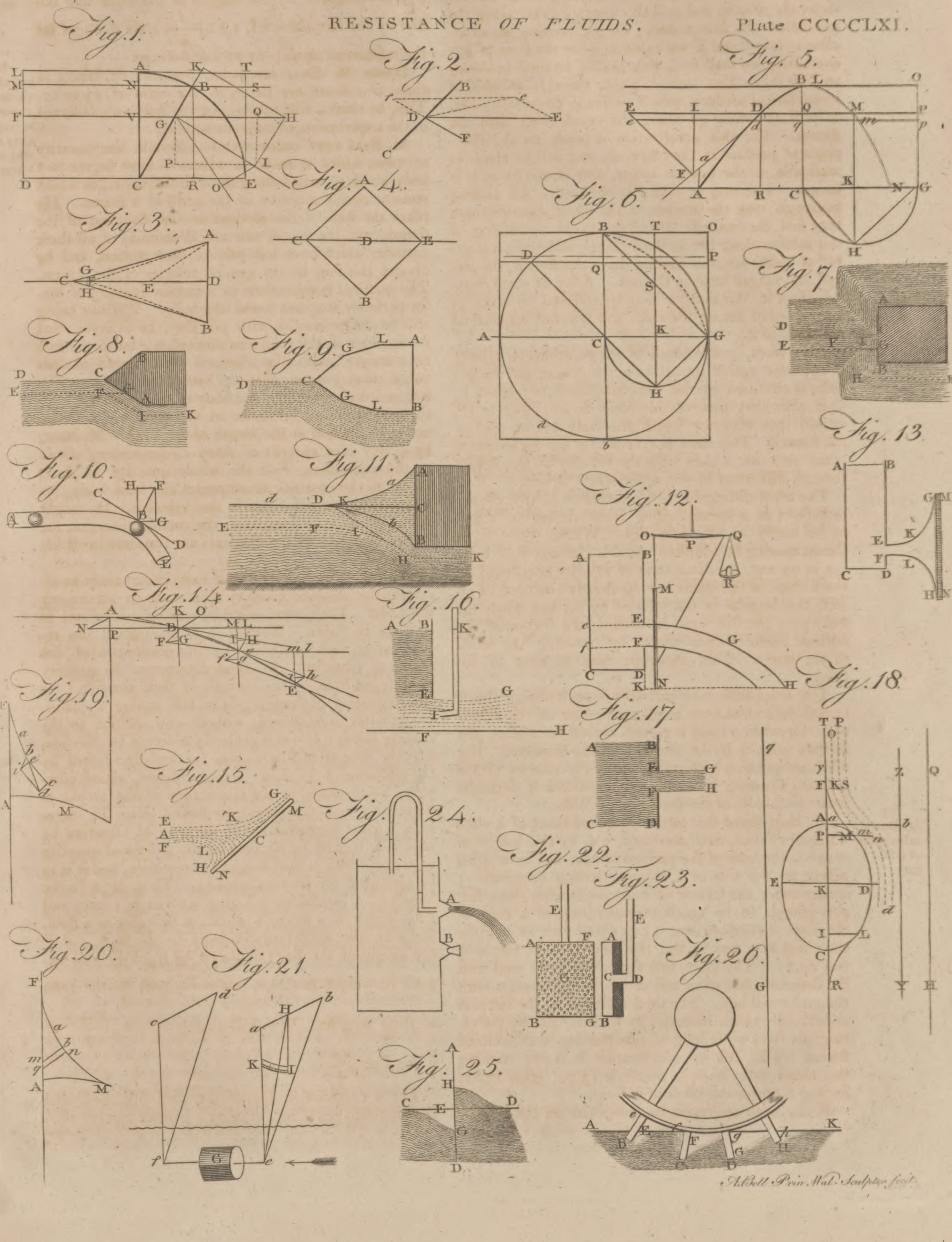
88 and of the quantity of water adhering to a body moving in still water, &c.

Hence M. Buat concludes, that the resistances in these two states are nearly in the ratio of 13 to 10. This, he thinks, will account for the difference observed in the experiments of different authors.

M. Buat next endeavours to ascertain the quantity of water which is made to adhere in some degree to a body which is carried along through still water, or which remains nearly stagnant in the midst of a stream. He takes the sum of the motions in the direction of the stream, viz. the sum of the actual motions of all those particles which have lost part of their motion, and he divides this sum by the general velocity of the stream. The quotient is equivalent to a certain quantity of water perfectly stagnant round the body. Without being able to determine this with precision, he observes, that it augments as the resistance diminishes; for in the case of a longer body, the filaments are observed to converge to a greater distance behind the body. The stagnant mass a-head of the body is more constant; for the deflection and resistance at the prow are observed not to be affected at the length of the body. M. Buat, by a very nice analysis of many circumstances, comes to this conclusion, that the whole quantity of fluid, which in this manner accompanies the solid body, remains the same whatever is the velocity. He might have deduced it at once, from the consideration that the curves described by the filaments are the same in all velocities.

He then relates a number of experiments made to ascertain the absolute quantity thus made to accompany the body. These were made by causing pendulums to oscillate in fluids. Newton had determined the resistances to such oscillation by the diminution of the arches of vibration. M. Buat determines the quantity of dragged fluid by the increase of their duration; for this stagnation or dragging is in fact adding a quantity of matter to be moved, without any addition to the moving force. It was ingeniously observed by Newton, that the time of oscillation was not sensibly affected by the resistance of the fluid: a compensation, almost complete, being made by the diminution of the arches of vibration; and experiment confirmed this. If, therefore, a great augmentation of the time of vibration be observed, it must be ascribed to the additional quantity of matter which is thus dragged into motion, and it may be employed for its measurement. Thus, let a be the length of a pendulum swinging seconds in vacuo, and l the length of a second's pendulum swinging in a fluid. Let p be the weight of the body in the fluid, and P the weight of the body displaced by it; $\text{P}+p$ will express its weight in vacuo, and $\frac{\text{P}+p}{p}$ will be the ratio of these weights. We shall therefore have $\frac{\text{P}+p}{p}=\frac{a}{l}$ and $l=\frac{ap}{\text{P}+p}$.

Let n express the sum of the fluid displaced, and the fluid dragged along, n being a greater number than unity, RESISTANCE *OF FLUIDS.* Plate CCCCLXI.



A. Bell Prin. Wal. Sculptor fecit.

Resistance. unity, to be determined by experiment. The mass in motion is no longer $P+p$, but $P+np$, while its weight in the fluid is still p. Therefore we must have $l=\frac{ap}{nP+p}=\frac{a}{\frac{nP}{p}+1}$, and $n=\frac{p}{P}\left(\frac{a}{l}-1\right)$.

A prodigious number of experiments made by M. Buat on spheres vibrating in water gave values of n, which were very constant, namely, from 1.5 to 1.7; and by considering the circumstances which accompanied the variations of n (which he found to arise chiefly from the curvature of the path described by the ball), he states the mean value of the number n at 1.583. So that a sphere in motion drags along with it about $\frac{6}{10}$ of its own bulk of fluid with a velocity equal to its own.

He made similar experiments with prisms, pyramids, and other bodies, and found a complete confirmation of his assertion, that prisms of equal lengths and sections, though dissimilar, dragged equal quantities of fluid; that similar prisms and prisms not similar, but whose lengths were as the square root of their sections, dragged quantities proportional to their bulks.

He found a general value of n for prismatic bodies, which alone may be considered as a valuable truth; namely, that $n=0.705\frac{\sqrt{s}}{l}+1.13$.

From all these circumstances, we see an intimate connection between the pressures, non-pressures, and the fluid dragged along with the body. Indeed this is immediately deducible from the first principles; for what Mr Buat calls the *dragged fluid* is in fact a certain portion of the whole change of motion produced in the direction of the bodies motion.

It was found, that with respect to thin planes, spheres, and pyramidal bodies of equal bases, the resistances were inversely as the quantities of fluid dragged along.

The intelligent reader will readily observe, that these views of the Chevalier Buat are not so much discoveries of new principles as they are classifications of consequences, which may all be deduced from the general principles employed by D'Alembert and other mathematicians. But they greatly assist us in forming notions of different parts of the procedure of nature in the mutual action of fluids and solids on each other. This must be very acceptable in a subject which it is by no means probable that we shall be able to investigate with mathematical precision. We have given an account of these last observations, that we may omit nothing of consequence that has been written on the subject; and we take this opportunity of recommending the *Hydraulique* of Mr Buat as a most ingenious work, containing more original, ingenious, and practically useful thoughts, than all the performances we have met with. His doctrine of *the principle of uniform motion of fluids in pipes and open canals*, will be of immense service to all engineers, and enable them to determine with sufficient precision the most important questions in their profession; questions which at present they are hardly able to guess at. See RIVERS and *WATER Works*.

89 Change of resistance produced by the void behind a body.

The only circumstance which we have not noticed in detail, is the change of resistance produced by the void, or tendency to a void, which obtains behind the body; and we omitted a particular discussion, merely because we could say nothing sufficiently precise on the subject. Persons not accustomed to the discussions in the physico-mathematical sciences, are apt to entertain doubts or false notions connected with this circumstance, which we shall attempt to remove; and with this we shall conclude this dissertation.

If a fluid were perfectly incompressible, and were contained in a vessel incapable of extension, it is impossible that any void could be formed behind the body; and in this case it is not very easy to see how motion could be performed in it. A sphere moved in such a medium could not advance the smallest distance, unless *some* particles of the fluid, in filling up the space left by it, moved with a velocity next to infinite. Some degree of compressibility, however small, seems necessary. If this be insensible, it may be rigidly demonstrated, that an external force of compression will make no *sensible* change in the internal motions, or in the resistances. This indeed is not obvious, but is an immediate consequence of the *quaquaversum* pressure of fluids. As much as the pressure is augmented by the external compressions in one side of a body, so much is it augmented on the other side; and the same must be said of every particle. Nothing more is necessary for securing the same motions by the same partial and internal forces; and this is fully verified by experiment. Water remains equally fluid under any compressions. In some of Sir Isaac Newton's experiments balls of four inches diameter were made so light as to preponderate in water only three grains. These balls descended in the same manner as they would have descended in a fluid where the resistance was equal in every part; yet, when they were near the bottom of a vessel nine feet deep, the compression round them was at least 2400 times the moving force; whereas, when near the top of the vessel, it was not above 50 or 60 times. 90 Explained.

But in a fluid sensibly compressible, or which is not confined, a void may be left behind the body. Its motion may be so swift that the surrounding pressure may not suffice for filling up the deserted space; and, in this case, a statical pressure will be added to the resistance. This may be the case in a vessel or pond of water having an open surface exposed to the finite or limited pressure of the atmosphere. The question now is, whether the resistance will be increased by an increase of external pressure? Supposing a sphere moving near the surface of water, and another moving equally fast at four times the depth. If the motion be so swift that a void is formed in both cases, there is no doubt but that the sphere which moves at the greatest depth is most resisted by the pressure of the water. If there is no void in either case, then, because the quadruple depth would cause the water to flow in with only a double velocity, it would seem that the resistance would be greater; and indeed the water flowing in laterally with a double velocity produces a quadruple non-pressure.—But, on the other hand, the pressure at a small depth may be insufficient for preventing a void, while that below effectually prevents it; and this was observed in some experiments of Chevalier de Borda. The effect, therefore, of greater immersion, or of greater compression, in an elastic fluid, does not follow a precise ratio of the pressure, but depends partly on absolute quantities. It cannot, therefore, be stated by any very simple formula what increase or diminution of resistance will result

Resistance result from a greater depth; and it is chiefly on this account that experiments made with models of ships and mills are not conclusive with respect to the performance of a large machine of the same proportions, without corrections, sometimes pretty intricate. We assert, however, with great confidence, that this is of all methods the most exact, and infinitely more certain than any thing that can be deduced from the most elaborate calculation from theory. If the resistances at all depths be equal, the proportionality of the total resistance to the body is exact, and perfectly conformable to observation. It is only in great velocities where the depth has any material influence, and the influence is not near so considerable as we should, at first sight, suppose; for, in estimating the effect of immersion, which has a relation to the difference of pressure, we must always take in the pressure of the atmosphere; and thus the pressure at 33 feet deep is not 33 times the pressure at one foot deep, but only double, or twice as great. The atmospheric pressure is omitted only when the resisted plane is at the very surface. D'Ulloa, in his *Examino Maritimo*, has introduced an equation expressing this relation; but, except with very limited conditions, it will mislead us prodigiously. To give a general notion of

Fig. 25. its foundation, let AB (fig. 25.) be the section of a plane moving through a fluid in the direction CD, with a known velocity. The fluid will be heaped up before it above its natural level CD, because the water will not be pushed before it like a solid body, but will be pushed aside. And it cannot acquire a lateral motion any other way than by an accumulation, which will diffuse itself in all directions by the law of undulatory motion. The water will also be left lower behind the plane, because time *must* elapse before the pressure of the water behind can make it fill the space. We may acquire some notion of the extent of both the accumulation and depression in this way. There is a certain depth CF ($=\frac{v^2}{2\varphi}$, where v is the velocity, and φ the accelerating power of gravity) under the surface, such that water would flow through a hole at F with the velocity of the plane's motion. Draw a horizontal line FG. The water will certainly touch the plane in G, and we may suppose that it touches it no higher up. Therefore there will be a hollow, such as CGE. The elevation HE will be regulated by considerations nearly similar. ED must be equal to the velocity of the plane, and HE must be its productive height. Thus, if the velocity of the plane be one foot per second, HE and EG will be $\frac{3}{16}$ of an inch. This is sufficient (though not exact) for giving us a notion of the thing. We see that from this must arise a pressure in the direction DC, viz. the pressure of the whole column HG.

Something of the same kind will happen although the plane AB be wholly immerged, and this even to some depth. We see such elevations in a swift running stream, where there are large stones at the bottom.—This occasions an excess of pressure in the direction opposite to the plane's motion; and we see that there must, in every case, be a relation between the velocity and this excess of pressure. This D'Ulloa expresses by an equation. But it is very exceptionable, not taking properly into the account the comparative facility with which the water can heap up and diffuse itself. It must always heap up till it acquires a sufficient head of water to produce a lateral and progressive diffusion sufficient for the purpose. It is evident, that a smaller elevation will suffice when the body is more immersed, because the check or impulse given by the body below is propagated, not vertically only, but in every direction; and therefore the elevation is not confined to that part of the surface which is immediately above the moving body, but extends so much further laterally as the centre of agitation is deeper: Thus, the elevation necessary for the passage of the body is so much smaller; and it is the *height* only of this accumulation or wave which determines the backward pressure on the body. D'Ulloa's equation may happen to quadrate with two experiments at different depths, without being nearly just; for *any two* points may be in a curve, without exhibiting its equation. Three points will do it with some approach to precision; but four, at least, are necessary for giving any notion of its nature. D'Ulloa has only given two experiments, which we mentioned in another place.

We may here observe, that it is this circumstance which immediately produces the great resistance to the motion of a body through a fluid in a narrow canal.—The fluid cannot pass the body, unless the area of the section be sufficiently extensive. A narrow canal prevents the extension sidewise. The water must therefore heap up, till the section and velocity of diffusion are sufficiently enlarged, and thus a great backward pressure is produced. (See the second series of Experiments by the French Academicians; see also Franklin's Essays). It is important, and will be considered in another place.

Thus have we attempted to give our readers some account of one of the most interesting problems in the whole of mechanical philosophy. We are sorry that so little advantage can be derived from the united efforts of the first mathematicians of Europe, and that there is so little hope of greatly improving our scientific knowledge of the subject. What we have delivered will, however, enable our readers to peruse the writings of those who have applied the theories to practical purposes. Such, for instance, are the treatises of John Bernoulli, of Bouguer, and of Euler, on the construction and working of ships, and the occasional dissertations of different authors on water-mills. In this last 91 Impulse of water on water mills. application the ordinary theory is not without its value, for the impulses are nearly perpendicular; in which case they do not materially deviate from the duplicate proportion of the sine of incidence. But even here this theory, applied as it commonly is, misleads us exceedingly. The impulse on one float may be accurately enough stated by it; but the authors have not been attentive to the motion of the water after it has made its impulse; and the impulse on the next float is stated the same as if the parallel filaments of water, which were not stopped by the preceding float, did impinge on the opposite part of the second, in the same manner, and with the same obliquity and energy, as if it were detached from the rest. But this does not in the least resemble the real process of nature.

Suppose the floats B, C, D, H (fig. 26.) of a wheel Fig. 26. immersed in a stream whose surface moves in the direction AK, and that this surface meets the float B in E. The part BE alone is supposed to be impelled; whereas the water, checked by the float, heaps up on it to *e*.—Then drawing the horizontal line BF, the part CF of the

the next float is fuppofed to be all that is impelled by the parallel filaments of the ftream; whereas the water bends round the lower edge of the float B by the furrounding preffure, and rifes on the float *c* all the way to *f*. In like manner, the float D, inftead of receiving an impulfe on the very fmall portion DG, is impelled all the way from D to *g*, not much below the furface of the ftream. The furfaces impelled at once, therefore, greatly exceed what this flovenly application of the theory fuppofes, and the whole impulfe is much greater; but this is a fault in the application, and not in the theory. It will not be a very difficult thing to acquire a knowledge of the motion of the water which has paffed the preceding float, which, though not accurate, will yet approximate confiderably to the truth; and then the ordinary theory will furnifh maxims of conftruction which will be very ferviceable. This will be attempted in its proper place; and we fhall endeavour, in our treatment of all the practical queftions, to derive ufeful information from all that has been delivered on the prefent occafion.

RESOLUTION *of* IDEAS. See LOGIC, Part I. chap. iii.

RESOLUTION, in *Mufic*. To *refolve* a difcord or diffonance, fays Rouffeau, is to carry it according to rule into a confonance in the fubfequent chord. There is for that purpofe a procedure prefcribed, both for the fundamental bafs of the diffonant chord, and for the part by which the diffonance is formed.

There is no poffible manner of refolving a diffonance which is not derived from an operation of cadence: it is then by the kind of cadence which we wifh to form, that the motion of the fundamental bafs is determined, (fee CADENCE). With refpect to the part by which the diffonance is formed, it ought neither to continue in its place, nor to move by disjointed gradations; but to rife or defcend diatonically, according to the nature of the diffonance. Theorifts fay, that major diffonances ought to rife, and minor to defcend; which is not however without exception, fince in particular chords of harmony, a feventh, although major, ought not to rife, but to defcend, unlefs in that chord, which is, very incorrectly, called *the chord of the feventh redundant*. It is better then to fay, that the feventh and all its derivative diffonances ought to defcend; and that the fixth fuperadded, and all its derivative diffonances, fhould rife. This is a rule truly general, and without any exception. It is the fame cafe with the rule of refolving diffonances. There are fome diffonances which cannot be prepared; but there is by no means one which ought not to be refolved.

With refpect to the fenfible note, improperly called a *major diffonance*, if it ought to afcend, this is lefs on account of the rule for refolving diffonances, than on account of that which prefcribes a diatonic procedure, and prefers the fhorteft road; and in reality, there are cafes, as that of the interrupted cadence, in which this fenfible note does not afcend.

In chords by fuppofition, one fingle chord often produces two diffonances; as the feventh and ninth, the ninth and fourth, &c. Then thefe two diffonances ought to have been prepared, and both muft likewife be refolved; it is becaufe regard fhould be paid to every thing which is difcordant, not only in the fundamental, but even in the continued bafs.

RESOLUTION, in *Chemiftry*, the reduction of a mixed body into its component parts or firft principles, as far as can be done by a proper analyfis.

RESOLUTION, in *Medicine*, the difappearing of any tumor without coming to fuppuration or forming an abfcefs.

RESOLVENTS, in *Medicine*, fuch as are proper for diffipating tumors, without allowing them to come to fuppuration.

RESONANCE, RESOUNDING, in *Mufic*, &c. a found returned by the air inclofed in the bodies of ftringed inftruments, fuch as lutes, &c. or even in the bodies of wind-inftruments, as flutes, &c.

RESPIRATION, the act of refpiring or breathing the air. See ANATOMY, N° 118. BLOOD, N° 29. MEDICINE, N° 104. and PHYSIOLOGY.

RESPIRATION of Fifhes. See ICHTHYOLOGY.

RESPITE, in *Law*, fignifies a delay, forbearance, or prolongation of time, granted to any one for the payment of a debt or the like. See REPRIEVE.

RESPONDENT, in the fchools, one who maintains a thefis in any art or fcience; who is thus called from his being to anfwer all the objections propofed by the opponent.

RESPONDENTIA. See BOTTOMRY.

RESPONSE, an anfwer or reply. A word chiefly ufed in fpeaking of the anfwers made by the people to the prieft, in the litany, the pfalms, &c.

RESSORT, a French word, fometimes ufed by Englifh authors to fignify the jurifdiction of a court, and particularly one from which there is no appeal.—Thus it is faid, that the houfe of lords judge *en dernier reffort*, or in the laft reffort.

REST, the continuance of a body in the fame place, or its continual application or contiguity to the fame parts of the ambient or contiguous bodies; and therefore is oppofed to motion. See the article MOTION.

REST, in *Poetry*, is a fhort paufe of the voice in reading, being the fame with the cæfura, which, in Alexandrine verfes, falls on the fixth fyllable; but in verfes of 10 or 11 fyllables, on the fourth. See POETRY, Part III.

REST-HARROW, or CAMMOCK, the *Ononis Arvenfis*. A decoction of this plant has been much recommended to horfes labouring under a ftoppage of urine. It is the peft of fome corn-fields; but in its younger ftate, before the plant has acquired its thorns, it is a moft acceptable food to fheep.

RESTAURATION, the act of re-eftablifhing or fetting a thing or perfon in its former good ftate.

RESTIO, a genus of plants belonging to the diœcia clafs. See BOTANY *Index*.

RESTITUTION, in a moral and legal fenfe, is reftoring a perfon to his right, or returning fomething unjuftly taken or detained from him.

RESTITUTION of Medals, or *Reftituted Medals*, is a term ufed by antiquaries for fuch medals as were ftruck by the emperors, to retrieve the memory of their predeceffors.

Hence, in feveral medals, we find the letters REST. This practice was firft begun by Claudius, by his ftriking afrefh feveral medals of Auguftus. Nero did the fame; and Titus, after his father's example, ftruck reftitutions of moft of his predeceffors. Gallienus ftruck a

Reſtive || Reſurrection.

a general reſtitution of all the preceding emperors on two medals; the one bearing an altar, the other an eagle, without the REST.

RESTIVE, or RESTY, in the manege, a ſtubborn, unruly, ill-broken horſe, that ſtops, or runs back, inſtead of advancing forward.

RESTORATION, the ſame with reſtauration. See RESTAURATION.

In England, the return of King Charles II. in 1660, is, by way of eminence, called the *Reſtoration;* and the 29th of May is kept as an anniverſary feſtival, in commemoration of that event, by which the regal and epiſcopal government was reſtored.

RESTORATIVE, in *Medicine*, a remedy proper for reſtoring and retrieving the ſtrength and vigour both of the body and animal ſpirits.

All under this claſs, ſays Quincy, are rather nutrimental than medicinal; and are more adminiſtered to repair the waſtes of the conſtitution, than to alter and rectify its diſorders.

RESTRICTION, among logicians, is limiting a term, ſo as to make it ſignify leſs than it uſually does.

RESTRINGENT, in *Medicine*, the ſame with aſtringent. See ASTRINGENTS.

RESULT, what is gathered from a conference, inquiry, meditation, or the like; or the concluſion and effects thereof.

1 Definition.

RESURRECTION, in *Theology*, is a riſing again from the ſtate of the dead; and is that event, the belief of which conſtitutes one of the principal articles in the Chriſtian creed.

2 Plan of the article.

In treating of this object of our faith, it has been uſual to mention, firſt, the reſurrection of our Bleſſed Lord, with the character of the witneſſes, and the authenticity of the goſpel hiſtory by which it has been proved, and from which, as a conſequence, ours is inferred. But as moſt of the arguments for his reſurrection are contained in the goſpels, and as merely to repeat them would afford, we hope, but little information to moſt of our readers, we mean here to take a view of the ſeveral grounds on which the belief of a future exiſtence is ſuppoſed to be founded; to collect together ſome of the ſentiments of authors and nations concerning the place where departed ſpirits reſide; concerning the nature of their preſent ſtate; concerning the kinds of their future deſtination; that we may afterwards ſee how far their notions differ and agree with what we conſider as the doctrines of Scripture.

3 The notion of a future ſtate unknown to ſome obſcure tribes.

Of a future ſtate, there have ſometimes been found a few wandering and obſcure tribes who ſeemed to entertain no notion at all; though it ſhould be remarked, that ſome of theſe were likewiſe obſerved in ſo low a degree of ſavage barbarity as not to be acquainted with the uſe of the bow, the dart, or the ſling, and as not knowing how to wield a club, or to throw a ſtone, as a weapon of defence*.

* See *Robertſon's Hiſt. of America.*

4 Has been almoſt univerſal.

Wherever the human mind has been cultivated, or properly ſpeaking, begun to be cultivated, the opinion has likewiſe generally prevailed that human exiſtence is not confined to the preſent ſcene; nay, ſo very general has this notion been found among mankind, that many are puzzled how to account for what they ſuppoſe to be almoſt next to its univerſality.

To explain the phenomenon, ſome have imagined that it is a notion derived by tradition from primeval revelation. They ſuppoſe that the firſt parent of mankind, as a moral agent accountable for his conduct, was informed by his Maker of every thing which it was of importance for him to know; that he muſt have been acquainted with this doctrine of a future ſtate in particular; and that he could hardly fail to communicate a matter ſo intereſting to his poſterity. They ſuppoſe, too, that the hiſtory of the tranſlation of Enoch muſt have made a great noiſe in the world, and that the remembrance of it muſt have been long retained and widely diffuſed; and they find in the book of Job plain intimations of a reſurrection from the dead, which, from the manner in which they are introduced, they think that very ancient patriarch muſt have received through this channel.

5 The origin of this notion derived by ſome from primeval revelation.

6 The uſual objections to this opinion of no force.

It is not thought to be any objection to theſe ſuppoſitions, that the Moſt High, when delivering his laws from the top of Mount Sinai, did not enforce them by the awful ſanctions of a future ſtate. The intelligent reader of the Scriptures knows that the ſanctions of a future ſtate belong to a different and more univerſal diſpenſation than was that of Moſes; that the primeval revelation related to that diſpenſation; and that the Jewiſh law, with its temporal ſanctions, was introduced only to preſerve the knowledge and worſhip of the true God among a people too groſs in their conceptions to have been properly influenced by the view of future rewards and puniſhments, of ſuch a nature as eye hath not ſeen, nor ear heard, neither hath it entered into the heart of man to conceive. He ſees at the ſame time, everywhere ſcattered through the Old Teſtament, plain indications of the Moſaic economy being no more than preparatory to the bringing in of a better hope; and he thinks it evident, that ſuch Jews as underſtood any thing of the nature of that better hope, muſt have been convinced, that, however the *ceremonial rites* of *their* religion might be ſufficiently guarded by temporal ſanctions, the *fundamental principles* of *all* religion and virtue are ſupported by rewards and puniſhments to be diſpenſed in a ſtate beyond the grave. See PROPHECY and THEOLOGY.

