WORKSHOP NOTES

FOR

JEWELERS & WATCHMAKERS

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BEING A COLLECTION OF THE LATEST PRACTICAL RECEIPTS ON THE MANUFACTURE AND REPAIRING OF WATCHES AND CLOCKS, AND ON THE VARIOUS PROCESSES ENTERING INTO THE MANUFACTURE AND REPAIRING OF JEWELRY, AS COLORING, POLISHING, ENAMELING, ANNEALING, OXYDIZING, ETC.; IN SHORT, A THOROUGH COMPENDIUM OF THE NUMEROUS MECHANICAL DEPARTMENTS OF THE JEWELERS' AND WATCHMAKERS' SHOP. . . . . . .

BY

ONE WHO HAS CONTRIBUTED SUCH MATTER TO THE JEWELERS' CIRCULAR FOR TWELVE YEARS.

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PREFACE.

SUBSCRIBERS to THE JEWELERS' CIRCULAR are well aware that since the appearance of its first number, 22 years ago, it has succeeded in collecting on its editorial staff writers second to none in this or any other country, and that its columns have contained technical instruction of a high order on the subjects of horology, jewelry, optics, and the kindred branches, both useful to the apprentice and the accomplished workman at the bench.

The management of THE JEWELERS' CIRCULAR has been repeatedly urged to collect and publish these articles, and issue them in book form, as they were considered to be too valuable to pass away.

The volume presented herewith is the result of these solicitations. It will be found to contain numerous valuable additions to the extracts from THE JEWELERS' CIRCULAR.

THE WATCH.

IT is well, perhaps, that we preface the more minute treatment of the watch in this work with a few cursory remarks.

It is the common verdict of both watchmakers and laymen that a well-constructed lever is the best for all practical purposes. A pocket chronometer is not as reliable, while, if of larger dimensions and furnished with all the possible mechanical appliances, auxiliaries, and improvements, as ship or marine chronometer, it is doubtless the best timepiece constructed. When we say "for practical purposes," it is not meant that the watch may be treated with impunity to any and every indignity, or be used as toy by children, as ladies' watches too often are.

Let us examine any other piece of machinery; how strong and powerful it is in any and all of its parts; still, it is never required to perform one-half of the work of the tiny watch, which unremittingly labors night and day, week day and Sunday, month and year, without intermission or stop, and if it has been duly cared for and considerately treated, it may arrive at the ripe age of one hundred years, while the ponderous machinery is cleaned and oiled repeatedly during the day, hosts of men attend to its wants, and after all it lasts only for a short time.

The watchmaker will readily understand that any external motions exert an important influence upon the vibration, and consequently upon the staff and pivots of the balance. If this external motion occurs in the direction of the vibrating plane of the balance, and a vibration takes place simultaneously in the same direction, the vibration arc is increased; if in the contrary direction, such an arc will be decreased, and it is only without damage to the time-keeping, if the external motion occurs in a vertical direction to the balance axis.

The most ordinary external motions, however, occur in another direction than that of the balance, whereby a sensible pressure is exerted upon the axis of the vibrating mass, productive of an increased friction of the pivots in their bearings, etc., and a retardation, never an acceleration, takes place. In most watches, the pivot holes of which are of ruby, the retard of a watch is much larger, but standing fairly well in ratio with its construction and finish.

A marine chronometer, regulated to an almost imperceptible difference, and having preserved an excellent rate during a long sea voyage, would, when worn as a watch, go too slow, in consequence of the external motions experienced; in fact, it would prove to be inferior to a good detached lever watch. Beside all imaginable auxiliary improvements, these chronometers are in a special box and suspended in such a way that they do, or should, remain in an equal position in all the different motions of the ship.

Watchmakers should recommend to their customers to wind their watches slowly, no matter whether key-winder or stem-winder, avoiding all jerky motions. They should be wound at a stated time in the morning; the watch will then work best during the day, as the spring will exert its best traction power, whereby the external motions to which the watch is exposed during the day's wear is fairly well counterbalanced; this is greatly better than when winding it at night, because it has only the weakened spring to offer as resistance next day. Nor need the breaking of the spring be feared; this is no longer at full tension during the night, and can stand better the ensuing cold.

Let watchmakers recommend to their customers that if they lay their watch at night either at an inclination, flat, or suspended, it should always be done in the same manner—not differing every night. The rate difference between the vertical and horizontal positions is often significant, in second-rate watches sometimes two or three minutes in one night; another vicious way is to suspend a watch from a nail in such a manner that it will rock to and fro like a pendulum, and a watch with a heavy balance will gain, and, *vice versâ*, one with a light one will lose. This lies of course in the nature of things. Similar observations can be made by clocks which are not firm in their case.

The temperature difference between the heat of the pocket and a wall nearly to the freezing point is about 77° to 88° F. and a watch should therefore never be either suspended or laid upon it—least of all an outside wall; the sudden change of temperature may cause the sudden breaking of the spring; also the oil thickens, especially if no longer pure, which cannot help but produce irregularities of rate; if the balance is not compensated, it must gain from this piece of carelessness, and should it possess constructive defects, it may stand still from the cold.

The watch wearer should clean his watch pocket frequently, to free it from accumulating dust and fibers. Even by the cleanest pursuits, a sort of fiber dust will gather in the pocket, caused by the friction of the watch case, and this very easily finds its way into the interior of the watch, and is much more pernicious than common dust, by wrapping around the little component parts, and retarding, sometimes preventing, their motion. No other articles should be carried in the watch pocket, such as keys, coin, etc.; it is often done, yet highly detrimental and careless. Watch crystals may be broken, the case indented, the dial and hands injured, etc. The watch should never be worn against the bony part of the body.

But by even the greatest of care, it is impossible that the watch can go forever without periodical repairs, and it should be cleaned once a year. All manner of machinery requires an occasional supervision, and this should be performed on the watch at least once a year; the oil has dried up by this time, and become mixed with particles of metallic dust, which acts like emery. The writer, during a long practice, has had occasion to manipulate costly watches, and several of them were almost ruined beyond repair by having run beyond the time. They generally belonged to people who were afraid to trust their timepieces to indifferent workmen, and sooner risked the consequences.

If the repairing watchmaker urges these points, and many, many more, upon his circle of customers, he may in time succeed in educating them into treating their watches with a little more consideration than is generally allotted them, to the satisfaction both of the repairer and the owner.

THE LEVER ESCAPEMENT.

A REVIEW of the different watch escapements is highly instructive, and an astonishing amount of ingenuity has often been put forth in their construction; nevertheless, practice has shown that all except four, to wit: the verge, cylinder, anchor or lever, and chronometer escapements, are unreliable. The verge is fast becoming obsolete, and only the last three are left. The escapement most universally used to-day is the lever, and is claimed to be an English invention, said to have been made in 1770, by Mr. Thos. Mudge; others accredit it to Tompion, and date its invention to 1695. The Swiss also claim the invention. It is very possible that it was invented simultaneously about the same time in England and Switzerland, and although the general form and principles to-day are the same, they varied largely about 100 years ago, at which time the Swiss construction rightfully deserved the name of "anchor" escapement, from its peculiar form, while the English called theirs "lever" escapement, with every show of reason; both appellations are still dominant in these two countries.

We borrow the description and action of the escapement from the excellent work on watchmaking by Mr. F. J. Britten, omitting the illustrations, as every watchmaker is so thoroughly acquainted with the functions and performance of the parts that an illustration is unnecessary. The cut shows the most usual form of the English lever escapement, in which the pallets scape over three teeth of the wheel. A tooth of the escape wheel is at rest upon the locking-face of the entering left-hand pallet. The impulse pin has just entered the notch of the lever and is about to unlock the pallet. The action of the escapement is as follows: The balance which is attached to the same staff as the roller, is traveling in the direction indicated by the arrow, which is around the roller, with sufficient energy to cause the impulse pin to move the lever and pallets far enough to release the wheel tooth from the locking-face, and allow it to enter on the impulse face of the pallet. Directly it is at liberty, the escape wheel, actuated by the mainspring of the watch, moves round the same way as the arrow, and pushes the pallets out of its path. By the time the wheel tooth has arrived at the end of the impulse face of the pallet, its motion is arrested by the exit or right-hand pallet, the locking-face of which has been brought into position to receive another tooth of the wheel. When the pallet was pushed aside by the wheel tooth, it carried with it the lever, which in its turn communicated a sufficient blow to the impulse pin to send the balance with renewed energy on its vibration, so that the impulse pin has the double office of unlocking the pallets by giving a blow on one side of the notch of the lever, and of immediately receiving a blow from the opposite side of the notch. The balance proceeds on its excursion, winding up, as it goes, the balance spring, until its energy is expended. After it is brought to a state of rest, its motion is reversed by the uncoiling of the balance spring, the impulse pin again enters the notch of the lever, but from the opposite direction, and the operation already described is repeated. The object of the safety pin is to prevent the wheel from being unlocked except when the impulse pin is in the notch of the lever. The banking pins keep the motion of the lever within the desired limits. They should be placed where every blow from the impulse pin on to the outside of the lever is received direct. They are sometimes placed at the tail of the lever, but in that position the locking pins receive the blow through the pallets, staff pivots, which are liable to be broken in consequence.

The escape wheel has fifteen teeth, and the distance between the pallets, from center to center, is equal to 60° of the circumference of the wheel. The pallets are planted as closely as possible to the wheel, so that the teeth of the wheel, in passing, just clear the belly of the pallets.* The width of each pallet is made as nearly as possible half the distance between one tooth of the escape wheel and the next. As the teeth of the wheel must be of an appreciable thickness and the various pivots must have shake, it is not found practicable to get the pallets of greater width than 10° of the circumference of the wheel, instead of 12°, which would be half the distance between one tooth and the next. This difference between the theoretical and actual width of the pallet is called the "drop." The lever is pinned to the pallets, and has the same center of motion. The distance between the center of the lever and the center of the roller is not absolute. The distance generally adopted is a chord of 96° of a circle representing the path of the tips of the escape-wheel teeth, that is the distance from the tip of one tooth to the tip of the fifth succeeding tooth. The proportion, as it is called, of the lever and roller is usually from 3 to 1 to 3½ to 1. In the former case, the length of the lever (measured from the center of the pallet staff to the center of impulse pin or mouth of notch) is three times the distance of the center of the impulse pin from the center of the roller, and in the latter case 3½ times. The portion of the lever to the left of the pallet-staff hole acts as counterpoise.

In this form of the lever escapement the pallets have not less than 10° of motion. Of this amount, 2° are used for locking, and the remainder for impulse. The amount of locking is to some extent dependent on the size of the escapement. With a large escapement, less than 1½° would suffice, while a small one would require more than 2°. The quality of the work, too, is an element in deciding the amount of locking. The lighter the locking the better, but it must receive every tooth of the wheel safely, and where all the parts of the escapement are made with care, the escapement can be made with a light locking, 10° pallets, with a lever and roller 3 to 1, give a balance arc of 30°, that is to say, the balance in its vibration is freed from the escapement except during 30°, when the impulse pin is in contact with the lever.

Presuming that the staff hole is correctly

* When the tooth is pressing on the locking, the line of pressure should pass through the center of the pallet staff. But as the locking-surface of the two pallets are not equidistant from the center of motion, a tangent drawn from the locking corner of one pallet would be wrong for the other, and as a matter of fact, if a diagram is made it will be found that even when the pallets are planted as close as possible they are hardly as close as they should be for the right-hand pallet. To plant as close as possible is therefore a very good rule and is the one adopted by the best pallet makers.

drilled with relation to the planes, a rough rule for testing 10° pallets is that a straight edge laid on the plane of the entering pallet, should point to the locking corner of the exit pallet.

When from setting the hands of a watch back, or from a sudden jerk, there is a tendency for the pallets to unlock, the safety pin butts against the edge of the roller. It will be observed that when the impulse pin unlocks the pallets, the safety pin is allowed to pass the roller by means of the crescent which is cut out of the roller opposite to the impulse pin. The teeth of the escape wheel make a considerable angle with a radial line (24°), so that their tips only touch the locking-faces of the pallets. The locking-faces of the pallets, instead of being curves struck from the center of motion of the pallets, as would be otherwise the case, are cut back at an angle, so as to interlock with the wheel teeth.* This is done so that the safety pin shall not drag on the edge of the roller, but be drawn back till the lever touches the banking pin. When the operation of setting the hands back is finished, or the other cause of disturbance removed, the pressure of the wheel tooth on the locking-face of the pallet draws the pallet into the wheel as far as the banking pin will allow. The amount of this "run" should not be more than sufficient to give proper clearance between the safety pin and the roller, for the more the run the greater is the resistance to unlocking. This rule is sometimes sadly transgressed and occasionally the locking is found to be, from excessive run, almost equal in extent to the impulse. It will generally be found that in these cases the escapement is so badly proportioned that the extra run has had to be given to secure a sound safety action. In common watches, the safety action is a frequent source of trouble. The more the path of the safety pin intersects the edge of the roller, the sounder is the safety action, and if the intersection is small, the safety pin is likely to jam against the edge of the roller, or even to pass it altogether.

With an ordinary single-roller escapement, a sound safety action cannot be obtained with a less balance arc than 30°. Even with a balance arc of 30°, the roller must be kept small in the following way to insure the soundness of the safety action. The hole for the impulse pin must not be left round. After it is drilled, a punch of the same shape as the impulse pin—that is, with one third of its diameter flattened off—should be inserted and the edge of the roller, where the crescent is to be formed, beaten in. By this means, the roller can be turned down small enough to get a sufficient intersection for the safety pin.

It is useful in estimating the balance arc of a watch to remember, if it has a three-armed balance, that 30° is one-fourth of the distance between two arms. With a compensation balance, a third of the distance between two of the quarter screws is 30°.

* The locking face forms an angle of 6° to 8° with a tangent to a circle representing the path of the locking corner.

THE CLUB-TOOTH LEVER ESCAPEMENT.

WATCHMAKERS know well that this form of escapement is almost exclusively used in all the countries on the continent, and since many specimens of it come to the workbench of the American repairer, it is well perhaps to turn our attention to it. The readers of the CIRCULAR WORKSHOP NOTES are well aware that the club-tooth escapement principally differs from the ratchet tooth in having the action divided between the pallet and the tooth, both having inclined impulse faces. The club tooth has also an advantage in closer escaping, the back of the tooth being undercut, thereby allows the pallet to pass inward at the back of the tooth, thus giving from one-half to a full degree more impulse arc in the scape wheel action, although no more in the pallet action.

The action of this style of escapement is a little more complex and difficult to understand than the ratchet tooth, but is quite as easy to repair if once the principle is understood. The American and Swiss watches have almost universally this form of escapement, consequently four-fifths of the watches the watchmaker has to repair are either of the one or the other of these makes. The American watch, being provided with exposed pallets set in slots, can be moved and manipulated until a near approximation of the correct action is obtained. This ease of change and adjustment, although very nice for those who thoroughly understand the principles involved, is very vexatious to those who are so unfortunate as to lack this knowledge. American scape wheels of all the factories are nearly duplicates of each other, so are also the pallet stones, consequently there are but few changes which need to be made except in setting the pallet stones.

The American watches made by the several factories have different methods of arriving at similar results. One factory acting from their convictions assume they can overcome slight inaccuracies by one method, while another insists their system is best. The most frequent disarrangement to which the American lever is subject is the breaking or loss of the jewel pin and the loosening and loss of a pallet stone.

INSPECTION OF THE CYLINDER ESCAPEMENT.

THIS form of escapement is also known as the horizontal, so called from the fact of the escape wheel lying horizontally, in distinction from the verge or vertical escapement. This escapement was invented by Tampion and perfected by Graham, early in the last century; it is now almost exclusively employed in watches made on the continent, the English turning their attention more toward patent levers. Movements of the flattest kind have cylinder escapements. The axis of the balance is a hollow cylinder, cut away to allow the passage of the scape wheel teeth. Though excellent for ordinary pocket watches, the cylinder escapement cannot be said to equal the lever and some others, where greater accuracy is required. The drop of the escapement is the cause of much trouble to watch repairers, but the following means will enable them to ascertain how far the drops are equal and correct:

The movement being slightly wound up, with a fine wire or strip of paper turn the balance till a tooth falls; now, try how much shake the escape wheel has, and allow the tooth to escape; then try again and go all round the wheel, to see how all the teeth and spaces agree in size. To correct any inequality is certainly a job for an expert hand, and directions will not avail much unless to an expert. When the tooth contained within the cylinder has no freedom and rubs at the point and heel, there is no internal drop; when the tooth has escaped and the cylinder shell rubs on the point of one tooth and the heel of the next, then there is no outside drop. The internal drop is increased by reducing the length of the teeth, the external by increasing the space between the teeth. When the drop is very slight, the watch is very liable to stop through the excessive friction; in the case of unequal drop the rate of a watch cannot be maintained, and occasional stoppages will occur.

This fault is found by dotting the balance with spots of rouge and carefully noting the vibrations, which, if unequal, indicate unequal drops. Though this is the usual cause, the same effect may be the result of some teeth lifting more than others.

A noisy drop is caused by badly polished surfaces, and in such a case the heel of the cylinder should be carefully noticed. If the pivot holes of the escape wheel are too large an immense amount of trouble will be caused, and, in fact, all the end shakes and side shakes of the cylinder require most careful adjustment. An excess of oil will also cause an infinity of errors to arise and should be most carefully guarded against. The points of the escape wheel teeth may catch in a slight burr, which is sometimes left at the lips of the cylinder, and, of course, would stop the watch. This is remedied by polishing the cylinder and rounding off the points of the scape wheel teeth.

The balance spring should be pinned up to have the escapement in perfect beat. This is done by pinning the stud on the spring so that it is exactly over a dot marked in the balance for the purpose of showing the position. Sometimes the lower corner of the heel of the scape wheel tooth touches the inside cylinder and stops the watch. But all these defects may be seen, or rather felt, by careful trial. If there is any doubt of parts touching where they should not, a spot of rouge put on will at once mark where it touches.

THE CLEANING OF A WATCH.

MANY methods and agents: Benzine and alcohol, cyanide of potassium, etc., are used for cleaning watches, and the horological press occasionally publishes a batch of new ones, so that the practical workman has every reason to look forward to the time when the movement need no longer be taken down, but is cleaned, lubricated and burnished up while the customer is waiting in the shop. But while we anxiously await the invention or discovery of this new method, let us meanwhile discuss, perhaps, the oldest and unexcelled—the washing in soap and water. The washing with a soft brush, warm water and an easily foaming soap is unsurpassed for the gilt parts, as well as the mat ground steel parts of a watch. After washing, the parts are only rinsed in pure alcohol, which dissolves all the particles of soap still adhering, and they are finally dried in sawdust. The original luster is hereby restored to the gilding, and it is necessary merely to lightly dab the pieces with a clean brush and to clean the holes.

Some of our readers will rejoin by saying that this method is too tedious; this is true of shops where the several agents necessary are not at disposal. Every shop should contain a wash table, with alcohol lamp and a small light copper kettle in which to heat the water over the flame. Cold water can also be used, but this will not take off the old oil.

The steel parts are most suitably cleaned in benzine and dried in sawdust. Polished brass parts must previously be retouched with the buffstick.

When all the parts have been taken out of the sawdust, they are finally cleaned in the order in which to be mounted in the movement, so that each cleaned part is at once located in its place upon the plate.

The wheels, and more especially the delicate parts, must, after cleaning, be scrutinized with the magnifier so as to be satisfied that no brush hair or other disturbing element has lodged anywhere. A hair is apt to lodge itself in the slit between the plate and the lower cylinder bridge, and, when transparent, it is easily overlooked. When this hair comes in contact with one of the escapement parts, it naturally will give rise to a very injurious disturbance.

When the plate has been cleaned and the cap jewel plate screwed in place, I clean first the fourth wheel, screw the bridge on, and satisfy myself of the correct end-shake and the perfect freedom of the wheel; the third and center wheels are then mounted; the pivot of the latter wheel is lubricated, the center staff is put into the cannon and the cannon pinion broached.

Some workmen will, after the fourth wheel, mount the scape wheel, and, if the fourth wheel is without seconds pivot, they begin the mounting with the cylinder scape wheel, as the freedom of this wheel is of great importance.

I think that my method is preferable, because it will happen that after the fastening of the cannon pinion a pinching of the center wheel will occur. Such a pinching is, in the absence of the scape wheel, far more easily seen and changed. An accidental trembling of the center staff, also, is more easily corrected.

When the scape wheel has been mounted, and its shake found correct, investigate the smooth action of the train in different positions, by occasionally exerting a slight pressure against the center wheel.

The cylinder bridge is then put together, and the cylinder, with spring, is fastened to the bridge. These parts are put together without oil, and examined whether everything is in thorough order. Only when the cylinder shake, the balance spring, and the drop has been arranged, put oil into the sinks. If too great a quantity is applied, so that it overruns the jewel, the oil will, by capillary action, draw away from the spot where it should be.

When putting together the barrel parts, never forget to lubricate the clickwork, more particularly that of the going barrel, as the injury occasioned thereby would soon show itself. The mainspring is to be lubricated only slightly. The stopfinger should always be fastened with a steel pin; it is more securely retained thereby. The barrel is mounted in the plate, and the spring is wound a few teeth to apply oil to the escapement.

I am of the opinion that it is best to apply a small portion of oil to each cylinder wheel pivot, while other workmen prefer to place a small drop of oil in the cylinder.

The oil placed in the cylinder draws at once to the surface of the plug, and outside of the cylinder up to the collet. It therefore may happen with long cylinders that the teeth receive little or no oil. With short ones it is immaterial in which manner the oil is applied to the escapement, as it will in every case draw upward, because the wheel teeth come very near to the plug surface.

Before the movement is set into the case this must be well cleaned within, because even new cases contain particles of dust and remnants of crocus. The case springs must invariably be taken out and cleaned; a large quantity of filth will often be found round about and behind them, which, if not removed, would fall into the movement. Do the same with the push button.

Only when the movement has been fastened in the case do I apply oil to those pivots which still can be reached. The minute wheel pinion, also, must be slightly moistened, because the pinion runs upon a steel pivot; therefore two steel parts lie against each other, which is apt to engender rust. A spreading spring will generally be necessary for the hour wheel, if the correct shake is not produced itself by the minute work or the hands themselves.

When the hands have been mounted the watch is ready for service, and only requires timing. With a cylinder watch it is well not to put the regulator entirely on "fast," because every such watch, after the course of a few months, has an inclination to lose, and the regulator must stand so that a subsequent difference of rate can be corrected.

The timing of a watch requires so much expert skill that we omit describing it.

TO CLEAN A WATCH.

TAKE the watch *all* apart and immerse in benzine, do not leave the cap jewel and jewel slip attached to cock and potence, or the potence to the plate, etc., but have everything apart so that each piece can be thoroughly cleaned. Take each piece out separately and dry with clean linen rag, and brush all the parts with clean brush, charged with billiard chalk and subsequently rubbed over a bone or dry crust of bread; be very careful to get the jewel holes thoroughly clean and bright, and leave no trace of dust between pinion leaves, wheel teeth, etc.; use watchmaker's tissue paper for holding parts in to clean; this paper is for sale by material dealers for 50 or 60 cents a box, containing 1,000 sheets; it is much better than ordinary tissue paper, as it lasts much longer and there is no "fluff," which is an important consideration. When everything is thoroughly cleaned, put the movement together, oil the mainspring liberally but not excessively; also the fusee pivot holes and the large center hole; be careful not to place so much oil that it will run on the plates or down the arbor, or it will be drawn off and be of little use where it is intended to be. In oiling the balance jewel holes, sharpen up a piece of pegwood and insert in the holes to insure the oil running down on the cap jewels, and then insert a little more oil; also be very careful in oiling scape teeth; too much will get to the body of the wheel, all over the pallets and on to the fork; a little on the tips of the teeth is all that is needed.

If the balance is now inserted and pinned so that the hairspring is flat and concentric and plays evenly between the regulator pins, the watch will start off with a fine motion, and will continue to run well and give the customer the best of satisfaction.

TO CLEAN WATCHES WITH CYANIDE OF POTASSIUM.

BEFORE detailing the process of cleaning a watch with cyanide of potassium, the CIRCULAR cannot desist from cautioning watchmakers who use it; while useful in its place, cyanide is dangerous and must be used with great care—dangerous to the person using it, to the gilding of the parts put into it, if allowed to remain too long—and dangerous to all steel articles around which can be reached by its vapors. If not thoroughly cleaned off, the trace of it remaining on the pieces will evaporize on the watch when put together, and rust the steel works of the movement. With this understanding on the part of the CIRCULAR it details the process of cleaning a watch by the use of cyanide of potassium. A small piece of the cyanide is dissolved in a common drinking glass filled with water, or, what is better, a wide-mouthed bottle with ground stopper. The movement to be cleaned is taken apart, and the balance, the lever, and other steel parts are placed in benzine. If the balance jewels are in settings, they are removed and also placed in the benzine. The plates and wheels are strung on a small brass or copper wire, bent so as to form a catch, similar to a safety pin with the pin part extended to hold it by, and dipped into the cyanide, then well rinsed in clean water (warm water is best), and then in alcohol, and placed in sawdust to dry. When dry, brush only enough to remove the sawdust. The parts in the benzine are cleaned in the usual way.

REPAIRING AND EXAMINING WATCHES.—METHODS.

EXPEDITION and certainty in watchmaking and repairing are primarily secured, says CLAUDIUS SAUNIER, by proceeding on a definite system both in the preliminary examination of the watch and in details of construction or repairing. The best watchmakers, and practical men generally, take their work in a certain order, from which any departure is exceptional. By this means they avoid the necessity of doing work twice over and of frequently taking up the same piece; a circumstance that often occurs with young watchmakers, owing to forgetfulness and to a want of sequence in their ideas. They should from the first accustom themselves to working methodically on a definite system.

It must, however, be understood that no method can be inflexible, nor can it be equally advantageous for different individuals, because men differ in regard to manual dexterity, goodness of eyesight and of memory, power of associating their ideas, etc. A system that is suitable to a person of unexcitable temperament will have to be modified by one who is oppositely disposed. Every one will be able to decide for himself as to the best system to adopt and the order in which to take up his daily work. These preliminary observations appear necessary, because the method explained below of examining a Geneva watch has been regarded by some as too long and minute. We would urge any young watchmaker who hears such ideas advanced to assure himself that it is a mistake, because the system here explained is only put forward subject to the modifications that experience suggests; and it is to be observed that many of the operations given can be performed more rapidly than they can be described.

When a watchmaker experiences a great loss of time, does it not usually arise from the fact that he is obliged to take a watch down, or nearly so, after its repairing and examination were thought to have been completed; or when a watch that has been repaired is brought back to be examined before the ordinary period of cleaning has elapsed? Let him add together the numerous hours spent in this kind of thankless work, let him sum up the worries experienced, and the discredit, etc., to which he has been subjected, and he will see that systematic work would have saved him both loss of money and loss of credit.

EXTERNAL EXAMINATION OF THE WATCH.

IN the following paragraphs, when the manner in which a given fault is not indicated at once, explanations will at a subsequent time be given.

CASE, GLASS, DIAL, DOME.

GLANCE at the case in order to ascertain that it has not received a blow or been subjected to pressure; that the joints and fly-springs work well; and that the hands, in rotating, touch neither the glass nor dial. By laying the nail on the surface of the glass, it will be easy to see whether there is sufficient freedom between the socket of the hand and the glass. In case of doubt, place a small piece of paper on the hand, close the bezel, and tap the glass with the finger while the watch is in an inclined position. If free, the paper will be displaced.

The set-hands square should be rounded at the end, and a trifle below the level of the dome, in order to avoid the possibility of contact in case of any accidental bending of the back of the watch, and the dome must not press on the balance-cock wing or the central dust cap (if present). The above remark also applies to the winding square of a fusee watch.

There must be sufficient freedom between the going-barrel teeth and the banking-pin of the balance on one hand, and the internal rim of the case, the fly-springs, and the joints on the other. Otherwise there is danger of contacts when the case is closed, which occasions irregularity and stoppage often difficult to detect.

The dome must be at a sufficient distance from all parts of the movement, more especially the balance-cock. If there is any occasion for doubt on this point, put a thin layer of rouge on the parts that are most prominent. Close the case, and, holding it in one hand to the ear, apply a pressure at all parts of the back with a finger of the other hand, listening attentively in order to ascertain whether the vibrations are interfered with. If the interval is insufficient, a trace of rouge will be found on the inside of the dome. In such a case, if the dome cannot be raised nor hollowed slightly in the mandrel (when formed of metal), lower as far as possible the index work and the balance-cock wing, and fix in the plate, close to the balance, one or two screws with mushroom heads that will serve to raise the dome.

Ascertain that the hands stand sufficiently apart; that the hour hand does not rub against the hole in the dial; and that the minute hand does not come nearer to the dial in one place than in another—a fault which may arise either from the dial not being flat or from the center wheel being badly planted.

Remove the movement from its case, after making sure that it is held firmly by the locking screws; take off the hands, and see that the hour wheel has the right amount of play; this freedom may be diminished if required by laying on the wheel small discs of tinsel cut out with a punch. If the dial presses against any part of the movement, or is not flat, or comes so near to any of the pivot holes as to draw off the oil, it must be ground away until a sufficient amount of freedom is obtained.

TO EXAMINE A GENEVA MOVEMENT.

ALTHOUGH the following remarksr efer in the main to foreign watches with a Lepine movement, many are also applicable to the English or American watch.

THE MOTION WORK AND HANDS.

ROTATE the wheels connecting the hour and minute hands by the aid of a key, and a glance will suffice to show whether the several depths, which should be light, are satisfactory. The wheels should not rub one against the other, the plate barrel, or stop work. The barrel should have been previously examined to ascertain that it is not inclined to one side, because, if it were, an error would probably be made in estimating the degree of freedom.

The set-hands arbor (the square of which should be a trifle smaller than that of the barrel arbor) must turn rather stiffly in the center pinion, and the cannon pinion must be held on the arbor sufficiently tight to avoid all chance of its rising and thereby becoming loose; for this would alter the play of the hands and motion work. If any fault is found in the adjustment correct it at once, so as to avoid doing so after the movement has been cleaned.

If it has not been done already, slightly round the lower end of the cannon pinion and the steel shield, care being taken to avoid forming a burr on the pinion leaves. These two pieces ought to rest on the ends of the center-pinion pivots, and at the same time be some distance removed from the plate and bar respectively.

FREEDOM AND END-SHAKE.

OBSERVE that there is sufficient clearance between the plate and barrel; the barrel and center wheel; the several wheels in succession, both between themselves, their cocks, and sinks; between the balance on the one hand and its cock, the center wheel, fourth-wheel cock, the balance-spring coils and stud on the other. The fourth wheel is frequently found to pass too near to the jewel forming the lower pivot-hole of the escape wheel.

The end-shake of the wheels may be tested by taking hold of an arm of each with tweezers, and lifting it. This may also be done in the case of the escape wheel, but, when the cock is slight, it will be sufficient to press gently upon it with a pegwood stick, then releasing it, and observing the apparent increase in the length of pivot. At the same time ascertain that the width and height of the passage in the cock is enough to allow the teeth, when carrying oil, to pass with requisite freedom.

Holding the watch on a level with the eye, lightly raise the balance with a pegwood point several times, each time allowing it to fall. The variation observed in the space between the collet and cock will indicate the end-shake of the balance staff.

ACTION OF THE ESCAPEMENT.

THE side play of the balance pivots in their holes can, with practice, be easily estimated by touch, or this may be done by the eye, attentively watching the upper pivot through the end-stone with a powerful glass, while the watch lies flat, and the lower pivot in the same manner with the watch inverted. If the end-stones are not clear enough, although such a case is rare, remove first one end-stone and examine the pivot; then replace it and remove the other.

It should be possible to rotate the balance until the banking-pin comes against its stop, without causing the escape wheel to recoil at all, or allowing a tooth to catch outside the cylinder behind the small lip. The banking-pin sometimes passes too near to the fourth-wheel staff. The U-arms should rest as nearly as possible in the middle of the banking-slot of the cylinder; that is to say, they should be as far from the upper as from the under edge of this slot, so that the end-shakes may have free play in all positions of the watch. Ascertain that the balance spring is flat; that it coils and uncoils regularly without constraint; that it does not touch the center wheel, the stud or the inner curb-pin (with its second coil). The rapid examination of the escapement may now be regarded as completed, if the watch in hand is merely cleaned after having previously gone well.

But, if engaged on a watch that has not gone well previously, or if examining a new one, the action of the escapement must be thoroughly tested in the manner customary among workmen.

VISIBLE DEPTHS.

WHILE the train is in motion through the force of the mainspring or the pressure of a finger against the barrel teeth, examine with a glass all the depths that are visible. That of the escapement, for example, can be easily seen through the jeweled pivot hole when this is flat, the watch being laid horizontal and a powerful glass used. When the action cannot be seen in this manner with sufficient distinctness, hold the watch up against the light and look through it. Depths that cannot be clearly seen, or about which any doubt exists, must be subsequently verified by the touch.

If examining a new watch, it may be found necessary to form inclined notches at the end of the cocks or near the center hole of the plate, so as to see the action of the depths. But it is important that the setting of the jewels are not disturbed, and indeed that enough metal is left round these holes to admit of their being rebushed, if necessary.

INVISIBLE AND DOUBTFUL DEPTHS.

THESE must be tested by the touch, and the requisite corrections applied after having repolished the pivots, etc., as may be necessary. We would observe that holes a trifle large are less inconvenient than those which afford too little play, providing the depths are in good condition.

LENGTH OF BALANCE PIVOTS: CENTERING THE BALANCE SPRING.

REMOVE the end-stone from the chariot, and see that the pivot projects enough beyond the pivot hole when the plate is inverted. Then remove the cock and detach it from the balance. Take off the balance spring with its collet from this latter, and place it on the cock inverted, so as to see whether the collet is central when the outer coil is midway between the curb pins. Remove the cock end-stone and end-stone cap, place the top balance pivot in its hole and see that it projects a little beyond the pivot hole.

Place the balance in the figure-of-8 caliper to test its truth, and, at the same time, to see that it is sufficiently in poise; it must be remembered, however, that the balance is sometimes put out of poise intentionally.

PLAY OF TRAIN-WHEEL PIVOTS.

ALLOW the train to run down; if it does so noisily or by jerks, it may be assumed that some of the depths are bad in consequence either of the teeth being badly formed, or the holes too large, etc. To test the latter point, cause the wheel to revolve alternately in opposite directions by applying a finger to the barrel or center-wheel teeth, at the same time noting the movement of each pivot in turn in its hole; a little practice, comparing several watches together, will soon enable the workman to judge whether the play is correct.

The running down of the train will also indicate whether any pivots are bent.

Now remove the barrel bar with its several attachments.

CENTER WHEEL: BAD UPRIGHTING.

REMOVE the third wheel, and, if necessary, test the uprighting of the center wheel by passing a round broach or taper arbor through it, and setting the plate in rotation about this axis, holding a card near the edge while doing so. This will indicate at once whether the axis of the wheel is at right angles to the plate.

When a marked deviation is detected, or the holes are found to be too large, they must be rebushed and uprighted again.

When, however, the error is but slight, the axes may be set vertical by bending the steady pins a little, in doing which proceed as follows:

Set the bar in its place alone, the screw or screws being a little unscrewed, and rest the side of the bar opposite to that toward which it is to be bent against a piece of brass held in the vise, and strike the farther edge of the plate one or two sharp blows with a small wooden mallet. Experience alone can teach the workman to proportion the blow so as to obtain a given amount of deviation, and must enable him to ascertain whether it is desirable or not to pass a broach through the steady-pin holes before operating as above explained. Some discretion is essential in practicing the method.

It is important that the center pivots project beyond the holes in the plate and bar. A circular recess is turned round the outer end of each of these holes so as to form reservoirs for oil. Owing to the neglect of these simple precautions, which are so easy to take, many watches, especially those that are thin, come back for repairs with their center pivots in a bad state, because the oil could not be applied in sufficient quantity, and has been drawn away by the cannon pinion or the steel shield.

If the watch has a seconds-hand, ascertain by means of the caliper that its wheel is upright. Finally, examine each jewel to see that it is neither cracked nor rough at the edges of the hole.

THE BARREL: TO TAKE DOWN AND REPAIR.

THE side spring, which must not be too strong, should reach with certainty to the bottom of the spaces between the teeth of the ratchet, and this latter should be held steadily in position by the cap. The barrel may be made straight and true on its axis by known methods, the arbor having been previously put in order if required. It is a good plan after making the extensive repairs here spoken of to again test the barrel and center pinion depth, either by touch or by drilling a hole for observation.

The screw of the star wheel must not project within the cover nor rub against the dial; it must be reduced if either case presents itself. The action of the stop-work must be well assured, especially when the actual stop occurs. It is a good plan to, as it were, "round up" the star wheel and finger piece, with an emery stick, supporting them on arbors. There must be no possibility of friction between the finger and the bottom of the sink.

TO TEST THE STOP-WORK.

TAKE up the winding square of an arbor, with the barrel, etc., in position, in a pair of sliding tongs or a Birch's key; hold the tongs between the last three fingers and the palm of the left hand, the first finger and thumb being applied to the circumference of the barrel so as to rotate it, first in one direction and then in the other. During this movement, take a pegwood point in the right hand, and try to turn the star wheel *against* the direction in which it would be impelled by the finger.

WATCH REPAIRING.

WATCHMAKERS will continue to repair the fourth pinion as long as it can be repaired, says Mr. Ganney, although in many cases it will not only be better but quicker to replace it with a new one, and I will briefly describe the method of working in a new fourth pinion.

Having selected a pinion of the correct size for the third wheel, and fixed to the long arbor an old screw ferrule, cut a thin boxwood slip to a thin edge, and with rather sharp red-stuff and oil proceed to polish out the leaves, resting the pinion on a hard cork or piece of soft wood. The screw ferrule on the arbor enables you to press the first finger of the left hand against it, and thus the pinion is held while polishing; the natural elasticity of the cork or wood allows the pinion to give a little to the motion of the polisher, thus keeping it flat. The leaves having been polished out with wet red-stuff, and finished with fine stuff or diamantine, the truth of the leaves can be tested by running in the turns. (Should the centers of pinion not be perfect, they must be made so before trying it, by turning through a runner.) Should the leaved portion or pinion on trial prove out of truth, it must be corrected in the following manner, at the same time I may caution those whose experience in the work is not great, that pinions are occasionally met with which it is impossible to get true, owing to one or two leaves being cut deeper than the rest from some fault in the cutting engine; such should unhesitatingly be rejected as useless.

If, while the pinion is in the turns, a piece of soft lead-pencil is held on the rest so that its point just touches the top of leaves, those that are furthest from the corner will be marked, thus forming a guide for the correction of the arbor. The *marked side* of the arbor being placed *downward*, in contact with either a soft steel or brass stake, the upper or hollow side can be stretched by a few light blows from the pane of a small hammer; the blows should be distributed at equal distances over the arbor, and, as these pinions are usually rather soft, some care is required not to overdo it. Having by this means straightened the leaves to run true, the arbors can be shortened to little more than the ultimate length of the pinion, and the centers turned true. Previous to commencing to work in the pinion, some little alteration is necessary to the following points: In some watches the banking, instead of being against a steed in the cock, is against the arbor of the fourth wheel; in this case the diameter of the arbor is of importance, as if too small and the watch caused to back by external agitation, the pin would jam against the arbor of the fourth wheel and stop the watch. Again, in some calipers of movements, the fourth pinion head comes close to the plane of the balance, and in some positions, if the pinion head is too high, or from excess of end-shake the banking pin touches it, forming a cause of stoppage rather difficult to detect sometimes.

The old pinion being removed from the wheel, all the measurements can be taken directly from it. The first thing will be to turn down the leaves to form a seat for the wheel, measuring the height from the pinion face. Care must be taken in fitting a pinion to an old wheel that the leaves fit into the marks made by the old pinion, otherwise a difficulty will be found in securing the wheel. Having fitted the wheel, try its truth in round in the turns, and, if untrue, shift its position on the pinion until it runs quite true, then mark the wheel and a leaf of pinion, so that its position can be found again. You will now shorten the leaves, leaving just sufficient to rivet soundly. If too much is left to be riveted the pinion face will be bulged and split. If the leaves project the thickness of a sheet of paper (10 millimeters), it will be sufficient (if the wheel fits properly) and should be but slightly undercut to insure a sound rivet. You will now rivet on the wheel, using a steel or bell-metal stake to support the pinion, and a polished steel punch of a size that fits just freely over the arbor. A piece of tissue paper between the face of pinion and stake will protect it during the riveting, and if care is taken to shift the wheel a little every blow, the wheel will be secured true and flat. The face of rivets can be turned flat and glossed and the hollow cut. The arbor should now be turned to size, leaving a slight shoulder close to the wheel to prevent the polisher coming in contact with it. The arbor can now be polished, burnished and the position of the upper pivot shoulder marked on it, measuring from the pinion face with the tenth measure. The pivot being turned down to within three degrees of its proper size, the pinion can be reversed in the centers and the seconds pivot turned down, its position being fixed by measuring from the upper pivot shoulder. The pivots being smoothed with red-stuff are burnished on the Jacot tool to size, leaving only the rounding up and turning off the extreme corners to complete the work. I may remark that the size of hollow necessary in the pinion face is regulated by the length of shoulder there is. Where this is extremely short, a hollow of considerable depth and breadth is required; on the other hand, where the shoulder is of considerable length, a small hollow will suffice.

An excessive end-shake to a barrel will often cause considerable trouble in more than one way, says *British Horologist;* but with the Geneva barrel we mostly notice the effect by seeing where the center wheel has left its marks by coming in contact with the surface of the barrel in some cases, while in other cases the teeth of the barrel have been left in such a rough state that freedom is impossible. I think that every barrel ought to have the top part of the teeth beveled off, which would insure freedom in this part, providing that the height of the center wheel was above the flat surface of the barrel; but, as it is, the barrel teeth are cut and the burr is left in its rough state, hence so many foulings of the center wheel, and all this would be avoided if the barrel teeth were properly beveled at the time of manufacture.

Of course, some of the better class of watches are left correct in this respect, but, for the sake of so little extra trouble, I think the commonest watch might be done so, as the job would not take a minute to put right, but if it is left for the repairer to bevel off, in order to free the center wheel after it has had considerable chafing, it not only spoils the appearance of the under side of the center wheel, but the gilding is taken from the edge of the barrel-teeth, therefore we have an unsightly piece of patchwork. I am aware that the job may be done without spoiling its appearance very much, if we are a little careful in the shape of the bevel, and polish the part that has been in contact with the graver; but to do this we should not let the graver go much beyond the bottom of the teeth, only just enough to make sure of removing all the burr, then it will look very well with its polished edge. I have sometimes really made an improvement in the appearance by this operation, for it does not look first-class to see gilding done upon a wheel that has such rough burr left after the cutting engine.

Now, there are times when this beveling off will not free the center wheel and barrel; when this is the case we must look for other cures; or, perhaps, I should rather say, we should look for other causes. In most cases the cause that is more frequently found than any other is the end-shake of the barrel arbor. There is more than one way to correct this. We will suppose the excessive end-shake will allow the barrel to get too high and foul with the center wheel when the inside shoulder of the barrel is in contact with the top shoulder of the barrel arbor; yet we find that if we press the barrel down so that the shoulder on the barrel lid is in contact with the bottom shoulder of the arbor, there is then sufficient freedom for the center wheel. Some would cure this by simply striking the center of barrel a sharp blow on a large round-headed punch, which would lessen the end-shake of the barrel arbor, and most likely correct the fault. But suppose this blow also puts the barrel out of truth, and the workman will very likely have produced a greater evil than before, and one which is corrected with much greater difficulty. It is better, therefore, to try some other method sooner than run the risk of ruining the barrel. Suppose we plant a small collet upon the barrel arbor—in this case at the top shoulder—this will have the required effect. Of course, we must have the collet a little smaller in diameter than the barrel arbor, while the hole in the collet should be only just large enough to fit on the shoulder; the thickness will vary according to the required amount in order to correct the end-shake. I may say here that a barrel end-shake should never be more than just free. Just see the detrimental effects of, in some cases, even the least amount of end-shake, where the fusee and chain are used. I have no doubt but that the most of my readers have, at some time or other, had a little trouble in this particular. With a very flat fusee watch the least thing in end-shake, either in the barrel or fusee, will cause the chain to run out of the fusee grooves. We then know what follows. Now, there are many who try to remedy this defect by closing the holes in the plate, which is done in many cases with a punch; this simply means that the next man who sees the job will be liable to ask if there has been a blacksmith at work. Yes, there are times when these punches are used, when it is a shame to use them. Why hammer and bruise a plate when the job can be done without any such methods? There is nothing that looks so bad to a practical man as to see a plate smashed about with a punch. It may be excusable to use a punch to close a hole in an old thirty-hour clock, but even in this it is doubtful, in these days of bouchons. I have seen watches and clocks hammered about in such a style that we are inclined to ask if the man had any conscience to smash plates about in such a wanton manner. Then, again, it is not only the look of the butchery; but just see what kind of a surface the hole has for the pivot to work in. Take, for instance, the top hole of the fusee, it will always near toward the barrel; hence, if the hole is closed, it has to be done on the side nearest the barrel, in order to bring the fusee upright to its original position. But when it is punched on this side, in all probability there is only just one part of the hole in contact with the fusee top pivot, and most likely this prominent part will very soon become worn down again, and the whole job be just as bad as before. In fact, in some respects, it is worse, for now the plate has been made a trifle thinner where it has been punched, in addition to the bad appearance.

Now, all this can be put right without any such botching. If a top-plate hole has become worn somewhat oblong, the proper way to put it right is to put a new hole in the place of the old; and this is very readily done, if we know the proper way of doing it. First of all, we notice if the fusee is perfectly upright, when it is brought back to the side farthest from the barrel. If this is right while the fusee is held in this position, we then know that the hole will have to be filed with a round file, on the opposite side, until it is as far from the central position as the other side has been worn. If the hole is opened with a broach before this filing is done, the fusee will not be upright when the job is finished, simply because the center is, under such conditions, brought to the center between the outside of the worn part and the opposite side that has not been worn; and hence it is half as far out of its original center as the amount the hole was worn. I speak of this particular here, because I know there are plenty who commence the job by simply broaching the hole from its oblong shape to a round, regardless of the detrimental effect it will bring in its train; for they often find that when they have the hole finished, it is just in such a position that the square of the fusee is making its obeisance to the barrel; and they wonder how that could have happened, for they have been particular in turning the hole upon a perfectly true turning arbor; but it seems that they had overlooked the fact which I have just commented upon. It is a well-known fact that many will do this job without ever thinking about such an important item. But I hope these remarks will help them to remember it in the future.

To resume, in this manner we get the hole filed on this opposite side as nearly as possible to the same amount. Of course, if the fusee has to be brought up a little more, we then file this side more in proportion to such requirements. There are times when the teeth of the fusee wheel run too near to the center wheel; this can now be altered by using the file to open the hole a little in the opposite direction to the center wheel. After the filing has been done, we can then use the opening broach, and make the hole perfectly round. We are then ready to turn up the bouchon to fit. See that the turning arbor is perfectly true. If there is room for putting a deep hole, put it—that is, if the fusee square has not been squared down to the level of the top plate, leave the hole standing up above the plate. When this is done, the bouchon should be turned with a very nice shoulder, so that it rests firmly upon the top surface of the top plate. It should also be turned to a true fit in the hole. I should also say that, in this case, the hole should be opened with the broach from the top side, so that the bouchon can be turned to an exact fit. Before it is riveted in, the under side of the hole should be chamfered to receive the rivet. If we are particular in getting the exact length for riveting over, we may perhaps finish it all right without having to use the mandrel in order to take off the surplus brass so that the end-shake is free. When we have made the hole secure, we then have to be particular in opening the hole to fit the fusee top pivot. If we let the broach get out of upright, we shall give a very queer shape to the hole, as it will not go through the plate at right angles, hence the sides of the hole will not touch the pivot all along their entire length, so that the pivot would be free when not in position, but as soon as the bottom pivot is in its hole, the top pivot binds; this is all avoided if we keep the broach upright while getting to size. When right, we simply chamfer the top a little for the oil, and the job is complete. If careful in riveting, it would take a close examination to tell that the new hole has been put in.