7 Reaſons in ſupport of the opinion.

That the progenitors of the human race muſt have been inſpired by their Creator with the knowledge of their immortality, and of every thing neceſſary to their everlaſting welfare, cannot, we ſhould think, be queſtioned by any one who believes that the world had a beginning, and that it is under the government of goodneſs and juſtice. The progreſs from ſenſe to ſcience is ſo ſlow, that however capable we may ſuppoſe the earlieſt inhabitants of this earth to have been of making philoſophical diſcoveries, we cannot believe that the Father of mercies left his helpleſs creature to diſcover for himſelf his future exiſtence. Death, when firſt preſented to him, muſt have been a ghaſtly object; and had he been left without any hope of redemption from it, he would undoubtedly have ſunk into liſtleſs deſpondency.

But a proſpect of immortality is ſo pleaſing to the human mind, that if it was communicated to the firſt man, it would of courſe be cheriſhed by his poſterity; and there is no difficulty in conceiving how it might be handed down by tradition to very remote ages, among ſuch of his deſcendents as were not ſcattered over the face of the earth in ſmall and ſavage tribes.—In the courſe of its progreſs, it would frequently be new-

Reſurrection.

new-modelled by the ever active imagination; and at laſt many abſurd and fantaſtic circumſtances would doubtleſs be combined with the original truth, that death puts not an end to human exiſtence.

But though we are firmly convinced that the firſt principles of uſeful knowledge, and among them the doctrine of a future ſtate, were communicated to man by his Maker; and though this doctrine, in large and permanent ſocieties, might certainly be conveyed more or leſs pure to late poſterity through the channel of tradition—we are far from attributing ſo much to tradition as ſome writers are diſpoſed to do, or thinking it the only ſource from which mankind could derive the belief of their exiſtence beyond the grave. In ſmall tribes of ſavages ſuch a tradition could hardly be preſerved; and yet ſome indiſtinct notions of a future ſtate have been found among tribes who are ſaid to have loſt all traditionary notions even of the being of a God.

8
Others imagine the notion might be conjectured from natural phenomena;

Others, therefore, are inclined to believe that, independent of any traditions, mankind might be led by certain phenomena to form ſome conjectures of a future ſtate. They obſerve, that although a few individuals perhaps may, yet it ſeldom happens that the whole individuals of any nation are exempted from dreaming: They obſerve, too, and this obſervation is founded on experience, that the images of the dead are from the remaining impreſſions of memory frequently ſummoned up in the fancy; and that it appears from all the languages of rude nations, who pay the greateſt attention to their dreams, and who ſpeak of ſeeing the dead in their viſions, that theſe images (A) have always been taken by them for realities; nay, ſome of the learned, and the celebrated Baxter is of the number, are diſpoſed to doubt whether theſe appearances be not ſomething more than illuſions of the brain: But whether they really be ſo or not, one thing is certain, that all nations in all countries, in the darkeſt ages and the rudeſt periods, are accuſtomed to dream; and whether ſleeping or waking, in the ſtillneſs of the night, in the gloom of ſolitude, in the fondneſs of friendſhip, in the rovings of love, the delirium of fever, and the anguiſh of remorſe, to ſee and converſe with the ſhades of the departed; and Lucretius * has remarked, that even the inferior animals are not exempted from ſuch illuſions of a reſtleſs fancy.

9
as from dreaming, &c.

* Lucret. lib. 4.

For often ſleeping racers pant and ſweat,
Breathe ſhort, as if they ran their ſecond heat;
As if the barrier down with eager pace
They ſtretch'd, as when contending for the race.
And often hounds, when ſleep hath clos'd their eyes,
They toſs, and tumble, and attempt to riſe;
They open often, often ſnuff the air,
As if they preſt the footſteps of the deer;
And ſometimes wak'd, purſue their fancy'd prey,
The fancy'd deer, that ſeem to run away,
Till quite awak'd, the follow'd ſhapes decay.
And ſofter curs, that lie and ſleep at home,
Do often rouſe, and walk about the room,
And bark, as if they ſaw ſome ſtrangers come.
And birds will ſtart, and ſeek the woods, by night,
Whene'er the fancy'd hawk appears in ſight,
Whene'er they ſee his wing or hear him fight.

CREECH.

Theſe powers of fancy extend wide over animal creation; and it is on this general principle that necromancers and dreamers have in all ages eſtabliſhed their trade, that the ſtories of goblins have at all times ſo very eaſily procured belief, and that

The village matron, round the blazing hearth,
Suſpends the infant audience with her tales,
Breathing aſtoniſhment! Of witching rhymes
And evil ſpirits; of the deathbed call
Of him who robb'd the widow and devour'd
The orphan's portion; of unquiet ſouls
Ris'n from the grave to eaſe the heavy guilt
Of deeds in life conceal'd; of ſhapes that walk
At dead of night, and clank their chains and wave
The torch of hell around the murderer's head.

AIKENSIDE.

Mankind in general would willingly diſpenſe with theſe troubleſome viſits of the dead. To prevent the return of the *zumbi* or the ghoſt, ſome nations of Africa uſe many ſuperſtitious rites *; and Kolben tells us, that the frighted Hottentots leave in the hut where a perſon has died all the utenſils and furniture, leſt the angry ghoſt, incenſed at their avarice, ſhould haunt them in their dreams, and infeſt them in the night. Divines and moraliſts have laboured to ſhow that theſe are merely imaginary terrors: but God and nature ſeem to have determined that they ſhall produce the ſame effects upon certain minds as if they were real; and that while there is any ſenſibility in the heart, while there is any remembrance of the paſt, and any conjuring power in the fancy; the ignorant, the benighted, the timid, ſhall often meet with the goblins of darkneſs, the ſpectres of the tomb, the apparitions that hover round the grave, and the forms of the dead in the middle dream. See SPECTRE.

* *Voyage to Congo and Angola, Churchill's Voyages.*

10
Probable inferences from dreams, &c.

From theſe phenomena, which have been ſo common in all countries and in all ages, what would mankind naturally infer? Would they not infer, that there is ſomething in the nature of man that ſurvives death, and that there is a future ſtate of exiſtence beyond the grave? Are not ſtill many ſpecimens of this reaſoning preſerved in the ancient poets? and is it not thus that Achilles † reaſons after imagining that he ſaw the ghoſt of his friend Patroclus?

† *Hom Iliad.* lib. xxiii. l. 103.

'Tis true, 'tis certain, man, though dead, retains
Part of himſelf; th' immortal mind remains:
The form ſubſiſts without the body's aid,
Aerial ſemblance, and an empty ſhade.

This

(A) Theſe images were called by the Greeks Ειδωλα Θανοντων; and among the Romans they had various names, as *umbræ*, *lemures*, *manes*, *larvæ*, and were ſometimes called *occurſacula noctium*, *buſtorum formidamina*, *ſepulchrorum terriculamenta*, *animæ errantes*, which are all comprehended under the *ſpecies mortuorum*.

Resurrection.

This night my friend, so late in battle lost,
Stood at my side a pensive plaintive ghost;
Ev'n now familiar as in life he came,
Alas! how diff'rent, yet how like the same. POPE.

* Lib. iii.

Lucretius *, a studious observer of nature, though no friend to the soul's immortality, acknowledges frankly that these phantoms often terrify the mind, haunt us in our sleep, and meet us while awake. He confesses, too, that by such appearances mankind have been led to believe the future existence of the soul; but, aware of the consequence,

——*Ne forte animas Acherunte reamur*
Effugere, aut umbras inter vivos volitare,

he endeavours to explain these curious phenomena on some of the odd and fantastic principles of the Epicureans. In doing this, however, he pretends not to deny that these images appear to be real; but candidly acknowledges that

———— They strike and shake
The airy soul, as when we are awake,
With stroke so lively, that we think we view
The absent dead, and think the image true.
CREECH.

We here see how the belief of the soul's immortality came to be general among mankind. But for this information we are much more indebted to the poets, who have given us faithful transcripts of nature, than to the philosophers who have wished to entertain us with their own theories, or to those laborious men of erudition, who have dreaded as much to examine the source of an ancient report as the friends of Ulysses to approach the coast of Cimmerian darkness. With them tradition is the ultimate boundary of research: and as gorgons, chimeras, and hydras, have come down to us by tradition; so they, with great sagacity, suspect, that tradition must likewise be at the bottom of the soul's immortality, and occasion the visions and phantoms of the dead.

11 Folly of allowing too much to tradition.

To tradition we have allowed all that it can justly claim; but we cannot allow it to be the only source of this opinion: and we have felt the highest indignation upon hearing men of learning and genius affirm, from a false zeal for the honour of revelation, that mankind, without this instruction, could never have acquired the art of building huts to screen them from the cold, or have learned the method of propagating their species! The reader must not here suppose that we allude to Polydore Virgil (B). We have in our eye persons now alive, with whom we have conversed on the subject, and who (terrified at the length to which some philosophers have carried the doctrine of instincts, and others the reasoning powers of the mind) have contended, with the utmost earnestness, that we know nothing—not even the functions of our animal nature—but by tradition or written revelation.

12 Opinion of philosophers.

Having now seen the source of the opinion concerning the future existence of the soul, and pointed out the natural phenomena by which mankind were led to embrace it, we come next to review the arguments by which the philosophers attempted to confirm it.

13 Pythagoras's notion of transmigration.

Pythagoras believed, with the rest of his country, that annihilation was never the end, and that nonentity was never the beginning of any thing that is. His general doctrine upon this subject was shortly expressed in very few words, *Omnia mutantur, nihil interit.* He afterwards learned from Egyptian priests that the soul migrates into new bodies; and being, it seems, a person of a most extraordinary and astonishing memory, he found there was some truth in the story: for after musing, he began to remember that he was Euphorbus, the son of Pantheus, that was slain by Menelaus in the Trojan war; and upon a jaunt to Peloponnesus, recollected the shield which he had worn at the time of the siege, in one of the temples of Juno at Argos! That none might question the truth of his assertion, his followers presently removed all doubts by the famous argument, the IPSE DIXIT of Egyptian origin.

14 Plato's doctrine of pre-existence.

As Pythagoras taught that human souls are frequently thrust into brute shapes, and, as some imagined, by way of punishment; it occurred to Plato, that all bodies, even the human, are a sort of prisons; and that, in consequence of this confinement, the soul was subjected to the rage of desire, appetite, and passion, and to all the wretched miseries of a jail. To explain this mystery, he supposed that desires and appetites belong to a soul that is purely animal residing in the body. But he was perplexed with another difficulty; for as he thought highly of the goodness of Deity, he could not imagine how he should imprison us without a crime. He supposed, therefore, that prior to its union with the present body the soul had existed in one of ether, which it still retains; but that even in this etherial body it had felt something of impure desire; and happening to indulge the vicious appetite, had contracted some stains of pollution, for which it was confined in its present body as a house of correction to do penance and improve its morals.

15 And mode of proving it.

To prove this ideal pre-existence of the soul, Plato availed himself of an opinion that was general in his time, that coincided with the doctrines of Pythagoras, and that was partly founded on a sort of reasoning and observation. He thought that matter and intelligence are coeternal (see PLATONISM); that there are various orders of souls; that those of both the man and the brute are parts or emanations (C) of the *anima mundi*, or soul of the world; that all are ultimately parts or emanations of Deity itself; and that all their faculties are

(B) This writer allots part of a chapter to show, "Quis primum instituerit artem meretriciam," as being in his opinion, a traditionary practice. See Lib. iii. cap. 17. *De Rerum Inventoribus.*

(C) The Deity was conceived by the ancients sometimes as a solid, when inferior souls were called *αποσπασματα*, i. e. fragments or parts broken off from him; and sometimes as a fluid, when they were considered as *απορροιαι* or emanations: but from none of these hypotheses did they reason consequentially. Their *αποσπασματα* were often after death reunited to the Deity; and their *απορροιαι* often remained separate and distinct for a long while, without flowing back as they ought to have done, and mingling with the great ocean of spirit.

Resurrection.

are more or less restricted and confined, according to those organised systems with which they are connected. Know first (says one delivering his doctrines),

Know first, that heav'n and earth's compacted frame,
And flowing waters, and the starry flame,
And both the radiant lights, one common soul
Inspires, and feeds, and animates the whole.
This active mind, infus'd through all the space,
Unites and mingles with the mighty mass:
Hence men and beasts the breath of life obtain,
And birds of air, and monsters of the main;
The ethereal vigour is in all the same,
And every soul is fill'd with equal flame;
As much as earthy limbs, and gross allay
Of mortal members, subject to decay,
Blunt not the beams of heav'n and edge of day (D).

DRYDEN.

Besides this hypothesis, that in some measure was common to others, Plato had an argument peculiarly his own. Happening to peep into the region of metaphysics, he was somewhat surprised on observing the ideas which we derive from reflection and consciousness; and supposing that they could not have entered by the senses, he naturally, though not very justly, concluded, that we must have received them in some state of prior existence.

As, according to him, the soul was eternal, as well as the matter which composed the body, and as their union was only temporary and accidental, he might have been satisfied that the death of the soul was not to be the consequence of their separation. But, some how or other, satisfied he was not. He had recourse to a new argument. As the soul, he said, was an active principle, and a self-moving, it did not depend for its life on another; and therefore would always continue to exist, though the body were reduced to the general mass out of which it was formed. See METAPHYSICS, Part III. chap. iv.

16
The opinions of the Gnostics.

Whether Plato had borrowed any of his doctrines from the eastern magi, we pretend not to say. We only observe a striking similarity, in some respects, between his and theirs. In Plato's philosophy, the sun, moon, and stars, were animated beings, and a sort of divinities that originally had sprung from the great fountain of heat and light, and our earthly bodies a sort of dungeons in which our miserable souls are benighted and debased by desires, appetites, and passions. In the magian philosophy, the Supreme Being was called *Oromasdes;* was the god of light, or was light itself, and represented by Mithras, a subordinate divinity, and the same with the sun. Another deity of very great power was Arimanes, the god of darkness, who presided over matter, and was the origin of all evil (see POLYTHEISM). The ancient Gnostics, who derived their tenets from this source, believed, with Pythagoras and Plato, in a great number of subordinate genii; and said, that Demiurgus, the god of matter and the soul or spirit of this world, had contrived the bodies of men and brutes; and in the former particularly, as in so many prisons, had confined a number of celestial spirits, that by exposing them to the low desires of appetite and passion, he might seduce them from their allegiance to the God of light, and render them more submissive to himself. From these prisons the Supreme Being was continually making attempts to rescue them; and in the mean time was frequently sending divine messengers to enlighten and instruct them, and to render them capable of returning to the regions of light and happiness, to which they had belonged (E).

The Stoics attempted to simplify this system, which appears anciently to have pervaded Egypt and the east, and which would seem to be no more than variously modified by Orpheus, Pythagoras, Plato, and others of the more northerly and western nations. None of them allowed a creation out of nothing; and the shaping and modelling of matter into forms was variously explained, according as they happened to be most addicted to superstition, to morals, or to physics. Some ascribed these operations to ancient Time, Chaos, and Darkness, and explained the future changes in nature by the genealogies of these deities; some observing attraction and repulsion, or at least a sort of agreement and discordance among bodies, were inclined to ascribe them to Friendship and Hatred, or Love and Antipathy; some observing, that while one body rose another descended, made Levity and Gravity primary agents; and some taking notice that living bodies sprung from corruption, were

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(D) The general doctrine, as delivered here in these verses of Virgil, is the same with that not only of Pythagoras, but of the Stoics.

(E) Plato made the stars the native residence of inferior souls; and when these were thoroughly purified below, returned them home again: and therefore, says Virgil, alluding to his doctrine,

—————— Some have taught
That bees have portions of ethereal thought,
Endu'd with particles of heav'nly fires;
For God the whole created mass inspires:
Thro' heav'n and earth, and ocean's depth, he throws
His influence round, and kindles as he goes.
Hence flocks, and herds, and men, and beasts, and fowls,
With breath are quicken'd, and attract their souls:
Hence take the forms his prescience did ordain,
And into him at length resolve again.
No room is left for death, they mount the sky,
AND TO THEIR OWN CONGENIAL PLANETS FLY. *Dryden.*

Reſurrection.

were diſpoſed to confer the ſame powers on Moiſture and Heat.

17 Of the Stoics.

The phyſical hypotheſes were what had moſt charms for the Stoics. From their ſyſtem immaterial beings were openly excluded; all things were regulated by phyſical laws or inexorable fate; and all things originated in the Τὸ Ἓν or the *Firſt One*, which was probably ſuggeſted by the Μονας of Pythagoras. This Τὸ Ἓν appears to have been a *materia prima* devoid of all the qualities of body. In their language it was an Αρχη or *firſt principle*, not ſubject to change. When it was inveſted with the properties of body, it then became a Στοιχειον or an *element;* and then, ſo far as reſpected its qualities, eſpecially its forms, it was ſubject to changes almoſt perpetual. The gods themſelves and the ſouls of men were in this ſyſtem only modifications of matter (F). Man was compoſed of their four elements, Fire, Air, Water, and Earth; and upon diſſolution, every part returned to the element from which it had come, as the water of a veſſel ſwimming in the ſea unites with the ocean when the veſſel is broken. This ſyſtem, it is plain, cannot poſſibly admit of any ſeparate conſciouſneſs of exiſtence (G). The ſame may be ſaid of the ſyſtems of Democritus and Epicurus, and all thoſe who undertook to explain things upon phyſical principles (H). The chief merit of the phyſical ſyſtems appears to be this: Abſurd as they were, it would ſeem from the whimſical and the almoſt childiſh reaſoning of Lucretius, that they had a tendency to lead mankind from extravagant hypotheſes to ſomething that was ſimilar to obſervation.

18 Of Ariſtotle.

What Ariſtotle thought of the ſeparate exiſtence of the ſoul after death is not very certain. The ſoul he calls an Εντελεχεια; and if the reader can divine the meaning of the word, he perhaps can divine the meaning of the *Stagyrite*, and will then be a better diviner than we. At other times he ſays, that the ſoul is ſomething divine; that it reſembles the element of the ſtars; that it is ſomething of a fiery nature; that it is the vicegerent of God in the body; and that the acuteneſs of the ſenſes, the powers of the intellect, with the various kinds of appetites and paſſions, depend entirely on the qualities of the blood (I).

19 Of Critias and others.

Another opinion of very old date was that of the late ingenious Mr Hunter. According to him, the living principle reſides in the blood. This opinion, which is mentioned by Moſes, was adopted by Critias and others of the ancients. Harvey likewiſe embraced it. But Mr Hunter, who always wiſhed to be thought an original, inclines to ſtand at the head of the opinion, and ſupports it by experiments ſimilar to thoſe of the famed Taliacotius in mending noſes. Should any of our readers wiſh to extract the ſoul's immortality from ſuch an opinion, we muſt refer them to the many reſources of ingenuity, ſophiſtry, and logic.

20 Of the Jews.

Among the Jews, the belief of a future and ſeparate exiſtence for a long time was deemed no eſſential article of their creed. Some thought that the ſoul was a ſpark in the moving of the heart; ſome imagined that it was the breath, and that upon the diſſolution of the body it naturally vaniſhed into ſoft air. The Sadducees denied the exiſtence of either angel or ſpirit. Many believed the doctrine of ghoſts, and were accuſtomed to invoke them at the grave. It is hence that we hear the prophets complaining that they were ſeeking from the living God unto dead men. Some imagined that there was a pre-exiſtence of ſouls; and, in the caſe of a blind man, aſked our Saviour, whether the man or his parents had ſinned that he was born blind? Others inclined to a revolution of ſoul and body, and thought that our Saviour was either Elias or one of the old prophets returned; and a great many new-modelled their opinion of the ſoul's immortality according to certain paſſages in Scripture. The inſpired mother of Samuel had ſaid, "The Lord killeth and maketh alive: he bringeth down to the grave, and bringeth up." Iſaiah had exclaimed, "Thy dead ſhall live; together with my dead body ſhall they ariſe: Awake, and ſing, ye that dwell in the duſt; for thy dew is as the dew of herbs, and the earth ſhall caſt out the dead." Daniel had declared, that many of them that ſleep in the duſt of the earth ſhall awake to everlaſting life, and ſome to ſhame and everlaſting contempt. In the viſion of the valley of dry bones, Ezekiel had ſeen that "at the word of the Lord" the bones came together, bone to his bone, the ſinews and the fleſh came upon them, and the ſkin covered them above, and the breath came into the bodies, and they lived and ſtood upon their feet. And a paſſage of Job led them to ſuppoſe, that at ſome diſtant and future period a particular time, which was called *the laſt* or the *latter day*, was appointed by heaven for the general reſurrection of all thoſe who are ſleeping in their graves. "I know (ſays Job) my Redeemer liveth, and that he ſhall ſtand at the latter day upon the earth; and though after my ſkin worms deſtroy this body, yet in my fleſh ſhall I ſee God."

Whether theſe paſſages were fairly interpreted agreeably to their true and original meaning, it is not here our buſineſs to inquire. It is ſufficient for us to obſerve, that from them many of the Jews inferred the reality of a general reſurrection (K). In this perſuaſion, Martha, ſpeaking of her brother Lazarus, ſays to our Lord, "I know that he ſhall riſe again in the reſurrection at the laſt day." This reſurrection appears to

(F) The Αρχη of the Stoics appears to be the ſame with the *Li* of the Chineſe.

(G) Yet without regarding the inconſiſtency, many of the Stoics believed, that the ſoul continued ſeparate long after death; though all in general ſeemed to deny a future ſtate of rewards and puniſhments.

(H) In his *Phyſical Coſmogony*, Plato differed but little from the Stoics; but he had another ſort of coſmogony, in which all things appear to have ſprung from, and to be almoſt wholly compoſed of metaphyſical entities, as ideas of forms, numbers, and mathematical figures. Theſe kinds of notions were common both to him and Pythagoras; and were originally borrowed from Egypt, where calculation and geometry were half deified. See PLATONISM.

(I) The immortal Harvey has collected theſe different opinions of the Stagyrite in Exercit. 52. *De Generatione Animalium.*

(K) At preſent ſome are for allowing only thoſe of their own nation to ſhare in the benefits of this reſurrection;

Resurrection.

to have been a general opinion among the Pharisees; for although it was a notion of the sect of the Sadducees that there was no resurrection, neither angel nor spirit, yet the Pharisees, we are told, confessed both. And this assertion is plainly confirmed by St Paul himself when his countrymen accused him before Felix. "I confess unto thee (says this eminent apostle), that after the way which they call heresy so worship I the God of my fathers, believing all things which are written in the law and in the prophets, and having hope toward God, which they themselves also allow, that there shall be a resurrection of the dead, both of the just and unjust."

21 Of the Christians.

This resurrection of the dead to judgment, though not perhaps in the same sense in which the old Pharisees conceived it, is now generally and almost universally (L) maintained by Christians (M). Yet the Christians differ considerably with respect to the nature of the human soul. Some imagine, that this spirit is naturally mortal, and that it is propagated along with the body from the loins of the parent. In support of this opinion, it has been observed that a great number of insects and plants transfer their lives to their posterity, and die soon after the act of propagation; that after this act the vital principle is in the most vigorous of plants and animals always found to be much exhausted; and that Tertullian a father of the church, in attempting some experiments of the kind, became subject to a momentary blindness, and felt a portion of his soul going out of him (N).

These imagine that immortality was only conditionally promised to man; that Adam forfeited this immortality by his disobedience; and that Christ has restored us to the hopes of it again by his sufferings and death: for as in Adam we have all died, so in Christ, they say, we shall all be made alive; and that now the sting is taken from death, and the victory over our souls from the grave.

Others have conceived the human soul as naturally immortal, and as setting death and the grave at defiance. Adam, they say, died only in a figure; and only from the consequences of this figure, which means sin, has our Lord saved us. In this sense Adam died on the very day in which he had sinned; or he died literally in 1000 years, which with the Lord are as one day. To these arguments their opponents reply, What then is the victory over death and the grave? You must still have recourse to a new figure, and betake yourselves to the second death; though, after all, where is your grave? To this it is answered, that the soul of itself is naturally immortal, and that it depends not either for its existence or the exercise of its faculties upon the body; that the properties of matter, as figure, magnitude, and motion, can produce nothing that is like to perception, memory, and consciousness. This is true, rejoin their opponents; but besides these few properties of matter, which are only the objects of that philosophy which has lately and properly been termed *mechanical*, the chemical philosophy has discovered other properties of matter; has found that matter is of various kinds; that it very often does not act mechanically; that it acquires many new properties by combination; and that no man, till farther experiment and observation, should venture to assert how far the soul is or is not dependent on its present organised system. The others, proceeding on their hypothesis, maintain that the soul, as being immaterial, is not divisible; and though the body of a frog may live without the head for a whole day; though the body of a tortoise may live without the head for a whole month; though a human limb may for some minutes after amputation continue to perform a vital motion, independent of a brain, a stomach, or a heart; and

tion; and some are not even for allowing them, except they be men of piety and virtue. To render this resurrection probable, the rabbins say, with some of the Mahometans, that there is a certain bone in the body which resists putrefaction, and serves as a seed for the next body *. What that bone is, is of no great moment, as any bone, we believe, in the skeleton will answer the purpose equally well. With respect to the manner of this resurrection, the learned Hody has quoted several opinions of the Jews, and, among others, that of the Chaldee paraphrast of the Canticles, asserting that the prophet Solomon had said, "When the dead shall revive, it shall come to pass that the Mount of Olives shall be cleft, and all the dead of Israel shall come out from thence; and the just too that died in captivity shall come through the way of the caverns under the earth, and shall come forth out of the Mount of Olives." He has likewise quoted Saunderson's Voyage to the Holy Land, in which, we are told that many of the Jews, by their own account, are to rise up in the valley of Jehoshaphat; and that in the *rowling* or *devolution* of the caverns, those at a distance must scrape their way thither with their nails.

* See Pharisee.

(L) The sect of the Quakers explain it figuratively.

(M) The last quoted author † (*Resurrection of the same Body, asserted from the traditions of the Heathens, the ancient Jews, and the primitive Church*) has endeavoured to show that this doctrine, in the same sense as we understand it, has been asserted by the ancient Magi, and by the present heathen Gaurs of Persia, the relics of the ancient Magi; by some of the ancient Arabians; by some of the Banians of India; by the present inhabitants of the island of Ceylon, of Java, of Pegu, of Transiana; by some amongst the Chinese; by the Arderians in Guinea; and by the ancient Prussians. The proofs which he brings, it must be confessed, are not however always very satisfactory. It appears, even from his own account, that some of these had derived their notions from certain Christians, Mahometans, or Jews. But the reader may judge of the great accuracy of his ideas from his bringing old Pythagoras and the Stoics, and even Democritus and Epicurus, in support of the same or a similar opinion.

† *Hody.*

(N) In illo ipso voluptatis ultimæ æstu quo genitale virus expellitur, nonne aliquid de anima quoque sentimus exire, utque adeo marcescimus et devigescimus cum lucis detrimento.