As a guide to the springer in selecting a proper spring, says Mr. Ganney, in his excellent series on repairing, the weight of the balance is used. When new work is being sprung, the springer associates certain sizes and weights of balances with springs of a certain number and strength, but the repairer can only gauge by lifting up the balance by the eye of the new spring, and noting its elongation by the weight. Springs are now too cheap to make as wanted, and the wire is not kept as a material as formerly; but the old method of making a spring, by drawing the wire into a spiral with a point of a joint pusher, and working the spring and pusher entirely with the thumb and forefinger, is very useful in setting the outer coils of old springs into shape again. Springing tweezers are made with the points concave and convex, so as to close or open the turns of the spring, as may be required; a spring blueing-tool is also very useful, or an ordinary blueing-pan, with the spring under a piece of glass, and a weight on it to keep it flat, will do. After blueing the spring, and letting it cool before removal, it will come out quite flat; the other operations connected with the spring, such as making a new stud, and properly fitting the index pins, are very simple and obvious, yet in no point of the watch is so much carelessness exhibited as in these; being simple jobs, they are supposed to want, and, indeed, do get little alteration.

The hairspring collet often gives trouble, owing to bad fitting, and want of freedom of the cock and the screw heads of index piece. I usually put my watches in beat by moving the collet with a fine screw-driver or drill in the slot, without shifting the stud out of the cock, resting the cock on the board paper, and simply drawing the balance a sufficient distance to get at the collet. I find out of beat a greater source of stoppage than anything else, and suppose the trouble and danger attending frequent removal of spring and balance the reason it is neglected, and devised this plan to save trouble, and insure accuracy of beat. With English sprung arbor watches it is a very much easier plan, as a bar of the balance, when the cock is removed, may be held by a stout pair of tweezers to free the bottom hole, and the alteration made at once by moving the collet. I earned a good fee in a minute or two by this plan of putting a watch into perfect beat, which the owner declared had never gone a month without an occasional stoppage, though he had had it in the hands of all the best men he could find in London for a number of years, who all said it was a first-class made watch, but none had been able to cure it. Thinking it useless to look for ordinary faults, as the watch seemed in perfect order, and all that a watch ought to be, I simply wore it, as I took it on the no cure no pay principle; and when it stopped, going on again before it could be opened, I noticed that it had very low angle pallets and rather strong lockings, and appeared very slightly out of beat on the second or discharging pallet. This was altered and it was put slightly out of beat on the other pallet, as the friction on the second pallet is that which necessitates the oil, and is known as engaging-friction, the surfaces opposing each other as they engage in work. The watch has given perfect satisfaction ever since, showing the importance of slight errors, and that one small error may be made to compensate another. Watches being out of beat are not very noticeable when fresh oiled and clean; but as the dirt and difficulties accumulate, the effect is very striking, and where escapements are unequal, the spring may be shifted to make the conditions more equal in performance.

The condition of the jewels in Swiss work is of some considerable importance, and if the repairer aspires to be a good jeweler, considerable practice with the lathe and mandrel will be necessary. If it is only desired to replace holes from a stock kept for that purpose, the holes can generally be replaced without much trouble, raising the edge of the setting at one side, or allow of the insertion of the jewel, and securing it in position by rubbing the setting well over the stone with a well-burnished rounding-center in a handle; a strong and fine pointed arbor will do to raise the edge for the insertion of the stone. Where a setting is too badly injured to hold a stone properly, an English hole with brass setting may be fitted in a chamfer, or soldered in; loose jewels may always be tightened with a rounding-arbor or center, and should always be tried for tightness, as troublesome variations of depth and freedoms are caused, which often escape observation.

To make a cock to the escape wheel—often on account of its being very much turned to free the teeth, it is liable to accidents—it is first desirable to get a sound slip of brass well hammered. Having drilled the screw hole and filed it to the proper shape, it must be firmly screwed down, and the steady-pin holes drilled through; the drill fitting the hole in the plate easily, the opening of the holes in cock and plate must be carefully done, and the steady-pins well fitted, or the cock is useless. The top pivot hole must now be made in the mandrel or uprighting tool; then an old upper plate should have some shellac melted on it, and placed in the mandrel; the flame of a spirit lamp, or other heat, applied, the cock is placed on it, and centered from the pivot hole; the slide-rest cutter is then used to turn the inside of the cock perfectly flat, and the slot, to free the wheel teeth, is cut a sufficient depth. When removed, the next thing will be to make the wheel the right height by filing away the superfluous brass, then to free the cock of the balance, and try the escapement, and send it for jeweling. If desired, the jeweler will do all the turning and mandrel work. If finished off with water-of-Ayre stone or buff, the cock will be more durable than when gilt. If not convenient to bend the cock, the holes should be plugged with a fine wire, and a hole made the same as a verge hole, with a fine drill and a bottoming broach, with end well burnished. This kind of hole will give better results than a common jewel hole, if properly made, and is in use in all the original escapements of the inventor of the horizontal (cylinder) escapement, George Graham. A good inside chamfer must be made to hold the oil; this kind of hole will also do good service for the balance holes, and is preferable to making shift with any cracked or bad jewel hole, if the points are well rounded and burnished.

It is much to be regretted that watch jewelers do not contribute more to the literature of the art. There is a good opportunity for any enterprising young jeweler to gain fame and business by descanting on the various qualities, and means of judging the quality and value of jewel holes, and showing in what way value is imparted, so that those who want to patronize this art may do so without discrimination. To most watchmakers, one jewel hole is much the same as another, unless it is cracked, and yet there is as much difference in watch jeweling as watch pivoting; the one, in fact, being a counterpart of the other. There seems to be some secret understanding among watch jewelers not to impart information, as applications for information by means of contributions to literature, have been refused, on the ground of injuring the interests of that branch. Saunier's valuable work, though very copious and full on all other subjects, gives very little information on the subject; or is it that very little can be said of cutting one stone with the dust of a harder one? The stone-mason rubbing marble into shape with sand and water illustrates the primitive idea; the ruby-hole maker, cutting his hole with the next hardest substance, diamond and diamond dust, shows the other extreme of the same process.

TOOLS USED IN REPAIRING.

SPEAKING of centers, another center made of brass is called the rounding-up center, and used for making pivots right lengths and rounding on burnishing them. It is simply a number of holes round a brass center, which has been filed sufficiently thin to allow the finest and shortest pivots to protrude; the holes must be of various degrees of fineness, and no more pivot allowed through than necessary, as the file or burnisher will break them off. Usually, the pinions to common Swiss works are very soft; this, though greatly facilitating their turning, when the work is large, becomes a troublesome quality as it gets fine; and it may be asserted that a fine pivot cannot be made from soft steel, as it will not stand the necessary pressure to turn or polish it to any degree of fineness, and no amount of finish can be displayed on soft steel, as it will not polish to advantage. In putting in a new third pinion, it is necessary to undercut the shoulder and leave a hollow in the pinion, or the oil may work into the leaves of the pinion and center-wheel teeth; before the wheel is riveted to the pinion, the balance should be put in to see if it is free, as in some calipers the circle intersects. The undercutting of the fourth pinion at the bottom pivot is also necessary to keep the oil in the sink, and the pinion left no higher than the third wheel requires, or it may foul the balance or banking-pin; in polishing the second, the best pivoters usually polish it like any other arbor, but if nervous or heavy-handed, a special brass center with half of its diameter filed away, and a convenient slit for the pivot to rest nearly all its length in may be used, but I do not recommend it, as a careless slip will destroy the pivot, which otherwise in the turns would have a certain amount of elasticity. The resting of the little finger on a convenient part of the turns, and letting it move with the polisher, is an item in polishing pivots, the finger being used to regulate the pressure of the arm and hand; the most troublesome pinion to pivot is the Geneva scape pinion, owing to its having no arbor. If a very thin and small brass ferrule is used, well chamfered to allow all parts of the pinion at its shortest to be turned, it may be opened to fit the pinion tightly, and the pinion driven in will hold sufficiently to pivot, or it may be fitted loosely, and shellac used to secure it to the ferrule. The value of good, pointed centers will be proved in pivoting this pinion, as it cannot possibly be done without them. The rivet should be well undercut and fitted to the wheel, or the riveting will raise a burr in the pinion where it acts in the fourth wheel; a few light blows must complete this riveting.

Good bows being necessary complements to good turns, the watch repairer cannot dispense with less than four, varying in length from 12 to 24 inches, and in strength from that sufficient only to make a balance pivot, with horse or human hair, without slipping on the ferrule when turning with a fine, pointed graver; and the others increasing in strength to what is required in turning barrel arbors, stoppings, and the larger drilling operations in watchwork; for the ordinary, every-day watch pivots and shoulders are sufficiently well finished with a cutting burnisher, one side of which is rubbed on a board or strip of lead charged with emery, as a few rubs on the small stone used by shoemakers to whet their knives for leather cutting is a handy substitute, and gives the requisite cutting power, and then a few rubs with burnisher, polished on a well-used burnishing-board, on which smooth emery has been distributed, will give a perfectly smooth and black pivot. The best English pivoters finish their pivots with the smooth burnisher in this way to harden them, though they have been previously highly polished with a soft steel polisher, which leaves the shoulder perfectly square and well polished. Using bell-metal polishers to finish, though putting on a higher gloss, destroys the squareness of the shoulder; the shoulders are protected from injury whilst burnishing the pivot by a small tissue-paper collet on the pivot, or by polishing the edge of the burnisher with a bell-metal polisher, and burnishing the pivot by moving the burnisher down (not up) the pivot as it revolves. Arbors are burnished in the same way, left from the steel polisher, and not too fine red-stuff in preference to more highly polishing bell-metal, as a square shoulder on the arbor is a *sine qua non* in good pivoting, and a too highly polished arbor will not burnish, but rubs brown or foxy under the burnisher; facing and rivet tools are simply pieces of iron wire, a tin tack, or an old nail with a hole in it, in which the arbor fits loosely, and these being filed and charged with polishing crocus, the pinion is revolved against them with a very weak bow, until the requisite finish is attained; the finest finish on faces is got from a tool made from a horse-shoe nail, the iron being a particular Swedish quality, and the hammering it receives in wear imparting qualities that cause the pivoter who finds one to prize it like a diamond; otherwise, a bell-metal tool to finish the face is necessary, but only to give a few finishing rubs, as it soon loses the flatness imparted by the file, and makes the face or rivet rounding; a very careful stroke of the bow is necessary, as only a back center is used, and the tool itself held in the hand forming the other center for the pinion to revolve in. The pressure of the hand is carefully regulated to insure a light and equal pressure; the progress of the face may be known by the noise the pinion makes; as it works the polishing stuff dry, it begins to sing or squeak, and this is the signal for ceasing operations. If all the parts of the face are well polished and the extreme edges as bright as the rest, it will do; if not, the tool must be refiled and fresh stuff applied, and the operation patiently repeated. More patience in this job is required than any other in watchwork, and though apparently most simple, and we may add the most unnecessary in watchwork, there are few who excel at it. The polishing of a square shoulder and pivot being a work of celerity, firmness, and skill, those who do the one often fail at the other, as shown by escapement makers, who make good pivots and bad faces to their one pinion, while the finisher as often as not produces better faces than pivots to his pinions. The repairer may emulate either or neither, but he ought to endeavor to replace old pieces with equally good, or consign the job to those who can. In large towns, he will not gain or lose much honor either way, his business being to get satisfactory performance from the watch, as a whole; but in putting in pieces to jobs, there are certain little numberless details that give success in action, and only the one who is responsible for the performance of the watch seems able to appreciate or develop them. This is why cheap, subdivided watchwork is a failure.

It happens sometimes that the cylinder pivots are bent, continues our author, an event which is of frequent occurrence, in the remedying of which some workmen have recourse to a pair of smooth plyers, made just hot enough to turn the color of the pivot to be straightened to a blue; but in this class of work, it is rare to meet with a pivot so hard as to require this treatment. It will generally be sufficient, after filling the body of the cylinder with shellac, and at the same time fixing either a bone or brass ferrule, to use a bell-metal polisher on the Jacot tool, taking care to select a notch slightly larger than the pivot, which you have previously measured with the gauge that accompanies the tool for that purpose. You will then use a smaller notch, finishing with a burnisher expressly made for this tool, and sharpened No. 1 emery stone, or emery of similar coarseness on zinc or lead block; the latter being the better material, the most convenient size being a square block about seven inches long and one and one-quarter inches wide, got up true on each of its four sides. The burnisher should be put in a Swiss handle, similar to a pen-holder and nearly as long, fastened in with shellac or sealing-wax; it can thus be set perfectly straight with the handle. In sharpening, the block should rest against the front of the work-board, pointing from you, and plentifully supplied with emery and oil, mixed not too thickly; the handle held lightly in the right hand, and the first finger of the left applied on the top of the burnisher, the stroke should be from point to heel, lifting it from the block for the return stroke. For reducing a pivot, the burnisher should be cut on a No. 2 stone or emery of a similar grade.

Should a pivot be broken in this process, a new plug will be necessary; the removal of the old plug should be done by means of a punch, of a knee shape, resting the shell of the cylinder on a brass stake for that purpose; the stake should have a slight recess turned in it, just large enough to admit the cylinder, and the hole sufficiently large to admit the plug when driven out; a slight tap with a light hammer will remove the plug, and a new one should be turned from a piece of staff steel, which has been previously hardened and tempered, let down to a full blue color. The part which enters the cylinder should be perfectly parallel, not tapered, or the shell would probably be burst in putting it in; if you have a micrometer to measure it with, it is a simple matter. Having fitted the plug to the shell (it should enter about one-third of the distance it has to go), the center has to be cut off and the head made flat and polished; this can be done in the screw-head or balance tool; the portion which is to form the new pivot and arbor you will roughly shape before cutting off.

PIVOTING A CYLINDER.

THE plug has now to be fixed in position in the cylinder; some workmen use a punch similar to the one used to remove the plug, only flat on the face, resting the shell of the cylinder on the punch, and tapping the plug in with the hammer; others press the plug in with the extreme end of a thin, flat burnisher, holding the plug in a vise or a stake for that purpose, the latter in my opinion being the preferable plan. The plug has now to be centered; you will use for this purpose a steel runner similar to the one used for rounding up the end of a pivot, but with larger holes; these should be loosely chamfered out, hardened and polished; the extreme end of the cylinder will work in one of these holes, which should be plentifully supplied with oil. The top pivot being protected by running in a brass runner, having a hole sufficiently large to admit the pivot freely, the shoulder taking the thrust, you can thus turn the extreme end of the plug true with the body of the cylinder. Having centered the plug, it only remains to turn the hollow and pivot, leaving the latter three degrees larger than it will ultimately be required, burnishing it down this amount first with the rough and then with the fine burnisher.

If the upper pivot is the one broken, it will sometimes be possible with a high cylinder to do without a new plug, by knocking out the old one sufficiently to allow you to turn another pivot on it; at the same time, this is not so good as replacing the plug with a new one, as the plug has a tendency to draw oil away from the wheel teeth. It will not be necessary to describe the method of replacing the upper plug, as it is nearly similar to the lower.

There is yet another way of replacing a pivot that is broken, viz.: by drilling through the old plug and inserting a piece of steel somewhat larger than the shoulder of the old. The centering runner described when speaking of the new plug must be used, and a recess turned in the plug sufficiently deep to start the drill truly. Of course, before doing this, the cylinder is to be filled with shellac or sealing-wax, to enable it to stand the pressure. Having turned the hollow sufficiently deep to bury the angle of the drill, the centering runner is to be removed and replaced with one having a hole in it to take a drill, which, for this purpose, should be strong and short, and not relieved much behind the cutting part. If ground to cut only one way, and tapered in thickness to the point, it will work quickly and well. Although the plugs of Swiss cylinders are not very hard, it is not well to use oil to the drill; spirits of turpentine is the best lubricator for this purpose. The pressure on the drill which, when cutting, will be considerable, should be relieved at the return stroke of the bow; if the drill is sufficiently hard and not driven too rapidly, the drilling will proceed pleasantly. Having drilled the plug through, you will insert a piece of steel, previously hardened, tempered, and polished down to size, and not too taper, or a piece of a cutting-pivot broach may be blued and inserted. Previous to inserting you will round up and burnish the end nicely, and any burr thrown up on the plug by the drill must be removed by a steel polisher and red-stuff, resting it on cork, while doing so, to keep it flat.

The new piece can be tapped in with a light hammer; while resting the shell on a punch replace the shellac in the cylinder, and with the centering runner turn the extreme end of plug to a center. You can now proceed as described in making a new plug.

To repair a broken Swiss balance staff, the repairer may procure a rough one from the material warehouse, or make one by driving a piece of steel wire into a brass collet or stopping, hardening it by heating it to a cherry red, and plunging it into oil or water; then it must be tempered by brightening a portion with Arkansas stone, or otherwise, and, being held near a flame, let down to a full blue; in this condition the center must be filed in the pin vise, the arbor turned true, and the brass collet turned an approximate size. All parts of the arbor and collet must be forwarded in equal ratios, or it will come to grief if one pivot is t..rned nearly right size before the other arbor and back hollow has been turned sufficiently small. The douzième and pinion gauges should be freely used on the broken staff, and if both pivots are broken, and the staff otherwise a good one, the broken staff will be a good guide for the new, and show where the shoulder must be for each pivot. The douzième applied outside of cock and foot jewels in the plate, with end-stones removed, will give the length of arbor and pivots, one division of the douzième being allowed for end-shake. The arbor should be turned as short as convenient, as long arbors, besides giving unnecessary trouble in turning, are apt to get bent in polishing. When the arbor has been turned small enough, the roller must be carefully fitted in the process of polishing with cutting crocus, and the arbor must be only slightly tapered, as Swiss rollers have no pipe like the English; they must be driven on when fitted with a brass hollow punch, the right distance, the last thing, when trying the escapement; if too tight, they will be difficult to get on or off, and if at all loose, will not hold. Taking them off is not contemplated in the ordinary routine, and the riveting clams and a punch over the pivot must be used to remove them. A very convenient stake is made by using a piece of metal with a hole large enough for the roller to go through; a slot is cut from this hole some distance to allow the arbor to pass along it, and the roller is thus supported all over at the back, and allows of force being used to remove it. This tool is very useful, also, for putting on the hairspring collet, as the roller can be passed underneath, allowing the seat for the balance to rest on the outer face, and saves injuring the roller, which must occur if the roller itself is in contact with a stake.

Having finished the arbor, and roughly formed the part for the bottom pivot, and what is called a safe, that is, turning the arbor nearly through below the pivot, so that in case of a slip or catch it may break there, we finish the collet, and fit the balance and hairspring collet. The height from bottom of brass collet to top pivot must be carefully noted by gauging or actual juxtaposition of the old and new piece, as the eye is apt to be deceived; and leaving the rivet rather high and the collet a little too long, the inexperienced will be surprised to find that the pivot and shoulder which appeared all right is just a pivot and shoulder too high, and the pleasure of turning or breaking a new pivot and shoulder out of the rough brass and steel will show the error he has made. The excellent practice of undercutting rivets and shoulders makes them appear as long again as they are, and a good graver and skill in using it are the sure roads to success at this job, the pivots being turned nearly right size and shape with a sharp-pointed graver. Then a cutting burnisher made from a piece of polished steel, hardened when made, with a rounded edge to form the conical shoulder; this, when sharpened on rough emery sticks to cut, and fine emery to burnish, will do all that is required for a perfect job in the ordinary turns. If not capable of turning anything finer than an arbor, the Jacot tool and pivot files may be used, and a nick being cut where the pivots are to be, by shifting the arbor from the large to the small nicks in the tool as it is reduced, a pivot may be worried out of the arbor with the pivot file, which will only be good enough for the commonest work. The pivots should be left full long and rounded the least thing after the balance is riveted, so that a chance is given of improving the freedom of the balance by making the end-shake and height right by shortening top or bottom pivot, as may be most desirable. The riveting should be done by a half-round punch, with the back whetted to a sharp edge nearly. This will go into the rivet and drive it down as well as out. A blow at four different parts of the rivet should tighten it flat and true, and then the hammer applied lightly to the punch, whilst the balance is continually moved with the finger, would finish it. If not flat, the rivet must be hammered at the part where the balance projects. If there are three arms to the balance, it may need flattening by striking them with a light hammer, or the pliers may be used with advantage; resting the point of the pliers near the center of the balance on the arm, and using the edge of the balance as a fulcrum; or the balance may be held in the fingers and pressed against the edge of the workbench to flatten it. A combination of these plans is sometimes necessary.

Escapement makers usually rub and burnish their balances on the staff before turning the pivots, by holding a pointed center against the rivet whilst revolving in the turns; but repairers will find this not so convenient or safe as the other plan of riveting, which must be adopted in the replacing of cylinders, and they will not get enough practice at both to be very reliable at either.

Most of the directions given for the balance staff are applicable to the pallet staff, though it differs from it, being secured to the lever and pallet by screwing. Working usually in thorough jewel holes will require a square-edged polisher and burnisher to finish the pivots. The arbor has usually a very thick bottom arbor or shoulder, which is held in the pliers when it is desired to unscrew the pallets and lever.

In making a new staff, a piece of steel wire may be turned whilst it is soft, and the screw made on it by using the lever itself as the screw plate; when a good thread has been formed on the arbor it should be hardened and tempered, and the height from the shoulder, on which the pallet rests, carefully gauged, and the bottom pivot made and finished. The action of the wheel on the pallets should now be observed by screwing lever and pallets together, and putting them in, and holding the arbor as upright as possible; or putting the escape cock lightly on in contact with the top arbor. If the position appears right, the height should be gauged from the old arbor, or by filing a piece of brass wire until it fits between top and bottom holes, and gauging that for the height. Internal gauges may be bought, which are very useful for this purpose.

When the pivot is finished, the escapement should be tried first without the balance. On moving the lever and pallets the tooth should have an equal amount of drop on to each pallet; this will prove the correct sizing and depth of the wheel and pallets, and an equal amount of run of the pallet after the tooth drops, before the lever comes against the banking which limits its motion. If there is much run on one pallet the other may not leave the tooth at all, or only just as the lever comes to the rest; this shows it out of angle; and if the steady pins are tight in pallet and lever the hole must be opened, or the pin filed or bent to allow it to be shifted on the lever, so that the pallet may leave the tooth before the lever has traveled the full distance. If both pallets refuse to leave the teeth, it would show that the bankings are not wide enough; but if the watch has ever gone, the fact proves the bankings to be wide enough; and the inability to leave one pallet is the same effect as inability to leave both, and all alterations which make one pallet deep make the other shallow in the same ratio. Common levers have considerable drop, and run up the pallet as well as variable draw or retentive action of the wheel on the pallet. Fine watches allow of these actions being very close if the wheel drops at equal distance of the lever's motion, and allows a little more motion of the lever before it comes to the banking; and then the ruby pin leaves freely and the guard action has a little shake between the banking and roller edge, without danger of sticking in the roller or allowing the wheel teeth to get off the locking face on to the impulse plane, until being pulled off by the action of the ruby pin, the escapement being free may be considered correct.

MOUNTING THE DIAL.

THE pin holes in the dial feet should be drilled with a very small drill, in such a direction that the pins will not come in the way of anything and will be easily gotten at; they should not be drilled below the surface of the plate, but broached until the pin touches it. If the hole should be a little below the surface it is better to lengthen the copper foot by squeezing it with a pair of blunt nippers until it is above the plate, than to leave it in such a position that no pin can stop it.

DUST PIPES.

DUST pipes are indispensable in a key-winding watch, and when properly screwed on the plate and fitted to the case are expensive. This part of the watch is frequently treated with utter disregard, and we recently saw a very bad case of dust pipe of the set-hand square of a three-quarter plate watch. It was so constructed that if it was made to touch the case, it would press upon the center pinion and stop the watch or make it go irregularly; to avoid this, the center parts are left with sufficient end-shake to defeat the purpose for which it is designed. A solid top offers advantages in respect to dust, and perfects the key-winding watch to an important degree.

THE BARREL ARBOR.

IF the pivots of the barrel arbor are of the proper shape (which they generally now are in the best movements, and certainly ought to be), the pivots and holes will only require smoothing, and the barrel freeing on the arbor. Instead of adopting the usual course of turning away the bosses in the barrel and cover to reduce the rubbing surfaces, a deep hollow should be turned and a shoulder formed on each side of the arbor of a sufficient width, and the bosses should be left on the brass as large as possible. It has not been the practice to snail barrel arbors of fusee watches, as there was no trouble with the adjustment of the mainspring, English springs being tapered and generally filed thin at the eye, but the arbor should be snailed (and they probably will be now by the movement makers), and the hook should not project beyond the thickness of the spring.

SHAPE OF RUBY PINS.

A CYLINDRICAL ruby pin cannot enter the notch so deep as it should, and the driving side of the notch will work very minutely toward the front part of the pin, and at the wheel's drop the off side of the notch will be some distance from the side of the pin; this vacuity between the notch and the pin is a loss of arc to the roller on each side of the discharge, and also causes some small portion of the lever's arc to be non-effectual immediately after unlocking, for directly after unlocking, the lever will drop across the vacant space, which is perhaps 1° of the lever's arc on each side. This loss of arc by notch and pin often misleads persons in the arc of the pallet from drop to drop. When the arc of the balance, from drop to drop, is about 30°, and the roller, from staff to pin, is about one-third length of the lever, the arc of the pallets is supposed to be 10°—they are more than 10°, generally 12°—the depths make a greater arc in unlocking than watchmakers are aware of.

THE PALLETS AND THEIR FUNCTIONS.

EACH of the two pallets is shaped for the double purpose of impulse and locking; by turning the escape wheel forward, a tooth of the wheel passes over one of the impulse planes, and thereby turns the pallets and lever together through a small arc of perhaps 9°; and as the roller and balance are linked to the lever by the pin and notch, the balance also is simultaneously turned through an arc, the balance's arc always being much greater than the lever's arc, according to the ratio existing between the radii and the small roller and long lever. At the extreme end of the pallet plane the impulse action ceases, and another tooth of the escape wheel drops on to one of the opposite lockings, stopping all the machinery of the watch except the balance and roller, for at the instant of the escape wheel's drop the roller jewel pin passes out of, or away from, the open notch of the lever, and the balance and roller revolve by themselves, perfectly detached from the rest of the mechanism of the watch.

TO PUT A JEWEL PIN INTO AN AMERICAN WATCH.

IN putting in a jewel pin, the repairer should always remove the lever from the movement, so as to get at the exact size of the fork, selecting a jewel pin which has only sufficient side-shake to be safe. To set a jewel pin, remove the hairspring and fill the hole where the jewel pin goes with cement drawn out into filaments about the size of a large bristle. Some little skill is required to do this expeditiously. The cement is made by mixing a little gum myrrh with the best shellac, and melting both together at the lowest temperature in which they will thoroughly unite. While the mass is warm, it is drawn out into threads of near the size of the hole in the roller. Take the balance (with the hairspring removed) in a pair of tweezers and move it back and forth through the blaze of your alcohol lamp, until hot enough to melt the cement when you touch the jewel pole with one of the filaments, and it will instantly be filled with cement; or a small piece of one of the cement threads can be broken off and inserted in the hole and melted. At any rate no great surplus of cement should be used, as it not only makes a smeary unworkmanlike job, but it is liable to get into the passing hollow and interfere with the guard-pin.

After the hole is filled, and while the roller is hot, insert the jewel pin with an extra pair of tweezers, being sure to keep the flat side of the jewel pin to the front and keeping the jewel pin upright. It need not perhaps be said, do not heat your balance as to change its color or burn the cement. In setting pallet stones, the same kind of cement is used. Some persons use shellac dissolved in alcohol; this cannot be recommended, as it leaves the cement or shellac porous from the bubbles formed by the alcohol when being driven off by heat.

In order to get at the proper angle and position of a pallet stone, the fork should be put in the watch and the banking screws turned so that the guard pin will just touch the roller; the balance should now be put in without the balance spring, and revolved to see if it enters the fork properly, bending the guard pin, if necessary, until this result is obtained. With the fork and roller action in this condition, the tooth should just reach the locking face of the pallet engaged. If we now remove the pallets and insert our pallet stone to be set, placing it as near in the correct position as we can judge, trying it with the scape wheel to see if it is too close outside or inside. Next place it in the watch and see if a tooth resting against it (the new jewel) just rests on the locking face. Now open the bankings until the tooth will escape, and it should be all right if the directions have been complied with. If, on the other hand, the pallet is in too far, the pallet should be removed and heated and the stone pushed back, trying it again with the scape wheel to see if the teeth pass readily between the pallets inside and outside.

To make the instructions still more explicit, we will recapitulate. If the guard pin rests against the roller and the other parts of the escapement are all right, the following conditions will exist:

The jewel pin will enter the fork freely, and the fork will pass over against the opposite banking pin, where it will rest, but as both banking pins are too close, the tooth which just touched on the locking face cannot escape, for the just mentioned reason, and they hold the guard pin against the roller. But remember the guard pin is in just the right place when, if pressed against the roller, it will barely permit the jewel pin to enter the fork, and the pallet is in just the right position (as far as locking is concerned) if the guard pin resting against the roller and the tooth engaging the pallet, is as near leaving the locking face of the pallet as it can, and not do so. But if on opening the bankings so as to remove the guard pin free of the roller, the pallets will escape, and only a good, fine secure lock is obtained, we may feel sure that the pallet stone is properly set.

The Swiss club-tooth escapement is not so easily managed, as they are frequently, especially in the cheaper grades of movements, faulty, both in the pallets and in the teeth.

TO HOOK IN THE MAINSPRING.

MANY springs are broken owing to the hook in the barrel arbor being too long; therefore, this is an important item to be examined by the operator, if he knows that springs in a certain watch are liable to frequent breakage. Some of the closely made English watches in which a small barrel is used, frequently get their springs broken because the arbor hook stands out too prominent. This hook should never be left longer than the thickness of a coil of the spring; this is quite sufficient to hold firmly, provided the hole in the spring is properly chamfered. The hole made in this end of the spring should be sufficiently large to allow the arbor hook plenty of room so that it will not raise or lower the center of the spring, if the hook should be a little out of the center. In some of the flat Geneva watches, for which a very thin spring is used, we have to be very careful in this particular; for, with such a thin—or low—spring there is not the room to make the hole sufficiently large for the hook, without making it a little weaker; or, if we are not careful, we are very liable to get the spring slightly ruptured in this part. Now, rather than run a risk of this kind, we had better stone off a part of the sides of the hook. Or, if the hook should be a little out of the center of the arbor, we can then stone off one side only, in order to bring the hole central.

When these little items are attended to, we are not very likely to have the center of the spring chafing on the cover or bottom of the barrel, unless the spring has not been properly finished, which is frequently the case with some of the cheap springs. Some of them have a rough burr on the edge, which will often cause considerable trouble; for in this instance, when the spring is nearly down and at its weakest point, it is then deprived of part of its strength by this chafing. Now, if the outside of the spring chafes, owing to its getting in any way bulged by riveting the hook on, this chafing is not so liable to affect the watch to such an extent, for, when this part of the spring is in action, there are more coils at work than when the spring is nearly exhausted; hence, its strength is better able to overcome the chafing. We see from this that the inner end of the spring should always be carefully examined; for we had better fit in a spring a size too low than allow any chafing whatever.

TOO MUCH DROP IN LEVER ESCAPEMENT.

IN correcting a lever escapement which has too much drop, we must put in new pallet stones; although generally in club-tooth escapements, if one pallet is corrected it will answer—but don't understand that this will do if both are equally faulty, because this is not what is meant. What is meant is that generally one pallet is very bad and the other will answer after the first is corrected. For if we sought to remedy all the faults of many of our cheap watches, the melting pot would be the first thing to use.

In testing a watch for a thin pallet which can be considered as causing too much drop (although the fault may be in the tooth, if a club tooth, but as it can be remedied by correcting the pallet, we call it all the fault of the pallet), we proceed as follows: We put a slight friction under the balance, and revolve it so as to unlock the escapement, and observe whether the tooth falls too far after being released from the pallet, and also notice from which pallet the most drop takes place, so as to be able to select which one is most in need of correction. Here, again, we must in a great measure depend on the judgment; but we know that the drop should not be more than $1\frac{1}{2}^\circ$, and here, again, the eye has a comparative standard, that is, the drop should not be much more than one-fourth of the angular motion of the tooth when acting on the impulse face of the pallet, or about one-fifth of the angular motion (12°) from locking face to locking face. The way to correct the thin pallet is to put in a new pallet stone which will hold the scape wheel longer, and, of course, convey more train power to the balance.

TO SET JEWELS.

SUPPOSE we have a watch that needs a new jewel in the bottom plate, and we have no jewel that will just fit the old seat and pivot too, or the bezel may be no good; we must select a jewel that will fit the pivot and is a trifle longer than the old seat, and proceed to cut a new seat and bezel for it. Having the face plate or universal head in place, put your plate up, and push the pump center into the hole where you wish to set the jewel. Now adjust the clamps to your plate, but before screwing them up, look in at the peep hole behind and see if the pump center is exactly in the hole. Now put on your top plate as though you were putting the watch together. The jewel or pivot hole in the top plate is supposed to be in the right place, so we will test the thing to see whether our work is centered. Take a full-length pegwood stick, and sharpen it to a nice point, and insert it into the jewel or pivot hole, and let it rest on the T-rest, which must be slipped within about one inch of the plate. Then, as you run the lathe slowly, watch the end of the pegwood, and if it does not stand still, but moves up and down, the plate is not truly centered, and you must center it by that stick, or else the wheel that is put into that place will not stand upright. To finish centering this, slacken the clamp a little, and with the hammer in hand, run your lathe slowly, and when the end of the pegwood is down, stop the lathe and tap the top edge of the plate, and start the lathe again, noting what effect your tapping had. It takes practice to center this way, but it is "dead sure." After you have centered, tighten the clamps, and take off the plate, and proceed to set your jewel.

TO MAKE A TRUE STAFF IN AN AMERICAN LATHE.

SAY we have a spring tempered piece of wire, No. 44, Stubb's gauge, which will fit a No. 22 chuck. I turn my staffs hard, while many men blank the staff out, and then take it out of the lathe and temper it, put it back and finish. Tempered steel turns much smoother than soft steel, although it is harder on gravers. I next place my piece of wire in the chuck, sticking it out far enough to turn the whole staff, and I finish the upper end, balance seat, collet seat, and pivot, then turn the hub perfectly true with the pivot and grind it with oil-stone dust; at the same time I grind the pivot, making it smoother than I have the hub, the right length or about it, and proceed to turn as much of the lower part or roller seat as I can before cutting it off. All that I turn before cutting off the staff is aimed to be perfectly in line with the pivot, and the hub is left perfectly straight—not beveled.

When I next cut off the staff, I grasp it by the hub, and after I get it the right length, I true it up with the graver, finding it an easy matter to true it up, as the hub is smoother and the lower part of the staff was turned in line with the pivot. When I get the lower part to run true, I know that my pivots will be in line, for they were turned in line before the staff was cut off. After finishing and polishing the pivot, I take the staff out, get another chuck that will fit the collet seat, and proceed to turn the slope on the hub, and my staff is finished.

CENTERING A BALANCE STAFF OR PIVOT.

I VERY often use a split chuck for a third or fourth wheel pivot, but I generally prefer a brass taper cement chuck for a balance staff or pivot. My method is as follows: After securing the brass taper in the chuck, I turn off the face perfectly smooth, to avoid being deceived in the center, then with a fine pointed graver find the center, which I cut about as deep as the length of the pivot, using a strong glass. To test its accuracy, I take a long pin tongue, soften it, and set the pointed end in the female center just cut—holding the other end against the thumb of my right hand; then by setting the rest close to the chuck, and holding a thin slip of pegwood under the pointed end of the pin, as it rests in the center, and revolving the lathe, the slightest error will be detected by the "wink" of the pin. After being assured of the accuracy of the center, I next apply the cement. By-the-way, about one-sixteenth of one inch from the end of the taper, I have soldered a small piece of thin brass like a washer, which holds the cement better and requires less heat to soften it. The pivot of the staff is then set in the center, and the cement heated until it softens and flows around the staff, and then allowed to cool until it will hold the balance without dropping out. Set the lathe in motion, and turn the other end of the staff by holding a piece of pegwood at rest under the old stump of the broken pivot or the next shoulder, the remaining part of the operation of drilling, setting plug, and turning, has often been described, and which I could not improve upon, except by the cautionary suggestion that the plug be fitted so that it will drive tight with the end touching the bottom of the hole drilled.

A plug, when fitted, is of course a little tapering, and as the hole is the same size when it is driven in, it really binds only at the outside, which is the largest part; and for this reason, a pivot will sometimes work loose when it is being turned off, particularly if the hole is large, with little depth. This may sometimes be remedied by striking the small end of the plug lightly with the hammer, raising a slight burr on the end, and then driving it in as before.

TO PUT IN A NEW SCAPE WHEEL.

LET us suppose the case that a new pinion was put in the scape wheel, and that the workman did not succeed in getting his pinion in true (a very usual occurrence), he now *tops off* the teeth,—very likely rounding up the points of the teeth to avoid "friction," until he gets his scape wheel too small. If our botch stopped here, the remedy would be simple enough; all there is to be done is to put in a new scape wheel of the correct style. A few words in regard to scape wheels, and we will go on with our problem.

Workmen who live at some distance from large stocks of scape wheels should keep a good supply of the commoner size on hand, letting extreme size (either large or small) be in the minority. If you have one of the correct size, all right, put it in; if not, select one the nearest you have *larger*. Set the wheel on the pinion and true it up. Next take your depthing tool, and set the points so they correspond to the holes in the plate. Some little judgment is required to set a depthing tool to exactly represent the distance between the two holes; the best way is to take the inside of the top plate (if an English lever), and set the points as nearly correct as the judgment dictates will be right; next, set one of the points in one hole and with the other sweep a short circle crossing the other hole; then with a double eye-glass determine if the line crosses exactly the center of the hole; if not, set the depthing tool until it does.

Put in your scape wheel and pallets, and try the depth—first by turning your scape wheel backward; if the wheel is entirely too large, it will not turn. Judgment must of course have been exercised in not selecting a scape wheel disproportionally large; still, if the instructions here given are observed, a wheel seemingly much too large can be used. The reader must not imagine that the writer considers this course as the *best*, because he does nothing of the kind; he only gives this as a method by which a fair result can be obtained by persons so situated as to be limited in their resources.

If the scape wheel will not turn backward, and indicates that the wheel is too large, remove the lever from the depthing tool (but be careful not to change the depth), and insert a slip of Arkansas stone so that it will be held steady, and with the fingers revolve the wheel so as to grind off the ends of the teeth. This should be repeated until the wheel turns freely backward. Next comes the testing for the lock, which is a delicate manipulation not difficult to do, but somewhat difficult to describe.

Let us suppose we turn the scape wheel backward, so that the back of the tooth acting against the egress pallet, which we will call *B*, will cause the ingress pallet, which we will call *A*, to advance the impulse face of (ingress) pallet *A*, inside of a part of circle or arc corresponding to the ends of the scape teeth. The scape wheel does not want to be turned back until the tooth against pallet *B* passes the angle of *B*, but only enough so that when the scape wheel is turned forward a tooth will engage the impulse face of *A* somewhat near the middle, if now the scape wheel is moved forward until the latter tooth leaves or drops from the pallet *A*. If everything is as it should be, the latter tooth will fall safely on the locking face of the pallet *B* and *draw* it inward. Both pallets can be tested by this system, only reversing the order, letting the back of the latter tooth strike *A* so as to let the tooth strike the impulse face of *B*, and bring the locking face of *A* into action in the same manner as we did at *B*. This process can be repeated until every tooth is tested as to lock and drop. After the teeth are stoned off to the correct length, they can be dressed up to a point by a slip of Arkansas stone; but only stone the back of the tooth, leaving the front intact. Skill and judgment must of course be used to preserve the correct form of the tooth.

TO PREVENT A WATCH FROM OVER-BANKING.

THE banking pins have nothing whatever to do with over-banking. They only regulate the *run*, or in other words the distance the pallet jewels travel in toward the scape wheel. If the banking pins are too far apart, the scape teeth reach too far up the *locking* planes of the pallet jewels, and the balance, having therefore to carry the fork so great a distance before the scape teeth act on the *impulse* planes, meets with so much resistance that the motion is very much increased thereby, and often causes the watch to stop altogether.

In a correct escapement, the fork should bank against the pins, *immediately* the scape tooth has dropped from one jewel to the other. If the watch over-banks, the fork is either too short or the roller is too small; in most cases the trouble lies with the fork unless the roller has been tampered with. The effective length of the fork should be such that, when the power is on the watch, if the guard point of the fork is pressed against the roller, it will, on being released, return to the bankings. In no case should the fork be left so short that it can be *wedged* against the roller, as the watch would be liable to stop at any time, and if it received a jar, would in all probability start off again and so cause a great deal of trouble in locating the stoppage, in annoyance to customers.

The fork in Swiss watches may be lengthened in several ways. Draw the temper, if necessary, and stretch it with the pane end of the hammer, on the part between the notch and the center. If done this way, care must be taken to see that it is not bent by the stretching, and, if so, straighten it before putting into the watch, or else it would have too much run on one side, and not escape on the other.

Another way is to file back the old guard point or edge, drill a hole and fit a new one having a pivot on the bottom to go through the hole. Rivet it in place, if possible; if not, solder it carefully. It can then be shortened to the correct length, and the fork repolished.

If the watch is an English one, the brass guard pin on the end of the fork will have to be bent forward a little, and if that won't rectify it a new fork must be fitted; but it is necessary to examine everything in connection first to make sure that the trouble is in the fork, as the balance jewels might be broken or too large in the holes, and thus allow the roller to drop away from the fork sufficiently to cause over-banking, or the balance staff might be badly out of true, which would cause the roller to be out in the round, and that would cause it. In any case examine the escapement thoroughly, and locate the defect before making any alterations.

THE "SETTING" OF SCAPE WHEELS.

IT is well known that a large scape wheel will set easier than a small one, since more power is required to propel a large wheel than a small one; and in case of an anchor movement, the pallets are set farther from the center of the wheel; mechanics teach that the farther any part is from a given center the more force it will require to move a given weight. We may express it in different words and say that a less pressure will stop a wheel, when it is large, simply because the contact is further from the center. This can easily be demonstrated by placing one's finger against any wheel in a train of a clock, or at the tip of the scape wheel teeth, when it will be found that the least touch will cause a stoppage. Should we try to hold the pinion, however, we will find that it requires much more pressure. It will, perhaps, be useful to give the relative proportions of this pressure in proportion to the size of wheels and pinions. It will assist in understanding the subject. Let us suppose that we have a wheel three inches in diameter, and on the same axis we attach another wheel one inch in diameter, place a piece of cord round the largest diameter and hang a 1-pound weight on the cord; now wind another cord the contrary way on the small diameter, and it will be found that it requires a 3-pound weight to hold the other in equilibrium; hence we see that if one wheel is three times larger than another, it will of necessity require three times more pressure before it can acquire its proper propelling force. Of course, we are aware that the scape wheels of watches do not vary as much as this, but we simply make use of this illustration to be more readily understood.

Now, when we consider these proportions from the barrel wheel to escape wheel, we can easily understand what a vast difference a slight variation in the size of the scape wheel will make in its propelling force, and this is the reason why we frequently see such strong mainsprings used in some of the inferior grade watches. If the makers were to study well the relative proportions of wheels and pinions, it is certain that they would not employ such strong springs.

After this short digression let us return to the subject. We must remember that a wheel, if too small, is also very detrimental, since, as it were, it seems too quick for the other parts of the escapement, and being so much under the control of the other wheels, it is rather obstinate, and not so willing to make its retrograde motion at the proper time. Of course, when the balance revolves so as to unlock the pallet, the wheel is forced to make this backward motion, but since the pressure is much stronger in a small wheel, when it is extra small, it must lock very hard, and it is therefore very liable to make a bad action, the same as would be produced by a deep depthing. I think I will be understood what I mean by saying that the wheel is too quick, for, with such a pressure it drops into the pallet jewel sooner than it would otherwise, and it is therefore really in advance of the lever and balance. Under these circumstances it is very liable to cut the pallet jewels or get its teeth exceedingly worn. A short time ago I had an escapement of this description under repairs; it had a very broad escape wheel, and the pallet jewels were very round, so that only a small portion of it came in contact with the wheel, which was perfectly flat, so that the jewels caught each tooth exactly in the center. The watch had only been going about eighteen months, but the pallets had "pitted" the wheel, owing to the excessive force, that all the front parts of the teeth were quite worn out of position.

This will also occasionally happen when a particle of oil-stone dust or any similar substance gets on the wheel teeth or pallets.

When the wheel has sufficient metal, this can be remedied by carefully filing the front part of the teeth until the "pits" are taken out; but it requires care, as the file must be held exactly in the same position with the angle of the teeth. If this is not observed, the wheel will most probably be ruined, since no good action can be expected of a watch when the angle of its scape wheel teeth has been disarranged.

THE COMPENSATED BALANCE.

A COMPENSATED balance is one which, when expanded by heat, contracts in some direction to neutralize the effect of that change, and *vice versâ*. The usual method of securing that result is by forming the balance rim of two metals, one of which is more affected by heat and cold than the other, as of steel and brass, with the brass on the outside. When the steel center bar expands and carries the entire rim outward, the brass portion expands more than the steel, and therefore curves the rim and carries the free end of the section, or "segment," nearer to the center than the other end, which is attached to the center bar. By attaching a weight to the free end of the rim, the effect of this movement is increased, as the center of weight of the rim, as a whole, determines the virtual working diameter of the balance, and this diameter is more rapidly varied as the weight thus moved inward and outward becomes greater, or nearer the free end of the segment of the rim. If the weight is moved too far, the vertical diameter of the balance is changed more by that motion than by the heat and cold, the effect of the latter is more than neutralized, and an error of the opposite kind is produced. In this case, the balance is said to be over-compensated, and the remedy is to move the weight (or screws) back from the free end of the rim, till its movements exactly neutralize the errors of time caused by the expansion of the balance by heat, or its contraction by cold. When this is done, the balance is correctly compensated, and the movement is adjusted for heat and cold.

It is obvious that a balance may be correctly made, but not afterwards compensated. It would then be a compensation or expansion balance, but not a compensated or adjusted one. A balance, the rim of which is not cut through entirely, is certainly not adjusted, and cannot be until it is cut. So, also, a cut balance the rim of which is not so made as to be susceptible of adjustment, may be a nuisance, causing the watch to run perfectly "wild." A well-made compensation balance, the rim of which is not cut, is no better than a plain gold balance, because its rim, though capable of compensating, has no chance to do so, its rim being fastened at all points. Consequently it expands and contracts under the influence of changed temperatures just as any other solid balance would do, whether made of gold or any other material. The screws may be ornamental, but they have no function as compensation weights, and such a balance is merely a "screw balance."

From the above will be seen that natural causes contend against plain gold, steel, brass, or any other metallic balances keeping as good time as a good compensated balance, or, indeed, are at all susceptible of keeping anything like correct time. A watch with a plain gold balance may be adjusted to position, and even this is very rarely done, except in movements with adjusted balances. The most usual adjustment is that of the balance to temperatures, and this, as has been shown, cannot be done with a balance of any single metal. The adjustment to positions relates to the balance pivots and their jewels, to secure equal vibration in all positions. The adjustment for isochronism relates principally to the hairspring.

RELATION OF MAINSPRING TO BARREL.

IF we wish to have a mainspring theoretically adjusted, there is no better method than simply to allow one third empty space, one third for the barrel arbor, and the remainder for the spring. When a spring is at rest on the barrel, it should occupy one-sixth of the barrel's inside diameter at either side of the arbor. If we divide a barrel into sixty equal parts, we should always see that the barrel arbor is just twenty of these parts. It is a great mistake to have a barrel arbor too small, for when such is the case, it is almost sure to break the mainspring, if the center is at all stubborn; as is very often the case with the cheap class of mainsprings in market.

THE MEANING "PITCH CIRCLE."

IN every depth the curved portions, both of the leaves and the teeth, which are known as the points or curves, always project beyond the pitch circles. In discussing any depth, we start with the supposition that if these two circles were to roll one on the other without friction, the depth would be perfect or primitive. Hence, they are known in scientific books as primitive, geometrical, or pitch circles, and their diameters and radii are also called geometrical or primitive. Thus in every wheel or pinion it is important to remember that the total diameter is the primitive diameter, plus twice the height of the point, or curve portion of tooth and leaf. Thus in a depth when it is said that the pinion radius is 1.25 inches, the geometrical radius is meant, which reaches from the center of the pinion to the part of the leaf where the curve starts. The geometrical diameter of the pinion is the total diameter less the thickness of a leaf measured at the pitch circle. The study of depthing is very interesting, and as it is impossible to design a correct depthing without thoroughly understanding the theory and necessary calculation involved, watchmakers, especially the younger, should make themselves masters of it.