Refurrection.

and though the parts of a plant, a polype, or a worm, may furvive their feparation and become living wholes*, yet the foul, they obferve, is not to be compared with the vital principles of plants and animals, nor ought to be divided on reafons fo flender as thofe of analogy. Even granting, they fay, that the foul were not naturally immortal of itfelf; yet the juftice of God, which is not remarkable for its equal diftribution of rewards and punifhments in the prefent world, is bound to make fome amends in the next. And to this again their opponents anfwer, as to the equal diftribution of juftice in a future world, of that we are affured on much better grounds than any of your's: our Lord has declared it in exprefs terms; and whether the foul be immortal or not, we can eafily believe what he faid is true, as we know him whom we have trufted.

* See *Polypus* and *Reproduction*.

Thefe, with Plato, fuppofe, that the foul is here as in prifon; though how or at what time it fhould firft have come into this dungeon they have not determined. They have only agreed, that upon its enlargement all its faculties are to receive an increafe of power; and "having already equipped it fo exquifitely with confcioufnefs, activity, and perception in and of itfelf, and put it into fo complete a capacity for happinefs and mifery in a feparate ftate," their hypothefis does not require them to admit the leaft occafion for a refurrection; which accordingly is faid to have been an article of Baxter's creed (o).

A third opinion, which extends likewife to every fpecies of plant and animal, is, that all fouls were created at once with bodies of ether; that thefe bodies, occupying only a very fmall fpace, were packed up in their firft progenitors, and there left to be afterwards evolved and clothed with matter of a groffer kind by acts of generation and confequent nutrition. For the proof of this theory we are referred to the fmall animals feen through the microfcope, and likewife to thofe which are fuppofed to efcape even microfcopic obfervation; but, above all, to the eggs of infects, which, though fcarcely perceptible, yet contain in embryo a future caterpillar and all its coats, and within thefe a future butterfly with its legs and wings. Thefe philofophers can perhaps account for the general taint of original fin in fome other way than has hitherto been done. We have only to add, that on their fcheme the refurrection is not a matter that feems to be indifferent.

22 Place of the dead near to the grave.

The next thing that falls to be confidered is the place of the dead. From a natural enough affociation of ideas, an opinion had very early prevailed, that the fpirit continued near to the body; and the offerings therefore intended for the dead were by moft nations prefented at the grave; and that on which the departed fpirit is fuppofed to reft is always placed near the grave in China.

23 In darknefs.

From the dreams of the night and the natural tendency of the fancy to work and to fummon up fpectres when the world around us is involved in darknefs, it has alfo been imagined, that thefe fpirits delight in the night and fhadow of death (P), or have been prohibited from enjoying the exhilarating beams of day. And hence we are told,

> That in the difmal regions of the dead
> Th' infernal king once rais'd his horrid head;
> Leap'd from his throne, left Neptune's arm fhould lay
> His dark dominions open to the day,
> And pour in light.

The nations, therefore, who have fancied a general receptacle for the dead, have thus been induced to place it in the weft (Q), where the night begins and the day ends. That part of the world which, in the divifion of his father's dominions, fell to Pluto the infernal god, and where, according to Lactantius, Satan holds the empire of darknefs, the Friendly Iflanders have placed to the weftward of a certain ifland which they call *Tejee;* fome tribes of American Indians, in a country beyond the weftern mountains; and Homer, fomewhere to the weftward of Greece at the boundaries of the ocean, 24 In the weft.

> Where in a lonely land and gloomy cells
> The dufky nation of Cimmeria dwells;
> The fun ne'er views th' uncomfortable feats
> When radiant he advances nor retreats.
> Unhappy race! whom endlefs night invades,
> Clouds the dull air, and wraps them round in fhades.

Another opinion entertained by the Greeks and fome other nations was, that the place of departed fpirits is under the earth. This opinion is frequently mentioned in Homer, in Virgil, and alluded to by the Jewifh prophets. As for the prophets, we know the circumftance from which they borrowed it: it was borrowed from thofe fubterraneous vaults where their chiefs were buried, and which have been defcribed by modern travellers. In the fides of thefe caverns there is ranged a great number of cells; and in thefe cells the mighty lay in a fort of ftate, with their weapons of war and their fwords at their head. To thefe kinds of Egyptian cemeteries Ezekiel alludes, when he fays, "that they fhall not lie with the mighty that are fallen of the uncircumcifed, who are gone down to hell with their weapons of war, and they have laid their fwords under their head." And Ifaiah, when thus fpeaking of the prince of Babylon, "Thou fhalt be brought down to hell, *to the fides of the pit.* Hell from beneath is moved for thee, to meet thee at thy coming; it ftirreth up the dead for thee, even all the chief ones of the earth; it hath raifed up from their thrones all the kings of the nations. All the kings of the nations, even all of them, lie in glory, every one in his own houfe." 25 Under the earth.

Many

(o) *An Hiftorical View of the Controverfy concerning an Intermediate State, and the Separate Exiftence of the Soul.*

(P) Some Turkifh ghofts are an exception, who ufe lamps or candles in their tombs, when their friends choofe to fupply them with thefe luxuries.

(Q) The *weft* and *darknefs* are fynonymous in Homer. Ω φιλοι, ου γαρ τ' ιδμεν όπη ζοφος, ουδ' οπη ηως. (*Odyf.*) "O my friends! which is the weft, or which is the eaft, the place of darknefs, or that of the morning, we cannot learn."

Reſurrection.

Many of the ancient fathers of the church aſſerted only, that the dead are now in *abditis receptaculis*, or in certain hidden and concealed places.

26 In hidden receptacles.

Orpheus, Origen, and ſome others of the fathers, with the ancient Caledonian bard Oſſian, and the learned Dodwell among the moderns, imagined that the ſoul, when it left the body, went into the air, and reſided ſomewhere between the ſurface of the earth and the moon.

27 In the air.

28 In new bodies.

Thoſe who believed in a tranſmigration cauſed the ſoul at death only to enter a new body, and kept the departed always with the living. This creed has been found in India, in Egypt, in Mexico, and in all thoſe countries where picture-writing has been much uſed. In this ſpecies of writing, the ſame picture is on fancied analogy transferred by metaphor to ſignify either a god or a man, a brute or a plant; and in thoſe countries where it was practiſed, men had uſually their names from animals, and were repreſented by their figure in writing (R). From this laſt ſtage of the proceſs, a tranſmigration was eaſily ſuppoſed: and hence we hear of the gods of Egypt wandering about like ſo many vagrants in brute ſhapes, and of princes being tranſlated into ſtars, becauſe a ſtar was their emblem in hieroglyphic, or ſtood for their name in figurative language. And, in like manner, we ſee, from the ſpecimen of this character which is ſtill preſerved on celeſtial globes, how the heavens at firſt came to be filled with bears, ſcorpions, and dragons, and with a variety of other animals.

29 State of the dead according to ſome rude nations.

The opinions concerning the ſtate of the dead are ſtill more numerous than thoſe concerning the place where they reſide. Rude nations have generally thought that the future ſtate is ſimilar to the preſent; that plants, animals, and inanimate things there, have their ſhades; and that theſe contribute as much to the pleaſures and conveniencies of the dead as their realities do to the living; that huſbands have their wives (S), lovers their miſtreſſes, warriors their battles, huntſmen their ſport; and that all their paſſions, amuſements, and buſineſs, are the ſame as formerly. For this reaſon, that the dead may not appear unprovided in the next world, like the ancient Gauls, ſome tribes of India, America, and Africa, bury with them in the ſame grave their wives, their arms, their favourite animals, and their neceſſary utenſils.

30 According to the Egyptians.

The ancient Egyptians, who believed in tranſmigration, ſuppoſed that the ſoul was after death obliged to animate every ſpecies of bird and quadruped, of reptile and inſect, and was not to return to a human form till after a period of 3500 years. Others have confined their tranſmigrations to particular animals, as the ſoul of man to the human form, and the ſoul of the brute to the bodies of the ſpecies to which it belonged. Some have changed the brute into man, and man into the brute, that man might ſuffer injuries ſimilar to what he had inflicted, and the brute retaliate what he had ſuffered. Others have confined the human ſoul in plants and in ſtones; and Bell of Antermony mentions an Indian who ſuppoſed that his anceſtors might be in fiſhes.

31 According to Homer.

The notions of Homer were probably thoſe of many of his time. But theſe notions were diſmal indeed. When his hero Ulyſſes viſited the ſhades, many of the ghoſts ſeemed to retain the mangled and ghaſtly appearance which they had at death; and, what is worſe, ſeemed to be all ſtarving with hunger, innumerable multitudes, with loud ſhrieks, flocking to the ſteams of his ſlain victim as to a moſt ſumptuous and delicious banquet.

For ſcarcely had the purple torrent flow'd,
And all the caverns ſmok'd with ſtreaming blood,
When, lo! appear'd along the duſky coaſts
Thin airy ſhoals of viſionary ghoſts;
Fair penſive youths, and ſoft enamour'd maids,
And wither'd elders, pale and wrinkl'd ſhades.
Ghaſtly with wounds, the forms of warriors ſlain,
Stalk'd with majeſtic port, a martial train.
Theſe, and a thouſand more, ſwarm'd o'er the ground,
And all the dire aſſembly ſhriek'd around.
Ulyſſes ſaw, as ghoſt by ghoſt aroſe,
All wailing with unutterable woes.
Alone, apart, in diſcontented mood,
A gloomy ſhade, the ſullen Ajax ſtood;
For ever ſad, with proud diſdain he pin'd,
And the loſt arms for ever ſtung his mind.

Upon Ulyſſes ſaying to Achilles,

Alive, we hail'd thee with our guardian gods;
And, dead, thou rul'ſt a king in theſe abodes;

The ſhade reply'd:

Talk not of ruling in this dol'rous gloom,
Nor think vain words (he cry'd) can eaſe my doom;
Rather I chooſe laboriouſly to bear
A weight of woes, and breathe the vital air,
A SLAVE TO SOME POOR HIND THAT TOILS FOR BREAD,
THAN LIVE A SCEPTER'D MONARCH OF THE DEAD.

In this gloomy region no one is rewarded for his virtue, nor is puniſhed for his crimes, unleſs committed, like thoſe of Siſyphus, Tantalus, and Ixion, againſt the gods. All indeed are claſſed into groups, from a certain analogy of age, ſex, fate, and diſpoſition; but all appear to be equally unhappy, having their whole heart and affections concentrated in a world to which they are fated never to return.

The Elyſium of Homer is allotted only for the relations and deſcendants of the gods; and Menelaus goes to this country of perpetual ſpring (T), not as a perſon of

(R) A military gentleman who reſided at Penobſcot during the late American war, aſſured us that the Indians, when deſired to ſubſcribe a written agreement, drew always the picture of the object or animal whoſe name they bore. But for fuller information on this ſubject, ſee Clavigero's Hiſtory of Mexico.

(S) The queſtion which the Sadducees put to our Saviour about the wife of the ſeven brothers, is a proof that the Phariſees thought there was a marriage and giving in marriage in the future ſtate, and that it was ſomewhat ſimilar to the preſent.

(T) Homer ſends the ghoſt of Hercules to the ſhades, while Hercules himſelf is quaffing nectar with Hebe in

Resurrection.

of superior merit, but because he had married the daughter of Jove.

32 Becomes a place of rewards and punishments.

Even long after a future state had become the scene of rewards and punishments, these for the most part were distributed, not according to moral, but physical distinctions. With the Greeks and Romans, the soul was condemned to many calamities for a number of years, if the body was not honoured with funeral rites. Among the Scandinavians, a natural death was attended with infamy, while a violent death, particularly in battle, gave a title to sit in the halls of Odin, and to quaff beer from the skulls of enemies. Among the Tlascalans, it was only the great that were permitted to animate birds and the nobler quadrupeds; the lower ranks were transformed into weasels, into paultry beetles, and such mean animals. Among the Mexicans, those who were drowned, who died of a dropsy, tumors, or wounds, or such like diseases, went along with the children that had been sacrificed to the god of water, and in a cool and delightful place were allowed to indulge in delicious repasts and varieties of pleasures: those who died of other diseases, were sent to the north or centre of the earth, and were under the dominion of the gods of darkness. "The soldiers who died in battle, or in captivity among their enemies, and the women who died in labour, went to the house of the sun, who was considered as the prince of glory. In his mansions they led a life of endless delight. Every day the soldiers, on the first appearance of his rays, hailed his birth with rejoicings and with dancings, and the music of instruments and voices. At his meridian they met with the women, and in like festivity accompanied him to his setting. After four years of this glorious life, they went to animate clouds, and birds of beautiful feathers and of sweet song; but always at liberty to rise again, if they pleased, to heaven, or descend to the earth, to warble their songs, and to suck flowers *."

33 These at first distributed according to physical distinctions;

* *Clavigero's Hist. of Mexico*, vol. vi. p. 136.

34 and afterwards according to moral distinctions.

These sentiments of a future state, conceived in a savage and a rude period, could not long prevail among an enlightened and civilized people. When the times of rapine and violence therefore began to cease; when societies regulated by certain laws began to be established; when martial prowess was less requisite, and the qualities of the heart had begun to give an importance to the character, the future state was also modelled on a different plan. In the Æneid of Virgil, an author of a highly cultivated mind, and of polished manners, it becomes a place of the most impartial and unerring justice; every one now receives a sentence suited to the actions of his past life, and a god is made to preside in judgement;

Who hears and judges each committed crime,
Inquires into the manner, place and time.
The conscious wretch must all his acts reveal,
Loth to confess, unable to conceal,
From the first moment of his vital breath,
To the last hour of unrepenting death.

The spirits of the dead no longer mingle together as in the less enlightened period of Homer; the vicious are dismissed to a place of torments, the virtuous sent to regions of bliss: indifferent characters are confined to a limbus *; and those who are too virtuous for hell, but too much polluted with the stains of vice to enter heaven without preparation, are for some time detained in a purgatory.

* *Or paradise of fools.*

35 Virgil's purgatory.

For there are various penances enjoin'd,
And some are hung to bleach upon the wind;
Some plung'd in waters, others purg'd in fires,
Till all the dregs are drain'd, and rust expires;
Till nothing's left of their habitual stains,
But the pure ether of the soul remains.

When thus purified, they become fitted to receive the rewards of their past virtues, and now enter into those regions of happiness and joy.

36 His heaven.

With ether vested, and a purple sky,
The blissful seats of happy souls below,
Stars of their own, and their own suns they know;
Where patriots live, who, for their country's good,
In fighting fields were prodigal of blood.
Priests of unblemish'd lives here make abode,
And poets worthy their inspiring god;
And searching wits, of more mechanic parts,
Who grac'd their age with new-invented arts:
Those who to worth their bounty did extend;
And those who knew that bounty to commend.

These good men are engaged in various amusements, according to the taste and genius of each. Orpheus is still playing on his harp, and the warriors are still delighted with their chariots, their horses, and their arms.

The place of torment is at some distance.

37 His hell.

A gaping gulf, which to the centre lies,
And twice as deep as earth is distant from the skies;
From hence are heard the groans of ghosts, the pains
Of sounding lashes, and of dragging chains.
Here, those who brother's better claim disown,
Expel their parents, and usurp the throne;
Defraud their clients, and, to lucre sold,
Sit brooding on unprofitable gold.
Who dare not give, and even refuse to lend,
To their poor kindred, or a wanting friend.
Vast is the throng of these; nor less the train
Of lustful youths for foul adult'ry slain.

Hosts

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in the skies. One soul of the hero is therefore repining with the ghosts of mortals in the regions below, while the other is enjoying all the happiness of the gods above. (See *Odyssey*, book ii. near the end). Philosophers since have improved on this hint of the poet; and men have now got rational, animal, and vegetable souls, to which sometimes a fourth one is added, as properly belonging to matter in general. Homer insinuates, that Menelaus was to be translated to Elysium without tasting death. This Elysium is the habitation of men, and not of ghosts, and is described as being similar to the seat of the gods. Compare *Odyss.* iv. l. 563. and *Odyss.* vi. l. 43. in the Greek.

Hofts of deferters, who their honour fold,
And bafely broke their faith for bribes of gold:
All thefe within the dungeon's depth remain,
Defpairing pardon, and expecting pain.

38 His paradife of fools.

The fouls of babes, of unhappy lovers, and fome others, feem to be placed in a paradife of fools refiding in a quarter diftinct from Elyfian Tartarus and Purgatory.

It is curious to obferve, how much thefe ideas of a future ftate differ from the vague and fimple conjectures of rude nations; and yet from their fimple and rude conjectures, we can eafily trace the fucceffive changes in the writings of Homer, Plato, and Virgil; and may eafily fhow, that thofe laws which different nations have prefcribed for their dead, have always borne the ftrongeft analogy to their ftate of improvement, their fyftem of opinions, and their moral attainments. Some nations, as thofe of India, have fancied a number of heavens and hells, correfponding to fome of their principal fhades in virtue and vice; and have filled each of thefe places refpectively with all the fcenes of happinefs and mifery, which friendfhip and hatred, admiration, contempt, or rancour, could fuggeft. But having already obferved the progrefs of the human mind in forming the grand and leading ideas of a future ftate, we mean not to defcend to the modifications which may have occurred to particular nations, fects, or individuals.

39 The ftate of the dead as revealed in Scripture.

The belief of Chriftians refpecting futurity demands our attention, as being founded on a different principle, namely, on exprefs revelations from heaven. From many exprefs declarations in Scripture, all Chriftians feem to be agreed, that there is a heaven appointed for the good and a hell for the wicked. In this heaven the faints dwell in the prefence of God and the uninterrupted fplendors of day. Thofe who have been wife fhine as the firmament, and thofe who have converted many to righteoufnefs as the ftars. Their bodies are glorious, immortal, incorruptible, not fubject to difeafe,

40 The nature of heaven.

to pain, or to death. Their minds are ftrangers to forrow, to crying, to difappointment; all their defires are prefently fatisfied; while they are calling, they are anfwered; while they are fpeaking, they are heard. Their mental faculties are alfo enlarged; they no more fee things obfcurely, and as through a cloud, but continually beholding new wonders and beauties in creation, are conftantly exclaiming, "Holy, holy, holy! is the Lord of Hofts, worthy is he to receive glory, and honour, and thankfgiving; and to him be afcribed wifdom, and power, and might; for great and marvellous are his works, and the whole univerfe is filled with his glory."

41 Of hell.

Their notions of hell differ confiderably. Some underftanding the Scriptures literally, have plunged the wicked into an abyfs without any bottom; have made this gulf darker than night; have filled it with rancorous and malignant fpirits, that are worfe than furies; and have defcribed it as full of fulphur, burning for ever. This frightful gulf has by fome been placed in the bowels of the earth; by fome in the fun; by fome in the moon; and by fome in a comet: but as the Scriptures have determined nothing on the fubject, all fuch conjectures are idle and groundlefs.

Others imagine, that the fire and fulphur are here to be taken in a figurative fenfe. Thefe fuppofe the torments of hell to be troubles of mind and remorfes of confcience; and fupport their opinion by obferving, that matter cannot act upon fpirit; forgetting, perhaps, that at the refurrection the fpirit is to be clothed with a body, and, at any rate, that it is not for man vainly to prefcribe bounds to Omnipotence.

42 Of the middle ftate, and different opinions about it.

What feems to have tortured the genius of divines much more than heaven or hell, is a middle ftate. On this fubject there being little revealed in Scripture, many have thought it incumbent upon them to fupply the defect; which they feem to have done in different ways. From the Scriptures fpeaking frequently of the dead as fleeping in their graves, thofe who imagine that the powers of the mind are dependent on the body, fuppofe that they fleep till the refurrection, when they are to be awakened by the trump of God, reunited to their bodies, have their faculties reftored, and their fentence awarded.

This opinion they fupport by what St Peter fays in the Acts, that David is not afcended into heaven; and that this patriarch could not poffibly be fpeaking of himfelf when he faid, "Thou wilt not leave my foul in hell, i. e. the place of the dead." They obferve, too, 43

43 According to fome, a ftate of fleep;

that the victory of Chrift over death and the grave feems to imply, that our fouls are fubject to their power; that accordingly the Scripture fpeaks frequently of the foul's drawing near to, of its being redeemed from, and of its defcending into, the grave; that the Pfalmift, however, declares plainly, that when the breath of man goeth forth, he returneth to his earth, and that very day his thoughts perifh. And fhould any one choofe to confult Ecclefiaftes, he will find, that the living know that they fhall die, but that the dead know not any thing: that their love, and their hatred, and their envy, are perifhed; and that there is no work, nor device, nor wifdom, nor knowledge, in the grave, whither they are gone.

44 According to others, a ftate of confcious exiftence.

Thofe who believe that the foul is not for the exercife of its faculties dependent on the body, are upon its feparation at death obliged to difpofe of it fome other way. In eftablifhing their theory, they ufually begin with attempting to prove, from Scripture or tradition, both its active and feparate exiftence; but with proofs from tradition we intend not to meddle. Their arguments from Scripture being of more value, deferve our ferious confideration; and are nearly as follow.

Abraham, they fay, Ifaac, and Jacob, are ftill living, becaufe Jehovah is their God, and he, it is allowed, is not the God of the dead, but of the living. But their opponents reply, That this is the argument which our Saviour brought from the writings of Mofes to prove a future refurrection of the dead; and that any perfon who looks into the context, will fee it was not meant of a middle ftate. From the dead living unto God, our Saviour infers nothing more than that they fhall live at the refurrection; and that thefe gentlemen would do well in future to make a diftinction between fimply living and living unto God: For though Abraham, Ifaac, and Jacob, be living unto God, our Saviour has affured us that Abraham is dead, and the prophets dead.

A fecond argument is that glimpfe which St Paul had of paradife about 14 years before he had written his Second Epiftle to the Corinthians. To this argument their opponents reply, That as St Paul could not tell whether, on that occafion, he was out of the body or in the body, it is more than probable that the whole

was

Resurrection. was a vision; and, at any rate, it is no proof of a separate existence.

A third argument is, St Paul's wishing to be absent from the body, and present with the Lord. But, say their opponents, St Paul desired not to be unclothed, but to be clothed upon: and as some of those who maintain a separate existence, bring Scripture to prove that the body * continues united to Christ till the resurrection; in that case, St Paul, if he wished to be present with the Lord, should have rather remained with his body than left it.

* *Shorter Catechism.*

A fourth argument is, the appearance of Moses and Elias upon the mount of transfiguration. To which their opponents reply, that these saints appeared in their bodies; that Elias was never divested of his body; and that the account which we have of the burial of Moses, has led some of the ablest critics and soundest divines to conclude, that he was likewise translated to heaven without tasting death. At any rate, say they, he might have been raised from the dead for the very purpose of being present at the transfiguration, as the bodies of other saints certainly were, to bear testimony to our Lord's resurrection and victory over the grave.

A fifth argument is, what our Saviour said to the thief, "Verily I say unto thee, to-day thou shalt be with me in paradise." The objection usually made here is, that the expression is evidently ambiguous, and that the sense depends entirely on the punctuation; for if the point be placed after *to-day*, the meaning will be "Verily, even now, I tell thee, thou shalt be with me in paradise." But the import of paradise in this place, say the opponents, is likewise doubtful. We learn from St Peter's explanation of the 16th Psalm, that our Saviour's soul was not to be left in hell; and we know that on the day of his crucifixion he went not to heaven: for after he had risen from the place of the dead, he forbade one of the women to touch him, as he had not yet ascended to the Father. Hell, therefore, and paradise, continue they, seem to be in this passage the very same thing, the place of the dead; and our Saviour's intention, they add, was not to go to heaven at that time, but to show his victory over death and the grave, to whose power all mankind had become subject by the disobedience of their first parents.

45 The soul is by some supposed to reside in the air till the resurrection.

Without pretending to enter into the merits of this dispute, the ingenious Burnet, in his Theory of the Earth, endeavours to prove, upon the authority of the ancient fathers, that paradise lies between the earth and the moon; and the learned Dodwell, on the same authority, has made it the common receptacle of souls till the resurrection; but has not told us whether or not they are to be accountable for the actions of this separate existence at the latter day, or are only to be judged according to the deeds that were done in their bodies.

46 The church of Rome supposes a purgatory.

This notion of a common receptacle has displeased many. The state of purgation, obscurely hinted in the doctrines of Pythagoras, and openly avowed by Plato and Virgil, has been adopted by the Romish divines, who support their opinion on certain obscure passages of Scripture, which are always of a yielding and a waxen nature, may easily be twisted to any hypothesis, and like general lovers espouse rather from interest than merit.

47 Others suppose that the soul after death enters a state of rewards and punishments in a certain degree.

It has displeased others, because they are anxious that the righteous should have a fore-taste of their joys, and the wicked of their torments, immediately after death, which they infer to be certainly the case from the parable of the rich man and Lazarus (U). But to this it is objected, that the rich man is supposed to be in hell, the place of torments, and that this punishment ought not to take place on their own hypothesis till after the sentence at the resurrection.

Another argument used for the intermediate state is the vision of St John in the Apocalypse. In this vision the Evangelist saw under the altar the souls of those that were slain for the word of God and for the testimony which they held. Their opponents doubt whether these visible souls were immaterial, as St John heard them cry with a loud voice, and saw white robes given unto every one of them. If they had bodies, that circumstance might chance to prove a resurrection immediately after death, and so supersede the general resurrection at the last day.

While such conclusions as are here drawn from the parable and vision, say the opposers of an intermediate conscious existence, imply that the dead are already raised, and are now receiving the respective rewards of their virtues and their crimes; those who maintain an intermediate separate existence, who speak of the body as a prison, and of the soul as receiving an increase of power when freed from the body, are certainly not more than consistent with themselves, when they think that this soul would derive an advantage from its after union with either a new system of matter or the old one, however much altered. Baxter, they say, who saw the inconsistency, was disposed to reason somewhat like Æneas,

> O, Father! can it be that souls sublime
> Return to visit our terrestrial clime?
> Or that the gen'rous mind, releas'd at death,
> Should covet lazy limbs and mortal breath?

In no one instance, they continue, have Christians perhaps more apparently than in this argument wrested the scriptures to their own hurt; by thus rashly attempting to accommodate the sacred doctrines of religion to a preconceived philosophical hypothesis, they have laid themselves open to the ridicule of deists, and have been obliged, for the sake of consistency, either to deny or to speak slightingly of the resurrection; which is certainly the surest foundation of their hope, seeing St Paul hath assured us, that if there be no resurrection of the dead, then they which are fallen asleep in Christ are perished, and those who survive may eat and drink, and act as they please, for to-morrow they die; and die, too, never to live again.

Though this reproof may be rather severe, we are sorry

(U) Whitby shows that this parable was conformable to the notions of the Jews at that time; and even the Mahometans, who believe in the resurrection of the dead, suppose likewise a state of rewards and punishments in the grave.

Resurrection.

sorry to observe that there seems to have been sometimes too much reason for it. A certain divine †, whose piety was eminent, and whose memory we respect, having written "An Essay towards the proof of a separate State of Souls between Death and the Resurrection, and the Commencement of the Rewards of Virtue and Vice immediately after death," has taken this motto, "Because sentence against an evil work is not executed speedily, therefore the heart of the sons of men is fully set in them to do evil." "The doctrine, he says, of the resurrection of the body and the consequent states of heaven and of hell, is a guard and motive of divine force, but it is renounced by the enemies of our holy Christianity; and should we give up the recompenses of separate souls, while the deist denies the resurrection of the body, I fear, between both we should sadly enfeeble and expose the cause of virtue, and leave it too naked and defenceless."