TO USE THE MAINSPRING WINDER.

ALTHOUGH a mainspring is often put in with the fingers, even by good workmen, still this way has its objections. When using the winder, the spring is to be hooked upon the arbor of the winder, then wound thereon, while holding the coil flat by the thumb on one side, and the second finger on the other side, with the first finger pressing on the outside of the spring to retain the winding. When fully wound, or very nearly so, the barrel is carefully placed over the spring, which is then allowed to slip around within the barrel until it becomes properly hooked, after which the barrel itself is allowed to slowly turn till it is entirely free, and the spring can be easily removed from the arbor.

The winder should of course not be used when the winding arbor is in the barrel, as in watches having a solid ratchet screwed to the bridge, and holding the barrel or barrel head fast on the bridge—otherwise the center of the spring would doubtless be badly bent. It is also necessary to use in the winder an arbor of the same diameter as the collet of the winding arbor, as a larger one would open the center of the spring, and a smaller one is very likely to cause the spring to snap off near the center. Caution must also be used to avoid dirtying the spring and barrel with the fingers, especially if the hands sweat much. That is done by holding the parts with a piece of clean tissue paper between them and the skin. It hardly needs to be said that the winder can work in either direction by moving the spring pressing on the ratchet pawl—and that the spring must not be allowed to slip from the fingers during the winding, else an inextricable snarl may result, damaging or breaking the spring. Many workmen do not use the winder at all, but hold the barrel in tissue paper, hook the outer end of the spring properly, then coil it in from the outside, pushing in a half-coil alternately on each side, with the thumbs. For thin and narrow springs this is as well as the other way, but thick and wide springs are less liable to be bent when inserted with the winder.

•TO CLEANSE A NICKEL MOVEMENT.

WATCHMAKERS sometimes think that nickel movements are more difficult to clean than gilt movements. This is not so, however, and the former are to be cleaned by the same process as the latter. It is also generally supposed that nickel is but little liable to tarnish. This is a great mistake, as it is far more liable to be affected by exposure to moisture, handling, etc., than gilding. In fact, it is almost as bad in this respect as iron, to which it is very similar in its chemical reactions. So far as is publicly known, the best agents for cleaning nickel are mechanical in their nature—that is to say, it is best done by the use of polishing powders. These should not be used dry, however, as the nickel would all be worn off before a polish is produced; nor will moisture make the action any better. Either soap and hot water, or, what is better, a very little oil on a piece of buff leather, mixed with the polishing powder, should be used, finishing with the soap and water, or the alcohol bath. A mere trace of oil on the tip of the finger, gently rubbed over the parts, will readily loosen and remove the dirt and tarnish, after which the oil can be removed as usual.

As far as patent or secret unguents and cleansing agents are concerned, they may, on the whole, be looked on with suspicion, and to the watchmakers at large there is really nothing more accessible or quick-acting than soap and water, or oily substances and polishing powders, with gentle rubbing.

A good polishing powder for polishing up nickel is finely powdered and sifted unslacked lime, used on a buff wheel with a little oil. It should be kept in tightly-corked bottles or jars to exclude the air, and only a little of it taken out and powdered, as wanted.

CORRECT LENGTH OF LEVER, ETC.

IT is quite frequently necessary to determine the correct length of the lever, size of table roller, size of the pallets, and depth of the escapement of lever watches. A lever, from the guard pin to the pallet staff, should correspond in length with twice the diameter of the ruby-pin table, and if such a table is accidentally lost, its correct size may be known by measuring half the lever between the points above named. For correct size of pallet, the clear spot between the pallets should correspond with the outside measure on the points of three teeth of the scape wheel. The only rule that can be given without the use of diagrams, for correct depth of the escapement, is to set it as close as it will bear, and still free itself perfectly, when in motion. This may be done by first placing the escapement into your depthing tool, and then setting it to the correct depth. Then by measuring the distance between the pivots of the lever staff and scape wheel, as now set, and the corresponding pivot holes in the watch, you determine correctly how much the depth of the escapement requires to be altered.

OVER-ACTIVE COMPENSATION.

SHOULD a balance be over-actively compensated, the screws must be set farther back toward the balance arms. Supposing, however, that it is not possible to remove the screws, then their weight must be lessened, in order to reduce the compensation. It is necessary in this case to regulate the movement screw, since it will now advance in mean temperature. This can be effected either by means of the balance spring or by an increase of weight of the two screws opposite the balance arms. When any correction whatever is made to the screws, carefully re-establish the equipoise of the balance.

TO MAKE A BURNISHER.

PROCEED the same way as in making pivot files, with the exception that you are to use fine flour of emery on a slip of oiled brass or copper, instead of the emery paper. Burnishers which have become smooth may be improved vastly with the flour of emery, as above, without drawing the temper. To prepare one for polishing, melt a little beeswax on the face of the burnisher. Its effect then on brass or other fine metals will be equal to the best buff. A small burnisher prepared in this way is the very thing with which to polish up watch wheels. Rest them on a piece of pith, while polishing.

TO POLISH STEEL.

TAKE crocus of oxide of tin and graduate it in the same way as in preparing diamond dust, and apply it to the steel by means of a piece of soft iron or bell metal, made of proper form, and apply it with flour of emery, the same as for pivot burnishers. To iron or soft steel, a better finish may be given by burnishing than can be imparted by the use of polishing powders of any kind whatever. The German mode of polishing steel is performed by the use of crocus on a buff wheel. Nothing can exceed the surpassing beauty imparted to steel or even cast-iron by this process.

POLISHING BROACHES.

POLISHING broaches are usually made of ivory, and used with diamond dust, loose, instead of having been driven in. Oil the broach slightly, dip it into the finest diamond dust, and work it into the jewel the same as you would the brass broach. Unfortunately, too many watchmakers do not attach sufficient importance to the polishing broach. The sluggish motion of watches nowadays is more often attributable to rough jewels than to any other cause.

OILING THE PALLETS OF DETACHED LEVERS.

THE question is often asked whether the lever pallets should be oiled. This depends somewhat on circumstances. Very fine movements are supposed to be so highly finished as not to need any oil here, which is held to be detrimental to fine time-keeping; but the more usual practice, especially with ordinary watches, is to oil them. They should not be *smeared* with oil, so as to run up on the under side of the lever fork, or on the top of the escape wheel, as it will gather dirt and lead to sticking and clogging the wheel, while passing near or under the fork. Only the pallet stones should be oiled, and sparingly.

TO OBSERVE BALANCE VIBRATION.

TO observe the extent of vibration of a balance, run your eye around the rim, and you will see some point, as a screw in the rim, a mark on it, or the end of one of the balance arms, which can be distinctly observed when the balance stops and begins to turn the other way. Notice some stationary part that is exactly opposite, or under that screw at the turning point of the vibration. Now, whenever that screw fails to reach that point or goes beyond it, you will see at once, and see how much it falls short or goes beyond it. By noticing how far the screw reaches in *both* directions, you have the extent of the vibration between these two points. If the screw reaches the same point from each direction, the vibration is "one turn." If it goes one-eighth of a turn further in each direction, that is one and one-fourth turns; and if it falls short one-eighth of a turn *both* ways, the vibration is three-quarters of one turn. A little practice will enable the watchmaker to notice the extent and variations, and to estimate the proportion of a turn.

TO USE THE DEPTHING TOOL.

TAKE your depthing tool and set the points so that they correspond to the holes in the plate. Some little judgment is required to set a depthing tool to exactly represent the distance between the two holes; the best way is to take the inside of the top plate (of an English lever) and set the points as nearly correct as the judgment dictates will be right; next, set one of the points in one hole, and with the other sweep a short circle crossing the other hole; then with a double eyeglass determine if the line crosses exactly the center of the hole; if not, set the tool until it does.

THE SIZE OF THE CYLINDER PIVOT.

TO establish the size of the pivot with relation to its hole is apparently an easy thing to do correctly, but to an inexperienced workman it is not so. The side-shake in cylinder-pivot holes should be greater than that for ordinary train holes; one-sixth is the amount prescribed by Saunier; the size of the pivot relatively to the cylinder about one-eighth the diameter of the body of the cylinder. It is very necessary that this amount of side-shake should be correctly recognized; if less than the amount stated, the watch, though performing well when the oil is fresh, fails to do so when it commences to thicken. The only accurate way of getting at the correct amount of shake is to make a pivot or two to a jewel hole by means of a micrometer; the eye will soon become capable of correctly estimating the amount necessary. If any doubt exists, a round broach can be used to size the pivot hole, and the micrometer will then decide the question.

TO CUT SCREW THREADS.

IT is quite a knack to make a nice screw, and beginners are generally apt to use too much force when cutting the thread. If the spindle has been turned too large for the hole in the screw-plate, there is danger of breaking the tool, which is very hard, and pieces will chip off; again, the piece to be tapped is apt to break and stop up the hole in the plate, thereby entailing the tedious job of drilling the piece out and cleaning the thread. It is better to begin with a hole much larger and working down gradually. It is natural that a certain amount of force must be employed, and a little practice will soon teach the beginner how much, to insure a full good thread. Now, put the screw back in the tool, and turn the head a little more than the required thickness, and cut the screw off by turning a groove above.

THE BALANCE SPRING.

THE study of the balance spring must ever be of the greatest importance to the watchmaker; because it is the principal agent with which he is able to control the rate of the watch. Debating the different kinds of springs, an authority says that the great advantage of an over-coil spring is that it distends in action on both sides, and the balance pivots are thereby relieved of the side pressure given with the ordinary flat spring. The Breguet spring, in common with the helical and all other forms in which the outer coil returns toward the center, offers opportunities of obtaining isochronism by slightly varying the character of the curve described by the outer coil, and thereby altering its power of resistance.

SPEED OF DIFFERENT TIMEPIECES.

THE balance of a so-called 18,000 train vibrates 300 per minute, 18,000 per hour, consequently 432,000 in 24 hours, 12,960,000 in 30 days—so-called month, 157,680,000 in 365 days.

A seconds pendulum makes 3,600 oscillations in one hour, 86,400 a day, 2,592,000 in 30 days, 31,536,000 in 365 days.

A marine chronometer, vibrating half-seconds, makes 14,400 vibrations per hour, 345,600 per day, 10,368,000 in 30 days, 126,144,000 in 365 days.

Let us suppose a watch vibrating 18,000 per hour were quietly laid down or hung up for about ten hours—whereby it would go correctly; but in the next succeeding fourteen hours it would be worn the general length of time, and each vibration of the balance were retarded only by 0.0001, it would be equal in fourteen hours to 25.2 vibrations, or 5.04 seconds; by a regular use, therefore, in one week, 35.28 seconds, and in one month, 2.52, or nearly three minutes.

KNIFE SUSPENSION.

IF a very exact rate is expected from a knife suspension of the pendulum, it stands to reason that neither at the polished edge nor in the pan the least rust must be visible, and the only way to prevent it is by slightly oiling the parts.

NEW METHOD FOR ANNEALING.

IN the oil bath, in which the annealing of the tempered utensils is to be performed lay a metallic ball of about the size of a pea, and consisting of an alloy of 2 parts lead and 1 part tin. This alloy melts at 232° C., and therefore indicates the correct time when the small tools are to be taken out of the bath. Alloys of 3 parts lead and 1 part tin, and 4 parts lead and 1 part tin, melt at 259° to 260° C., at which temperature the utensils become softer.

TO MANIPULATE THE MAINSPRING.

WHEN I take a watch down that has run twelve months and more, I first examine the mainspring, by taking off the cap (head) of the barrel, carefully removing the arbor; then, holding the barrel between the thumb and fingers of the left hand, with a small, round-nose pliers I lift out the inner end of the spring, holding the thumb and fingers in such a manner as to allow the spring to uncoil itself out of the barrel in a gentle manner into the hand; and if sound and of the right strength, I proceed to clean it with a piece of domestic (Yankee) muslin—a piece of your old worn-out shirt, if you please, after a thorough washing, this being soft and free from starch and all foreign matter calculated to injure steel. Holding the cloth or rag in the left hand, the spring in my right, just as it comes out of the barrel, gently moving it back and forth, holding two or three of the coils between the thumb, first and second (middle) fingers, pressing the coil slightly over with the ball of the thumb (not nails), so as not to materially change the natural curvature of the spring in any way during the operation. In this way the entire spring can be cleaned, with the exception of a small portion of the inner coil, which can be cleaned by using a corner of the rag, applied with a piece of pegwood, or by a slight brushing with a brush used for a like purpose. A first-class spring (and no watchmaker should use any other, if he values time and reputation) thus cleaned, with proper space in the barrel, and with the arbor free, of proper size, and a *liberal* application of good watch oil (but not flooded with it) turned up to its proper capacity, will give out its full force for one or two years at least, without breaking, rusting, or becoming gummy and foul.

WATCH DIALS.

THE dial of a watch, says M. GROSSMANN, though of a material rather inconvenient to handle, is not much open to improvements. The liability to injury of the enamel has led to many attempts to replace it by some more suitable material. But the principal considerations of a good dial, distinctness, has never been attained in such perfection as with the enameled. A perfectly white surface, with deep black figures on it, cannot be surpassed for this purpose.

For these reasons, the enameled dial, in spite of its fragility and thickness, is and will be kept in use by all those who do not leave out of sight its principal purpose; but it cannot be denied that the invention of a metallic or other appropriate material, possessed of the indispensable qualities, would indeed prove a great progress in practical horology. Here is ample room for useful inventions. There was a period when in England and elsewhere dials were preferred of a yellowish or greyish tint. These are, of course, not so fit for the purpose as those of pure white enamel. In the same way the slightly frosted surface of the English dials is thought a great improvement, as it is said to allow of looking at the watch in any direction without being disturbed by the reflection of the dial surface. This is a strange mistake, for if the dial of a watch does not reflect when held in an awkward direction, the glass over it will certainly do so. Besides it is so very easy to look at a watch without any danger of annoying reflex.

The fastening of the dial in its position is effected by pins or screws. It is not advisable to fix the dial with unduly small screws and holes drilled through it, because the dial is greatly exposed to injury by the slightest sideward pressure when shutting the case, the holes being so very near the edge of the dial. This method of fastening dials was formerly preferred by the best French and Swiss makers, and many a fine dial has been spoiled by it.

A dial fastened in this way requires some care of the repairer when putting it on. He ought to screw both the screws gently down, but afterward to release each of them by about one-quarter of a turn, so as to ease the dial in its position.

Another way of fastening the dial is with pillars, or feet, and pins. It is quite efficient, and involves no danger; therefore it has been much in favor in English watches, and if the movement can be gotten at, there is nothing to be said against it. But in the movements of the present period, the greater part of which do not open with a joint, the fastening with pins would be rather troublesome, because, for taking off the dial, it would be necessary to take the movement out of the case.

In all movements cased in this way, the dial pillars ought to be held by key screws, which allow taking off the dial without removing the movement.

A very good method of fastening the dial is to set it in a thin rim of silver or gold, and adjust this rim nicely on the outer edge of the pillar plate. Then, of course, the dial requires no feet, and all the difficulties resulting of collision of these feet with the parts under the dial of complicated watches are done away with.

The hands, in order to be distinctly seen, ought to be of a dark color, and the generally adopted blue steel is far preferable to gold for this purpose, and the figures and hands ought to be a little more substantial than the present taste prescribes for them. The most convenient shape for the purpose is the spade pattern; the Breguet and fleurs-de-lis hands not being so easily distinguished.

The circle of seconds ought to have every fifth degree visibly marked by a longer and stronger stroke, in order to facilitate the reading of seconds.

Formerly, all the dials had flat seconds, but since about thirty years it has been quite common to have sunk seconds, even for inferior watches. There is some advantage in that, especially in flat watches, where it affords accommodation for the seconds hand, but at the same time it weakens the dial considerably. This may be the reason why some makers have the sunk part much smaller, and the seconds painted on the main dial, the lines extending inward to the edge of the sink; the seconds hand is then shorter, and moves in the sink. The dial ought never to be made larger than the pillar plate.

TO CORRECT THE CENTER STAFF.

THE repairer will often find, especially with stem-winding watches, that the center staff moves too easily. He will also find that this defect has been corrected by working burr on the staff by means of a graver or a sharp file; it is true that this remedy will, for a time, be quite efficacious, as it will, so to speak, enlarge the staff and produce a stiff motion. This is not of great duration, however, since, by the moving backward and forward of the hands, the burr will gradually drop off, and finally become a good grinding material by combining with the oil, and in due time will aggravate the defect by wearing the center staff and the hole of the center pinion, and the motion of the hands becomes still looser. Should next the loosened burr leave the pinion and combine with the oil of the pivot, the consequence will be still graver than formerly, because the jewel holes and pivots of the center wheel will be interfered with to such an extent that the watch must become faulty in its rate.

It is the purpose of these lines to acquaint my colleagues with another less known method, which is both shorter and accomplishes the purpose much more securely than the above. Fasten the square of the center staff in the pin vise; if the staff has at some previous time been treated in the above described manner, go over it with the pivot file and remove all traces; then with a fine rat-tail file file in it a so-called lantern, in such a manner that it is about one-third of the length of the center pinion away from the square. Then lay the staff flat upon an underlay, and gently tap it with the hammer in such a manner that the upper part of the notch slightly inclines to one side. This notch, which will now exert a slightly springy motion, will produce a greater tightness of the staff, and if the operator is careful not to file away more than from one-third to one-half of the staff the watch will not be exposed to the inconveniences frequently occasioned by too great a looseness of the motion work.

LONG OR SHORT FORKS.

BY long and short forks we mean to distinguish those, the length of which contains the diameter or rather the semi-diameter of the table roller a greater or less number of times. Thus we call a short fork one which is 3 or 3½ times the length of the semi-diameter of the table roller, and we would call a long fork one which is 5 or 6 times the length of the semi-diameter of the table roller. In both instances the table roller is to be measured from the staff hole center to the radial center of the jewel pin, and the fork from staff hole center to that point in slot where it comes in contact with jewel pin. Supposing the pallets acting with long and short forks having the same impulse angles, say 5° on each side, then the short fork, as stated above, would give from 30° to 35° impulse to balance and the long fork would give from 50° to 60° impulse to balance. The first point which forces itself upon our observation is the disparity between the unlocking and impulse angles of the two, as shown by the balance, *i.e.*, by the angular motion traversed, for we have to suppose that the unlocking angle, as between wheel and pallet, is about the same or as short as possible in both instances. Presuming this to be the case, the unlocking of the escapement by means of the long fork is easier, but of longer duration, while that by means of the short fork is harder, but of shorter duration. But as the most acute resistance in unlocking the escapement is felt at the beginning, the unlocking by means of the long fork would have an advantage over that by means of the short fork, where the stronger impact would make an unfavorable impression on the balance pivot or pivots, and affect position unfavorably and very unevenly in watches with unequal motive power, or a going barrel during the twenty-four hours running. But if both escapements, with long and short forks, are proportioned in their other parts, as they should be, there is still a further advantage in favor of the long fork by the pallet-staff pivots having less pressure, and therefore less friction on account of the larger escape wheel, making the unlocking easier on that account, and this is quite important.

Another point in favor of the long fork is shown by the following argument: Most lever escapements can be brought to a standstill on the unlocking faces of the pallets by an immoderate increase of the motive power, showing thereby that the unlocking resistance of the escapement is not in proportion to the impulse force, and the former is too great. But as the long fork lessens this resistance by making the unlocking easier and of longer duration, instead it shows a move in the right direction, which has a tendency to make the motion of the balance more uniform with a varying motive power (a going barrel), and therefore more isochronous, regardless of any condition of the balance spring.

Furthermore, as the long continued impulse on the balance by means of the long fork for 50, 60 or more degrees, has the effect to accelerate the motion of the balance more and more during the progress of the impulse, the retarding of the motion of the balance by the unlocking resistance of the escapement is more likely to be neutralized, and we are more likely to come near a perfect isochronism by means of the hairspring in adjusted watches. Adjusters of watches will readily see this, as the unlocking of the escapement is their great bugbear.

We will next discuss the advantages of the short fork, the advantages of the one being the disadvantages of the other.

It is a well-known fact that all watches having the lever escapement have a tendency to gradually go slow or lose on their rate on account of the oil on the escapement, and it is principally on this account that the chronometer escapement excels the lever escapement. This tendency is more pronounced the longer the escape wheel lingers on the pallet faces during the running of the watch. Therefore, watches with lively motions are desirable and will perform better or keep their rate better for a long time than those with short motion, and it is a standing rule that the contact between the balance and the escapement should be of as short a duration as possible to avoid the oil influence as much as possible. This is in favor of short forks or a short impulse angle and quick beat. But in order to derive the full benefit from them, it is indispensably necessary to have all the details of the escapement executed in the most perfect manner, as a deep locking, too much drop or carelessly fitted pivot holes (either any one or all of them) would neutralize any advantage which we might have a right to expect from a short impulse angle or a quick beat, and a short motion with a short fork is no better and not as good as a large motion with a long fork, where the extent of vibration would more than equalize matters. It has always seemed to me to be a popular error to assert that a quick beat, or, say, an 18,000 beat train, should go better on a railroad than 16,200 beat train, as the latter is more easily isochronized. Of course, a good deal always depends on the general construction, extent of vibration and weight of balance, or, as the French would say, "le tout ensemble."

THE IMPORTANCE OF THE PROPORTIONS OF A WATCH BALANCE.

ABOUT thirty-five years ago fusee watches had the lead in this country. Adjusting watches to heat, cold and position was hardly known and not appreciated, because the public had not been educated. A Charles Frodsham watch was the *ne plus ultra*. The only watch not having a fusee and which began to assert itself about this time, was the watch made by Jules Jurgensen, of Locle, Suisse. Of all the Swiss watches I had seen before the advent of this one or which I have seen since, none would hold its rate for years as well as this one, though during the twenty-four hours' running it did not equal the fusee watch for regularity, but it would always show an error during the last two hours of its running or before being re-wound. Gradually the competition between fusee watches and going barrel watches became intensified. Finally it was established to the satisfaction of the two parties in this country, who took opposite views in the matter, that it was possible to make a watch with a going barrel which would run with the same regularity as a fusee watch, and the fact was clearly established that it could be accomplished by proportioning the momentum of the balance to the motive power in such a manner, that, should the vibration of the balance be disturbed by local or external influences, the motive power stood in such proportion to the momentum of the balance and the escapement, that they would not disturb the regularity of the time-keeping, or, in other words, that the time lost in the motion of the balance in unlocking the escapement was recovered by the accelerating effect of the impulse, no matter what the extent of the vibration might be. Heretofore the large sized English fusee watches usually carried balances weighing as much as 16 grains, while the weight of the balances in our best American going barrel watches is probably between 8 and 9 grains. It is not the weight of the balance only, however, which is our guide, but it is the *momentum* of the balance with which we have to deal.

A balance measuring 1 inch in diameter, controlled by a balance spring which brings it to time, would have to be four times as heavy if it were only ½ inch in diameter, if it were to be controlled by the same balance spring as the former, being 1 inch in diameter. But why? Because the rim of the small balance is only half the distance from the center, and any given point in the rim would have only half the distance to travel for an equal angular motion with the large balance. But the smaller balance would have double the momentum of the large balance, because momentum is weight multiplied by velocity, and if we multiply the weight of the small balance, which is four times as great as that of the large balance, by the velocity, which is one-half of the large balance, we have a momentum twice as great,

$$\text{or, } 1 \text{ inch} \times 16 \text{ grs.} = 16.$$
$$\tfrac{1}{2} \text{ ''} \times 64 \text{ grs.} = 32.$$

Here, then, we have the power to regulate the momentum of the balance and make it suitable to any watch, and here, also, we have the power to make the momentum suitable to any motive power and to make a watch run uniform, no matter how much the extent of vibration may vary.

If this is true, can we wonder how some watches, even with isochronized hairsprings, run so much poorer than some others. The whole trouble in such cases lies in the badly proportioned balances, if the escapement and everything else has been attended to. Long and short forks, lockings and impulse angles, pivots, etc., all are factors in the problem.

Next: As I understand it, the prevalent and accepted theory is that the balance spring must always be made to suit the balance for isochronism. But we can also so change the momentum of the balance, as to produce isochronism without ever changing the spring one particle. Small and heavy balances have a greater tendency to go fast in the short vibrations, while large and light balances (both being to time with the same balance spring) have a tendency to go fast on short motions, and all this is owing to a different development of the momentum between the two. The small and heavy balance develops its momentum faster and overcomes the resistance of the balance spring easier on the long vibrations, and causes a watch to go slow on the long vibrations. The larger and lighter balance develops its momentum slower; in fact, it can never develop the same amount of momentum under any condition as the small balance, because the proportion between the arm and the rim shows a less pronounced difference.

A similar theory applies to watches having slow and quick trains. The slower the vibrations of a watch the less control has the balance spring over the balance, if the latter is of the same proportion as the balance of a quick beat train, and the development of the momentum of the balance in a slow beat train is proportionately faster than the development of the force of the balance spring, the latter being, by the very force of circumstances, weaker and incapable of developing the same force as the balance spring in the quick beat train. The effect on the isochronous condition of the balance springs of the two becomes at once apparent.

ISOCHRONISM.

ALTERING the length of the balance spring brings a multitude of new factors into operation, which more justly claim and are constantly quoted as being the actual causes of isochronism and its variation; and this may explain the confusion of ideas and the contradictions so general on this subject. Most writers and practical men, who do not take the trouble to theorize, are quite sure of the fact that a variation of length causes a variation of isochronism. Saunier's book on horology quotes and indorses various authorities to show that a certain length of spring is necessary to secure isochronism, especially with spiral or flat springs. Mr. Glasgow, in his admirable practical articles on springing, contends for length as a prime element in securing isochronism, and makes no reference to the spring being made eccentric or small, except as a matter of convenience or as a means of altering the adjustment for position. I can find no reference to the eccentric action of the spring as a means of curing errors of isochronism, until Mr. Kullberg gave me the idea, and there can be no doubt but that it is correct.

Like will cure like—that which causes the disease will cure it. The want of concentricity or truth in action is the cause of variation in long and short arcs, or want of isochronism, and long springs, tapered springs, Breguet springs and double-curve springs are used and proved to promote isochronism; yet notwithstanding the inferiority of the flat spring—a single look at which in action shows its marked inferiority—practical results are obtained with it equaling the more perfect springs; and if acceleration of the short arc is desired, to neutralize the retarding influence of oil in cold, is most easily obtained by it. This shows that the error which is incident to this spring, as usually applied, causes the watch to gain on the long arcs and lose on the short. By reversing this error, we can utilize it. A spring pinned to be quite true at the collet and stud when at rest, develops a series of eccentric circles of increasing eccentricity as the arc of vibration increases. As the eccentricity, so is the error in long and short arcs. A spring being most easily wound when most true, the eccentricity causes a relative increase of power or butting action, which accelerates the action where it occurs. If we fix the spring on the collet and stud so as to throw the eccentricity when at rest near the stud, we can have all the eccentricity in the short arcs of vibration causing their acceleration, or, dividing it between the long and short arcs, secure a circulation of the spring in the middle of its vibration. The matter may be summed up as one of convenience, and in springing with the flat, the circularity of the spring, with the balance turned half the distance it usually vibrates, must be created, if it is to be isochronous. The Breguet and chronometer springs do not, when perfect, move on the balance circle, but with it; the flat spring travels to and from the center if pinned quite true, and the spring circle is only eccentric when at rest, and the whole of its eccentric action is on one side of the balance, on which it exerts a constantly increasing influence. When pinned out of circle when at rest, the circle travels with a diminishing eccentricity to the center of the balance, then becomes concentric with it, and the increased motion creates increasing eccentricity on the other side of the center of the balance. By this means the eccentricity of the spring may be utilized to secure or vary isochronism; and this, doubtless, is the basis of all the changes that are recognized as resulting from altering the length of spring. Perfect truth in a spiral spring being impossible, the spring is shifted about until the error it contains is neutralized or balanced. In the face of this fact, one will be astonished at the opposite opinions expressed on this point. Urban Jurgersen states that the taped spring will give isochronism, which is correct, and twice asserts that the short arcs are quickened with ordinary springs by increasing the length of spring. This is contrary to what is usually asserted, though some writers say, if the short arcs are not accelerated by taking up the spring, let some out. Mr. Immisch repudiates length as of any consequence; and Mr. F. Cole, in his treatise, says the altered length of spring has of itself no influence as a principle in counteracting errors of isochronism, which is chiefly effected by the change of length, altering the mechanical relation of the collet with the stud. Mr. Cole's essay, I am inclined to think, is the most valuable one we have on the subject, as he proves that the subject of isochronism of the balance includes the whole art of watchmaking, and also shows that isochronism, pure and simple, is only to be found apart from watchworks, as a branch of pneumatics relating to vibrating or oscillating bodies, though he makes the singular mistake of asserting that no sufficient test of the isochronism of vibrating strings, reeds or pipes can be had in long and short arcs of vibration, as these only have an extent of a few seconds time after any given blow or impulsion.

I will conclude with an experiment showing the value of the Kullberg idea of putting the spring close to the stud or index. A common eight-day lever timepiece, a constant eye-sore, owing to its gaining some three or four minutes when fully wound, and losing the same when nearly run down, offered an inviting field for experiment; and making no alteration beyond setting its spring well toward the stud, no difference could be detected between the first and last of the eight days in its time, which seemed perfect. I have not succeeded in getting it to gain in the short arcs, and a recent experiment in putting the spring very much out of circle toward the stud, seems to develop so much friction at the pivots, which are not jeweled —it being a common Yankee with the usual steel holes—that the original fault seems to develop; and it may be observed that balancing the friction at the pivots, as shown by increased arc of vibration, and observing the circular appearance of the spring in actual motion, is the best practical guide for success in this direction.

TO POLISH A WHEEL.

EASY as it may seem, nevertheless the polishing of a wheel is quite a difficult matter—that is, to a workman who is not accustomed to polishing—to insure success. It is like everything else in watch work, it requires a fair amount of practice, personal instruction and the greatest cleanliness. If the operator is unsuccessful, he may, in the majority of cases, trace his failure to a want of cleanliness. Put a cork, cut flat on top, in the vise, place the wheel on the cork as far as the pinion will allow; take a bluestone, which was previously reduced to an even face by having been rubbed on a stone, and water, and stone the wheels smooth and flat, at the same time keep turning the wheel round with the left hand; then wash it out and put in a box with some slaked powdered lime; the object of this is merely to dry it, and prevent the pinion from getting stained or rusty. Then brush it out nice and clean, put another cork, cut clean and flat, in a vise; then pound on a stake some fine red-stuff. Some workmen add a little rouge, but that is according to fancy. Take a slip of tin, about the size of a watchmaker's file, only thicker; file the end of one side flat and smooth, charge it with a little of the red-stuff and polish the wheel, keeping it turning all the time with the left hand, and do not leave off until the wheel and tin polisher are almost dry, so that you can see the polish; and, if to your satisfaction, clean it off with pieces of soft bread, and brush it out. If it has scratches on it bread them off, and clean off the tin and charge it again with the red-stuff. As said, cleanliness is of great importance, for if there be any grit about the red-stuff, polisher, or the fingers of the workman, the work will be full of scratches.

The above system applies to solid train wheels only.

Escape wheels are polished in the same way, but before they are put on the pinion.

Solid wheels, such as fusee and movement wheels, are polished in the turns, using soft wood or burdock pith instead of tin. There is another way for polishing them, however, which is quite as often employed, by which they are fixed to a small brass block. The block is heated in a bluing pan, and a piece of resin passed lightly over it so as to leave a very thin varnish only, which is quite enough to make the wheel adhere; there should be circles marked on the face of the block as a guide for fixing the wheel as nearly central as possible, or else a small pin in the center of the block to go through the hole in the wheel with the same object. The wheel fixed to the block is first rubbed till quite flat on a piece of bluestone having a true surface, which is kept moistened with water; it is rubbed with a circular motion by means of a pointer (generally a drill stock), and pressed down on the middle of the back of the block, which is hollow. The wheel is thoroughly cleaned and then polished on a block of grain tin with sharp red-stuff and oil well beaten up previously. The block of tin rests on a leather pad. When one side of the wheel is finished it is placed again in the bluing pan. The old resin is cleaned off, and the finished side of the wheel fixed to the block. After both sides are polished, the wheel is placed in spirits of wine to remove any resin adhering to it.

Pierced wheels are first rubbed flat on a cork with a bluestone. After cleansing they are polished with a soft tin polisher and moderately sharp red-stuff, using a slightly circular stroke. Instead of a plain cork some finishers use a half round cork resting in a notch cut in another cork. When quite smooth the wheels are washed in soap and water, and burnished on a clean hard cork with a burnisher well rubbed on a board with rotten-stone or red-stuff.

Another method for polishing wheels is also much employed: Grind the wheel well upon a cork, and pay strict attention to remove all the burr from the limbs. Then polish with a zinc file moistened with crocus and alcohol. After the wheel has been polished with it, take a sword file and finish polishing with it. Before using, the sword file is to be sharpened and rubbed with a little wax, after which the file is wiped off upon a piece of cloth, so that only a film of wax remains upon it. A brass wheel may also be polished in the following manner, viz.: by grinding it with slate stone and oil, and polishing with diamantine upon boxwood with a few short strokes. For sharpening the sword file emery paper is much employed, after which the file is in gradation sharpened upon decreasing by emery.

INERTIA.

THE meaning of scientific terms, says a contemporary, is often in part lost when they are employed by practical men. Thus the word inertia is, with them, synonymous with equilibrium; a balance of a watch, a wheel or a pair of pallets is in a state of inertia, according to the erroneous language of the workshop, when that balance, etc., is equilibrated on the horizontal axis in all the positions we can cause it to assume. Such an employment of the term is unfortunate.

Inertia is that property by which a body, when at rest, remains at rest, and when in motion remains in motion. It is exemplified in the excessive resistance offered by a body to being suddenly set in motion or brought suddenly to rest when in motion.

A horse, harnessed to a heavy wagon, strains violently and makes great efforts in order to set it in motion, but draws it along with ease when this is once accomplished. On the contrary, when the wagon has attained a considerable velocity, the horse cannot stop suddenly without receiving a violent push forward. These two effects are due to the inertia of the mass of the wagon.

FUNCTION OF INERTIA IN THE ACTION OF ESCAPEMENT. — HEAVY WHEELS.

EVERY wheel, however light it be, must have some appreciable weight; it is, therefore, subject to the law of inertia. Hence results that when we wish to set in motion a wheel round its axis it cannot commence moving at once; there is a transition period of rest which, although not always perceptible, is none the less real, and the wheel only attains its maximum velocity after a certain arc has been traversed by any point on its circumference.

As the effects of inertia thus increase with the weight of the body, and its velocity, it is important to note the influence on escapements, especially during the lift action; the wheel then travels during a very short space of time with a considerable velocity. The following example of the influence of inertia has actually occurred in practice: In a detent escapement, with an escape wheel full heavy, the motion of the balance was sluggish and the vibration was of but moderate extent. The workman engaged on it cut away part of the interior of the wheel and reduced its arms; in short, materially diminished its weight, and, by this simple change, very appreciably increased the extent of the vibration of the balance.

It is hardly necessary to explain that the heavy wheel, offering an excessive resistance to motion, supplemented the resistance caused by friction and oil; as the wheel was longer in commencing its motion and turned more sluggishly, it did not come in contact with the lever of impulse until the latter had traversed a considerable portion of its angular path. The final result was a noise and but slight impulse. The wheel, after being reduced, commenced its motion sooner, and, almost immediately coming in contact with the lever, accelerated its motion to the required extent.

ERRORS WITH REGARD TO LIGHT WHEELS.

FROM observations analogous to that above described, it is generally assumed and set down as a mechanical truth, that in every escapement the wheel should be as light as possible. A question which has not received sufficient attention has thus been decided in a very absolute manner, and the solution of a particular problem has been made binding on all the escapements used in horology. Would a wheel entirely wanting in inertia be a valuable acquisition? There seems to be great reason to suppose that it would not. But although such a case could not occur, since the metals employed always have an appreciable weight, it is none the less useful to point out that the velocity of rotation to be communicated to a wheel depends on the manner in which it influences the lever of the balance, and on the amount of energy it is required to give out while actually impelling the balance. The following observation of a clever watchmaker, M. Moinet, will do more to explain the subject than a considerable amount of argument, and will also illustrate the converse of the case above cited: A chronometer escapement worked well although the wheel was somewhat heavy, but when this was rendered lighter it caused the escapement to catch. The excessive lightness of the wheel was evidently the cause of this fault, as it changed position more rapidly than the balance; that is to say, instead of contact with the face of the pallet when it had time to recoil to a suitable position, the wheel commenced moving with considerable rapidity and struck the angular extremity of the lever, producing a butting action.*

Every watchmaker is aware that a slight displacement of the lever of impulse is all that is required in order to avoid stoppage, and that the above case is only quoted as an example of the influence of inertia. Experiment and a consideration of the nature of the metals actually employed show without doubt that in those watches in which the vibrations are rapid, it is necessary to make the escape wheel as light as possible, but care must be taken not to unduly diminish its solidity. The word solidity does not here merely imply that the wheel must resist certain causes of breakage or distortion; but an escapement wheel must be absolutely firm throughout, and this firmness can only be secured by care in the choice of the metal employed and of the form given to the wheel. Thus, an arm of a wheel of rectangular section is less rigid when placed edgeways than when its broader face is parallel to the plane of the wheel. With regard to such horological appliances as are regarded by a pendulum or a heavy annular balance, it remains for experiment to ascertain whether a certain slight amount of resistance due to inertia in the wheel is not necessary, since the wheel must move with a velocity determined (1) by the greater or less inertia of a train of wheels of a definite weight which abandons its state of rest or recoil; and (2) by the velocity acquired by the lever on which the wheel acts, a lever whose motion is slow in comparison with the velocities met with in watch movements. Inertia is proportional to the masses of bodies when their velocities are equal, and to the squares of their velocities when their masses are equal.

* The editor urges the following objection to this conclusion: This does not appear a sound argument against a light wheel. Evidently the heavy wheel moved slower on account of its weight, and therefore allowed the balance time to travel far enough to receive the scape wheel tooth on the impulse roller; set the roller back half a degree and this error could not occur, no matter how light the escape wheel.

PIVOTING A BALANCE STAFF.

PINIONS vary, so do working methods. We all may have our peculiar notions how a job should be done, and it is not well for any one to prescribe the way in which, and in no other, it should be done. Let us take as an illustration the putting of a pivot into a staff. Some say it should first be driven out of the balance; I never do it, however, and I flatter myself that I do a job not inferior to that of many. I am convinced that both the staff and the balance are liable to sustain more injury by being driven out and put back than by carefully drawing the temper. If the watch is of so fine a quality that the temper might not be drawn, then for the same reason a pivot should not be put into it, but a new staff. In such a case I always turn the rivet off, so that the staff comes out easily, without straining the balance.

Many years of experience have taught me to regard my way of putting in a staff or pinion to be the best. It is as follows: Take a slice of potato, a quarter of an inch or so thick, and another much thinner, place your wheel or balance fairly in the middle of the hole between the two slices, the thin slice on the side in which the pivot is to be put. If it is the lower pivot, blow a jet of gas parallel with the balance. This ought not to alter the temper of the balance. If it is a top pivot, stick a piece of potato on the other pivot and blow a sharp jet of gas through the hole. The slices of potato must be pressed firmly together, and fastened by sticking a few pins obliquely through them. Now cement a brass or ivory collet on with beeswax, place it in the turns, with the broken end running on the stump or shoulder. See that the balance runs true and flat; you will probably find it all right; if not, make it so before proceeding further.

I might say here that I do all this kind of work with the bow and turns, and consider it the only correct way. I have been fooled a few times in doing this kind of a job with a lathe and chuck, and found that when I supposed the job was finished, I have discovered that the end gripped in the chuck, instead of running to its center, had been describing a small circle. Being satisfied that the balance runs true, turn or reduce with a file to the shoulder, whether it be long or short—having previously noticed or gauged the length of it, down to the part on which the spring collet fits. Find your center as near as you can; it is desirable to get the center, but not absolutely necessary, with the top pivot. Chamfer it out with a piece of hard steel with three-sided point. Put it into the turns, and proceed to drill it with a large drill, and see to it that the old pivot in this and all subsequent operations turns on a brass center, clean and well oiled, or you may find to your discomfort by the time your job is finished, that it is worn so short as to render the staff useless. I have for several years made my drills of piano wire. It is very soft when annealed, and very strong with a hard temper, and in just the proper temper for pivots, as you buy it. Try it once, and you will never use anything else.

Harden your small drills by giving a red heat, and a vigorous shake in the air; large ones by sticking them in a potato, soap or wax. When hard, clean them by holding them loosely with finger and thumb, resting on a cork in the vise, and rub with pumice stone as you would any piece of steel work for a watch. If you use the wire I have recommended, just a tinge of straw color will cut well. Having drilled the hole deep enough, fit your pivot in by filing first, and then grinding it in with a little oil-stone dust; when fitted well, cut the piece off as long as required, to give room for turning, take a little off the end that goes in the staff, with a slip of stone, put your balance and staff in the riveting stake, and drive your pivot with a few light taps of the hammer, moving your job round a bit between each tap. Point the new pivot, and put it into your turns; your balance will now show any deviation from the center. Alter the point till the balance runs perfectly true, then proceed to turn a new shoulder and pivot. All this will apply to a wheel and pinion.

CLOCK REPAIRING.

A CONSIDERABLE part of the life of the country watchmaker, says a correspondent in one of our European exchanges, is spent in repairing and cleaning clocks, so that a few practical remarks on this subject may perhaps be of use to some who may not have the advantage of being able to refer to an experienced workman when in a difficulty. Occasionally even good workmen are nonplussed, an instance of which occurred only a few days before writing. A fine chime clock by a good maker was sent to him with a message "that it stopped sometimes, and the chimes persisted in getting wrong"; it had only recently been in the hands of a good workman, who had passed it as correct. On examination the correspondent found the quarter gathering pallet split right through the boss, consequently when the train was stopped by the tail of the gathering pallet engaging with the pin in the rack, the pallet opened and allowed the square on the arbor to rotate, thus throwing the chimes into confusion. On taking the clock to pieces and opening the barrels, he found, as he had anticipated, that several of the inner coils of the springs were lying close round the barrel arbors, proving that the springs were exhausted or set; this accounted for the stopping which occurred toward the end of the week. The correspondent mentioned this instance simply to show how easy it is for even an experienced workman to be deceived unless he pursues a methodical course in examining for faults.

The course that I have always followed has been: After taking the movement from its case, removing the hands, dial, minute cock, and bridge, to try the escapement with some power on, and note any faults there. Next remove the cock and pallets—putting a peg between the escape wheel arms to prevent it from running down—and carefully let down the spring; you will meet with a difficulty here sometimes; if the spring has been set up too far, and the clock is fully wound up, it may not be possible to move the barrel arbor sufficiently to get the click out of the ratchet. In many old clocks there will be found a contrivance to meet this difficulty. It is simply a hole drilled at the bottom of and between the great wheel teeth directly over the tail of the click, so that it is possible to put a key on the fusee square and the point of a fine joint pusher through the hole, release the click, and allow the fusee to turn gently back until it is down. This is a great convenience sometimes, and it is a wonder that it is not still done. Having let down the spring, try all pivots for wide holes, and if it is a striking clock, do the same with the striking train, paying particular attention to the pallet pinion front pivot to see if it is worn, and the rack depth made unsafe thereby—also seeing that none of the rack teeth are bent or broken. Having noted the faults, if any, I take the clock to pieces, and look over all the pivots, and note those that require repolishing. Finally I take out the barrel cover and see to the condition of the springs; as I have already referred to the appearance of a spring when it is exhausted or soft, I need not do so again here.

In most cases, some repairs will be required to the pallets, as these nearly always show signs of wear first; if they are not much cut, the marks can be polished out without much trouble—and for this purpose you will find that a small disc of corundum, about three inches in diameter, mounted truly on an arbor, and run at a high speed on the lathe, will be of great assistance; finishing off with the iron or steel polisher and sharp red-stuff. If you have to close the pallets to make the escape correct, see that the pallet arms are not left hard, or you may break them.

If the pallets require much alteration, or you have to make a new pair, use any one of the tools found at the material stores. After making any alteration in the pallets, you will generally find it necessary to correct the depth. Should it only require a slight alteration, probably it will be sufficient to knock out the steady pins in the cock, and screw it on so that it can be shifted by the fingers until you have the depth correct, then screw it tight and broach out the steady pin holes, and fit new pins. The repairer will occasionally meet with a pallet arbor that has been bent to correct the depth. This is a practice that cannot be too strongly condemned, as it throws an unequal pressure on the pivots, and causes them to cut rapidly. If much alteration in the depth is required, it may be necessary to put in a new back pallet hole; this can be made from a piece of hollow bushing, broached out and turned true on an arbor, and to a length equal to the thickness of the plate. It is not safe to rely on the truth of this bushing, unless it is turned on an arbor first. The hole in the plate is now with the round filer drawn in the direction required, and opened with a broach from the inside until the bushing enters about half way. Of course, in finishing broaching the hole, you will roughen the extremities to form rivets. Drive the bushing in, and rivet it with a round-faced punch from the outside, reverse it, and rest the bushing on the punch, and rivet the inside with the pane of the hammer; remove any excess of brass with the file, chamfer out the oil sink, and stone off any file marks; finally opening the hole for the pivot to the proper size. Of course, if you have a depthing tool that will take in the escape wheel and pallets, it will be quicker to put them in the tool, fill up both holes with solid bushings, and replant them.

The repairer will also very frequently meet with a scape pinion that has become so badly cut or worn as to be useless, and one cannot always purchase a new one of the right size; in this case, it will be necessary to make it from the wire which can be obtained of every size at the tool shops. In sectoring the pinion wire to the wheel, bear in mind that it will become slightly smaller in filling up. As perhaps some workmen may not have had any experience in making pinions, I will briefly describe the process; but considerable practice is required to make good shaped pinions quickly and well.

A piece of pinion wire of a slightly greater diameter than the pinion is to be when finished is cut about one-eighth of an inch longer than required, and the position of the leaves or head marked with two notches with a file. The level portion of the wire that is not required is now carefully filed down on a filing block, taking care not to remove any of the arbor in so doing; a center is then filed at each end true with the arbor, and these centers turned true through a hole in a runner or center in the throw. If this has been carefully done, the pinion will be nearly true; it is now set quite true, and the arbor and faces of the pinion turned square and smooth. The pinion is now filed out true, using a hollow-edged bottoming file for the spaces, and a pinion rounding file for the sides of the leaves. In using the bottoming file, the pinion is rested in the gallows tool and held in the fingers of the leaves, when finishing, to keep them flat. The file marks are now taken out with fine emery and oil; the polishers that I always have used for this purpose are pieces of wainscot oak, about a quarter of an inch thick, five inches broad and six inches long, used *endway* of the grain. One end is planed to a V-shape, to go between the leaves, and the other cut into grooves by rubbing it on the sharp edges of the pinion itself, which speedily cuts it into grooves to fit. The pinion is rested, while being polished, in a block of soft deal, which allows it to give to the hand, and keep it flat.

When the file marks are all out, the pinion is ready for hardening. Twist a piece of stout binding wire around it, and cover it with soap; heat it carefully in a dead fire, and quench it in a pail of water that has been stirred into a whirlpool by an assistant, taking care to dip it vertically. Having dried it, it is covered with tallow and held over a clear fire, until the tallow ignites; it is allowed to burn for a moment, and then blown out and allowed to cool. The leaves are now polished out with crocus and oil in the same way that they previously were with emery. Now, if the pinion is put in the centers and tried, it will probably be found to have warped a little in hardening. This is corrected in the following manner.

The *rounding* side of the arbor is laid on a soft iron stake, and the *hollow* side stretched by a series of light blows with the *pane* of the hammer, given at regular intervals along the curve. Having got the leaves to run quite true by this means, turn both arbors true and polish them with the double sticks —these are simply two pieces of thin boxwood, about three-eighths of an inch wide and three inches long—fastened together at one extremity and open at the other; between these the arbor is pinched with oil and fine emery, and they are traversed from end to end, to take out the graver marks.