† Dr Watts.

This author, who wishes much that the punishment of crimes should follow immediately after death, is of opinion, that if heaven intended to check vice and impiety in the world, it has acted unwisely, if it really has deferred the punishment of the wicked to so late a period as the resurrection. "For such, he observes, is the weakness and folly of our natures, that men will not be so much influenced and alarmed by distant prospects, nor so solicitous to prepare for an event which they suppose to be so very far off, as they would for the same event, if it commences as soon as ever this mortal life expires. The vicious man will indulge his sensualities, and lie down to sleep in death with this comfort, I shall take my rest here for 100 or 1000 years, and perhaps in all that space my offences may be forgotten; or let the worst come that can come, I shall have a long sweet nap before my sorrows begin: and thus the force of divine terrors is greatly enervated by this delay of punishment."

Thus far our author, who thinks that his hypothesis, if not true, is at least expedient, and that from motives of expediency it ought to be inculcated as a doctrine of Scripture: but how far his reasons can be here justified we mean not to determine; we shall leave that to be settled by others, reminding them only that the distance of future rewards and punishments is not greater on the supposition of the sleep of the soul than on the contrary hypothesis. Every man who has but dipt into the science of metaphysics knows, and no man ever knew better than he who is believed to have been the author of the work before us, that time unperceived passes away as if in an instant; and that if the soul be in a state void of consciousness between death and the resurrection, the man who has lain in his grave a thousand years will appear to himself to have died in one moment and been raised in the next. We would likewise recommend to those who may henceforth be inclined to inculcate any thing as a doctrine of scripture merely on account of its supposed expediency, always to remember that God is above, that they are below, that he is omniscient, that they are of yesterday and know little, that their words therefore should be wary and few, and that they should always speak with respect of whatever concerns the Sovereign of the universe, or relates to his government either in the natural or moral world. For wilt thou, says the Highest, disannul my judgement? Wilt thou condemn me that thou mayest be righteous? shall he that contendeth with the Almighty instruct him? He that reproveth God let him answer it.

If, in stating these opposite opinions, we may seem to have favoured what has been called the sleep of the soul, it is not from any conviction of its truth, for there are particular texts of Scripture which appear to us to militate against it. We are satisfied, however, that it is a very harmless opinion, neither injurious to the rest of the articles of the Christian faith nor to virtuous practice; and that those who have poured forth torrents of obloquy upon such as may have held it in simplicity and godly sincerity, have either mistaken the doctrine which they condemned, or been possessed by a spirit less mild than that of the gospel (x).

48

The resurrection repeatedly asserted in Scripture.

Whatever be the fate of the middle state, the resurrection stands on a different basis. It is repeatedly asserted in Scripture; and those grounds on which we believe it are authenticated facts, which the affectation, the ingenuity, and the hatred of sceptics, have numberless times attempted in vain to disprove. These facts we are now to consider, referring our readers for the character of the witnesses, the authenticity of the gospel-history, and the possibility of miracles, to the parts of this work where these subjects are treated (See MIRACLE, METAPHYSICS, Part I. chap. vii. and RELIGION); or, should more particular information be required, to the writings of Ditton, Sherlock, and West.

49

The possibility of it shown by our Saviour's raising several persons from the dead;

Our Lord, after proving his divine mission by the miracles which he wrought, and by the completion of ancient predictions in which he was described, declared that the doctrine of a resurrection was one of those truths which he came to announce. To show that such an event was possible, he restored to life the daughter of Jairus, a ruler of the synagogue, a young man of Nain, who was carried out on his bier to be buried, and his friend Lazarus, whose body at the time was thought to have become the prey of corruption. Though the two first of these miracles were wrought in the presence of a number of witnesses, yet the last, owing to particular circumstances, produced a much greater noise among the Jews. It was performed on a person seemingly of some note, in the village of Bethany, not far from Jerusalem, and in the presence of a great many persons who from the metropolis had come to condole with Mary and Martha. No doubts were entertained of the reality of Lazarus's death. Our Lord was at a distance when

(x) Perhaps no man has been more culpable in this respect than the celebrated Warburton, who seems at first to have himself denied an intermediate state of conscious existence. He afterwards imagined that such a state is supposed, though not expressly asserted, in Scripture; and at last he maintained it with all the zeal and warmth of a proselyte. To prove the sincerity of his conversion, he treated his adversaries with scurrilous nicknames, banter, and abuse; a species of reasoning which seldom succeeds in recommending a bad cause, and which never confers credit on one that is good.

Reſurrection.

when he expired, and his body had already been lying for ſome days in the grave. When he came forth at the voice of our Lord, all were aſtoniſhed. Thoſe from Jeruſalem, on returning home, are impatient to relate what they had ſeen; thoſe who heard of ſo memorable an event cannot conceal it; the report reaches the ears of the Phariſees and chief prieſts. They are ſoon made acquainted with every circumſtance; and dreading the iſſue, they think it neceſſary to call a council upon the occaſion, and concert the meaſures that ought to be purſued in a matter which was likely to be attended with ſo many and important conſequences. In this council, is ſeems to be agreed, that our Lord had performed, and was ſtill continuing to perform, many miracles: that this laſt miracle, as being of an extraordinary kind, would make many converts; and that if meaſures were not ſpeedily taken to prevent theſe uncommon diſplays of his power, all would believe on him; the jealouſy of the Romans would be excited, the rulers depoſed, and the nation of the Jews deprived of its few remaining privileges, Yet notwithſtanding theſe private conceſſions made in the council, the members who dreaded to let their ſentiments be known to the people, affect in public to treat our Saviour as an impoſtor. But he who had already demonſtrated the abſurdity of their opinions, who ſuppoſed that his miracles were wrought by Beelzebub prince of the devils, is again ready to confute the ridiculous aſſertion of thoſe who pretended to ſay that they were a deception. His friend Lazarus was ſtill living at the diſtance of only a few miles, and many of the Jews who had gone to ſee him were ready to atteſt the truth of the report. If the rulers, apprehending the conſequences of the truth, be afraid to know it, and if they are unwilling to go to Bethany, or to ſend for Lazarus and thoſe who were preſent at his reſurrection, our Lord gives them a fair opportunity of detecting his fraud, if there was any ſuch to be found in him. To preſerve their power, and remove the jealous ſuſpicion of the Romans, it had been already determined in council to put him to death; and our Lord foretels that the third day after his death he ſhall riſe from the grave. Here no place was reſerved for deception. The ſect of the Phariſees and the chief prieſts are openly warned and put upon their guard; and very fortunately for the cauſe of Chriſtianity, this ſingular prediction was not heard with ſcorn, or indeed, if with ſcorn, it was only affected. We know from the ſentiments expreſſed in the council, that our Lord was ſecretly dreaded by the rulers; and that his predictions, in their private opinion, were not to be ſlighted. The means accordingly which they employed to prevent, even in the very appearance, the completion of his prophecy, were admirably calculated to remove the ſcruples of the moſt wary and ſceptical inquirers, if their object was only to ſearch after truth. At the next feſtival of the paſſover, when the ſcheme of Caiaphas was put in execution, and when it was deemed expedient by the council that he ſhould die, to ſave the nation from the jealouſy of the Romans; as a proof of their ſteady loyalty to Rome he was apprehended, was tried as an enemy to her government, was at laſt condemned upon falſe evidence, and ſuſpended on a croſs until they were fully ſatisfied of his death. Even after his death, the ſpear of a ſoldier was thruſt into his ſide: and the water that guſhed out with the blood is a proof to thoſe who are acquainted with the ſtructure and economy of living bodies, that he muſt have been ſome time dead.

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After he was taken down from the croſs, a ſeal was put on the door of the ſepulchre in which he was laid, as the beſt check againſt ſecret fraud; and a guard of ſoldiers was ſtationed around it, as the beſt ſecurity againſt open violence. In ſpite, however, of all theſe precautions, the prediction was accompliſhed; the angel of God, deſcending from heaven with a countenance like lightning, and with raiment white as ſnow; the watch ſhake, and become as dead men; the earth quakes; the ſtone is rolled from the mouth of the ſepulchre; the angel ſits on it, and our Lord comes forth.

50 And above all by His own reſurrection.

It was in vain for the Jews to allege that his diſciples came in the night, and ſtole him away, while the watch were aſleep. One muſt ſmile at theſe puerile aſſertions. How came the diſciples to know that the watch were aſleep; or what excuſe had the watch for ſleeping, and incurring a puniſhment which they knew to be capital in the Roman law? and how came they, in the name of wonder, to be brought as an evidence for thoſe tranſactions that happened at the time when they were aſleep?

Whatever credit may be given by modern infidels to this ill-framed ſtory, it is paſt diſpute that it had none among the Jewiſh rulers at the time that it was current. Not long after our Saviour's reſurrection, the apoſtles were called before the council, and threatened with death for teaching in the name of Jeſus. Their boldneſs upon that occaſion was ſo provoking to the rulers, that the threat would have been inſtantly put in execution, had not Gamaliel, a doctor of the law of high reputation, put them in mind of other impoſtors who had periſhed in their attempts to miſlead the people; and concluded a very ſenſible ſpeech with theſe remarkable words: "And now, I ſay unto you, refrain from thoſe men, and let them alone; for if this counſel, or this work, be of men, it will come to nought; but *if it be of God*, ye cannot overthrow it, leſt haply ye be found even to fight againſt God." This advice the council followed. But is it poſſible that Gamaliel could have given it, or the council paid the leaſt regard to it, had the ſtory of the diſciples ſtealing the body been then credited? Surely ſome among them would have obſerved, that a work or counſel, founded on impoſture and fraud, could not be *ſuppoſed to be of God*, and they would unqueſtionably have ſlain the apoſtles.

The ſtory of ſtealing the body is indeed one of the moſt ſenſeleſs fictions that ever was invented in ſupport of a bad cauſe. Our Lord was on the earth 40 days after he aroſe. He appeared frequently to his diſciples. He ate and drank in their preſence; and when ſome of them doubted, he bade them handle him and ſee that he was not a ſpectre, ſhowed the mark of the ſpear in his ſide, and the prints of the nails in his feet and hands. Beſides thus appearing to his diſciples, he was ſeen by more than 500 brethren at one time; all of whom, as well as his diſciples, muſt neceſſarily have known him previous to his ſuffering, and could therefore atteſt that he was the perſon who was once dead, but was then alive. Yet for ſtrangers in general, who had not ſeen him previous to his death, and could not therefore identify his perſon after he aroſe, our Lord reſerved many other proofs that were equally convincing. Before his aſcenſion, he bade his diſciples wait till they received power, by the Holy

Resurrection. Ghost descending upon them: That then they should be witnesses with him, both in Jerusalem, and in all Judea, and in Samaria, and unto the uttermost ends of the earth; in order that the people of all these nations, observing the miracles wrought in his name, might themselves become ocular witnesses that those who preached his resurrection were warranted to do so by his authority; and that this authority, on which so numerous miracles attended, must be divine.

51 Minute objections and trifling cavils.

We intend not here to examine the minute objections and cavils that have been advanced respecting the truth of this important fact. The kinds, however, we shall mention in general. Some have doubted of our Lord's resurrection, as being an event which is not confirmed by general experience, because they imagine that what happens once should happen again, and even repeatedly, in order to be true. Some, taking their own to be preferable schemes, have objected to the way in which it happened, and to the manner in which it is narrated.—Some have imagined, that possibly the gospel history may be false; that possibly the disciples were very ignorant, and might be deceived; that possibly, too, they were deep politicians, and a set of impostors; and that possibly the writings which detected their falsehoods may have been destroyed. It is difficult to reason, and worse to convince, against this evidence of possibilities: but we flatter ourselves, that to the candid reader it will appear sufficiently overturned in our article MIRACLE; where it is shown that neither clowns nor politicians could have acted the part that was acted by the apostles, had not the resurrection been an undoubted fact.

Some of the objectors to it have also maintained, that possibly there is nothing material without us, that there is nothing mental within us, and that possibly the whole world is ideas. This mode of arguing we pretend not to explain; it is thought by some to proceed entirely from a perverseness of mind or disposition, while in books of medicine it is always considered as a symptom of disease, and the patient recommended to be treated in the hospital, and not in the academy.

52 Importance of the doctrine of a resurrection.

By his raising others, and particularly by rising himself, from the dead, our Saviour demonstrated that a resurrection from the dead is possible. And on that authority, which by his miracles he proved to be divine, he declared to his followers, that there is to be a general resurrection both of the just and of the unjust, instructing his disciples to propagate this doctrine through all nations; St Paul confessing, that if there be no resurrection of the dead, preaching is vain, and our faith is vain.

53 Of the order in which the dead are to be raised.

As to the order of succession in which the dead are to be raised, the Scriptures are almost silent. St Paul says, that every man is to rise in his own order, and that the dead in Christ are to rise first: and St John observed in his vision, that the souls of them which were beheaded for the witness of Jesus, and for the word of God, and which had not worshipped the beast, neither his image, neither had received his mark upon their foreheads, or in their hands, lived and reigned with Christ a thousand years; but the rest of the dead lived not again until the thousand years (Y) were finished.

54 With what bodies they shall rise.

A question that has much oftener agitated the minds of men is, with what sort of bodies are the dead to be raised? St Paul has answered, with incorruptible and immortal bodies (Z). And to silence the disputatious caviller of his day, he illustrated his doctrine by the growth of grain. "Thou fool (said he), that which thou sowest, thou sowest not that body that shall be, but bare grain, it may chance of wheat or of some other grain." To us it appears very surprising, that any one who reads this passage with the slightest attention, should perplex himself, or disturb the church with idle attempts to prove the identity of the bodies with which we shall die and rise again at the last day. The apostle expressly affirms, that "flesh and blood cannot inherit the kingdom of God; that we shall all be changed, in a moment, in the twinkling of an eye, at the last trump; that there are celestial bodies and bodies terrestrial; and that the glory of the celestial is one, and the glory of the terrestrial another."

That this implies a total change of qualities, will admit of no dispute; but still it has been considered as an article of the Christian faith, that we are to rise with the same bodies in respect of substance. What is meant by the identity of substance, with qualities wholly different, it is not very easy to conceive. Perhaps the meaning may be, that our incorruptible bodies shall consist of the same material particles with our mortal bodies, though these particles will be differently arranged to produce the different qualities. But as the particles of our present bodies are constantly changing, and as different particles compose the body at different times, a question has been put, With what set of particles shall we rise? Here a singular variety of opinions have been held. Some* contend, that we shall rise with the original stamina of our bodies derived from our parents; some are for rising with that set of particles which they had at birth; some with the set which they are to have at death; and some with the particles which remain after maceration in water†; though, God knows, that if this maceration be continued long, these may arise with few or no particles at all. Another query has given much alarm. What if any of these particles should enter a vegetable, compose its fruit, and be eaten by a man, woman, or a child? Will not a dispute, similar to that apprehended by the Sadducees about the wife of the seven brothers, necessarily follow, whose particles are they to be at the resurrection? Against this confusion, they trust that the goodness and wisdom of heaven will take all the proper and necessary measures; and they even venture to point out a way in which that may be done. A foot deep of earth, they observe, in two or three of the counties of England, supposing each person to weigh on an average about seven stones and a few pounds, would amply supply with material

* *Leibnitz.*

† *Hody.*

(Y) These thousand years formed the happy millenium so often mentioned in the ancient fathers; and the learned Burnet, in his Theory of the Earth, has endeavoured to prove, that a similar notion prevailed among the Jews See MILLENIUM.

(Z) Our Saviour rose with the same body, both as to substance and qualities; because it was necessary that his person should be known and identified after his resurrection.

Resurrection.

§ See *Hody's Resurrection of the same body asserted.*

terial bodies 600,000,000 of souls for no less a space than 20,000 years §; and therefore there seems to be no necessity for the vamping up of their old materials to lodge and accommodate new souls.

But, unluckily here, the question is not about the possibility of keeping the particles of different bodies separate and distinct. The question is rather, What have the Scriptures determined on the subject? Now the Scriptures say, that the spirit returns unto God who gave it. And should it be asked, in what place does he reserve it till the resurrection? the Scriptures reply, in the place of the dead; because the soul descends into the pit, is redeemed from the grave; and the sting of death, the last enemy that is to be destroyed, shall be taken away when the trumpet of God shall sound: at which time the dead that sleep in their graves shall awake, shall hear the voice, and shall come forth. There is not here so much as a word concerning the body; and therefore it was asked with what bodies are the dead to be raised? To which it was answered, the vile body is to be changed. The body which is, is not the body which shall be; for the incorruptible must put on incorruption, and that which is mortal, put on immortality.

This curious discovery of the sentiments of Scripture we owe to a layman, the celebrated Locke; who, in one of his controversies with the bishop of Worcester, came to understand what he knew not before, namely, that nowhere have the Scriptures spoken of the resurrection of the same body in the sense in which it is usually conceived. The resurrection of the same person is indeed promised; and how that promise may be fulfilled, notwithstanding the constant change of the particles of the body, has been shown in another place. See METAPHYSICS, Part III. Chap. iii.

The advocates, therefore, for the resurrection of the mortal body, have again been obliged to betake themselves to the shifts of reasoning. It is proper, say they, that the same bodies which have been accomplices in our vices and virtues, should also share in our rewards and punishments. Now, granting they will, shall one set of particles be bound for the crimes, or be entitled to receive the rewards, of the animal system, from its first commencement to its dissolution? or shall every particle rise up successively, and receive its dividend of rewards and punishments for the vices and virtues that belonged to the system during the time that they were in union with the sentient principle? and is the hand that fell in defending a father to be (as is supposed in some of the eastern countries) rewarded in heaven; while the other that struck him when the son became vicious, is dismissed into torments?

Finding this hypothesis supported by neither Scripture nor reason, they next appeal to the ancient fathers. And they, it is confessed, are for the resurrection of the very same flesh. But this notion is directly contrary to the Scriptures, which have said, that flesh and blood are not to inherit the kingdom of God.

55
State after the resurrection.

But whatever be the bodies with which the dead are to be raised at the general resurrection, all mankind must appear in judgment, and receive sentence according to the deeds done in the body, without regard, so far as we know, to their actions and conduct in the middle state. After this sentence, the righteous are to enter into celestial and eternal joys, and the wicked to suffer the punishments of hell. These punishments some have supposed to be everlasting; others think, that after some temporary punishment, the souls of the wicked are to be annihilated; and others imagine, that after doing purgatorial penance for a while in hell, they are to be again received into favour; inclining to explain the denunciations of the Almighty as a child would do the threatenings of his mother, or a lover the affected chidings of his mistress.

Resurrection || Reticula.

RESUSCITATION, the same with resurrection and revivification. See the preceding article and REANIMATION.

The term *resuscitation*, however, is more particularly used by chemists for the reproducing a mixed body from its ashes; an art to which many have pretended, as to reproduce plants, &c. from their ashes.

RETAIL, in *Commerce*, is the selling of goods in small parcels, in opposition to wholesale. See COMMERCE.

RETAINER, a servant who does not continually dwell in the house of his master, but only attends upon special occasions.

RETAINING FEE, the first fee given to a serjeant or counsellor at law, in order to make him sure, and prevent his pleading on the contrary side.

RETALIATION, among civilians, the act of returning like for like.

RETARDATION, in *Physics*, the act of diminishing the velocity of a moving body. See GUNNERY, MECHANICS, PNEUMATICS, and PROJECTILES.

RETE MIRABILE, in *Anatomy*, a small plexus or network of vessels in the brain, surrounding the pituitary gland.

RETENTION is defined by Mr Locke to be, a faculty of the mind, whereby it keeps or retains those simple ideas it has once received, by sensation or reflection. See METAPHYSICS, Part I. Chap. ii.

RETENTION is also used, in medicine, &c. for the state of contraction in the solids or vascular parts of the body, which makes them hold fast their proper contents. In this sense, retention is opposed to evacuation and excretion.

RETICULA, or RETICULE, in *Astronomy*, a contrivance for measuring very nicely the quantity of eclipses, &c. This instrument, which was introduced by the Academy of Sciences at Paris, is a little frame composed of 13 fine silken threads, parallel to, and at equal distances from each other, placed in the focus of object glasses of telescopes; that is, in the place where the image of the luminary is painted in its full extent. The diameter of the sun or moon is of consequence thus seen divided into 12 equal parts or digits; so that, in order to ascertain the quantity of the eclipse, there is nothing more to do than to number the parts that are dark, or that are luminous.

As a square Reticule is only proper for the diameter of the luminary, not for the circumference of it, it is sometimes made circular, by drawing six concentric, equidistant circles, which perfectly represents the phases of the eclipse.

But it is obvious that whether the Reticule be square or circular, it should be perfectly equal to the diameter or circumference of the sun or star, such as it appears in the focus of the glass; otherwise the division cannot be just. Another imperfection in the Reticule is, that its

its magnitude is determined by that of the image in the focus, and of courſe it will only fit one particular magnitude.

But a remedy for theſe inconveniences has been found out by M. de la Hire, who contrived that the ſame Reticule may ſerve for all teleſcopes, and all magnitudes of the luminary in the ſame eclipſe. Two object glaſſes applied againſt each other, having a common focus, and theſe forming an image of a certain magnitude, this image will increaſe in proportion as the diſtance between the two glaſſes is increaſed, as far as to a certain limit. If therefore a Reticule be taken of ſuch a magnitude, as juſt to comprehend the greateſt diameter the ſun or moon can ever have in the common focus of two object glaſſes applied to each other, it is only neceſſary to remove them from each other, as the ſtar comes to have a leſs diameter, to have the image ſtill exactly comprehended in the ſame Reticule.

As the ſilken threads are apt to deviate from the parallelifm, &c. by the different temperature of the air, another improvement is, to make the Reticule of a thin looking glaſs, by drawing lines or circles upon it with the fine point of a diamond.

RETICULAR BODY (*corpus reticulare*), in *Anatomy*, a very fine membrane, perforated, in the manner of a net, with a multitude of foramina. It is placed immediately under the cuticle; and when that is ſeparated from the cutis, whether by art or accident, this adheres firmly to it, and is ſcarce poſſible to be parted from it, ſeeming rather to be its inner ſuperficies than a diſtinct ſubſtance. In regard to this, we are to obſerve, firſt, the places in which it is found, being all thoſe in which the ſenſe of feeling is moſt acute, as in the palms of the hands, the extremities of the fingers, and on the ſoles of the feet. The tongue, however, is the part where it is moſt accurately to be obſerved: it is more eaſily diſtinguiſhable there than anywhere elſe, and its nature and ſtructure are moſt evidently ſeen there.

Its colour in the Europeans is white; but in the negroes and other black nations it is black; in the tawny it is yellowiſh: the ſkin itſelf in both is white; and the blackneſs and yellowneſs depend altogether on the colour of this membrane.

The uſes of the corpus reticulare are to preſerve the ſtructure of the other parts of the integuments, and keep them in their determinate form and ſituation. Its apertures give paſſage to the hairs and ſweat through the papillæ and excretory ducts of the ſkin: it retains theſe in a certain and determinate order, that they cannot be removed out of their places, and has ſome ſhare in preſerving the ſoftneſs of the papillæ, which renders them fit for the ſenſe of feeling. See ANATOMY, N° 83.

RETICULUM, is a Latin word, ſignifying a *little* or *caſting net*. It was applied by the Romans to a particular mode of conſtructing their buildings. In the city of Salino (ſee SALINO) are ſtill to be ſeen remains of ſome walls, evidently of Roman origin from the *reticulum*. This ſtructure conſiſts of ſmall pieces of baked earth cut lozengewiſe, and diſpoſed with great regularity on the angles, ſo as to exhibit to the eye the appearance of cut diamonds; and was called *reticular*, from its reſemblance to fiſhing-nets. The Romans always concealed it under a regular coating of other matter; and Mr Houel informs us, that this was the only ſpecimen of it which he ſaw in all his travels through Sicily, Malta, and Lipari. It appears to be the remains of ſome baths, which have been built for the convenience of ſea-bathing.

RETIMO, the ancient *Rhitymnia* of Stephen the geographer, and called by Ptolemy *Rhitymna*, is a fine city, lying at one end of a rich and fertile plain, on the north coaſt of the iſland of Candia. It is but a ſmall place, containing ſcarce 6000 inhabitants; but it is a biſhop's ſee, and the harbour is defended by a citadel, where a baſhaw reſides. It was taken by the Turks in 1647, and has been in their hands ever ſince. It is about 45 miles from Candia. E. Long. 24. 45. N. Lat. 35. 22.

The citadel, which ſtands on a rock jutting out into the ſea, would be ſufficient for the defence of the city, were it not ſituated at the foot of an high hill, from which it might be cannonaded with great advantage. The harbour is now almoſt filled with ſand, and is no longer acceſſible to ſhipping; nor do the Turks in any meaſure oppoſe the ravages of time, but behold with a careleſs eye the moſt valuable works in a ſtate of ruin. The French had formerly a vice-conſul at Retimo, to which ſhips uſed to repair for cargoes of oil; but they have been long unable to get into the harbour: to repair which, however, and to revive the commerce of Retimo, would be a moſt uſeful attempt. The plains around the city abound in a variety of productions. Great quantities of oil, cotton, ſaffron, and wax, are produced here; and they would be produced in ſtill greater quantities if the inhabitants could export their commodities. The gardens of Retimo bear the beſt fruits in the iſland; excellent pomegranates, almonds, piſtachio nuts, and oranges. The apricot-tree, bearing the michmich, the juice of which is ſo delicious, and its flavour ſo exquiſite, is found here. It is a kind of early peach, but ſmaller and more juicy than thoſe of France.

RETINA, in *Anatomy*, the expanſion of the optic nerves over the bottom of the eye, where the ſenſe of viſion is firſt received. See ANATOMY, N° 142. and OPTICS (*Index*) at *Eye* and *Viſion*.

RETINUE, the attendants or followers of a prince or perſon of quality, chiefly in a journey.

RETIRADE, in fortification, a kind of retrenchment made in the body of a baſtion, or other work, which is to be diſputed, inch by inch, after the defences are diſmantled. It uſually conſiſts of two faces, which make a re-entering angle. When a breach is made in a baſtion, the enemy may alſo make a retirade or new fortification behind it.

RETIREMENT, means a private way of life or a ſecret habitation. "Few (ſays an elegant writer) are able to bear ſolitude; and though retirement is the oſtenſible object of the greater part, yet, when they are enabled by ſucceſs to retire, they feel themſelves unhappy. Peculiar powers and elegance of mind are neceſſary to enable us to draw all our reſources from ourſelves. In a remote and ſolitary village the mind muſt be internally active in a great degree, or it will be miſerable for want of employment. But in great and populous cities, even while it is paſſive, it will be conſtantly amuſed. It is impoſſible to walk the ſtreets without finding the attention powerfully ſolicited on every

Dr Knox.

every fide. No exertion is neceffary. Objects pour themfelves into the fenfes, and it would be difficult to prevent their admittance. But, in retirement, there muft be a fpirit of philofophy and a ftore of learning, or elfe the fancied fcenes of blifs will vanifh like the colours of the rainbow. Poor Cowley might be faid to be melancholy mad. He languifhed for folitude, and wifhed to hide himfelf in the wilds of America. But, alas! he was not able to fupport the folitude of a country village within a few miles of the metropolis!