The brass for the collet, to which the wheel is riveted, is now drilled, broached, and turned roughly to shape on an arbor. The position on the pinion arbor is marked with a fine nick, and the collet soldered on with soft solder and a spirit-lamp, taking care not to draw the temper of the arbor when doing so. Wash it out in soda and water, and polish the arbors with crocus, turn the collet true, and fit the wheel on. If the pinion face is to be polished, it is now done, the facing-tool being a piece of iron about one-sixteenth of an inch thick, with a slit in it to fit over the arbor with slight friction, and using oil-stone dust first, and then sharp red-stuff.

Generally, cut pinions are used for the centers, and in this case the body of the arbor is sufficiently large to allow the front pivot to be made from the solid arbor; but in some movements, particularly those used for spring dials, the center pinions are made from pinion wire in the manner just described; but for the front pivot a hollow tube of hardened and tempered steel is soldered on to the arbor. This piece should always project sufficiently far through the pivot hole to allow it to be squared to receive the friction spring which carries the motion work. In cases where this pivot is much cut, it is best to remove this piece and substitute a new one, and as these pinions are very long and flexible, some difficulty will be experienced in turning this pivot unless some form of backstay is used to support the arbor, and prevent it springing from the graver.

THE PENDULUM CRUTCH.

THE clock repairer will occasionally come in contact with a clock with a crutch filed so wide by some botch that there is room for two pendulum wires to work freely in it, and the result is that he must either make a new crutch or solder a piece on each side in order to make it fit properly again. It is well known by practical men that many make a mistake in this particular; an unduly wide crutch is detrimental, while one that is too narrow will soon stop the clock entirely; it should be just wide enough for the pendulum to move freely in it, when this is at the outside arc of oscillation. Although there is not much difference between it when in this position and when at zero, still there is a little difference, even when the sides of the crutch are very thin; but when the sides are a little thicker, it makes a difference in proportion to their thickness; therefore, when it is a thickly made crutch we are obliged to make a little more room for the pendulum, in order for it to act freely at the outside arc of oscillation.

The reason of this is the crutch is working in a circle around the pivots of the tail piece and pallets, while the pendulum is working from a suspension string, which is ever subject to deviation from a circular path, while the tail piece must necessarily keep the same distance from its central action. Now, from this we see that an escapement which requires a wide arc of oscillation, requires also a wider crutch in order to give the pendulum its proper play. The performance of an escapement of this kind, when it runs to an extreme, is to be regarded as doubtful; for if a crutch must be cut so wide in order to be at the outside of the arc, see what a quantity of space there is when the pendulum is at zero. At every tick the pendulum must cross this space in the crutch, and instead of the clock saying "tick, tick," it says "clink, clink." Take the Dutch clock for an example. Let the crutch be wide, and the noise caused by the pendulum striking the side of the crutch will be as great as the tick proper; hence, 'clink, clink, clink," is the monotonous tones we hear.

Suppose a clock is running in this form for a long time without any oil, the result is both wire and crutch are considerably worn, and there is no measuring the extra friction in consequence. The only proper way to correct such a job is to fit a new pendulum wire and crutch, noticing that they act correctly with each other when replaced. Always avoid letting the pendulum wire ride on the back of the crutch; let each hang perpendicularly at the required place, so that the wire touches nothing but the sides of the crutch, and all is well.

ACCELERATION.

IT is noticed that new chronometers and watches, instead of steadily gaining or losing a certain number of seconds each day, go faster day by day. There is no certainty as to the amount or ratio of this acceleration, nor as to the period which must elapse before the rate becomes steady, but an increase of a second a month for a year may be taken as the average extent in marine chronometers.

It is pretty generally agreed among chronometer makers that the cause of acceleration is seated in the balance spring, though some assert that centrifugal action slightly enlarges the balance, if the arc of vibration is large, as it would be when the oil is fresh, and that as the vibration falls off, centrifugal action is lessened, and acceleration ensues from the smaller diameter of the balance. Though thin balances do undoubtedly increase slightly in size in the long vibrations from centrifugal action, this theory is disposed of by the fact that old chronometers do not accelerate after re-oiling. Others aver that the unnatural connection of the metals composing the compensation balance is responsible for the mischief, and that after being subjected to heat the balance hardly returns to its original dimensions again. If true, this may be a reason for exposing new chronometers, before they are rated, to a somewhat higher temperature than they are likely to meet with in use, as is the practice of some makers, but then chronometers accelerate on their own rates when they are kept in a constant temperature, and also if a new spring is put to an old balance, or even if a plain uncut balance is used.

When the overcoil of a balance spring has been much bent or "manipulated" in timing, it is noticed that the acceleration is sure to be excessive. This is just what might be expected, for a spring unduly bent so as to be weakened, but not absolutely crippled, recovers in time some of its elasticity. But however carefully a spring is bent, the acceleration is not entirely gotten rid of, though the spring is heated to redness and again hardened after its form is complete. There is little doubt that the tendency of springs is to increase slightly in strength for some time after they are subjected to continuous action, just as bells are found to alter a little in tone after use. As a proof that acceleration is due to the bending of the overcoil, an authority asserts that if the spring of an old chronometer is distorted and then restored to its original form, the chronometer will accelerate as though it were new. Helical springs of small diameter have been proposed by some as a means of lessening acceleration, on the ground that the curves are less liable to distortion in action than when the springs are larger. Springs elongate in hardening, and it has been suggested that they afterwards gradually shorten to their original length, and so cause acceleration, but there does not seem to be much warrant for this assumption. Unhardened springs do not accelerate, but they rapidly lose their strength, and are, therefore, not used. Flat springs do not accelerate as much as springs with overcoil. Palladium springs accelerate very much less than hardened steel springs.

MEM.

NOTHING proclaims the skilful workman as well as the finish of the new article. Always make the best finish possible; nothing looks as well as a good shine. Your customers demand it in everything, and it is a good sign. Encourage it all you can; condemn the botch that sends out work without finish. A well arranged set of polishing tools saves much time; keep them always in good order, and remember to exclude dirt and dust.

WATCH OIL.

I HAVE always prepared an excellent article of watch oil from deer's or elk's feet; take off the skin, prepare the feet with great cleanliness; fry them out well, and filter the obtained fat through clean filtering paper. I have prepared my oil in this manner for twenty-five years, and it has kept well invariably, in jewel holes and cylinders up to seven years.

TO MAKE PALLETS, UNLOCKING PALLETS, ETC.

THIS may either be done on the lap or else by using files of soft steel, copper, or tin. In the first case the stones are roughed out while held by the hand, and the required form is given while holding them in a small carrier that fits into the T rest support, but the forms of such stones are so various that no special details can be given. Use diamond powders of different degrees of fin.-ness, as in making jewel holes.

TO BLEACH WATCH DIALS, ETC.

DISSOLVE one-half ounce cyanide of potassium in a quart of hot water, and add two ounces strong liquor of ammonia, and one-half ounce spirits of wine (these two may have been mixed previously). Dip the dials, whether silver, gold, or gilt, in it for a few seconds, then put them in warm water; brush well with soap, and afterward brush, rinse, and dry in hot box-wood dust. Another good plan is to gently heat the dials and dip in diluted nitric acid, but this must not be employed for dials with painted figures, as these would be destroyed.

OVERBANKING.

ONE of the causes of overbanking is that the steady pin is too far from the table roller; it may also happen at times that the roller jewel is a trifle too short, and will allow the fork to spring under it; if there are any forks at all—steady pin and roller jewel being right—there is no danger of overbanking. It is but seldom that the banking pins will allow overbanking, and they are mostly there for the purpose of keeping the fork from going so far that the jewel can strike inside of the same. However, they must be far enough apart to allow the pallet to drop the tooth freely.

TO MOUNT DIAMOND DRILLS AND GRAVERS.

DRILL a hole or fill a notch in the end of a piece of brass wire to correspond with the fragment of diamond; heat the end in a spirit lamp and lay on it a piece of good sealing-wax or shellac. When this commences to melt, set the diamond in position and leave the whole to cool. Diamond drills are very commonly mounted at the end of a pin that has had its point filed off; mark a point at the end with a graver and drill the hole, which should be very shallow. Holding the pin in a pin-vise, with its point projecting about one-tenth of an inch, heat the vise in a lamp and proceed as above explained.

HOW TO REPLACE A BALANCE STAFF.

IT is quite a knack to select another balance staff, when one is either ruined or lost. Take the watch partly down, that is, remove the balance bridge, the lever, scape wheel, the hands, dial, and face wheel, also, remove the cap jewel plate, the regulator, and cap jewel from the balance bridge. Now we will suppose there was nothing but the balance wheel and balance spring left, so remove them and screw the balance bridge back into its place. There are several ways of getting the measure of a staff. Some watchmakers will just put a pair of calipers on the outside of balance bridge over the center of jewel hole, and get the outside measurement, and proceed to guess at the rest of the work. A simple way to measure, and perhaps as good as any in use, is to use a pair of three-screw calipers, at the points they turn outwardly in the form of a T, when they are closed. This tool is made for the express purpose of getting the measure under the bridges for balance staffs, or any other pinion wished to be replaced. These calipers being sharp at the points, you will just set them into the pivot hole, which will enable you to get the shoulder measure of your staff. The turning is done in the customary way.

TO SHARPEN CUTTING TOOLS.

CARBOLIC acid is recommended for moistening the tools with which hardened steel is worked. The effect of the grindstone is even said to be increased by the use of the acid. The dark and impure acid can be used for this purpose.

TO EXTRACT BROKEN WATCH SCREWS.

TAKE a C-shaped cramp or bracket large enough to reach across the watch plates, very strong at the bow, so as to stand any screwing up without springing. Put a screw hole through each end and provide with two or three sets of steel screws with different sized hardened points, which points pass within the cramp. To use it, tighten that screw of the cramp which is against the point of the broken screw, and when you have a firm grip turn the whole tool round, and the broken screw will invariably be drawn out.

TO GILD STEEL.

DISSOLVE a certain quantity of gold in nitro-muriatic acid; boil the fluid to evaporation; again dissolve the residue in water, and add three times as much sulphuric ether. The fluid is then filled into a bottle, in which it is left to stand quietly for twenty-four hours, after which time it will have become fully settled. If the steel is then dipped into this fluid it will be gold-plated at once, and if certain portions of it were covered with a varnish reserve, a handsome drawing upon the steel will be produced.

TO TIME A WATCH.

IN ordinary watches two positions are taken, viz., pendant up or vertical, and dial up or horizontal. In the finer grade of work adjustments are made in the quarters, that is, with 3 up and 9 up. This adjustment is a delicate and often a difficult operation, and it is only by constant study and application that the watchmaker can hope for success. The object of timing or adjusting to positions is to ascertain how far a change of position modifies the compensation and isochronism and to verify the poising of the balance. Saunier says the balance cannot possibly be accurately poised in all positions if the pivots and pivot holes are not perfectly round, and the poising will be modified with a change of temperature if the two arms do not act identically; as will be the case when the metals are not homogeneous, when one or both arms have been strained owing to want of skill on the part of the workman, or careless work, etc. After accurately timing in a vertical position with XII up, make it go for twelve hours with VI up and the same number of hours with III and IX up. Observe with care both the rates and the amplitude of the arcs and note them down. Assuming the pivots and pivot holes to be perfectly round and in good condition, and that the poising of the balance has been previously tested with care by the ordinary means, if the variations in the four positions are slight the poising may be regarded as satisfactory. As a general, but not invariable, rule, a loss in one position on the rate observed in the inverse position may be taken to indicate that the weight of the upper part of the balance is excessive when it does not vibrate through an arc of 360° or the lower part if the amplitude exceeds this amount. Independently of the balance this loss may be occasioned by excessive friction of the pivots due to a too great pressure owing to the caliper being faulty, or to a distortion of the hairspring causing its center of gravity to lie out of the axis of the balance. If these influences become at all considerable their correction will be beyond the power of the isochronal hairspring, and indeed it will be impossible to counteract them. Changes in the rate on changing from the vertical to the horizontal position may also arise from the following causes: 1. The action of the escape wheel, which is different according as it tends to raise the balance staff or to force it laterally; 2, a hairspring that starts to one side and so displaces its center of gravity, a balance that is not well poised, pivots or pivot holes that are not perfectly round, faults which, although of but little importance in the vertical position of the balance staff, become serious when it is horizontal; 3, the more marked portion of the friction of the pivots may take place against substances of different degrees of hardness in the two cases, the end stones being frequently harder than the jewels. Saunier further says that satisfactory results will be obtained in most cases by employing the following methods, either separately or two or more together, according to the results of experiments on the rates, the experience and the judgment of the workman:

1. Flatten slightly the ends of the balance pivots so as to increase their radii of friction; when the watch is lying flat the friction will thus become greater.

2. Let the thickness of the jewel holes be no more than is absolutely necessary. It is sometimes thought sufficient to chamfer the jewel hole so as to reduce the surface on which friction occurs; but this does not quite meet the case, since an appreciable column of oil is maintained against the pivot.

3. Reduce the diameters of the pivots, of course changing the jewel holes. The resistance due to friction, when the watch is vertical, increases rapidly with any increase in the diameters of pivots.

4. Let the hairspring be accurately centered, or it must usually be so placed that the lateral pull tends to lift the balance when the watch is hanging vertical. In this and the next succeeding case it would sometimes be advantageous to be able to change the point at which it is fixed, but this is seldom possible.

5. Replace the hairspring by one that is longer or shorter, but of the same strength; this is with a view to increase or diminish the lateral pressure in accordance with the explanation given in the last paragraph.

6. Set the escapement so that the strongest impulse corresponds with the greatest resistance of the balance.

7. Replace the balance. A balance that is much too heavy renders the timing for positions impossible.

8. Lastly, when these methods are inapplicable or insufficient there only remains the very common practice of throwing the balance out of poise.

THE BALANCE.

THE size and weight of a balance are important factors in the time-keeping qualities of a watch, although the dimensions of a balance are not criteria of the time in which the balance will vibrate. The balance is to a pocket timepiece what the pendulum is to the clock; although there are two essential points of difference. The time of vibration of a pendulum is unaffected by its mass, because every increase in that direction carries with it a proportional influence of gravity; but if we add to the mass of the balance we add nothing to the strength of the hairspring, but add to its load, and therefore the vibrations become slower. Again, a pendulum of a given length, as long as it is kept at the same distance from the earth's center, will vibrate in the same time because the gravity is always the same; but the irregularity in the force of the hairspring produces a like result in the vibration of the balance. Britten says there are three factors upon which the time of the vibration of the balance depends:

1. The weight, or rather the mass, of the balance.*

* The mass of a body is the amount of matter contained in that body, and is the same irrespective of the distance of the body from the center of the earth. But its weight, which is mass × gravity, varies in different latitudes.

2. The distance of its center of gyration from the center of motion, or to speak roughly, the diameter of the balance. From these two factors the moment of inertia may be deducted.

3. The strength of the hairspring, or, more strictly, its power to resist change of form.

Balances are of two kinds, known as plain or uncut, and cut or compensation. The plain balance is only used in this country on the very cheapest variety of movements. The compensation balance is used on the better grade of watches. The plain balance is usually made of brass or steel, while the compensation balance is made of steel and brass combined. Some English makers use gold for plain balances, it being denser than steel and not liable to rust or become magnetized. The process of compensation balance making, as carried on in our American factories, is as follows: A steel disc, one-eighth of an inch thick and five-eighths of an inch in diameter, is first punched from a sheet of metal. It is then centered and drilled partially through, the indentation serving as a guide in the operations to follow. A capsule of pure copper three-fourths of an inch in diameter is then made, and in the center of this capsule the steel disc is lightly secured. A ring of brass one-sixteenth of an inch in thickness is then made and placed between the copper capsule and the blank, and the whole is fused together. It is then faced upon both sides. It is then placed in a lathe and cut away in the center until a ring is formed of steel, which is lined or framed with brass. It then goes into the press, where two crescents are cut from it, leaving only the inner lining of the ring and the cross-bar of steel. The burr is then removed and the balance is ready to be drilled and tapped for the balance screws. This method of making balances is known as the "capsule method."

THE EXPANSION AND CONTRACTION OF BALANCES.

The American Waltham Watch Co. use a simple little contrivance for indicating the expansion and contraction of balances. It is composed of a steel disc, on one side of which a scale is etched and opposite the scale a hole is drilled and tapped to receive the screw that holds the balance. One of the screws of the balance to be tested is removed and the indicating needle is screwed in its place. The steel disc is held by means of a pair of sliding tongs over an alcohol lamp, or can be heated in any other way and the expansion will be indicated by the movement of the needle on the scale. With an increase of temperature the rim is bent inward, thus reducing the size of the balance. This is owing to the fact that brass expands more than steel, and in endeavoring to expand it bends the rim inward. The action is, of course, reversed by lowering the temperature below normal. Some adjusters spin a balance close to the flame of a lamp before using in order to subject it to a higher temperature than it is likely to meet in use. The balance is then placed upon a cold iron plate, and afterward tested for poise. The balance is then trued if found necessary, and the operation is repeated until it is found to be in poise after heating. Britten says that it has been demonstrated that the loss in heat from the weakening of the hairspring is uniformly in proportion to the increase of temperature. The compensation balance, however, fails to meet the temperature error exactly, the rims expand a little too much with decrease of temperature, and with increase of temperature the contraction of the rims is insufficient, consequently a watch or chronometer can be correctly adjusted for temperature at two points only. Watches are usually adjusted at about 50° and 85°. In this range there would be what is called a middle temperature error of about two seconds in twenty-four hours with a steel balance spring. The amount of the middle temperature error cannot be absolutely predicated, for in low temperatures, when the balance is larger in diameter, the arc of vibration is less than in high temperatures when the balance is smaller, and consequently its time of vibration is affected by the isochronism or otherwise of the hairspring. Advantage is sometimes taken of this circumstance to lessen the middle temperature error by leaving the piece fast in the short arcs. To avoid middle temperature error in marine chronometers, various forms of compensation balances have been devised, and numberless additions or auxiliaries have been attached to the ordinary form of balance for the same purpose. Poole's auxiliary, and Molyneaux's, may be taken to represent the two principles on which most auxiliaries are constructed. Poole's consists of a piece of brass attached to the fixed ends of the rim and carrying a regulating screw, the point of which checks the outward movement of the rim in low temperatures. Molyneaux's is attached to each end of the arm by a spring, the free ends of the rim acting on it in high temperatures only. It illustrates this auxiliary when the temperature has been raised, its free ends to which the adjusting screws are attached, having approached nearer the center of the balance, carrying with them the free ends of the auxiliary, so that the small projection no longer comes in contact with the short end of the balance rim, as it would in a temperature of 55°. This auxiliary is made of steel.

SIZES AND WEIGHTS OF BALANCES.

The size and weight of the balance are two very important elements in the timing of a watch, and especially in adjusting to positions. The rules governing the sizes and weights of balances are of a complex nature, and though positive are difficult of application on account of the impracticability of determining the value of the elements on which we have to base our calculations. These elements are the mainspring or motive power, the hairspring representing the force of gravity on the pendulum, momentum and friction. The relation of the motive power or the mainspring to the subject under discussion lies first in the necessary proportion between it and the amount of tension of the spring to be overcome, according to the extent and number of vibrations aimed at; and, second, to that of friction affecting the motion of the balance and incidental to it. In an 18,000 train the mainspring has to overcome resistance of the hairspring for 432,000 vibrations daily. The hairspring having its force established by the relative force of the motive power circumscribes the proportions of the mass called balance and is so co-agent for overcoming friction.

Momentum overcomes some of the elastic force of the spring and friction. It is the force of a body in motion, and is equal to the weight of the body multiplied by its velocity. Velocity in a balance is represented by its circumference, a *given point* in which travels a *given distance* in a *given time*. Weight is that contained in its rim. A balance is said to have more or less momentum in proportion, as it retains force imparted to it by impulsion. If a watch has a balance with which it has been brought to time, and this is changed to one-half the size, it requires to be four times as heavy, because its weight is then only half the distance from the center, and any given point in its circumference has only half the distance to travel. On the other hand, a balance twice the size, would have one-fourth the weight. In the first case the balance would have twice as much momentum as the original one, because if we multiply the weight by the velocity we have a product twice as great. In the latter case a like operation would give a product half as great as in the original balance.

It follows that the smaller and heavier a balance the more momentum, and *vice versâ* the less momentum it has, always on condition that the hairspring controls both equally. Friction, affecting the vibration of the balance, is that of the pivots on which it moves and that of the escapement. It is in proportion to the force with which two surfaces are pressed together and their area. In a balance, weight is synonymous with pressure area, and is represented by the size of its pivots and the thickness of the pivot holes. The first, pivot friction, is continuous and incidental, and is overcome by combined forces, the motive power, the elasticity of the hairspring, and the momentum of the balance. The latter, or escapement friction, is intermitting, and is overcome by contending forces, the hairspring and the momentum of the balance on one side and the motive power on the other.

Having it in our power, as shown above, to obtain the desired momentum of the balance by differing relative pressure and diameter, we can regulate pivot friction within certain limits and distribute the labor of overcoming it, among the co-operative forces, in such a manner that the proportions of such distributions shall not be disturbed during their (forces) increase or decrease. Incidental pivot friction is that caused by the contact of the balance with the escapement. Escapement friction is that caused by the unlocking on the impulse. The first causes retardation, the latter acceleration in the motion of the balance, regardless of isochronism. It is easy to comprehend that a heavy balance would, by its greater momentum, unlock the escapement with less retardation than a light one; but, on the other hand, the acceleration by the impulse would be less also; and with a varying motive power a disturbing element would be introduced by a change in the relative proportions of these forces, the momentum of the balance decreasing or increasing faster than the motive power, constituting as it does relatively a more variable force. In argument the reverse of this might be advanced in regard to a balance which is too light. Without, however, entering further into the subject it is plain how the rate of a watch under such conditions might be affected after being apparently adjusted in stationary positions by being used on a locomotive or under conditions where external disturbances should lessen the extent of vibration, and making the contact between the balance and the escapement of less duration.

The almost universal abandonment of watches with uniform motive power and the introduction of stem-winders with going barrels invests the subject with special interest; and as stated in the beginning, applying rules for defining these desirable proportions being impracticable, the only solution of the problem which remains to us is the study by observation of certain symptoms which do exist to determine that which by other means cannot be done. During the progress of horology similar difficulties had to be met in every kind of watch which happened to be in use. The old verge watch had its balance proportioned thus that it could lie inside in the mainspring barrel, and the watch, when set going without a balance spring, would indicate by the hand on the dial a progress of twenty-seven and one-half minutes during one hour running. It was said that under these circumstances it would be least affected by inequalities of the motive power, and the verge would not be cut by the escape wheel. The balance in the cylinder watch was to be sized according to the proportion of the train, each successive wheel to be one-half smaller than the preceding one and the balance to be twice the size of the escape wheel, the weight to be determined by the equal running of the watch during all the changes of an unequal motive power. The cutting of the steel pallets in duplex watches or chronometers is caused more by too heavy balances than by any other defect in their parts. It might be well to note the following, which is very important and too often neglected, and that is the arrangement of the mainspring in the barrel so as to avoid coil friction, and the smallest advantage of the old fusee watch was not the facility of obtaining five turns of the fusee to three or three and one-half of the mainspring, but being enabled thereby to arrange the latter around a small arbor in such a manner that the coils never touched, insuring a smooth motive power and lessening the chances of breakage beyond estimation.

TO PUT IN A HAIRSPRING.