"With a virtuous and cheerful family, with a few faithful and good-humoured friends, with a well-felected collection of elegant books, and with a competency, one may enjoy comforts even in the deferted village, which the city, with all its diverfions, cannot fupply."

RETORT, in *Chemiftry*, an oblong or globular veffel of glafs or porcelain, with its neck bent, proper for diftillation.

In the fifth volume of the Tranfactions of the London Society for the Encouragement of Arts, p. 96. we find a paper containing a method for preventing ftone retorts from breaking; or ftopping them when cracked, during any chemical operation, without lofing any of the contained fubject. "I have always found it neceffary (fays the writer) to ufe a previous coating for filling up the interftices of the earth or ftone, which is made by diffolving two ounces of borax in a pint of boiling water, and adding to the folution as much flaked lime as will make it into a thin pafte; this, with a common painter's brufh, may be fpread over feveral retorts, which when dry are then ready for the proper preferving coating. The intention of this firft coating is, that the fubftances thus fpread over, readily vitrifying in the fire, prevent any of the diftilling matters from pervading the retort, but do in nowife prevent it from cracking.

"Whenever I want to ufe any of the above coated retorts; after I have charged them with the fubftance to be diftilled, I prepare a thin pafte, made with common linfeed oil and flaked lime well mixed, and perfectly plaftic, that it may be eafily fpread: with this let the retorts be covered all over except that part of the neck which is to be inferted into the receiver; this is readily done with a painter's brufh: the coating will be fufficiently dry in a day or two, and they will then be fit for ufe. With this coating I have for feveral years worked my ftone retorts, without any danger of their breaking, and have frequently ufed the fame retort four or five times; obferving particularly to coat it over with the laft mentioned compofition every time it is charged with frefh materials: Before I made ufe of this expedient, it was an even chance, in conducting operations in ftone and earthen retorts, whether they did not crack every time; by which means great lofs has been fuftained. If at any time during the operation the retorts fhould crack, fpread fome of the oil compofition thick on the part, and fprinkle fome powder of flaked lime on it, and it immediately ftops the fiffure, and prevents any of the diftilling matter from pervading; even that fubtile penetrating fubftance the folid phofphorus will not penetrate through it. It may be applied without any danger, even when the retort is red hot; and when it is made a little ftiffer, is more proper for luting veffels than any other I ever have tried; becaufe if properly mixed it will never crack, nor will it indurate fo as to endanger the breaking the necks of the veffels when taken off."

RETRACTS, among horfemen, pricks in a horfe's feet, arifing from the fault of the farrier in driving nails that are weak, or in driving them ill-pointed, or otherwife amifs.

RETREAT, in a military fenfe. An army or body of men are faid to retreat when they turn their backs upon the enemy, or are retiring from the ground they occupied: hence every march in withdrawing from the enemy is called a *retreat*.

That which is done in fight of an active enemy, who purfues with a fuperior force, is the moft important part of the fubject; and is, with reafon, looked upon as the glory of the profeffion. It is a manœuvre the moft delicate, and the propereft to difplay the prudence, genius, courage, and addrefs, of an officer who commands: the hiftorians of all ages teftify it; and hiftorians have never been fo lavifh of eulogiums as on the fubject of the brilliant retreats of our heroes. If it is important, it is no lefs difficult to regulate, on account of the variety of circumftances, each of which demands different principles, and an almoft endlefs detail. Hence a good retreat is efteemed, by experienced officers, the mafterpiece of a general. He fhould therefore be well acquainted with the fituation of the country through which he intends to make it, and careful that nothing is omitted to make it fafe and honourable. See WAR.

RETREAT, is alfo a beat of the drum, at the firing of the evening gun; at which the drum-major, with all the drums of the battalion, except fuch as are upon duty, beats from the camp-colours on the right to thofe on the left, on the parade of encampment: the drums of all the guards beat alfo; the trumpets at the fame time founding at the head of their refpective troops. This is to warn the foldiers to forbear firing, and the centinels to challenge, till the break of day that the reveille is beat. The retreat is likewife called *fetting the watch*.

RETRENCHMENT literally fignifies fomething cut off or taken from a thing; in which fenfe it is the fame with fubtraction, diminution, &c.

RETRENCHMENT, in the art of war, any kind of work raifed to cover a poft, and fortify it againft the enemy, fuch as fafcines loaded with earth, gambions, barrels of earth, fand-bags, and generally all things that can cover the men and ftop the enemy. See FORTIFICATION and WAR.

RETRIBUTION, a handfome prefent, gratuity, or acknowledgement, given inftead of a formal falary or hire, to perfons employed in affairs that do not fo immediately fall under eftimation, nor within the ordinary commerce in money.

RETROMINGENTS, in *Natural Hiftory*, a clafs or divifion of animals, whofe characteriftic is, that they ftale or make water backwards, both male and female.

RETURN (*returna* or *retorna*), in *Law*, is ufed in divers fenfes. 1. Return of writs by fheriffs and bailiffs is a certificate made by them to the court, of what they have done in relation to the execution of the writ directed to them. This is wrote on the back of the writ by the officer, who thus fends the writ back to the court from whence it iffued, in order that it may be filed. 2. Return of a commiffion, is a certificate or answer sent to the court from whence the commission issues, concerning what has been done by the commissioners. 3. Returns, or days in bank, are certain days in each term, appointed for the return of writs, &c. Thus Hillary term has four returns, viz. in the king's-bench, on the day next after the octave, or eighth day after Hillary day: on the day next after the fifteenth day from St Hillary; on the day after purification; and on the next after the octave of the purification. In the common pleas, in eight days of St Hillary: from the day of St Hillary, in fifteen days: on the day after the purification: in eight days of the purification. Easter term has five returns, viz. in the king's-bench, on the day next after the fifteenth day from Easter: on the day next after the three weeks from Easter: on the day next after one month from Easter: on the day next after five weeks from Easter: and on the day next after the day following ascension-day. In the common pleas, in fifteen days from the feast of Easter: in three weeks from the feast of Easter: in one month from Easter day: in five weeks from Easter day: on the day after the ascension-day. Trinity term has four returns, viz. on the day following the second day after Trinity: on the day following the eighth day after Trinity: on the day next after the fifteenth day from Trinity: on the day next after three weeks from Trinity. In the common pleas, on the day after Trinity: in eight days of Trinity: in fifteen days from Trinity: in three weeks from Trinity. Michaelmas term has six returns, viz. on the day next after three weeks from St Michael: on the day next after one month of St Michael: on the day following the second day after All-souls: on the day next after the second day after St Martin: on the day following the octave of St Martin: on the day next after fifteen days of St Martin. In the common pleas, in three weeks from St Michael: in one month from St Michael: on the day after All-souls: on the day after St Martin: on the octave of St Martin: in fifteen days from St Martin. It is to be observed, that, as in the king's-bench, all returns are to be made on some particular day of the week in each term, care must be taken not to make the writs out of that court returnable on a non-judicial day; such as Sunday, and All-saints, in Michaelmas term, the purification in Hillary, the ascension in Easter, and Midsummer-day, except it should fall on the first day of Trinity term.

Returns, in a military sense, are of various sorts, but all tending to explain the state of the army, regiment, or company; namely, how many capable of doing duty, on duty, sick in quarters, barracks, infirmary, or hospital; prisoners, absent with or without leave; total effective; wanting to complete the establishment, &c.

RETUSARI, an island in Russia, is a long slip of land, or rather sand, through the middle of which runs a ridge of granite. It is 20 miles from Petersburg by water, four from the shore of Ingria, and nine from the coast of Carelia. It is about 10 miles in circumference, and was overspread with firs and pines when Peter first conquered it from the Swedes. It contains at present about 30,000 inhabitants, including the sailors and garrison, the former of whom amount to about 12,000, the latter to 1500 men. The island affords a small quantity of pasture, produces vegetables, and a few fruits, such as apples, currants, gooseberries, and strawberries, which thrive in this northern climate.

Coxe's Travels into Russia.

RETZ, Cardinal de. See Gondi.

RETZIA, a genus of plants belonging to the pentandria class, and to the 29th natural order, *Campanaceæ*. See Botany *Index*.

RETULINGEN, a handsome, free, and imperial town of Germany, in the circle of Suabia, and duchy of Wirtemberg; seated in a plain on the river Eschez, near the Neckar, adorned with handsome public buildings, and has a well frequented college. E. Long. 9. 10. N. Lat. 48. 31.

REVE, Reeve, or *Greve*, the bailiff of a franchise, or manor, thus called, especially in the west of England. Hence shire-reeve, sheriff, port-greve, &c.

REVEILLE, a beat of drum about break of day, to give notice that it is time for the soldiers to arise, and that the sentries are to forbear challenging.

REVEL, a port town of Livonia, situated at the south entrance of the gulf of Finland, partly in a plain and partly on a mountain; 133 miles south-west of Petersburg, and 85 south east of Abo. It is a place of great trade, and holds two fairs yearly, which are visited by merchants from all countries, but particularly by those of England and Holland. It is a strong and a rich place, with a capital harbour. It is surrounded with high walls and deep ditches, and defended by a castle and stout bastions. It was confirmed to the Swedes at the peace of Oliva, conquered by Peter the Great in 1710, and ceded to Russia in 1721. The conquest of it was again attempted by the Swedes in 1790. The duke of Sudermania, with the Swedish fleet, attempted to carry the harbour; but after an obstinate engagement with the Russian fleet, he was obliged to give it up; but it was but for a very short while. He retired about 10 leagues from the harbour, to repair the damage his fleet had sustained, and to prepare for a second attack before any relief could be afforded to the Russian fleet. As soon as he had refitted, he sailed for the harbour, at a league distant from which the Russian fleet was discovered, ready to dispute with the Swedes the entrance. Upon a council being held by the duke, it was resolved to attack the Russians; and the signals being given, the fleet bore down for the attack, which was maintained for near six hours with the utmost fury: at length the Swedes broke the Russian line, which threw them into much confusion; when the Swedes, taking the advantage of the general confusion into which the Russians were thrown, followed them with their whole force into the harbour, where the conflict and carnage were dreadful on both sides, though the Swedes certainly had the worst of it; but at the same time their skill and bravery are indisputable.

This valuable place was again confirmed to Russia by the peace. The government of Revel or Esthonia is one of the divisions of the Russian empire, containing five districts. 1. Revel, on the Baltic sea. 2. Baltic-port, about 40 versts westward from Revel. 3. Habsal, or Hapsal, a maritime town. 4. Weissenstein, on the rivulet Saida, about 80 versts from Revel. 5. Wesenberg, about 100 versts from Revel, at about an equal distance from that town and Narva.

REVELATION, the act of revealing, or making a thing public that was before unknown; it is also used for

for the diſcoveries made by God to his prophets, and by them to the world; and more particularly for the books of the Old and New Teſtament. See BIBLE, CHRISTIANITY, MIRACLE, RELIGION, and THEOLOGY.

The principal teſts of the truth of any revelation, are the tendency of its practical doctrines; its conſiſtency with itſelf, and with the known attributes of God; and ſome ſatisfactory evidence that it cannot have been derived from a human ſource.

Before any man can receive a written book as a revelation from God, he muſt be convinced that God exiſts, and that he is poſſeſſed of almighty power, infinite wiſdom, and perfect juſtice. Now ſhould a book teaching abſurd or immoral doctrines (as many chapters of the Koran do, and as all the traditionary ſyſtems of Paganiſm did), pretend to be revealed by a God of wiſdom and juſtice, we may ſafely reject its pretenſions without farther examination than what is neceſſary to ſatisfy us that we have not miſunderſtood its doctrine. Should a book claiming this high origin, enjoin in one part of it, and forbid in another, the ſame thing to be done under the ſame circumſtances, we may reject it with contempt and indignation; becauſe a being of infinite wiſdom can never act capriciouſly or abſurdly. Still, however, as it is impoſſible for us to know how far the powers of men may reach in the inveſtigation or diſcovery of uſeful truth, ſome farther evidence is neceſſary to prove a doctrine of divine origin, than its mere conſiſtency with itſelf, and with the principles of morality; and this evidence can be nothing but the power of working miracles exhibited by him by whom it was originally revealed. In every revelation confirmed by this evidence, many doctrines are to be looked for which human reaſon cannot fully comprehend; and theſe are to be believed on the teſtimony of God, and ſuffered to produce their practical conſequences. At this kind of belief the ſhallow infidel may ſmile contemptuouſly; but it has place in arts and ſciences as well as in religion. Whoever avails himſelf of the demonſtrations of Newton, Bernoulli, and others, reſpecting the reſiſtance of fluids, and applies their concluſions to the art of ſhip-building, is as implicit a believer, if he underſtand not the principles of fluxions, as any Chriſtian; and yet no man will ſay that his faith is not productive of important practical conſequences. He believes, however, in man, while the Chriſtian believes in God; and therefore he cannot pretend that his faith reſts on a ſurer foundation.

Mr Locke, in laying down the diſtinct provinces of reaſon and faith, obſerves, 1. That the ſame truths may be diſcovered by revelation which are diſcoverable to us by reaſon. 2. That no revelation can be admitted againſt the clear evidence of reaſon. 3. That there are many things of which we have but imperfect notions, or none at all; and others, of whoſe paſt, preſent, or future exiſtence, by the natural uſe of our faculties we cannot have the leaſt knowledge: and theſe, being beyond the diſcovery of our faculties, and above reaſon, when revealed, become the proper object of our faith. He then adds, that our reaſon is not injured or diſturbed, but aſſiſted and improved, by new diſcoveries of truth coming from the fountain of knowledge. Whatever God has revealed is certainly true; but whether it be a divine revelation or not, reaſon muſt judge, which can never permit the mind to reject a greater evidence to embrace what is leſs evident. There can be no evidence that any traditional revelation is of divine original, in the words we receive it, and the ſenſe we underſtand it, ſo clear and ſo certain as that of the principles of reaſon: and, therefore, nothing that is contrary to the clear and ſelf-evident dictates of reaſon, has a right to be urged or aſſented to as a matter of faith, wherein reaſon has nothing to do.

REVELATION *of ST JOHN*. See APOCALYPSE.

REVELS, entertainments of dancing, maſking, acting comedies, farces, &c. anciently very frequent in the inns of court and in noblemen's houſes, but now much diſuſed. The officer who has the direction of the revels at court is called the *MASTER of the Revels*.

REVENGE, means the return of injury for injury, and differs materially from that ſudden reſentment which riſes in the mind immediately on being injured; which, ſo far from being culpable when reſtrained within due bounds, is abſolutely neceſſary for ſelf-preſervation. Revenge, on the contrary, is a cool and deliberate wickedneſs, and is often executed years after the offence was given; and the deſire of it is generally the effect of littleneſs, weakneſs, and vice; while, to do right, and to ſuffer wrong, is an argument of a great ſoul, that ſcorns to ſtoop to ſuggeſted revenges.

> Revenge is but a frailty incident
> To craz'd and ſickly minds; the poor content
> Of little ſouls, unable to ſurmount
> An injury, too weak to bear affront. DRYDEN.

Revenge is generally the concomitant of ſavage minds, of minds implacable, and capable of the moſt horrid barbarities; unable to ſet any limits to their diſpleaſure, they can confine their anger within no bounds of reaſon.

> Cruel revenge, which ſtill we find
> The weakeſt frailty of a feeble mind.
> Degenerous paſſion, and for man too baſe,
> It ſeats its empire in the ſavage race.
> JUVENAL.

The inſtitution of law prevents the execution of private revenge, and the growth of civilization ſhows its impropriety. Though in modern times a ſpecies of revenge is ſanctioned by what is called the law of honour, which evades the law of the land indeed, but which is equally mean and diſgraceful as the other kinds, and is of conſequences equally baneful. See ANGER, DUELLING, and RESENTMENT.

REVENUE, the annual income a perſon receives from the rent of his lands, houſes, intereſt of money in the ſtocks, &c.

Royal REVENUE, that which the Britiſh conſtitution hath veſted in the royal perſon, in order to ſupport his dignity and maintain his power; being a portion which each ſubject contributes of his property, in order to ſecure the remainder. This revenue is either *ordinary* or *extraordinary*.

I. The king's *ordinary* revenue is ſuch as has either ſubſiſted time out of mind in the crown; or elſe has been granted by parliament, by way of purchaſe or exchange for ſuch of the king's inherent hereditary revenues as were found inconvenient to the ſubject.—In ſaying that it has ſubſiſted time out of mind in the crown, we do not mean that the king is at preſent in the actual poſſeſſion of the whole of his revenue. Much (nay the

Revenue. greateſt part) of it is at this day in the hands of ſubjects; to whom it has been granted out from time to time by the kings of England: which has rendered the crown in ſome meaſure dependent on the people for its ordinary ſupport and ſubſiſtence. So that we muſt be obliged to recount, as part of the royal revenue, what lords of manors and other ſubjects frequently look upon to be their own abſolute rights; becauſe they and their anceſtors are and have been veſted in them for ages, though in reality originally derived from the grants of our ancient princes.

Blackſt. Comment.

1. The firſt of the king's ordinary revenues, which may be taken notice of, is of an eccleſiaſtical kind (as are alſo the three ſucceeding ones), viz. the cuſtody of the temporalities of biſhops. See TEMPORALITIES.

2. The king is entitled to a CORODY, as the law calls it, out of every biſhopric; that is, to ſend one of his chaplains to be maintained by the biſhop, or to have a penſion allowed him till the biſhop promotes him to a benefice. This is alſo in the nature of an acknowledgement to the king, as founder of the ſee, ſince he had formerly the ſame corody or penſion from every abbey or priory of royal foundation. It is ſuppoſed to be now fallen into total diſuſe; though Sir Matthew Hale ſays, that it is due of common right, and that no preſcription will diſcharge it.

3. The king alſo is entitled to all the tithes ariſing in extraparochial places: though perhaps it may be doubted how far this article, as well as the laſt, can be properly reckoned a part of the king's own royal revenue; ſince a corody ſupports only his chaplains, and theſe extraparochial tithes are held under an implied truſt that the king will diſtribute them for the good of the clergy in general.

4. The next branch conſiſts in the firſt-fruits and tenths of all ſpiritual preferments in the kingdom. See TENTHS.

5. The next branch of the king's ordinary revenue (which, as well as the ſubſequent branches, is of a lay or temporal nature) conſiſts in the rents and profits of the demeſne lands of the crown. Theſe demeſne lands, *terræ dominicales regis*, being either the ſhare reſerved to the crown at the original diſtribution of landed property, or ſuch as came to it afterwards by forfeitures or other means, were anciently very large and extenſive; compriſing divers manors, honours, and lordſhips; the tenants of which had very peculiar privileges, when we ſpeak of the tenure in ancient demeſne. At preſent they are contracted within a very narrow compaſs, having been almoſt entirely granted away to private ſubjects. This has occaſioned the parliament frequently to interpoſe; and particularly after King William III. had greatly impoveriſhed the crown, an act paſſed, whereby all future grants or leaſes from the crown for any longer term than 31 years or three lives, are declared to be void; except with regard to houſes, which may be granted for 50 years. And no reverſionary leaſe can be made, ſo as to exceed, together with the eſtate in being, the ſame term of three lives or 31 years; that is, when there is a ſubſiſting leaſe, of which there are 20 years ſtill to come the king cannot grant a future intereſt, to commence after the expiration of the former, for any longer term than 11 years. The tenant muſt alſo be made liable to be puniſhed for committing waſte; and the uſual rent muſt be reſerved, or, where there has uſually been no rent, one-third of the clear yearly value. The misfortune is, that this act was made too late, after almoſt every valuable poſſeſſion of the crown had been granted away for ever, or elſe upon very long leaſes; but may be of benefit to poſterity, when thoſe leaſes come to expire.

6. Hither might have been referred the advantages which were uſed to ariſe to the king from the profits of his military tenures, to which moſt lands in the kingdom were ſubject, till the ſtatute 12 Car. II. c. 24. which in great meaſure aboliſhed them all. Hither alſo might have been referred the profitable prerogative of purveyance and pre-emption: which was a right enjoyed by the crown of buying up proviſions and other neceſſaries, by the intervention of the king's purveyors, for the uſe of his royal houſehold, at an appraiſed valuation, in preference to all others. and even without conſent of the owner: and alſo of forcibly impreſſing the carriages and horſes of the ſubject, to do the king's buſineſs on the public roads, in the conveyance of timber, baggage, and the like, however inconvenient to the proprietor, upon paying him a ſettled price. A prerogative which prevailed pretty generally throughout Europe during the ſcarcity of gold and ſilver, and the high valuation of money conſequential thereupon. In thoſe early times, the king's houſehold (as well as thoſe of inferior lords) were ſupported by ſpecific renders of corn, and other victuals, from the tenants of the reſpective demeſnes; and there was alſo a continual market kept at the palace-gate to furniſh viands for the royal uſe. And this anſwered all purpoſes, in thoſe ages of ſimplicity, ſo long as the king's court continued in any certain place. But when it removed from one part of the kingdom to another (as was formerly very frequently done), it was found neceſſary to ſend purveyors beforehand, to get together a ſufficient quantity of proviſions and other neceſſaries for the houſehold: and, leſt the unuſual demand ſhould raiſe them to an exorbitant price, the powers beforementioned were veſted in theſe purveyors; who in proceſs of time very greatly abuſed their authority, and became a great oppreſſion to the ſubject, though of little advantage to the crown; ready money in open market (when the royal reſidence was more permanent, and ſpecie began to be plenty) being found upon experience to be the beſt proveditor of any. Wherefore, by degrees, the powers of purveyance have declined, in foreign countries as well as our own: and particularly were aboliſhed in Sweden by Guſtavus Adolphus, towards the beginning of the laſt century. And, with us in England, having fallen into diſuſe during the ſuſpenſion of monarchy, King Charles, at his reſtoration, conſented, by the ſame ſtatute, to reſign entirely thoſe branches of his revenue and power: and the parliament, in part of recompenſe, ſettled on him, his heirs, and ſucceſſors, for ever, the hereditary exciſe of 15d. per barrel on all beer and ale ſold in the kingdom, and a proportionable ſum for certain other liquors. So that this hereditary exciſe now forms the ſixth branch of his majeſty's ordinary revenue.

7. A ſeventh branch might alſo be computed to have ariſen from wine-licences; or the rents payable to the crown by ſuch perſons as are licenſed to ſell wine by retail throughout Britain, except in a few privileged places. Theſe were firſt ſettled on the crown by the ſtatute 12 Car. II. c. 25. and, together with the hereditary

Revenue. ditary excife, made up the equivalent in value for the lofs fuftained by the prerogative in the abolition of the military tenures, and the right of pre-emption and purveyance: but this revenue was abolifhed by the ftatute 30 Geo. II. c. 19. and an annual fum of upwards of 7000l. per annum, iffuing out of the new ftamp duties impofed on wine-licences, was fettled on the crown in its ftead.

8. An eighth branch of the king's ordinary revenue is ufually reckoned to confift in the profits arifing from his forefts. See FOREST. Thefe confift principally in the amercements or fines levied for offences againft the foreft-laws. But as few, if any, courts of this kind for levying amercements have been held fince 1632, 8 Char. I. and as, from the accounts given of the proceedings in that court by our hiftories and law-books, nobody would wifh to fee them again revived, it is needlefs to purfue this inquiry any farther

9. The profits arifing from the king's ordinary courts of juftice make a ninth branch of his revenue. And thefe confift not only in fines impofed upon offenders, forfeitures of recognizances, and amercements levied upon defaulters; but alfo in certain fees due to the crown in a variety of legal matters, as, for fetting the great feal to charters, original writs, and other forenfic proceedings, and for permitting fines to be levied of lands in order to bar entails, or otherwife to infure their title. As none of thefe can be done without the immediate intervention of the king, by himfelf or his officers, the law allows him certain perquifites and profits, as a recompenfe for the trouble he undertakes for the public. Thefe, in procefs of time, have been almoft all granted out to private perfons, or elfe appropriated to certain particular ufes: fo that, though our law proceedings are ftill loaded with their payment, very little of them is now returned into the king's exchequer; for a part of whofe royal maintenance they were originally intended. All future grants of them, however, by the ftatute 1 Ann. ftat. 2. c. 7. are to endure for no longer time than the prince's life who grants them.

10. A tenth branch of the king's ordinary revenue, faid to be grounded on the confideration of his guarding and protecting the feas from pirates and robbers, is the right to *royal fifh*, which are whale and fturgeon: and thefe, when either thrown afhore, or caught near the coafts, are the property of the king, on account of their fuperior excellence. Indeed, our anceftors feem to have entertained a very high notion of the importance of this right; it being the prerogative of the kings of Denmark and the dukes of Normandy; and from one of thefe it was probably derived to our princes.

11. Another maritime revenue, and founded partly upon the fame reafon, is that of SHIPWRECKS. See WRECK.

12. A twelfth branch of the royal revenue, the right to mines, has its original from the king's prerogative of coinage, in order to fupply him with materials; and therefore thofe mines which are properly royal, and to which the king is entitled when found, are only thofe of filver and gold. See MINE.

13. To the fame original may in part be referred the revenue of treafure-trove. See *TREASURE-Trove*.

14. Waifs. See WAIF.

15. Eftrays. See ESTRAY.

Befides the particular reafons, given in the different articles, why the king fhould have the feveral revenues of royal fifh, fhipwrecks, treafure-trove, waifs, and eftrays, there is alfo one general reafon which holds for them all; and that is, becaufe they are *bona vacantia*, or goods in which no one elfe can claim a property. And, therefore, by the law of nature, they belonged to the firft occupant or finder; and fo continued under the imperial law. But in fettling the modern conftitutions of moft of the governments in Europe, it was thought proper (to prevent that ftrife and contention which the mere title of occupancy is apt to create and continue, and to provide for the fupport of public authority in a manner the leaft burdenfome to individuals) that thefe rights fhould be annexed to the fupreme power by the pofitive laws of the ftate. And fo it came to pafs, that, as Bracton expreffes it, "hæc, quæ nullius in bonis funt, "et olim fuerunt inventoris de jure naturali, jam efficiuntur principis de jure gentium."

16. The next branch of the king's ordinary revenue confifts in forfeitures of lands and goods for offences; *bona confifcata*, as they are called by the civilians, becaufe they belonged to the *fifcus* or imperial treafury; or, as our lawyers term them, *foris facta*, that is, fuch whereof the property is gone away or departed from the owner. The true reafon and only fubftantial ground of any forfeiture for crimes, confift in this; that all property is derived from fociety, being one of thofe civil rights which are conferred upon individuals, in exchange for that degree of natural freedom which every man muft facrifice when he enters into focial communities. If, therefore, a member of any national community violates the fundamental contract of his affociation, by tranfgreffing the municipal law, he forfeits his right to fuch privileges as he claims by that contract; and the ftate may very juftly refume that portion of property, or any part of it, which the laws have before affigned him. Hence, in every offence of an atrocious kind, the laws of England have exacted a total confifcation of the moveables or perfonal eftate; and, in many cafes, a perpetual, in others only a temporary, lofs of the offender's immoveables or landed property; and have vefted them both in the king, who is the perfon fuppofed to be offended, being the one vifible magiftrate in whom the majefty of the public refides. See FORFEITURE and DEODAND.

17. Another branch of the king's ordinary revenue arifes from efcheats of lands, which happen upon the defect of heirs to fucceed to the inheritance; whereupon they in general revert to and veft in the king, who is efteemed, in the eye of the law, the original proprietor of all lands in the kingdom.

18. The laft branch of the king's ordinary revenue, confifts in the cuftody of idiots, from whence we fhall be naturally led to confider alfo the cuftody of lunatics. See IDIOT and LUNATIC.

This may fuffice for a fhort view of the king's *ordinary* revenue, or the proper patrimony of the crown; which was very large formerly, and capable of being increafed to a magnitude truly formidable: for there are very few eftates in the kingdom that have not, at fome period or other fince the Norman conqueft, been vefted in the hands of the king, by forfeiture, efcheat, or otherwife. But, fortunately for the liberty of the fubject, this hereditary landed revenue, by a feries of improvident

Revenue improvident management, is funk almoft to nothing; and the cafual profits, arifing from the other branches of the *cenfus regalis*, are likewife almoft all of them alienated from the crown. In order to fupply the deficiencies of which, we are now obliged to have recourfe to new methods of raifing money, unknown to our early anceftors; which methods conftitute,

II. The king's *extraordinary* revenue. For, the public patrimony being got into the hands of private fubjects, it is but reafonable that private contributions fhould fupply the public fervice. Which, though it may perhaps fall harder upon fome individuals, whofe anceftors have had no fhare in the general plunder, than upon others, yet, taking the nation throughout, it amounts to nearly the fame; provided the gain by the extraordinary fhould appear to be no greater than the lofs by the ordinary revenue. And perhaps, if every gentleman in the kingdom was to be ftripped of fuch of his lands as were formerly the property of the crown; was to be again fubject to the inconveniences of purveyance and pre-emption, the oppreffion of foreft-laws, and the flavery of feodal-tenures; and was to refign into the king's hands all his royal franchifes of waifs, wrecks, eftrays, treafure-trove, mines, deodands, forfeitures, and the like; he would find himfelf a greater lofer than by paying his *quota* to fuch taxes as are neceffary to the fupport of government. The thing, therefore, to be wifhed and aimed at in a land of liberty, is by no means the total abolition of taxes, which would draw after it very pernicious confequences, and the very fuppofition of which is the height of political abfurdity. For as the true idea of government and magiftracy will be found to confift in this, that fome few men are deputed by many others to prefide over public affairs, fo that individuals may the better be enabled to attend their private concerns; it is neceffary that thofe individuals fhould be bound to contribute a portion of their private gains, in order to fupport that government, and reward that magiftracy, which protects them in the enjoyment of their refpective properties. But the things to be aimed at are wifdom and moderation, not only in granting, but alfo in the method of raifing, the neceffary fupplies; by contriving to do both in fuch a manner as may be moft conducive to the national welfare, and at the fame time moft confiftent with economy and the liberty of the fubject; who, when properly taxed, contributes only, as was before obferved, fome part of his property in order to enjoy the reft.

Thefe extraordinary grants are ufually called by the fynonymous names of *aids*, *fubfidies*, and *fupplies*; and are granted by the commons of Great Britain, in parliament affembled. See PARLIAMENT and TAX.

The clear nett produce of the feveral branches of the revenue, after all charges of collecting and management paid, amounted in the year 1786 to about 15,397,000l. fterling, while the expenditure was found to be about 14,477,000l. How thefe immenfe fums are appropriated, is next to be confidered. And this is, firft and principally, to the payment of the intereft of the national debt. See *NATIONAL Debt* and FUNDS.

The refpective produces of the feveral taxes were originally feparate and diftinct funds; being fecurities for the fums advanced on each feveral tax, and for them only. But at laft it became neceffary, in order to avoid confufion, as they multiplied yearly, to reduce the number of thefe feparate funds, by uniting and blending them together; fuperadding the faith of parliament for the general fecurity of the whole. So that there are now only three capital funds of any account, the *aggregate* fund, and the *general* fund, fo called from fuch union and addition; and the *South-fea* fund, being the produce of the taxes appropriated to pay the intereft of fuch part of the national debt as was advanced by that company and its annuitants. Whereby the feparate funds, which were thus united, are become mutual fecurities for each other; and the whole produce of them, thus aggregated, liable to pay fuch intereft or annuities as were formerly charged upon each diftinct fund: the faith of the legiflature being moreover engaged to fupply any cafual deficiencies.

The cuftoms, excifes, and other taxes, which are to fupport thefe funds, depending on contingencies, upon exports, imports, and confumptions, muft neceffarily be of a very uncertain amount; but they have always been confiderably more than was fufficient to anfwer the charge upon them. The furpluffes, therefore, of the three great national funds, the aggregate, general, and South-fea funds, over and above the intereft and annuities charged upon them, are directed by ftatute 3 Geo. I. c. 7. to be carried together, and to attend the difpofition of parliament; and are ufually denominated the *finking fund*, becaufe originally deftined to fink and lower the national debt. To this have been fince added many other entire duties, granted in fubfequent years; and the annual intereft of the fums borrowed on their refpective credits is charged on, and payable out of, the produce of the finking fund. However, the nett furpluffes and favings, after all deductions paid, amount annually to a very confiderable fum. For as the intereft on the national debt has been at feveral times reduced (by the confent of the proprietors, who had their option either to lower their intereft or be paid their principal), the favings from the appropriated revenues muft needs be extremely large.

But, before any part of the aggregate fund (the furpluffes whereof are one of the chief ingredients that form the finking fund) can be applied to diminifh the principal of the public debt, it ftands mortgaged by parliament to raife an annual fum for the maintenance of the king's houfehold and the civil lift. For this purpofe, in the late reigns, the produce of certain branches of the excife and cuftoms, the poft-office, the duty on wine-licences, the revenues of the remaining crown-lands, the profits arifing from courts of juftice, (which articles include all the hereditary revenues of the crown), and alfo a clear annuity of 120,000l. in money, were fettled on the king for life, for the fupport of his majefty's houfehold, and the honour and dignity of the crown. And, as the amount of thefe feveral branches was uncertain, (though in the laft reign they were computed to have fometimes raifed almoft a million), if they did not rife annually to 800,000l. the parliament engaged to make up the deficiency. But his prefent majefty having, foon after his acceffion, fpontaneoufly fignified his confent that his own hereditary revenues might be fo difpofed of as might beft conduce to the utility and fatisfaction of the public, and having gracioufly accepted a limited fum, the faid hereditary and other revenues are now carried into, and made a part of, the aggregate fund; and the aggregate fund is charged with the

the payment of the whole annuity to the crown. The limited annuity accepted by his prefent majefty was at firft 800,000l. but it has been fince augmented to 900,000l. The expences themfelves, being put under the fame care and management as the other branches of the public patrimony, produce more, and are better collected than heretofore; and the public is a gainer of upwards of 100,000l. per annum by this difinterefted bounty of his majefty.

The finking fund, though long talked of as the laft refource of the nation, proved very inadequate to the purpofe for which it was eftablifhed. Minifters found pretences for diverting it into other channels; and the diminution of the national debt proceeded flowly during the intervals of peace, whilft each fucceeding war increafed it with great rapidity. To remedy this evil, and reftore the public credit, to which the late war had given a confiderable fhock, Mr Pitt conceived a plan for diminifhing the debt by a fund, which fhould be rendered unalienable to any other purpofe. In the feffion 1786, he moved that the annual furplus of the revenue above the expenditure fhould be raifed, by additional taxes, from 900,000l. to one million fterling, and that certain commiffioners fhould be vefted with the full power of difpofing of this fum in the purchafe of ftock (fee FUNDS), for the public, in their own names. Thefe commiffioners fhould receive the annual million by quarterly payments of 250,000l. to be iffued out of the exchequer before any other money, except the intereft of the national debt itfelf; by thefe provifions, the fund would be fecured, and no deficiencies in the national revenues could affect it, but fuch muft be feparately provided for by parliament.

The accumulated compound intereft on a million yearly, together with the annuities that would fall into that fund, would, he faid, in 28 years amount to fuch a fum as would leave a furplus of four millions annually, to be applied, if neceffary, to the exigencies of the ftate. In appointing the commiffioners, he fhould, he faid, endeavour to choofe perfons of fuch weight and character as correfponded with the importance of the commiffion they were to execute. The fpeaker of the houfe of commons, the chancellor of the exchequer, the mafter of the rolls, the governor and deputy governor of the bank of England, and the accountant-general of the high court of chancery, were perfons who, from their feveral fituations, he fhould think highly proper to be of the number.

To the principle of this bill no objection was made, though feveral fpecious but ill-founded ones were urged againft the fufficiency of the mode which the chancellor of the exchequer had adopted for the accomplifhment of fo great and fo defirable an end. He had made it a claufe in his bill, that the accumulating million fhould never be applied but to the purchafe of ftock. To this claufe Mr Fox objected, and moved that the commiffioners therein named fhould be impowered to accept fo much of any future loan as they fhould have cafh belonging to the public to pay for. This, he faid, would relieve that diftrefs the country would otherwife be under, when, on account of a war, it might be neceffary to raife a new loan: whenever that fhould be the cafe, his opinion was, that the minifter fhould not only raife taxes fufficiently productive to pay the intereft of the loan, but alfo fufficient to make good to the finking fund whatfoever had been taken from it.

If, therefore, for inftance, at any future period a loan of fix millions was propofed, and there was at that time one million in the hands of the commiffioners, in fuch cafe they fhould take a million of the loan, and the *bonus* or *douceur* thereupon fhould be received by them for the public. Thus government would only have five millions to borrow of fix; and from fuch a mode of proceeding, he faid, it was evident great benefit would arife to the public.

This claufe was received by Mr Pitt with the ftrongeft marks of approbation, as was likewife another, moved by Mr Pulteney, enabling the commiffioners named in the bill to continue purchafing ftock for the public when it is above par, unlefs otherwife directed by parliament. With thefe additional claufes the bill was read a third time on the 15th of May, and carried up to the Lords, where it alfo paffed without meeting with any material oppofition, and afterwards received the royal affent.

The operation of this bill furpaffed perhaps the minifter's moft fanguine expectation. The fund was ably managed, and judicioufly applied; and in 1793 the commiffioners had extinguifhed fome millions of the public debt. The war, however, in which the nation was that year involved, and which continued for eight years after that period, made it neceffary to borrow additional fums, fo large, that many years of peace muft elapfe before the operation of the fund can contribute fenfibly to the relief of the people.

The clear produce of the taxes raifed on the people of this country was, in the year 1792, very near 17,000,000l.; and in the year ending 5th Jan. 1806, it amounted to the enormous fum of 48,890,896l.

REVENUE, in hunting, a flefhy lump formed chiefly by a clufter of whitifh worms on the head of the deer, fuppofed to occafion the cafting of their horns by gnawing them at the root.

REVERBERATION, in *Phyfics*, the act of a body repelling or reflecting another after its impinging thereon.

REVERBERATION, in *Chemiftry*, denotes a kind of circulation of the flame by means of a reverberatory furnace.

REVERBERATORY, or *REVERBERATING Furnace*. See FURNACE.

REVEREND, a title of refpect given to ecclefiaftics.—The religious abroad are called *reverend fathers*, and abbeffes, prioreffes, &c. *reverend mothers*. In England, bifhops are *right reverend*, and archbifhops *moft reverend*. In France, before the Revolution, their bifhops, archbifhops, and abbots, were all alike *moft reverend*. In Scotland, the clergy individually are *reverend*, a fynod is *very reverend*, and the general affembly is *venerable*.

REVERIE, the fame with delirium, raving, or diftraction. It is ufed alfo for any ridiculous, extravagant imagination, action, or propofition, a chimera, or vifion. But the moft ordinary ufe of the word among Englifh writers, is for a deep diforderly mufing or meditation.

REVERSAL *of* JUDGEMENT, in *Law*. A judgement may be falfified, reverfed, or voided, in the firft place,

place, *without a writ of error*, for matters foreign to or *dehors* the record, that is, not apparent upon the face of it; so that they cannot be assigned for error in the superior court, which can only judge from what appears in the record itself; and therefore, if the whole record be not certified, or not truly certified, by the inferior court, the party injured thereby (in both civil and criminal cases) may allege a diminution of the record, and cause it to be rectified. Thus, if any judgement whatever be given by persons who had no good commission to proceed against the person condemned, it is void; and may be falsified by shewing the special matter, without writ of error. As, where a commission issues to A and B, and twelve others, or any two of them, of which A or B shall be one, to take and try indictments; and any of the other twelve proceed without the interposition or presence of either A or B: in this case all proceedings, trials, convictions, and judgements, are void for want of a proper authority in the commissioners, and may be falsified upon bare inspection, without the trouble of a writ of error; it being a high misdemeanour in the judges so proceeding, and little (if any thing) short of murder in them all, in case the person so attainted be executed and suffer death. So likewise if a man purchases land of another; and afterwards the vender is, either by outlawry, or his own confession, convicted and attainted of treason or felony previous to the sale or alienation; whereby such land becomes liable to forfeiture or escheat: now, upon any trial, the purchaser is at liberty, without bringing any writ of error, to falsify not only the time of the felony or treason supposed, but the very point of the felony or treason itself; and is not concluded by the confession or the outlawry of the vender, though the vender himself is concluded, and not suffered now to deny the fact, which he has by confession or flight acknowledged. But if such attainder of the vender was by verdict, on the oath of his peers, the alienee cannot be received to falsify or contradict the *fact* of the crime committed; though he is at liberty to prove a mistake in time, or that the offence was committed after the alienation, and not before.

Secondly, a judgement may be reversed, *by writ of error*, which lies from all inferior criminal jurisdictions to the court of king's-bench, and from the king's-bench to the house of peers; and may be brought for notorious mistakes in the judgement or other parts of the record: as where a man is found guilty of perjury, and receives the judgement of felony, or for other less palpable errors; such as any irregularity, omission, or want of form in the process of outlawry, or proclamations; the want of a proper addition to the defendant's name, according to the statute of additions; for not properly naming the sheriff or other officer of the court, or not duly describing where his county-court was held: for laying an offence, committed in the time of the late king, to be done against the peace of the present; and for many other similar causes, which (though allowed out of tenderness to life and liberty) are not much to the credit or advancement of the national justice.— These writs of error, to reverse judgements in case of misdemeanours, are not to be allowed of course, but on sufficient probable cause shown to the attorney general; and then they are understood to be grantable of common right, and *ex debito justitiæ*. But writs of error to reverse attainders in capital cases are only allowed *ex gratia*; and not without express warrant under the king's sign-manual, or at least by the consent of the attorney-general. These therefore can rarely be brought by the party himself, especially where he is attainted for an offence against the state: but they may be brought by his heir or executor after his death, in more favourable times; which may be some consolation to his family. But the easier and more effectual way is,

Lastly, to reverse the attainder by act of parliament. This may be and hath been frequently done upon motives of compassion, or perhaps the zeal of the times, after a sudden revolution in the government, without examining too closely into the truth or validity of the errors assigned. And sometimes, though the crime be universally acknowledged and confessed, yet the merits of the criminal's family shall after his death obtain a restitution in blood, honours, and estate, or some or one of them, by act of parliament; which (so far as it extends) has all the effect of reversing the attainder, without casting any reflections upon the justice of the preceding sentence. See ATTAINDER.

The effect of falsifying or reversing an outlawry is, that the party shall be in the same plight as if he had appeared upon the *capias*: and, if it be before plea pleaded, he shall be put to plead to the indictment; if, after conviction, he shall receive the sentence of the law; for all the other proceedings, except only the process of outlawry for his non-appearance, remain good and effectual as before. But when judgement, pronounced upon conviction, is falsified or reversed, all former proceedings are absolutely set aside, and the party stands as if he had never been at all accused; restored in his credit, his capacity, his blood, and his estates: with regard to which last, though they be granted away by the crown, yet the owner may enter upon the grantee, with as little ceremony as he might enter upon a disseisor.—But he still remains liable to another prosecution for the same offence: for, the first being erroneous, he never was in jeopardy thereby.

REVERSE of a medal, coin, &c. denotes the second or back side, in opposition to the head or principal figure.

REVERSION, in *Scots Law*. See LAW, N° clxix. 1—3.

REVERSION, in the law of England, has two significations; the one of which is an estate left, which continues during a particular estate in being; and the other is the returning of the land, &c. after the particular estate is ended; and it is further said to be an interest in lands, when the possession of it fails, or where the estate which was for a time parted with, returns to the granters, or their heirs. But, according to the usual definition of a reversion, it is the residue of an estate left in the granter, after a particular estate granted away ceases, continuing in the granter of such an estate.

The difference between a remainder and a reversion consists in this, that the remainder may belong to any man except the granter; whereas the reversion returns to him who conveyed the lands, &c.

In order to render the doctrine of reversions easy, we shall give the following table; which shows the present value of one pound, to be received at the end of any number

Reversion.

number of years not exceeding 40; discounting at the rate of 5, 4, and 3 per cent. compound interest.

Years	Value at 5 per ct.	Value at 4 per ct.	Value at 3 per ct.
1	.9524	.9615	.9709
2	.9070	.9245	.9426
3	.8638	.8898	.9151
4	.8227	.8548	.8885
5	.7835	.8219	.8626
6	.7462	.7903	.8375
7	.7107	.7599	.8131
8	.6768	.7307	.7894
9	.6446	.7026	.7664
10	.6139	.6756	.7441
11	.5847	.6496	.7224
12	.5568	.6246	.7014
13	.5303	.6006	.6809
14	.5051	.5775	.6611
15	.4810	.5553	.6419
16	.4581	.5339	.6232
17	.4363	.5134	.6050
18	.4155	.4936	.5874
19	.3957	.4746	.5703
20	.3769	.4564	.5537
21	.3589	.4388	.5375
22	.3418	.4219	.5219
23	.3255	.4057	.5067
24	.3100	.3901	.4919
25	.2953	.3757	.4776
26	.2812	.3607	.4637
27	.2678	.3468	.4502
28	.2551	.3335	.4371
29	.4229	.3206	.4243
30	.2314	.3003	.4120
31	.2204	.2965	.4000
32	.2099	.2851	.3883
33	.1999	.2741	.3770
34	.1903	.2636	.3660
35	.1813	.2534	.3554
36	.1726	.2437	.3450
37	.1644	.2343	.3350
38	.1566	.2253	.3252
39	.1491	.2166	.3158
40	.1420	.2083	.3066

The use of the preceding table.—To find the present value of any sum to be received at the end of a given term of years, discounting at the rate of 3, 4, or 5 per cent. compound interest. Find by the above table the present value of 1l. to be received at the end of the given term; which multiply by the number of pounds proposed, (cutting off four figures from the product on account of the decimals), then the result will be the value sought: For example, the present value of 10,000l. to be received 10 years hence, and the rate of interest 5 per cent. is equal to $.6139 \times 10,000 = 6139.0000$l. or 6139l. Again, the present value of 10,000l. due in ten years, the rate of interest being 3 per cent. is $.7441 \times 10,000 = 7441$.

Reversion, Revivification.

REVERSION of Series, in *Algebra*, a kind of reversed operation of an infinite series. See SERIES.

REVETEMENT, in *Fortification*, a strong wall built on the outside of the rampart and parapet to support the earth, and prevent its rolling into the ditch.

REVIVIFICATION, in *Chemistry*, a term generally applied to the distillation of quicksilver from cinnabar.

REVIVIFICATION, in *Physiology*, the recalling of animals apparently dead, to life. There are many kinds of insects which may be revivified, after all the powers of animation have been suspended for a considerable time. Common flies, small beetles, spiders, moths, bugs, &c. after being drowned in spirit of wine, and continuing apparently dead for upwards of 15 minutes, have been restored to life merely by being thrown among wood-ashes slightly warm.

While Dr Franklin was in France, he received a quantity of Madeira wine from America, which had been bottled in Virginia. He found a few dead flies in some of the bottles, which he exposed to the sun in the month of July; and in less than three hours these seemingly dead animals recovered life which had been so long suspended. At first they appeared as if convulsed; they then raised themselves on their legs, washed their eyes with their fore feet, dressed their wings with those behind, and in a short time began to fly about.

But the most remarkable instance of revivification we have heard of, is the following. In the warmer parts of France there is an insect very pernicious to the rye, apparently beginning its operations at the root of the plant, and gradually proceeding towards the ear. If the plant be thoroughly dried while the insect is in the root or stem, the animal is irrecoverably killed; but after it has reached the grain, the case is very different. There have been instances of these insects being brought to life in 15 minutes, by a little warm water, after the grains, in which they were lodged, had been kept dry for 30 years.

What is the metaphysician to think of these phenomena, or what conclusion is he to draw from them respecting the mind? If he be a sober man he will draw no conclusion, for this reason, that he knows nothing of the sentient principle of insects, or of any animal but man. He is conscious that it is the same individual being which in himself, thinks, and wills, and feels; he knows that part of his thought is not in one place, and part of it in another; and therefore he concludes that this thinking being is not matter, while experience teaches him that it quits the material system, when that becomes unfit to discharge its functions, and cannot be recalled. Experience teaches him, on the other hand, that the sentient principle of these insects does not quit the system when unfit for its functions; and hence he ought to infer, that the minds of men and of insects are very different, and that the bond which unites the material and immaterial parts of an insect, is certainly different from that which unites the mind and body of man. This is the only inference which can be fairly drawn from

from these phenomena; and he who makes them the basis of materialism, must have his judgement warped by some passion or prejudice.

COMMISSION OF REVIEW, is a commission sometimes granted, in extraordinary cases, to revise the sentence of the court of delegates, when it is apprehended they have been led into a material error. This commission the king may grant, although the statutes 24 and 25 Hen. VIII. declare the sentence of the delegates definitive: because the pope, as supreme head by the canon law, used to grant such commission of review; and such authority as the pope heretofore exerted is now annexed to the crown by statutes 26 Hen. VIII. c. 1. and 1 Eliz. c. 1. But it is not matter of right, which the subject may demand *ex debito justitiæ*; but merely a matter of favour, and which therefore is often denied.

REVIEW, is the drawing out all or part of the army in line of battle, to be viewed by the king, or a general, that they may know the condition of the troops.

At all reviews, the officers should be properly armed, ready in their exercise, salute well, in good time, and with a good air; their uniform genteel, &c. The men should be clean and well dressed; their accoutrements well put on; very well sized in their ranks; the serjeants expert in their duty, drummers perfect in their beatings, and the fifers play correct. The manual exercise must be performed in good time, and with life; and the men carry their arms well; march, wheel, and form with exactness. All manœuvres must be performed with the utmost regularity, both in quick and slow time. The firings are generally 36 rounds; viz. by companies; by grand divisions; by sub-divisions; obliquely, advancing, retreating; by files; in the square; street firings, advancing and retreating; and lastly, a volley. The intention of a review is, to know the condition of the troops, see that they are complete and perform their exercise and evolutions well.

REVIEW is also applied to literary journals, which give a periodical view of the state of literature;—as the Monthly Review, the Critical Review, the British Critic, &c. The number of works of this description in Britain has increased greatly of late years, and some of them have a very extensive circulation.

RE-UNION ISLAND, an island in the South sea, discovered by the French on the 16th December 1773; lying, according to M. de Pages, in latitude 48° 21″, and longitude 66° 47″, the variation of the needle being 30° always towards north-west. The road and harbour are extremely good, and the latter from 16 to 8 fathoms deep at the very shore. The coast on each side is lofty, but green, with an abrupt descent, and swarms with a species of bustards. The penguins and sea-lions, which swarmed on the sands, were nowise alarmed at the approach of those who landed; from whence M. de Pages concluded that the country was wholly uninhabited. The soil produces a kind of grass, about five inches long, with a broad black leaf, and seemingly of a rich quality—but there was no vestige of a tree or human habitation. See *Travels round the World*, by M. de Pages, vol. iii. chaps. 8. and 9.

REVOLUTION, in politics, signifies a change in the constitution of a state; and is a word of different import from *revolt*, with which it is sometimes confounded. When a people withdraw their obedience from their governors for any particular reason, without overturning the government, or waging an offensive war against it, they are in a state of revolt; when they overturn the government and form a new one for themselves, they effect a *revolution*.

That which is termed *the revolution* in Britain is the change which, in 1688, took place in consequence of the forced abdication of King James II. when the Protestant succession was established, and the constitution restored to its primitive purity. Of this important transaction, which confirmed the rights and liberties of Britons, we have endeavoured to give an impartial account under another article (see BRITAIN, N° 281, &c.). Of the rise and progress of the American revolution, which is still fresh in the memory of some of our readers, a large detail is given under the article AMERICA. By the revolution which took place in Poland about the end of the 18th century, that kingdom was dismembered and seized by Austria, Prussia and Russia. For an account of this revolution, see POLAND; and for the history and progress of the French revolution, the most extraordinary of all, whether considered with regard to the events which accompanied, or the consequences which followed it, see FRANCE.

REVOLUTION, in *Geometry*, the motion of rotation of a line about a fixed point or centre, or of any figure about a fixed axis, or upon any line or surface. Thus, the revolution of a given line about a fixed centre, generates a circle; and that of a right-angled triangle about one side, as an axis, generates a cone; and that of a semicircle, about its diameter, generates a sphere or globe, &c.

REVOLUTION, in *Astronomy*, is the period of a star, planet, or comet, &c. or its course from any point of its orbit, till it return to the same again.

REVULSION, in *Medicine*, turning a flux of humours from one part to another by bleeding, cupping, friction, sinapisms, blisters, fomentations, bathings, issues, setons, strong purging of the bowels, &c.

REYN, JAN DE, an eminent history and portrait painter, born at Dunkirk in 1610. He had the good fortune to be a disciple of Vandyke, was the first performer in his school, and was so attached to his master that he followed him to London, where it is thought he continued as long as he lived. In these kingdoms he is mostly known by the name of *Lang Jan*. He died in 1678: and it is imagined that the scarcity of his works is occasioned by so many of them being imputed to Vandyke; a circumstance which, if true, is beyond any thing that could be said in his praise.

REYNEAU, CHEARLS-RENE, commonly known by the name of Father Reyneau, a celebrated mathematician of France, was born in the year 1656, at Brissac in the province of Anjou. When 20 years of age, he connected himself with the *Oratorians*, a sort of religious order, the members of which lived in community without binding themselves to the observance of any vows, and turned their chief attention to the instruction of youth. He afterwards taught philosophy at Pezenos, and next at Toulon, which requiring some degree of geometrical knowledge, he became extremely fond of that science, and cultivated and improved it to a great extent. He was, in consequence of his knowledge, invited to fill the mathematical chair at Angers in 1683, and he was also elected a member of the academy, in 1694.

He

Reyneau, Reynolds.

He undertook to reduce into a body, for the benefit of his pupils, the chief theories which were ſcattered through the works of Newton, Des Cartes, Leibnitz, Bernoulli, the Leipſic Acts, the Memoirs of the Paris Academy, and ſeveral other works, to which he gave the name of *Analyſe Demontrée*, or Analyſis Demonſtrated, which was publiſhed in 1708, in 2 vols. 4to.

He gave to this work the name of Analyſis Demonſtrated, becauſe he therein demonſtrates various methods which had not been demonſtrated by their authors, or at leaſt not with ſufficient accuracy and perſpicuity. This work of Reyneau was very much applauded, and it became a general maxim in France, that to follow him was the beſt, if not the only way, to make any extraordinary progreſs in the ſtudy of mathematics.

Such was his ambition to be uſeful, that in 1714 he publiſhed his *Science du Calcul des Grandeurs*, intended for the benefit of ſuch as were wholly unacquainted with the ſcience of geometry. Of this work a very able judge was pleaſed to obſerve, that "though ſeveral books had already appeared upon the ſame ſubject, ſuch a treatiſe as that before him was ſtill wanting, as in it every thing was handled in a manner ſufficiently extenſive, and at the ſame time with all poſſible exactneſs and perſpicuity." Although many branches of the mathematics had been well diſcuſſed prior to his time, no good elements were to be met with, even of practical geometry.

When the Royal Academy of Sciences at Paris gave admiſſion to other learned and eminent men, Father Reyneau was received into the number. The works already mentioned are all he ever publiſhed, or perhaps ever compoſed, with the exception of a little piece upon logic; and materials for a ſecond volume of his *Science du Calcul* were left behind him in manuſcript. Towards the cloſe of life he was too much afflicted with ſickneſs to give much application to ſtudy; and he died in 1728, at 72 years of age. His many virtues and extenſive erudition made this event much regretted by all who had the pleaſure of being acquainted with him. It was regarded as an honour and a happineſs by the firſt men in France, to number him among their friends, ſuch as the chancellor of the kingdom and Malbranche, of the latter of whom Reyneau was a faithful and zealous diſciple.

REYNOLDS, Sir Joshua, the celebrated painter, was, on July the 16th 1723, born at Plympton, a ſmall town in Devonſhire. His father was miniſter of the pariſh, and alſo maſter of the grammar-ſchool; and being a man of learning and philanthropy, he was beloved and reſpected by all to whom he was known.—Such a man, it will naturally be ſuppoſed, was aſſiduous in the cultivation of the minds of his children, among whom his ſon Joſhua ſhone conſpicuous, by diſplaying at a very early period a ſuperiority of genius, and the rudiments of a correct taſte. Unlike other boys, who generally content themſelves with giving a literal explanation of their author, regardleſs of his beauties or his faults, young Reynolds attended to both theſe, diſplaying a happy knowledge of what he read, and entering with ardour into the ſpirit of his author. He diſcovered likewiſe talents for compoſition, and a natural propenſity to drawing, in which his friends and intimates thought him qualified to excel. Emulation was a diſtinguiſhing feature in his mind, which his father perceived with the delight natural to a parent; and deſigning him for the church, in which he hoped that his talents might raiſe him to eminence, he ſent him to one of the univerſities.

Reynolds.

Soon after this period he grew paſſionately fond of painting; and, by the peruſal of Richardſon's theory of that art, was determined to make it his profeſſion through life. At his own earneſt requeſt, therefore, he was removed to London; and about the year 1742 became a pupil to Mr Hudſon, who, though not himſelf an eminent painter, was preceptor to ſeverals who afterwards excelled in the art. One of the firſt advices which he gave to Mr Reynolds was to copy carefully Guercino's drawings. This was done with ſuch ſkill, that many of the copies are ſaid to be now preſerved in the cabinets of the curious as the originals of that very great maſter.

About the year 1749, Mr Reynolds went to Italy under the auſpices, and in the company, of the late Lord (then Commodore) Keppel, who was appointed to the command of the Britiſh ſquadron in the Mediterranean. In this garden of the world, this magic ſeat of the arts, he failed not to viſit the ſchools of the great maſters, to ſtudy the productions of different ages, and to contemplate with unwearied attention the various beauties which are characteriſtic of each. His labour here, as has been obſerved of another painter, was "the labour of love, not the taſk of the hireling;" and how much he profited by it is known to all Europe.

Having remained about two years in Italy, and ſtudied the language as well as the arts of the country with great ſucceſs, he returned to England, improved by travel and refined by education. On the road to London from the port where he landed, he accidentally found in the inn where he lodged Johnſon's life of Savage; and was ſo taken with the charms of compoſition, and the maſterly delineation of character diſplayed in that performance, that, having begun to read it while leaning with his arm on the chimney-piece, he continued in that attitude inſenſible of pain till he was hardly able to raiſe his hand to his head. The admiration of the work naturally led him to ſeek the acquaintance of its author, who continued one of his ſincereſt admirers and warmeſt friends, till 1784, when they were ſeparated by the ſtroke of death.

The firſt thing that diſtinguiſhed him after his return to his native country, was a full length portrait of Commodore Keppel; which in the polite circles was ſpoken of in terms of the higheſt encomium, and teſtified to what a degree of eminence he had arrived in his profeſſion. This was followed by a portrait of Lord Edgecumbe, and a few others, which at once introduced him to the firſt buſineſs in portrait painting; and that branch of the art he cultivated with ſuch ſucceſs as will for ever eſtabliſh his fame with all deſcriptions of refined ſociety. Having painted ſome of the firſt-rate beauties of the age, the polite world flocked to ſee the graces and the charms of his pencil; and he ſoon became the moſt faſhionable painter, not only in England, but in all Europe. He has indeed preſerved the reſemblance of ſo many illuſtrious characters, that we feel the leſs regret for his having left behind him ſo few hiſtorical

hiſtorical paintings; though what he has done in that way ſhows (A) him to have been qualified to excel in both departments. The only landſcape, perhaps, which he ever painted, except thoſe beautiful and chaſte ones which compoſe the back grounds of many of his portraits, is "A View on the Thames from Richmond," which in 1784 was exhibited by the Society for Promoting Painting and Deſign in Liverpool.

In 1764 Mr Reynolds had the merit of being the firſt promoter of that club, which, having long exiſted without a name, became at laſt diſtinguiſhed by the appellation of the *Literary Club.* Upon the foundation of the Royal Academy of Painting, Sculpture, and Architecture, he was appointed preſident; and his acknowledged excellence in his profeſſion made the appointment acceptable to all the lovers of art. To add to the dignity of this new inſtitution, his majeſty conferred on the preſident the honour of knighthood; and Sir Joſhua delivered his firſt diſcourſe at the opening of the Academy on January 2. 1769. The merit of that diſcourſe has been univerſally admitted among painters; but it contains ſome directions reſpecting the proper mode of proſecuting their ſtudies, to which every ſtudent of every art would do well to pay attention. "I would chiefly recommend (ſays he), that an implicit obedience to the *rules of art*, as eſtabliſhed by the practice of the great maſters, ſhould be exacted from the young ſtudents. That thoſe models, which have paſſed through the approbation of ages, ſhould be conſidered by them as perfect and infallible guides; as ſubjects for their imitation, not their criticiſm. I am confident, that this is the only efficacious method of making a progreſs in the arts; and that he who ſets out with doubting, will find life finiſhed before he becomes maſter of the rudiments. For it may be laid down as a maxim, that he who begins by preſuming on his own ſenſe, has ended his ſtudies as ſoon as he has commenced them. Every opportunity, therefore ſhould be taken to diſcountenance that falſe and vulgar opinion, that rules are the fetters of genius. They are fetters only to men of no genius; as that armour which, upon the ſtrong, becomes an ornament and a defence, upon the weak and miſhapen turns into a load, and cripples the body which it was made to protect."

Each ſucceeding year, on the diſtribution of the prizes, Sir Joſhua delivered to the ſtudents a diſcourſe of equal merit with this: and perhaps we do not hazard too much when we ſay, that, from the whole collected, the lover of belles lettres and the fine arts will acquire juſter notions of what is meant by taſte in general, and better rules for acquiring a correct taſte, than from multitudes of thoſe volumes which have been profeſſedly written on the ſubject.

In the autumn of 1785 he went to Bruſſels, where he expended about 1000l. on the purchaſe of paintings, which, having been taken from the different monaſteries and religious houſes in Flanders and Germany, were then expoſed to ſale by the command of the emperor Joſeph! Gainſborough and he had engaged to paint each other's portrait; and the canvas for both being actually ſtretched, Sir Joſhua gave one ſitting to his diſtinguiſhed rival; but, to the regret of every admirer of the art, the unexpected death of the latter prevented all further progreſs.

In 1790 he was anxiouſly deſirous to procure the vacant profeſſorſhip of perſpective in the academy for Mr Bononi, an Italian architect; but that artiſt not having been yet elected, an aſſociate was of courſe no academician, and it became neceſſary to raiſe him to thoſe ſituations, in order to qualify him for being a profeſſor. Mr Gilpin being his competitor for the aſſociateſhip, the numbers on the ballot proved equal, when the preſident by his caſting vote decided the election in favour of his friend, who was thereby advanced ſo far towards the profeſſorſhip. Soon after this, an academic ſeat being vacant, Sir Joſhua exerted all his influence to obtain it for Mr Bononi; but finding himſelf outvoted by a majority of two to one, he quitted the chair with great diſſatisfaction, and next day ſent to the ſecretary of the academy a formal reſignation of the office, which for twenty-one years he had filled with honour to himſelf and his country. His indignation, however, ſubſiding,

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(A) As the lovers of painting may wiſh to have a catalogue of this great maſter's hiſtorical pieces, we ſubjoin the following from the European Magazine, which we have good reaſon to believe accurate, as the editors of that miſcellany grudge neither trouble nor expence to procure authentic information. Sir Joſhua's principal hiſtorical pieces, then, are the following: Hope nurſing Love; Venus chaſtiſing Cupid for having learned to caſt accounts; Count Ugolino in the dungeon; the calling of Samuel; Ariadne; a Captain of banditti; Beggar Boy; a Lady in the character of St Agnes; Thais; Dionyſius the Areopagite; an infant Jupiter; Maſter Crewe in the character of Henry VIII.; the death of Dido; a Child aſleep; Cupid ſleeping; Covent Garden Cupid; Cupid in the Clouds; Cupids painting; Boy laughing; Maſter Herbert in the character of Bacchus; Hebe; Miſs Meyer in the character of Hebe; Madona, a head; the Black-guard Mercury; a little boy (Samuel) praying; an old Man reading; Love looſing the zone of Beauty; the Children in the Wood; Cleopatra diſſolving the Pearl; Garrick in the character of Kitely; Garrick between Tragedy and Comedy; Mrs Abingdon in the character of Comedy; a Child ſurrounded by Guardian Angels; Miſs Beauclerc in the character of Spenſer's Una; Reſignation; the Ducheſs of Mancheſter in the character of Diana; Lady Blake in the character of Juno; Mrs Sheridan in the character of St Cecilia; Edwin, from Beattie's Minſtrel; the Nativity, Four Cardinal Virtues, and Faith, Hope, and Charity, for the window of New College Chapel, Oxford; the Studious Boy; a Bacchante; a daughter of Lord W. Gordon as an Angel; the Holy Family; the Cottagers, from Thomſon; the Veſtal; the Careful Shepherdeſs; a Gypſey telling Fortunes; the infant Hercules ſtrangling the Serpent; the Mouſe-trap girl; Venus; Cornelia and her Children; the Bird; Melancholy; Mrs Siddons in Tragedy; Head of Lear; Mrs Talmaſh in the character of Miranda, with Proſpero and Caliban; Robin Goodfellow; Death of Cardinal Beaufort; Macbeth, with the Caldron of the Witches.

Reynolds. ding, he suffered himself to be prevailed upon to return to the chair, which within a year and a half he was again desirous to quit for a better reason.

Finding a disease of languor, occasioned by an enlargement of the liver, to which he had for some time been subject, increase upon him, and daily expecting the total loss of sight, he wrote a letter to the academy, intimating his intention to resign the office of president on account of bodily infirmities, which disabled him from executing the duties of it to his own satisfaction. The academicians received this intelligence with the respectful concern due to the talents and virtues of their president; and either then did enter, or designed to enter, into a resolution, honourable to all parties, namely, that a deputation from the whole body of the academy should wait upon him, and inform him of their wish, that the authority and privileges of the office of president might be his during his life; declaring their willingness to permit the performance of any of its duties which might be irksome to him by a deputy.

From this period Sir Joshua never painted more. The last effort of his pencil was the portrait of the Honourable Charles James Fox, which was executed in his best style, and shows that his fancy, his imagination, and his other great powers in the art which he professed, remained unabated to the end of his life. When the last touches were given to this picture,

"The hand of Reynolds fell, to rise no more."

On Thursday February the 23d 1792, the world was deprived of this amiable man and excellent artist, at the age of 68 years; a man than whom no one, according to Johnson, had passed through life with more observation of men and manners. The following character of him is said to be the production of Mr Burke:

"His illness was long, but borne with a mild and cheerful fortitude, without the least mixture of any thing irritable or querulous, agreeably to the placid and even tenor of his whole life. He had from the beginning of his malady a distinct view of his dissolution, which he contemplated with that entire composure which nothing but the innocence, integrity, and usefulness of his life, and an unaffected submission to the will of Providence, could bestow. In this situation he had every consolation from family tenderness, which his tenderness to his family had always merited.

"Sir Joshua Reynolds was, on very many accounts, one of the most memorable men of his time: He was the first Englishman who added the praise of the elegant arts to the other glories of his country. In taste, in grace, in facility, in happy invention, and in the richness and harmony of colouring, he was equal to the great masters of the renowned ages. In portrait he went beyond them; for he communicated to that description of the art in which English artists are the most engaged, a variety, a fancy, and a dignity, derived from the higher branches, which even those who professed them in a superior manner did not always preserve when they delineated individual nature. His portraits remind the spectator of the invention of history and the amenity of landscape. In painting portraits he appears not to be raised upon that platform, but to descend to it from a higher sphere. His paintings illustrate his lessons, and his lessons seem to be derived from his paintings.

Reynolds || Rhama.

"He possessed the theory as perfectly as the practice of his art. To be such a painter, he was a profound and penetrating philosopher.

"In full happiness of foreign and domestic fame, admired by the expert in art, and by the learned in science, courted by the great, caressed by sovereign powers, and celebrated by distinguished poets, his native humility, modesty, and candour, never forsook him, even on surprise or provocation; nor was the least degree of arrogance or assumption visible to the most scrutinizing eye in any part of his conduct or discourse.

"His talents of every kind—powerful from nature, and not meanly cultivated in letters—his social virtues in all the relations and all the habitudes of life, rendered him the centre of a very great and unparalleled variety of agreeable societies, which will be dissipated by his death. He had too much merit not to excite some jealousy, too much innocence to provoke any enmity. The loss of no man of his time can be felt with more sincere, general, and unmixed sorrow."

REZAN, or REZANSKOI, an ancient town of Russia, and capital of a duchy of the same name, with an archbishop's see. It was formerly considerable for its extent and riches; but it was almost ruined by the Tartars in 1568. The country is populous, and was formerly governed by its own princes. E. Long. 42. 37. N. Lat. 54. 54.

RHABDOLOGY, or RABDOLOGY, in arithmetic, a name given by Napier to a method of performing some of the more difficult operations of numbers by means of square little rods. Upon these are inscribed the simple numbers; then by shifting them according to certain rules, those operations are performed by simply adding or subtracting the numbers as they stand upon the rods.

RHADAMANTHUS, a severe judge, and king of Lydia; the poets make him one of the three judges of hell.

RHAGADES, in *Medicine*, denotes chaps or clefts in any part of the body. If seated in the anus, and recent, the patient must sit still, and sit over the steam of warm water. The epulotic cerate may also be applied. If the lips of these fissures are callous, they must be cut or otherwise treated as to become new ulcerations.

RHAMA, or RAMA, an incarnate deity of the first rank, in Indian mythology. Sir William Jones believes he was the Dionysos (A) of the Greeks, whom they named *Bromius*, without knowing why; and *Bugenes*, when

(A) The learned president, whose death will be lamented by every scholar, by the orientalist and the divine especially, imagines, that this would fully appear from comparing together the *Dionysiaca* of Nonnus and the *Ramayan* of Valmic, the first poet of the Hindoos. He adds, that, in his opinion, Rhama was the son of Cush, and that he might have established the first regular government in that part of Asia, in which his exploits are said to have been performed.

when they represented him *horned*, as well as *Lyaios* and *Eleutherios* the deliverer, and *Tryambos* or *Dythyrambos* the triumphant. "Most of those titles (says Sir William) were adopted by the Romans, by whom he was called *Bruma*, *Tauriformis*, *Liber*, and *Triumphus*; and both nations had records or traditionary accounts of his giving laws to men and deciding their contests, of his improving navigation and commerce, and, what may appear yet more observable, of his conquering India and other countries with an army of satyrs, commanded by no less a personage than Pan; whom Lillius Gyraldus, on what authority I know not, asserts to have resided in Iberia 'when he had returned, says the learned mythologist, from the Indian war, in which he accompanied Bacchus.' It were superfluous in a mere essay to run any length in the parallel between this European god and the sovereign of Ayodhya, whom the Hindoos believe to have been an appearance on earth of the preserving power; to have been a conqueror of the highest renown, and the deliverer of nations from tyrants, as well as of his consort Sita from the giant Ravan king of Lanca; and to have commanded in chief a numerous and intrepid race of those large monkeys, which our naturalists, or some of them, have denominated Indian satyrs: his general, the prince of satyrs, was named *Hanumat*, or "with high cheek bones;" and, with workmen of such agility, he soon raised a bridge of rocks over the sea, part of which, say the Hindoos, yet remains; and it is probably the series of rocks to which the Mussulmans or the Portuguese have given the foolish name of *Adam's* (it should be called *Rama's*) bridge. Might not this army of satyrs have been only a race of mountaineers, whom Rama, if such a monarch ever existed, had civilized? However that may be, the large breed of Indian apes is at this moment held in high veneration by the Hindoos, and fed with devotion by the Brahmans, who seem in two or three places on the banks of the Ganges to have a regular endowment for the support of them: they live in tribes of three or four hundred, are wonderfully gentle (I speak as an eye-witness), and appear to have some kind of order and subordination in their little sylvan polity." The festival of Rhama is held on the 9th day of the new moon of Chaitra, on which the war of Lanca is dramatically represented, concluding with an exhibition of the fire-ordeal, by which the victor's wife Sita gave proof of her connubial fidelity. Among the Hindoos there is a variety of very fine dramas of great antiquity on the story of Rhama.

Asiatic Researches, vol. i. p. 221, &c.

There are three Rhamas mentioned in the Indian mythology, who, together with Crishna, the darling god of the Indian women, are described as youths of perfect beauty. The third Rhama is Crishna's elder brother, and is considered as the eighth Avatar (A), invested with an emanation of his divine radiance. Like all the Avatars, Rhama is painted with gemmed Ethiopian or Parthian coronets; with rays encircling his head, jewels in his ears, two necklaces, one straight and one pendant on his bosom, with dropping gems; garlands of well-disposed many-coloured flowers, or collars of pearls, hanging down below his waist; loose mantles of golden tissue or dyed silk, embroidered on the hems with flowers elegantly thrown over one shoulder, and folded like ribbands across the breast; with bracelets, two on one arm and on each wrist: all the Avatars are naked to the waists, and uniformly with dark azure flesh, in allusion probably to the tint of that primordial fluid on which Narayan moved in the beginning of time; but their skirts are bright yellow, the colour of the curious pericarpium in the centre of the water-lily.

RHAMNUS, the BUCKTHORN, a genus of plants belonging to the pentandria class; and in the natural method ranking under the 43d order *Dumosæ*. See BOTANY and MATERIA MEDICA *Index*.

The paliurus, or thorn of Christ, a deciduous shrub or tree, belongs to this genus, and is a native of Palestine, Spain, Portugal, and Italy. It grows to nearly the height of 14 feet, and is armed with sharp thorns, two of which are at each joint, one of which is about half an inch long, straight, and upright; the other is scarcely half that length, and bent backward; and between them is the bud for next year's shoot. June is the time of flowering, and the flowers are succeeded by a small fruit, surrounded by a membrane. "This plant (says Hanbury) is undoubtedly the sort of which the crown of thorns for our blessed Saviour was composed. The branches are very pliant, and the spines of it are at every joint strong and sharp. It grows naturally about Jerusalem, as well as in many parts of Judæa; and there is no doubt that the barbarous Jews would make choice of it for their cruel purpose. But what farther confirms the truth of these thorns being then used, are the ancient pictures of our blessed Saviour's crucifixion. The thorns on the crown of his head exactly answer to those of this tree; and there is great reason to supppose these were taken from the earliest paintings of the Lord of Life: and even now our modern painters copy from them, and represent the crown as composed of these thorns. These plants, therefore, should principally have a share in those parts of the plantation that are more peculiarly designed for religious retirement; for they will prove excellent monitors, and conduce to due reflection on and gratitude to 'Him who hath loved us, and has washed us from our sins,' &c.

RHAMPHASTOS, a genus of birds belonging to the order of *Picæ*. See ORNITHOLOGY *Index*.

RHAPIS, a genus of plants belonging to the hexandria class; and in the natural method ranking under the first order *Palmæ*. See BOTANY *Index*.

RHAPSODI, RHAPSODISTS, in *Antiquity*, persons who made a business of singing pieces of Homer's poems.

(A) *Avatar* means the descent of the deity in his capacity of preserver. The three first of these descents relate to some stupendous convulsion of our globe from the fountains of the deep, and the fourth exhibits the miraculous punishment of pride and impiety, appearing to refer to the deluge. Three of the others were ordained for the overthrow of tyrants or giants. Of these Avatars we have mentioned in the text, that Rhama is the eighth; Buddha, who appears to have been a reformer of the doctrines contained in Vedas, is the ninth: the tenth Avatar, we are told, is yet to come, and is expected to appear mounted (like the crowned conqueror in the Apocalypse) on a white horse, with a scimetar blazing like a comet, to mow down all incorrigible and impenitent offenders who shall then be on the earth.

poems. It has been ſaid, that the Rhapſodi were clothed in red when they ſung the Iliad, and in blue when they ſung the Odyſſey. They performed on the theatres, and ſometimes ſtrove for prizes in conteſts of poetry, ſinging, &c. After the two antagoniſts had finiſhed their parts, the two pieces or papers they were written in were ſoon joined together again: whence the name, *viz.* from ραπτω *ſuo*, and ωδη *canticum*: but there ſeem to have been other Rhapſodi of more antiquity than theſe people, who compoſed heroic poems or ſongs in praiſe of heroes and great men, and ſung their own compoſitions from town to town for a livelihood; of which profeſſion Homer himſelf is ſaid to have been. See Bard.

RHAPSODOMANCY, an ancient kind of divination performed by pitching on a paſſage of a poet at hazard, and reckoning on it as a prediction of what was to come to paſs. There were various ways of practiſing this rhapſodomancy. Sometimes they wrote ſeveral papers or ſentences of a poet on ſo many pieces of wood, paper, or the like, ſhook them together in an urn, and drew out one which was accounted the lot: ſometimes they caſt dice on a table whereon verſes were written, and that whereon the die lodged contained the prediction. A third manner was by opening a book, and pitching on ſome verſe at firſt ſight. This method they particularly called the *ſortes Prœneſtinœ;* and afterwards, according to the poet, made uſe of *ſortes Homericœ, ſortes Virgilianœ*, &c. See Sortes.

RHAPSODY, in *Antiquity*, a diſcourſe in verſe ſung or rehearſed by a rhapſodiſt. Others will have rhapſody to ſignify a collection of verſes, eſpecially thoſe of Homer, which having been a long time diſperſed in pieces and fragments, were at length by Piſiſtratus's order digeſted into books called *rhapſodies*, from ραπτω *ſuo*, and ωδη *canticum*. Hence, among moderns, *rhapſody* is alſo uſed for an aſſemblage of paſſages, thoughts, and authorities, raked together from divers authors, to compoſe ſome new piece.

RHE, or Ree, a little iſland in the bay of Biſcay, near the coaſt of Aunis in France. It was taken during the war with France which ended in 1763, in the expedition commanded by Hawke and Mordaunt.

RHEA americana. The American oſtrich of authors has been frequently mentioned, but till of late years very imperfectly known. See Ornithology *Index*.

RHEEDIA, a genus of plants belonging to the polynadria claſs, and in the natural method ranking with thoſe of which the order is doubtful. See Botany *Index*.

RHEGIUM, in *Ancient Geography*, ſo very ancient a city as to be ſuppoſed to take its name from the violent burſting of the coaſt of Italy from Sicily, thought to have been formerly conjoined (Mela, Virgil). A city of the Bruttii, a colony of Chalcidians from Eubœa: a ſtrong barrier oppoſed to Sicily (Strabo); mentioned by Luke; ſurnamed *Julium* (Ptolemy), from a freſh ſupply of inhabitants ſent hither by Auguſtus, after driving Sextus Pompeius out of Sicily (Strabo); and thus was in part a colony, retaining ſtill the right of a municipium (Inſcription). The city is now called *Reggio*, in the Farther Calabria.

RHEIMS, a city of France, in the department of Marne, and capital of Rhemois. It is one of the moſt ancient, celebrated, and largeſt places in the kingdom, had an archbiſhop's ſee, whoſe archbiſhop was a duke and peer of France. It is about four miles in circumference, and contains ſeveral fine ſquares, well-built houſes, and magnificent churches. It had a mint, an univerſity, and five abbeys, the moſt famous of which is that of St Remy. There are alſo ſeveral triumphal arches and other monuments of the Romans. It is ſeated on the river Veſle, on a plain ſurrounded by hills, which produce excellent wine. E. Long. 4. 8. N. Lat. 49. 14.

RHENISH wine, that produced on the hills about Rheims. This wine is much uſed in medicine as a ſolvent of iron, for which it is well calculated on account of its acidity. Dr Percival obſerves, that it is the beſt ſolvent of Peruvian bark; in which, however, he thinks its acidity has no ſhare, becauſe an addition of vinegar to water does not augment its ſolvent power.

RHETORES, amongſt the Athenians, were ten in number, elected by lot to plead public cauſes in the ſenate-houſe or aſſembly. For every cauſe in which they were retained, they received a drachm out of the public money. They were ſometimes called Συνηγοροι, and their fee το Συνηγορικον. No man was admitted to this office before he was 40 years of age, though others ſay 30. Valour in war, piety to their parents, prudence in their affairs, frugality, and temperance, were neceſſary qualifications for this office, and every candidate underwent an examination concerning theſe virtues, previous to the election. The orators at Rome were not unlike the Athenian rhetores. See Orator.

RHETORIANS, a ſect of heretics in Egypt, ſo denominated from Rhetorius their leader. The diſtinguiſhing tenets of this hereſiarch, as repreſented by Philaſtrius, was, that he approved of all the hereſies before him, and taught that they were all in the right.

RHETORIC, the art of ſpeaking copiouſly on any ſubject, with all the advantages of beauty and force. See Oratory.

RHEUM, a thin ſerous humour, occaſionally oozing out of the glands about the mouth and throat.

Rheum, *Rhubarb;* a genus of plants of the enneandria claſs, and in the natural method ranking under the 12th order, *Holoraceœ*. See Botany and Materia Medica *Index*. Here, after enumerating the ſpecies, we ſhall introduce what has been ſaid on the cultivation of this valuable plant. There are five ſpecies, viz. 1. The rhaponticum, or common rhubarb, has a large, thick, fleſhy, branching, deeply-ſtriking root, yellowiſh within; crowned by very large, roundiſh, heart-ſhaped ſmooth leaves, on thick, ſlightly-furrowed foot-ſtalks; and an upright ſtrong ſtem, two or three feet high, adorned with leaves ſingly, and terminated by thick cloſe ſpikes of white flowers. It grows in Thrace and Scythia, but has been long in the Engliſh gardens. Its root affords a gentle purge. It is, however, of inferior quality to ſome of the following ſorts; but the plant being aſtringent, its young ſtalks in ſpring, being cut and peeled, are uſed for tarts. 2. The palmatum, palmated-leaved true Chineſe rhubarb, hath a thick fleſhy root, yellow within; crowned with very large palmated leaves, being deeply divided into acuminated ſegments, expanded like an open hand; upright ſtems, five or ſix feet high or more, terminated by large ſpikes of flowers. This is now proved to be the true foreign rhubarb, the purgative quality of which is well known. 3. The compactum, or Tartarian rhubarb, hath a large, fleſhy, branched root, yellow within; crowned by very large, Rheum. heart-ſhaped ſomewhat lobated, ſharply indented, ſmooth leaves, and an upright large ſtem, five or ſix feet high, garniſhed with leaves ſingly, and branching above; having all the branches terminated by nodding panicles of white flowers. This has been ſuppoſed to be the true rhubarb; which, however, though of ſuperior quality to ſome ſorts, is accounted inferior to the rheum palmatum. 4. The undulatum, undulated, or waved-leaved Chineſe rhubarb, hath a thick, branchy, deep-ſtriking root, yellow within; crowned with large, oblong, undulate, ſomewhat hairy leaves, having equal foot-ſtalks, and an upright firm ſtem, four feet high; garniſhed with leaves ſingle, and terminated by long looſe ſpikes of white flowers. 5. The Arabian ribes, or currant rhubarb of Mount Libanus, has a thick fleſhy root, very broad leaves, full of granulated protuberances, and with equal foot-ſtalks, and upright firm ſtems, three or four feet high, terminated by ſpikes of flowers, ſucceeded by berry-like ſeeds, being ſurrounded by a purple pulp. All theſe plants are perennial in root, and the leaves and ſtalks are annual. The roots being thick, fleſhy, generally divided, ſtrike deep into the ground; of a browniſh colour without and yellow within: the leaves riſe in the ſpring, generally come up in a large head folded together, gradually expanding themſelves, having thick foot-ſtalks, ; and grow from one to two feet high, or more in length and breadth, ſpreading all round: amidſt them riſe the flower-ſtems, which are garniſhed at each joint by one leaf, and are of ſtrong and expeditious growth, attaining their full height in June, when they flower; and are ſucceeded by large triangular ſeeds, ripening in Auguſt. Some plants of each ſort merit culture in gardens for variety; they will effect a ſingularity with their luxuriant foliage, ſpikes, and flowers; and as medical plants, they demand culture both for private and public uſe.

They are generally propagated by ſeeds ſown in autumn ſoon after they are ripe, or early in the ſpring, in any open bed of light deep earth; remarking, thoſe intended for medical uſe ſhould generally be ſowed where they are to remain, that the roots, being not diſturbed by removal, may grow large. Scatter the ſeeds thinly, either by broad-caſt all over the ſurface, and raked well in; or in ſhallow drills a foot and half diſtance, covering them near an inch deep. The plants will riſe in the ſpring, but not flower till the ſecond or third year; when they, however, are come up two or three inches high, thin them to eight or ten inches, and clear out all weeds; though thoſe deſigned always to ſtand ſhould afterwards be hoed out to a foot and a half or two feet diſtance: obſerving, if any are required for the pleaſure ground, &c. for variety, they ſhould be tranſplanted where they are to remain in autumn, when their leaves decay, or early in ſpring, before they ſhoot: the others remaining where ſowed, muſt have the ground kept clean between them; and in autumn, when the leaves and ſtalks decay, cut them down, and ſlightly dig the ground between the rows of plants, repeating the ſame work every year. The roots remaining, they increaſe in ſize annually: and in the ſecond or third year many of them will ſhoot up ſtalks, flower, and perfect ſeeds; and in three or four years the roots will be arrived to a large ſize; though older roots are generally preferable for medical uſe.

In Mr Bell's Travels we have an account of ſome curious particulars relating to the culture of rhubarb. He tells us, that the beſt rhubarb grows in that part of Eaſtern Tartary called *Mongalia*, which now ſerves as a boundary between Ruſſia and China. The marmots contribute greatly to the culture of the rhubarb. Wherever you ſee 10 or 20 plants growing, you are ſure of finding ſeveral burrows under the ſhades of their broad-ſpreading leaves. Perhaps they may ſometimes eat the leaves and roots of this plant; however, it is probable the manure they leave about the roots contributes not a little to its increaſe; and their caſting up the earth, makes it ſhoot out young buds and multiply. This plant does not run, and ſpread itſelf, like docks and others of the ſame ſpicies; but grows in tufts, at uncertain diſtances, as if the ſeeds had been dropped with deſign. It appears that the Mongals never accounted it worth cultivating; but that the world is obliged to the marmots for the quantities ſcattered, at random, in many parts of this country: for whatever part of the ripe ſeed happens to be blown among the thick graſs, can very ſeldom reach the ground, but muſt there wither and die; whereas, ſhould it fall among the looſe earth thrown up by the marmots, it immediately takes root, and produces a new plant.

After digging and gathering the rhubarb, the Mongals cut the large roots into ſmall pieces, in order to make them dry more readily. In the middle of every piece they ſcoop a hole, through which a cord is drawn, in order to ſuſpend them in any convenient place. They hang them, for the moſt part, about their tents, and ſometimes on the horns of their ſheep. This is a moſt pernicious cuſtom, as it deſtroys ſome of the beſt part of the root; for all about the hole is rotten and uſeleſs; whereas, were people rightly informed how to dig and dry this plant, there would not be one pound of refuſe in an hundred; which would ſave a great deal of trouble and expence, that much diminiſh the profits on this commodity. At preſent, the dealers in this article think theſe improvements not worthy of their attention, as their gains are more conſiderable on this than on any other branch of trade. Perhaps the government may hereafter think it proper to make ſome regulations with regard to this matter.

Two ſorts of rhubarb are met with in the ſhops. The firſt is imported from Turkey and Ruſſia, in roundiſh pieces freed from the bark, with a hole through the middle of each; they are externally of a yellowiſh colour, and on cutting appear variegated with lively reddiſh ſtreaks. The other, which is leſs eſteemed, comes immediately from the Eaſt Indies in longiſh pieces, harder, heavier, and more compact than the foregoing. The firſt ſort, unleſs kept very dry, is apt to grow mouldy and worm-eaten; the ſecond is leſs ſubject to theſe inconveniences. Some of the more induſtrious artiſts are ſaid to fill up the worm holes with certain mixtures, and to colour the outſide of the damaged pieces with powder of the finer ſorts of rhubarb, and ſometimes with cheaper materials: this is often ſo nicely done, as effectually to impoſe upon the buyer, unleſs he very carefully examines each piece.

The Turkey rhubarb is, among us, univerſally preferred to the Eaſt India ſort, though this laſt is for ſome purpoſes at leaſt equal to the other; it is manifeſtly more aſtringent, but has ſomewhat leſs of an

 aromatic

Rheum.

aromatic flavour. Tinctures drawn from both with rectified spirit have nearly the same taste: on distilling off the menstruum, the extract left from the tincture of the East India rhubarb proved considerably the strongest.

Rhubarb has been cultivated in Britain with considerable success, and for medical purposes is found to equal that of foreign growth, as is proved by the Transactions of the London Society for encouraging Arts, Manufactures, and Commerce, who have rewarded several persons both for cultivating and curing it. In the Transactions for 1792, the gold medal was adjudged to Sir William Fordyce, for raising from seed in the year 1791 upwards of 300 plants of the true rhubarb, or rheum palmatum of the London Pharmacopœia 1788, which in the second and third weeks of October were transplanted into a deep loam, at four feet distance from each other, according to rules laid down by the society. In 1793 it was adjudged to Mr Thomas Jones, from whose papers we derive the following information.

After giving an accurate account of his experiments and observations, he concludes, that the season for sowing is the spring about March or April, or in autumn about August and September; that those plants which are raised in the spring should be transplanted in autumn, and *vice versa*; that they cannot have too much room; that room and time are essentially necessary to their being large, of a good appearance, and perhaps to the increase of their purgative qualities; that to effect these purposes, the soil must be light, loamy, and rich, but not too much so, lest the roots should be too fibrous; that their situation can scarcely be too dry, as more evils are to be expected from a superabundancy of moisture than any actual want of it: and lastly, we may conclude, that in particular the injuries which they are subject to are principally during their infancy, and to be imputed to insects and inattention to the planting season; afterwards, from too great an exposure to frost: but that none can be dreaded from heat; and that in general they are hardy and easy of cultivation, when arrived beyond a certain term.

The method of curing rhubarb, as proposed by Dr Tirruogel of Stockholm, is as follows; "No roots should be taken up till they have been planted ten years: they should be taken out of the ground either in winter, before the frost set in, or in the beginning of spring, and immediately cut into pieces, and carefully barked; let them be spread upon a table for three or four days, and be frequently turned, that the juices may thicken or condense within the roots. After that process, make a hole in each piece, and put a thread through it; by which let them hang separately, either within doors, or in some sheltered shady shed. Some persons dry them in a different way; they inclose the roots in clay, and make a hole in the clay, about the thickness of a goose-quill, and in this manner hang up each piece to dry separately, that the moisture may not evaporate, nor the strength of the root be weakened. But the methods which the Tartars follow is a bad one: they dig the roots out of the deserts where they grow, bark them, and immediately string them, and hang them round the necks of their camels, that they may dry as they travel; but this greatly lessens the medical virtue of the root."

Mr Thomas Halley of Pontefract in Yorkshire, to whom the London Society voted the silver medal in 1793, informs us, that his father tried various experiments for curing rhubarb, as washing, brushing, barking, and peeling, and he dried them in the sun, on a kiln, in a stove, or in a warm kitchen. But of the success of all or either of these methods we have no account, owing to the death of Mr Halley's father. He sent, however, to them five different specimens, which the Society acknowledges to be superior to any rhubarb hitherto cured in England, and produced to them. The roots sent, Mr Halley says, were planted about the year 1781 in a light sandyish soil, but were much neglected. They were taken up in the spring of 1792, and being thoroughly divested of the adhering earth, were placed for some weeks on the floor of a cool warehouse: the fibres were then taken off, cut up, and dried on the flue of a greenhouse; but, from mismanagement, were entirely spoiled. The prime roots were severed in small pieces, peeled clean, and thoroughly cleared of every particle of unsoundness. Part was separately laid in sieves, and the remainder perforated, strung, and suspended in festoons from the cieling of a warm kitchen. The manner of dressing consists in paring off the external coat with a sharp knife, as thin and clean as possible, and then finishing it off by a bit of fish skin, with its own powder; which powder may be procured from the chips and small pieces, either by grinding or pounding it in a large mortar.

In the year 1794 the Society adjudged the gold medal to Mr William Hayward of Hanbury, Oxfordshire, for propagating rhubarb by offsets taken from the crowns of large plants, instead of seeds, for the purpose of bringing it to perfection in a shorter time, which fully answered his expectations. Mr Hayward was a candidate in the year 1789 for the gold medal; but having misunderstood their rules, he was not entitled to it, though with great propriety they voted to him the silver medal; in consequence of which he sent them his method of culture and cure. His method of cultivating Turkey rhubarb from seed is thus explained to the Society: "I have usually sown the seed about the beginning of February, on a bed of good soil (if rather sandy the better), exposed to an east or west aspect, in preference to the south; observing a full sun to be prejudicial to the vegetation of the seeds, and to the plants whilst young. The seeds are best sown moderately thick (broadcast), treading them regularly in, as is usual with parsnips and other light seeds, and then raking the ground smooth. I have sometimes, when the season has been wet, made a bed for sowing the rhubarb seeds upon, about two feet thick, with new dung from the stable, covering it near one foot thick with good soil. The intent of this bed is not for the sake of warmth, but solely to prevent the rising of earth-worms, which, in a moist season, will frequently destroy the young crop. If the seed is good, the plants often rise too thick; if so, when they have attained six leaves they should be taken carefully up (where too close), leaving the standing crop eight or ten inches apart: those taken up may be planted at the same distance, in a fresh spot of ground, in order to furnish other plantations. When the plants in general are grown to the size that cabbage plants are usually set out for a standing crop, they are best planted where they are to remain, in beds four feet wide, one row along the middle of the bed, leaving two yards diſtance betwixt the plants, allowing an alley between the beds about a foot wide, for conveniency of weeding the plants. In the autumn, when the decayed leaves are removed, if the ſhovelings of the alleys are thrown over the crowns of the plants, it will be found of ſervice.

His mode of cultivating the ſame plant by offsets is thus given: "On taking up ſome plants the laſt ſpring, I ſlipped off ſeveral offsets from the heads of large plants: theſe I ſet with a dibble about a foot apart, in order, if I found them thrive, to remove them into other beds. On examining them in the autumn, I was ſurpriſed to ſee the progreſs they had made, and pleaſed to be able to furniſh my beds with 40 plants in the moſt thriving ſtate. Though this was my firſt experiment of its kind, I do not mean to arrogate the diſcovery to myſelf, having known it recently tried by others, but without being informed of their ſucceſs. I have reaſon to think this valuable drug will, by this method, be brought much ſooner to perfection than from ſeed."

His method of curing rhubarb is thus deſcribed: "The plants may be taken up either early in the ſpring, or in autumn, when the leaves are decayed, in dry weather if poſſible, when the roots are to be cleared from dirt (without waſhing): let them be cut into pieces, and with a ſharp knife freed from the outer coat, and expoſed to the ſun and air for a few days, to render the outſide a little dry. In order to accelerate the curing of the largeſt pieces, a hole may be ſcooped out with a penknife: theſe and the ſmaller parts are then to be ſtrung on packthread, and hung up in a warm room (I have always had the conveniency of ſuch a one over a baker's oven), where it is to remain till perfectly dry. Each piece may be rendered more ſightly by a common file, fixing it in a ſmall vice during that operation: afterwards rub over it a very fine powder, which the ſmall roots furniſh in beautiful perfection, for this and every other purpoſe where rhubarb is required."

In the year 1794, too, the Society adjudged the gold medal to Mr Ball for his method of curing the true rhubarb, which is as follows: "I take the roots up when I find the ſtalks withering or dying away, clean them from the earth with a dry bruſh, cut them in ſmall pieces of about four or five inches in breadth, and about two in depth, taking away all the bark, and make a hole in the middle, and ſtring them on packthread, keeping every piece apart; and every morning, if the weather is clear and fine, I place them in the open part of the garden, on ſtages, erected by fixing ſmall poſts about ſix feet high in the ground, and ſix feet aſunder, into which I fix horizontal pegs, about a foot apart, beginning at the top; and the rhubarb being ſtringed croſswiſe on ſmall poles, I place them on theſe pegs; ſo that if it ſhould rain, I could eaſily remove each pole with the ſuſpended pieces, into any covered place. I never ſuffer them to be out at night, as the damps at this ſeaſon would be apt to mould them; and if at any time I perceive the leaſt mark of mould, I rub it off with a dry cloth. In ſome of the pieces of rhubarb which I have cured this year, I have made holes about half an inch diameter in the middle, for the free paſſage of air, and have found that every one of theſe pieces dried better than the others where no ſuch holes were made; and have likewiſe hung ſeveral ſtrings in the kitchen, and never expoſed them in the open air, and found them to dry exceedingly well, and much better than thoſe in the open air. Some years ſince I dried a quantity of rhubarb on a malt-kiln, keeping up the thermometer to 80 degrees, which anſwered well, but I think rather dried too quick: the roots which I have cured this year are a part of the plantation of 1789, and for which the Society was ſo kind as to give me a medal (A)."

RHEXIA, a genus of plants belonging to the octandria claſs; and in the natural method ranking with thoſe of the 17th order, *Calycanthemæ*. See BOTANY *Index*.

RHINANTHUS, a genus of plants belonging to the didynamia claſs; and in the natural method ranking under the 40th order, *Perſonatæ*. See BOTANY *Index*.

RHINE, a large river of Germany, famous both in ancient and modern hiſtory. It riſes among the Alpes Lepontiæ, or Griſons; and firſt traverſing the Lacus Acronius, divides the Rhæti and Vindelici from the Helvetii, and then the Germans from the Gauls and Belgæ; and running from ſouth to north for the greateſt part of its way, and at length bending its courſe weſt, it empties itſelf at ſeveral mouths (Cæſar); at three mouths into the German ocean, (Pliny); viz. the weſtern, or Helius; the northern, or Fleuvus; and the middle between both theſe, which retains the original name, *Rhenus;* and in this Ptolemy agrees.—Mela and Tacitus mention two channels, and as many mouths, the right and left; the former running by Germany, and the latter by Gallia Belgica: and thus alſo Aſinius Pollio, and Virgil; the cut or trench of Druſus not being made in their time, whereby the middle channel was much drained and reduced, and therefore overlooked by Tacitus and Mela; and which Pliny calls the *Scanty*. To account for Cæſar's ſeveral mouths, is a matter of no ſmall difficulty with the commentators; and they do it no otherwiſe than by admitting that the Rhine naturally formed ſmall drains or rivulets from itſelf; the cut of Druſus being long poſterior to him; in whoſe time Aſinius Pollio, quoted by Strabo, who agrees with him therein, affirmed that there were but two mouths, finding fault with thoſe who made them more: and he muſt mean the larger mouths, which emitted larger ſtreams. The Romans, eſpecially the poets, uſed the term *Rhenus* for *Germany*, (Martial). —At preſent, the river, after entering the Netherlands at Schenkinhaus, is divided into ſeveral channels, the two largeſt of which obtain the names of the *Lech* and the *Waal*, which running through the United Provinces, falls into the German ocean below Rotterdam.

Lower Circle of the RHINE, conſiſts of the palatinate of the Rhine, and the three eccleſiaſtical electorates, viz. thoſe of Cologne, Mentz, and Triers.

Upper Circle of the RHINE, conſiſted of the landgraviates of Alſace and Heſſe, comprehending the Weteraw;

(A) The Society alſo adjudged to Mr Ball the medal in 1790, for cultivating rhubarb.

Rhineberg || Rhinegau.

raw; but now only Heſſe can be accounted a part of Germany, Alſace being long ago united to France.

RHINEBERG, a town of Germany, in the circle of the Lower Rhine, and dioceſe of Cologne. It was in the poſſeſſion of the French, but reſtored to the archbiſhop of Cologne by the treaty of Utrecht. It is ſeated on the Rhine, in E. Long. 6. 39. N. Lat. 51. 30.

RHINECK, a town of Germany, in the archbiſhopric of Cologne, ſeated on the Rhine, E. Long. 7. 53. N. Lat. 50. 27.—There is another town of the ſame name in Swiſſerland, capital of Rhinthal, ſeated on the Rhine, near the lake of Conſtance, with a good caſtle. E. Long. 9. 53. N. Lat. 47. 38.

RHINFELD, a ſmall but ſtrong town of Germany, in the circle of Suabia, and the beſt of the four foreſt-towns belonging to the houſe of Auſtria. It has been often taken and retaken in the German wars; and is ſeated on the Rhine, over which there is a handſome bridge. E. Long. 7. 53. N. Lat. 47. 40.

RHINEGAU, a beautiful diſtrict of the electorate of Mentz, is ſituated on the Rhine, about three miles from the city of Mentz, and is ſo populous that it looks like one entire town intermixed with gardens and vineyards. The Rhine here grows aſtoniſhingly wide, and forms a kind of ſea, near a mile broad, in which are ſeveral well wooded little iſlands. The Rhinegau forms an amphitheatre, the beauties of which are beyond all deſcription. At Walluf, the very high hills come nearly down to the river ſide; from thence they recede again into the country, forming a kind of half circle, the other end of which is 15 miles on at Rudeſheim, on the banks of the Rhine. The banks of the river, the hills which form the circles, and the ſlopes of the great mountains, are thick ſown with villages and hamlets. The white appearance of the buildings, and the fine blue ſlated roofs of the houſes playing amidſt the various green of the landſcape, have an admirable effect. In the ſpace of every mile, as you ſail down the river, you meet with a village which in any other place would paſs for a town. Many of the villages contain from 300 to 400 families; and there are 36 of them in a ſpace of 15 miles long and ſix miles broad, which is the width of this beautiful amphitheatre. The declivities of all the hills and mountains are planted thick with vineyards and fruit trees, and the thick wooded tops of the hills caſt a gloomy horror over the otherwiſe cheerful landſcape. Every now and then a row of rugged hills run directly down to the ſhore, and domineer majeſtically over the leſſer hills under them. On one of theſe great mountains, juſt about the middle of the Rhinegau, you meet *Johannis-Berg*, a village which produces ſome of the beſt Rheniſh. Before this village is a pretty little riſing, and near the banks of the river there is a very fine old caſtle, which gives unſpeakable majeſty to the whole landſcape. Indeed, in every village, you meet with ſome or other large building, which contributes very much to the decoration of the whole. This country is indebted for its riches to this ſemicircular hill, which protects it from the cold winds of the eaſt and north, at the ſame time that it leaves room enough for the ſun to exerciſe his benign influences. The groves and higher ſlopes of the hills make excellent paſtures, and produce large quantities of dung, which, in a country of this ſort, is of ineſtimable value.

Reiſbach's Travels through Germany, iii. 226.

The bank of the Rhine, oppoſite to the Rhinegau, is exceedingly barren, and heightens the beauty of the proſpect on the other ſide by the contraſt it exhibits; on this ſide, you hardly meet above three or four villages, and theſe are far diſtant from each other. The great interval between them is occupied by heaths and meadows, only here and there a thick buſh affords ſome ſhade, and a few corn fields among the villages enliven the gloomy landſcape. The back ground of this country is the moſt pictureſque part of it. It is formed by a narrow gullet of mountains, which diminiſh in perſpective between Rudeſheim and Bingen. Perpendicular mountains and rocks hang over the Rhine in this place, and ſeem to make it the dominion of eternal night. At a diſtance, the Rhine ſeems to come out of this landſcape through a hole under ground; and it appears to run tediouſly, in order to enjoy its courſe through a pleaſant country the longer. Amidſt the darkneſs which covers this back ground, the celebrated Mouſe towers ſeems to ſwim upon the river. In a word, there is not any thing in this whole tract that does not contribute ſomething to the beauty and magnificence of the whole; or, if I may be permitted the expreſſion, to make the paradiſe more welcome. As you ſail along the Rhine, between Mentz and Bingen, the banks of the river form an oval amphitheatre, which makes one of the richeſt and moſt pictureſque landſcapes to be ſeen in Europe. The inhabitants of theſe regions are ſome of them extremely rich, and ſome extremely poor. The happy middle ſtate is not for countries the chief product of which is wine; for, beſides that the cultivation of the vineyard is infinitely more troubleſome and expenſive than agriculture, it is ſubjected to revolutions, which in an inſtant reduce the holder of land to the condition of a day-labourer. It is a great misfortune for this country, that, though reſtrained by law, the nobility are, through connivance of the elector, allowed to purchaſe as much land as they pleaſe. The peaſant generally begins by running in debt for his vineyard; ſo that if it does not turn out well, he is reduced to day-labour, and the rich man extends his poſſeſſions to the great detriment of the country. There are ſeveral peaſants here, who having incomes of 30,000, 50,000, or 100,000 guilders a-year, have laid aſide the peaſant, and aſſumed the wine-merchant; but, ſplendid as their ſituation is, it does not compenſate, in the eyes of the humane man, for the ſight of ſo many poor people with which the villages ſwarm. In order to render a country of this kind proſperous, the ſtate ſhould appropriate a fund to the purpoſe of maintaining the peaſant in bad years, and giving him the aſſiſtance which his neceſſities, and his want of ready money, may from time to time make convenient.

The inhabitants of the Rhinegau are a handſome and uncommonly ſtrong race of men. You ſee at the very firſt aſpect that their wine gives them merry hearts and ſound bodies. They have a great deal of natural wit, and a vivacity and jocoſeneſs, which diſtinguiſhes them very much from their neighbours. You need only compare them with ſome of theſe, to be convinced that the drinker of wine excels the drinker of beer and water, both in body and mind, and that the inhabitant of the ſouth is much ſtouter than he who lives in the north; for though the wine-drinker may not have quite as much fleſh as he who drinks only beer, he has better blood,

blood, and can bear much more work. Tacitus had already obferved this, in his treatife *De moribus Germanorum.* "The large and corpulent bodies of the Germans (fays he) have a great appearance, but are not made to laft." At that time almoft all the Germans drank only water; but the mere drinking of wine has effected a revolution in feveral parts of Germany, which makes the prefent inhabitants of thefe countries very different from thofe defcribed by Tacitus. Black and brown hair is much commoner here than the white, which made the Germans fo famous in old Rome. "It will be eafily imagined (fays Baron Reifbeck), that the monks fare particularly well in fo rich a country. We made a vifit to the prelate of Erbach. Thefe lordly monks, for fo in every refpect they are, have an excellent hunt, rooms magnificently furnifhed, billiard tables, half a dozen beautiful finging women, and a ftupendous wine cellar, the well ranged batteries of which made me fhudder. A monk, who faw my aftonifhment at the number of the cafks, affured me, that, without the benign influence which flowed from them, it would be totally impoffible for the cloifter to fubfift in fo damp a fituation."

RHINFELD, a caftle of Germany, in the circle of the Lower Rhine, in a county of the fame name. It is looked upon as one of the moft important places feated on the Rhine, as well in regard to its ftrength as fituation. It is near St Goar, and built on a craggy rock. This fortrefs commands the whole breadth of the Rhine, and thofe who pafs are always obliged to pay a confiderable toll. In the time of war it is of great importance to be mafters of this place. It was taken by the French in 1794. E. Long. 7. 43. N. Lat. 50. 3.

RHINLAND, a name given to a part of South Holland, which lies on both fides of the Rhine, and of which Leyden is the capital town.

RHINOCEROS, a genus of quadrupeds belonging to the order of belluæ. See MAMMALIA *Index*.

RHINOCEROS-Bird. See BUCEROS, ORNITHOLOGY *Index*.

RHITYMNA. See RETIMO.

RHIZOBALUS, a genus of plants, belonging to the polyandria clafs; and in the natural method ranking under the 23d order, *Trihilatæ*. Of this there is only one fpecies, viz. *Pekia*. The nuts are fold in the fhops as American nuts; they are flat, tuberculated, and kidney-fhaped, containing a kernel of the fame fhape, which is fweet and agreeable. Clufius gives a good figure of the nut, and Aublet has one of the whole plant.

END OF THE SEVENTEENTH VOLUME.

DIRECTIONS FOR PLACING THE PLATES OF VOL. XVII.

PART I.

PART II.