I HAVE before me an old anchor watch, in which I am about to put a new spring. The spring is soft. The watch has been a remarkable close time-keeper for over thirty years. The movement is very large and requires a large spring in the round. On the dial is marked "Railroad Time-keeper" in red letters in a circle. In my stock of springs I have none large enough in the round. I select one for strength, which is very closely coiled. To get the desired size in the round, I lay it on a flat barrel head and hold over the spirit lamp until it uncoils to the desired size in the round. I test the hole in the collet with broach. If not parallel with balance I broach it to bring it parallel. I put the outer end in the collet and fit a pin with flat side next the spring; press it in tightly and mark the ends carefully and lay it away for future use, and use it for permanent fastening. I now test the spring in the usual way by counting the train or by setting the second hand at sixty and moving the lever back and forward, counting the beats for fifteen or thirty seconds, which multiplied by two or four gives the number of beats in one minute. I fit the spring at the collet, with coiling tweezers, with proper curve, and fit around the collet at the proper distance, so as not to come in contact with the collet in vibrating, leaving about the same space as between the coils. For trial, I fasten the spring in the collet with pegwood and take hold of the outer end of spring with a pair of tweezers and vibrate the balance on a flat glass for fifteen or thirty seconds. If too strong move further out; if slow move back until I get the desired number of beats. At this point I mark the spring with a little red-stuff (English, you know). I test the hole in stud to find if parallel; if not, I broach it to bring it right. I now fasten spring in stud, leaving the mark a little outside between curb pins and stud. I lay my spring on the cock with spring between pins. I put pegwood down though the collet point in jewel hole and find if the spring crowds at any point; if so, it must be connected by getting the coils equal all around. I now put the permanent pin in place and manipulate the spring at the collet to get it right in the flat. I get the spring to have the same play between the pins when turned fast or slow. I put the balance with spring in the calipers and ascertain whether there is any wabbling; if so, it must be corrected. I now set the ruby pin in direct line with balance and pallet staff and mark on balance directly opposite the stud hole and bring the stud to that point and the watch will be in perfect beat. The balance must be carefully poised. Where there are no screws, it must be done by adding or taking from the rim. Balances with screws can be poised by using washer if light, or reducing the weight by turning the screws out if too heavy. About two years ago I cleaned an American full-plate watch. In a few weeks the watch was brought back with the inside coil over the curb pin. The watch was carried by an engineer. The jumping of the engine made the spring overlap. It set me to reflecting. I came to the conclusion that by shortening the pins so that the spring working at the ends of the pins and beveling the outside pin and polishing it smooth, if it did occur it would slip back again, which proved to be correct, as it has not occurred since. The new spring has to be tested for isochronism. A spring is isochronal when it causes any point in the balance rim to pass through equal and unequal spaces in equal time. The moment a balance receives an impulse, that moment does it begin to wind up the hairspring, and continues to wind it until it reaches the extreme point of its tension. But the first ten degrees of the return motion of the balance should be neither quicker nor slower than the last ten, and would not be if the spring were isochronal. By making the spring isochronous the watch is made to maintain the same rate in the long as in the short motions of the balance. Rate the watch (fully wound) for six hours in the hanging position, then rate it the same length of time in a lying position. Wind it full for both trials. Should it go slower in the lying than in the hanging position it shows that the spring is too long for its strength, and must be taken up. When the watch is made to keep the same rate in both positions the spring is isochronous. The principle of isochronism consists in the length of the spring being in exact proportion to its strength, consequently if a spring be too strong for its length there is no point that is isochronous, but if the spring be sufficiently long for its strength the isochronal point may be found. I do not advise the use of soft springs. In American watches I use tempered springs in all cases. I do use soft springs in lower grades, where they have run close to time with soft springs. In my experience I have found that soft springs for low-grade watches are not affected by extreme heat and cold to the same extent as hard springs. In conclusion, if there are any points in the above that will be appreciated by the craft, let them "make a note of it," as Captain Cuttle says.

TO FIT THE CENTER BUSH.

PIN the two plates together and put them in universal face plate or head, centering by the center hole in top plate, and turn the old bush out and traces of soft solder off the bottom plate. Turn up a new bush, and leave it as long as possible, so as to better support the pivot, and retain the oil.

Saunier says, "There is no advantage to be gained by diminishing the extent of the surfaces of contact in depths, in liftings and even in rests of escapements, as is too often done under the impression that friction is thereby reduced. Since the same blow or pressure is withstood by a smaller number of elements, it will act with a greater force on them, and will distort the surface more rapidly; the accuracy of their forms will thus be destroyed in a less time. Also when the bearing surfaces are not of sufficient extent, any excess of pressure expels the oil, causing a destruction of the surfaces and increased friction." Therefore it is plain to be seen what a bad effect a thin bush will occasion.

A bush should support the pivot for three-fourths of its length, and also have a sufficiently deep oil sink to retain enough oil to keep the pivot moist for a year or a year and a half. Bushes should always be fitted in from the side the shoulder of pivot rests against, and the other end should be well undercut and turned to a knife edge that will just project through the plate, and then one or two taps will be sufficient to rivet it firmly. The center wheel should have very little end-shake, as it runs so close to both the 3d wheel and great wheel and barrel, and the end-shake should always be tested with the plates pinned together with *all* the pins.

FITTING THE RUBY PIN.

A BRASS pin having been inserted in table roller, it will be necessary to replace it with a jewel, and by that I don't mean the *glass* "ruby pins" to be bought for about twenty-five cents a gross, but the genuine garnet and ruby pins that cost about one dollar a gross; they are in all certainty sufficiently low-priced, and any watch that is worth having a ruby pin fitted at all is worth having one costing a cent, notwithstanding which, we frequently find glass, steel, brass and even copper ones inserted. It is a disgrace that such work should be done, and as it most certainly *is* done, it is to be hoped that any who have been in the habit of so doing, either from the want of proper instruction or otherwise, will turn over a new leaf and in future use *proper materials* in *all* cases.

Knock out the brass pin, pick out a jewel that fits the slot in the fork with very slight shake, the less shake the better, freedom being insured. Sometimes ruby pins are fitted that do not fill more than half the slot, and as a consequence, about half the impulse that would be communicated to the balance by the fork if the ruby pin fitted the slot, is lost, and a small, struggling motion is the result. Insert the jewel in the roller and set it with shellac, using one of the several designs of ruby pin setters in the market. After the pin is firmly and correctly set, fit the roller on the balance staff and test the action of ruby pin and fork in the depthing tool to see that the pin enters the slot, and does not enter so deeply as to touch against the back of it.

TO FIT THE DIAL FEET.

GRIND away the enamel where the feet are broken off with emery lap, and turn up two new feet, shaping them the same as a plate screw, the part corresponding to the head being large enough to get a strong job when soft soldered to the copper plate of dial, solder them on so that when fitted on plate the center of seconds hole will correspond with the hole in fourth or second wheel jewel, mark the points to drill for the dial pins so that when the pins are inserted they will touch the plate and thus keep the dial from rattling.

TO FIT NEW BANKING PINS.

KNOCK out the old pins and insert Waltham banking studs, if the old banking-pin holes are too far apart. By fitting Waltham banking studs you can turn the pins around to the proper position at will. Turn them so that at all points the shake between the fork and pins at the one end and guard pins and roller at the other will be the same, and reduce the shake as much as possible. When the pins are adjusted to suit the fork and roller, put the movement together and see that the banking pins are sufficiently far apart to allow the scape wheel to escape. Should the wheel escape on one side and not on the other, the pin binding the pallets and fork together will have to be knocked out and the pallets moved sufficiently to allow the scape wheel teeth to escape on the other side. If they require to be moved very slightly, the pallets and fork can be firmly held in hand vise and the holes broached out in line with each other, or else the hole in fork must be filled up and a new one drilled.

TO REPAIR CENTER PIVOT.

THE pivot, if cut so that it is smaller than the cannon arbor, or part the cannon fits on, will have to have a pipe fitted. Chuck the center pinion in a lathe, and turn what remains of the pivot flush with the cannon arbor, take a piece of Stubb's wire of requisite thickness, and drill it so that it will fit down over arbor snugly, turn the ends flat and square, leaving it of sufficient length so that the cannon pinion will rest against it and be clear of scraping against the plate, as would be the case if cut off too short, fit it in position, using a speck of soft solder if necessary, in which case do it carefully and without discoloring the rest of the pinion, and then boil out in alcohol to destroy the bad effect of the soldering acid (I wish it understood right here that I am no advocate of soft solder in any shape or form, except when it is absolutely necessary to use it, and occasionally it is, but even then it may be done so that it is not noticeable). Then turn the pipe true and to the desired size, and grind and polish with oil-stone dust and crocus on bell-metal slip.

TO CLEANSE POLISHING LEATHERS.

A CORRESPONDENT complains that his polishing leathers have shrunk together after washing them, as directed by us. This can only have been caused by the use of very hot water, which should hardly be lukewarm. Wash your leathers with ordinary soap which contains much potash, and renew the water as often as necessary, until perfectly clean. Then beat soap to froth, and meanwhile mix a little olive oil, using barely a tablespoonful per leather. Next rinse the leather well, and wring dry, stretch it to all sides, and for the purpose of thoroughly drying, hang it in a place free from dust, but not near a stove. The oil is for the purpose of making the leather soft and supple, and no fears need be entertained that the oil will make it smeary. The leathers can also be washed in benzine; they must then be wrung out in a soft linen rag or handkerchief, and rubbed with it until thoroughly dry, otherwise they would shrink together and become hard.

THE MARINE CHRONOMETER.

PROBABLY no piece of human mechanism represents more brain labor, or a greater amount of unyielding endeavor, to overcome obstacles than we find embodied in a first-class marine chronometer. And yet the instrument is far from the state of perfection which " theory " would promise. We are beset with difficulties on every hand, which, although purely mechanical, are still serious enough to be perplexing. These mechanical imperfections beset us the instant we enter the workshop and seek to realize our *theories;* and these imperfections will impede our operations, and stand a barrier to our progress to perfection forever; yet patience and skill will remedy many, and modify other of those difficulties, until, like the problem of squaring the circle, although perfection can never be reached, still, an approximation to it can be attained, which will leave little to be desired. I do not propose to follow the development of the instrument up to its present state of perfection through all its modifications, but rather to call notice to inherent faults which exist and admit of remedy to a certain extent. First and foremost among the imperfections stands compensation for heat and cold, as counteracted by the composite curb, or, as it is usually called, the chronometer balance. It is unnecessary to describe this appliance to readers of THE CIRCULAR, as it is supposed to be thoroughly understood in all its actions by them from articles hitherto published in its columns. But certain features exist in it not generally known and appreciated—first, its imperfections in extreme temperatures; several devices exist to remedy this defect to a limited extent; second, its elasticity begets the trouble to a great extent of " shop rate," and " sea rate "; third, its susceptibility to centrifugal action. I will waive the first count of the indictment and proceed to the second and third, which, in reality, grow out of the same cause, *i.e.*, the springy nature of the compound curbs or segments of the balance rim. It is a well-known feature of a curved spring that it is more easily bent outward than inward, or, in other words, it requires less force to straighten a curved spring than it does to increase the curve; hence, any motion or disturbing influence, like the sway of a vessel, will tell in the line of least resistance; this proposition is proved by the fact that in nine cases out of ten the " sea rate " of a chronometer is slower than the " shop rate." The exceptions to this rule is with inferior chronometers having unsteady rates. In regard to the effects of centrifugal action, it is more serious than at first would seem probable. It is impossible to construct a balance in which both segments are exactly alike in elasticity or resilient power; but we will suppose we can seize and comprehend the exact conditions of a balance just at the instant it pauses on a return vibration; we will conceive it to be in a perfect condition of repose in all its particles—a condition we will see does not and cannot exist with this form of balance—the tension of the balance (pendulum) spring causes the return vibration to set in, our segment with its adjustable weight yields to the centrifugal action first, the center of gravity (poise) is disturbed, and the pivots thrown to one side of the hole jewels; the opposite segment and its weight follows, and if we could see the pivots in such a way as to take cognizance of their action, we would find them taking advantage of the side-shake in the jewel holes at the rate of *several* shakes a second; I say several, for it is much to be doubted if those shakes are a *constant* number, and if not constant they must in some degree affect the performance of the instrument. It is a well-known test with old and experienced adjusters, that a chronometer must, in its " tick," give out a pure musical tone; or in other words, the vibrations in its component parts must be synchronous—in harmony. It is a well-known fact that if two springs whose vibrations represent certain musical tones, if not *exactly* harmonious, will compromise if near each other, and produce a tone intermediate to both. So probably, to a certain extent, a compromise takes place in the balance of a chronometer, and a synchronous harmony is established; but, on the other hand, a discord can also set in, which would tell irregularly on the chronometer's rate. It must be evident to all minds which give the problem careful attention, that centrifugal action on the segments must beget a train of unequal resistances, which tell unequally on the balance and all its belongings. I wish the reader to understand that I have no axe to grind, nor do I propose any better form of balance, but I wish to bring the facts to the attention of the thinking portion of our expert mechanics, and see if there is no better way to counteract the effects of heat and cold on movable time-keepers. But I would beg to say that, practically, up to the present time, the compound curved segments (in some form) give the best results. A few suggestions may not be displaced—not my own, understand, but such as have been thrown out during the development of the expansion balance as it now exists. What is required in a balance for correcting heat and cold effects are: perfect and equitable compensation through all ranges of exposure; rigidity of form except by caloric effects. To produce these results various devices have been offered; many with merit, some with varied points of excellence, which are worthy of consideration. The prominent ones of interest are based on two principles: first, keeping the timepiece exposed to an exalted temperature above anything it would be exposed to, and maintaining this temperature to constantly exactly the same degree; second, a mechanical arrangement of levers operated something similar to a gridiron pendulum. The problem is open, and will yet be solved by the ingenuity of some person, who will confer a great favor on humanity, and if properly managed, result in a financial return to the inventor. I am aware that I am venturing on a ground which has been carefully gone over by deep thinkers and skillful men —yet, twenty years ago, if a man had foretold the success of breech-loading guns, the very men who were supposed to know the most about such things would have treated the suggestion with contempt—but one small idea established or made practicable breech-loading guns, and this was the metallic cartridge. Now, in our case, may not some idea be thrown up by discussing the subject, which will happily solve the question? A balance free from dilation by centrifugal force would be much easier to match with an isochronal spring. There is another point deserving of consideration, which is, a compound segment is always liable to deterioration, like a hairspring or mainspring, but even more rapidly; there is a constant antagonism between the two metals which can never be reconciled. I think that my experience will agree with others when I say that chronometer balances will show some queer freaks. A chronometer which has been under one's care for years, and showing a marvelous fine rate, will all at once fly off on a tangent (" kick up " is a better phrase), and vary more in one day than it previously did in a month. Now, generally, the trouble lies in the hairspring, but sometimes a new balance is required—some latent defect has existed in the balance, and all at once it is developed in full force.

TO POLISH STEEL.

IF the steel is of moderately good temper, use a zinc polisher with diamantine; for soft steel a tin polisher is better. The diamantine should be mixed on glass, with very little watch oil. Diamantine mixed with ordinary oil becomes gummy, and is quite unfit for use in a day or two, and if brought into contact with metal in mixing, turns black.

TO HARDEN PINIONS.

EVERY watchmaker knows that heated steel dipped into water becomes hard. When heating the steel, care must be taken not to let the steel burn, but simply bring it to a red heat. For hardening pinions or other large steel objects, do as follows, to prevent the ruinous warping: Make a box of sheet iron with a well-fitting cover upon it, and heat it to a white heat before using. Then fill it one-half with bone black, place the piece of steel into it, fill it entirely with bone black, put the lid on, and secure the box with binding wire. Then put the box into a charcoal fire until white hot, withdraw and immerse it in cold water, leaving it immersed until cold; the color of the steel will be gray, it has no scale, and is not warped. Steel hardened in this manner must not be annealed quite as much as is done with other—instead of dark blue, make it dark yellow.

FLAT POLISH.

To polish such parts as rollers and collets, first get a flat surface, by rubbing with fine emery on a glass plate or a bell-metal block, and afterward finish off on a zinc block with diamantine; but for levers, you must use a long, flat bell-metal or zinc polisher, and press the lever into a piece of soft wood (willow is the best) in the vise, moving the polisher instead of the work. For large articles, such as indexes or repeater racks, which are not solid and spring, it will be found best to wax them on to a small brass block and polish them underhand, in the same manner as rollers.

TO TEMPER GRAVERS.

GRAVERS and other instruments larger than drills may be tempered in quicksilver, or you may take lead instead of quicksilver. Cut down into the lead, say half an inch, then, having heated your instrument to a bright cherry-red, press it firmly into the cut. The lead will melt around it, and an excellent temper will be imparted.

TO DRAW TEMPER.

THE following method is said to be excellent for drawing the temper from delicate steel pieces, without springing them. Place the article from which you desire to draw the temper into a common clock key. File around it with brass or iron filings, and then plug up the hole with a steel, iron, or brass plug made to fit closely. Take the handle of the key with your pliers, and hold its pipe into the blaze of a lamp till nearly hot, then let it cool gradually. When sufficiently cold to handle, remove the plug, and you will find the article with its temper fully drawn, but in all other respects as it was before. You will understand the reason for having the article thus plugged up while passing through the heating and cooling process, when you know that springing always results from the action of changeable currents of atmosphere. The temper may be drawn from cylinders, staffs, pinions, or any other delicate pieces by this mode with perfect safety.

TO STRAIGHTEN SCAPE WHEEL.

THE *Traité de l'Horlogerie Moderne* contains a method of truing a cylinder escape wheel that has been cockled in the hardening; the following is a modification of the process there described: In the middle of a square plate that is moderately thick, fit a strong screw with a large and long head; this screw must pass freely through a disc that is perfectly flat and fits easily into the upper side of the escape wheel. Now fix the plate between the jaws of a bench vise, and placing the wheel between this plate and the disc with a moderate pressure applied to the screw, hold a lamp to the under side, gradually tightening the screw as the steel changes color, so as to obtain a maximum pressure when a blue temper is reached. Leave the whole to cool in position.

FINE LUBRICATING OIL.

BY putting pure olive oil into a clear glass bottle with a few strips or pieces of sheet lead, and exposing to the sun for two or three weeks, an exceedingly fine lubricating oil may be obtained that will not gum or corrode. Only that part should be poured off which is perfectly clear.

TO RENEW OLD FILES.

THE process of cleaning and renewing old files will be found useful, whenever there is a lot of apparently worthless files lying around the shop. Very often they do not need recutting, but are merely clogged up with dirt and grease and are of little service. To restore them, take the following advice of a correspondent: Some time ago I gathered together a lot of old worn-out files, both large and small, coarse and fine, and boiled them for half an hour in saleratus water (4 oz. saleratus to 1 quart water). I then washed them in clean water and placed them in a solution of sulphuric acid and water (4 oz. of sulphuric acid to 1 quart water). I removed the smaller and finer files at the end of forty-five minutes, but the larger and coarser I let remain for two or three hours, looking at them occasionally to see that they didn't cut too much. I then washed them thoroughly with a stiff brush and plenty of clean water, then dried and oiled them a little to prevent their rusting. I have used them for several months and think they cut as well as new files, and have lasted almost quite as long.

BROKEN SCREWS.

I HAVE two methods for taking broken plate screws out of American watches: 1. When it can be done, I turn them out with the sharp point of a graver. When this cannot be done, with a thin screw file I file into the end of the post until the broken screw is reached, and a slot made in it by which it can be easily raised. Some may be disposed to call it botch-work, but I cannot see that it injures the post, and when the upper plate is on and the screw in, the place cannot be seen.

TO APPLY WATCH OIL.

WATCH oil should be conveyed to the watch only with an absolutely clean medium, and steel is to be preferred by all odds. Many use brass, but this cannot be kept as clean, nor is it as easily cleaned as steel, and we would recommend to our fellow-workmen to use steel exclusively.

TO FASTEN SPRING ON COLLET.

WHEN the spring is firmly fastened on the collet, the first turn cannot be too close to it, but it must not touch it, and must form a true or slightly expanding circle with it. It must then be placed in the turns, or an arbor, and revolved with the bow, and looked at with the glass to see that the spring revolves truly with the collet, and that there is no jumping action in it. If the eye of the spring is much larger than the collet, it will be difficult to make it revolve truly, but in repairing a bad spring many judicious touches with the tweezers may be given while it is on the arbor, and anything like a crank action of the spring and collet must be corrected.

TO RESET THE RUBY PIN.

I HAVE so often seen watch repairers, every time they wished to tighten or reset a ruby pin in a lever movement, remove the roller from the staff, heat it in the alcohol lamp until the shellac was softened, and perhaps the roller blued and disfigured, beside losing the entire adjustment and injuring the time-keeping qualities of the watch, by replacing the roller without the aid of a beat block, that I offer a simple little device which may be useful to some of your readers. Take a piece of medium sized pin wire, about two and a half inches long; anneal about one-half or three-quarters of an inch of each end, then bend into the shape of a shepherd's hook, hammering the open end flat, and it is ready for use. Holding the balance with the roller table uppermost, now heat the hook, and place it carefully around the staff body underneath the roller table. You will find it will communicate sufficient heat to the roller to soften the shellac, and no other part of the balance staff or spring will be sufficiently heated to damage them in the least, while the ruby pin may be readily and easily adjusted to its proper position.

THE WATCH TRAIN.

WHEN examining a watch handed you for repairs, examine the train of wheels. If the scape depth, as often happens, is shallow, as shown by much side-shake, drive the scape cock by pressure from behind, if freedom allows, the second pivot hole being always very shallow. A pivot broach pressed by the finger underneath in opening the hole will cut away one side of the hole, into which a French bouchon or stopping is being inserted and riveted, we have a new depth as the result of a few minutes' work.

TO REDUCE DIAL.

RESTING the dial in an inclined position against a block, file its edge with a smooth or half smooth file, which must only be allowed while advancing, and is, at the same time, displayed sideways and turned so as to follow the contour of the dial. The file should be dipped occasionally in turpentine, and when sufficient enamel has been removed, pass a new emery stick over it to remove the file marks.

TO EASE AN INDEX.

IT is a common but bad practice among watchmakers, says Saunier, to scrape the inside of the ring of the index or cut it through. A better method is as follows: Resting the index on a cork, cover the inside of its ring with oil-stone dust, and make the cap rotate in its seat by means of a pinion caliper, the two points of which are inserted in the screw holes. The operation is repeated as often as may be required.

MAGNITUDE OF PALLET IMPULSE.

THE average magnitude of pallet impulse angles is 10°. It is a matter which depends greatly on the quality of the work. If a pallet with an impulse angle of 7½° has much side-shake on its pivots, then the ruby pin becomes the center of motion where the impulse should commence, and hence a greater part of the moment would be lost. Though a large impulse angle gives less moment, nevertheless it will neutralize the evil of badly fitting holes; hence, pallets with small impulse angles should always have jeweled holes, and brass pallet holes require larger impulse angles. This appears so self-evident that diagrams are not necessary to prove it.

TO REMOVE A BROKEN SCREW.

A CORRESPONDENT of THE JEWELERS' CIRCULAR complains that he has a bad case of broken screw in a watch plate, and asks for information how to extract it. Our columns have heretofore contained practical recipes, to which we refer him, adding another one. With a screw-head file cut a slit in the top of the broken screw deep enough for a screw-driver to have a firm hold. Then pressing the screw-driver firmly in the slit, turn it to the left, and in most cases the screw will give way. After turning it once or twice it is advisable to file off the top of the screw nearly level with the watch plate and recut the slit. If this method does not answer, place the plate with the top of the broken screw over one of the holes in the riveting stake corresponding to the size of the screw, and with a joint pusher placed on the bottom of the screw, give a sharp blow with a hammer or mallet, which generally breaks the thread and partly drives it through the plate, after which it can be pulled out with a pair of pliers. Re-tap the hole and fit in a new screw.

TO WRITE UPON STEEL.

A GOOD fluid with which to write upon steel is prepared by mixing one part of nitric acid with about one-sixth part of hydrochloric acid. Cleanse the part to be operated on with oil and cover it with a coating of beeswax. With a pointed tool write upon the wax, letting each stroke penetrate down to the metal; then with a fine brush, dipped into above said acid mixture, follow the strokes of the writing. When these strokes have been filled with this mixture, let the work stand for about five minutes, and then dip it into water to interrupt the further operation of the acid.

TO SOLDER BROKEN BROACHES.

STEEL broaches and other tools are soldered by cleaning well the parts broken, then dipping them into a solution of sulphate of copper, and soldering them with ordinary soft solder. The joint is a good one, and will stand ordinary hard wear.

TRANSPARENT BLUE FOR STEEL.

DAMAR varnish, ½ gallon; finely pulverized Prussian blue, ½ oz.; mix thoroughly. Makes a splendid appearance. Excellent for bluing hands.

HOW TO SUPPLY OIL.

BE very careful in lubricating. The manner of doing this is much more important than many imagine, and has a greater influence upon the duration of the good performance and timing. To single out the escapement: Many watchmakers put too much oil into the cylinder, under the impression that when the wheel passes through each tooth will take its required amount. This is a bad method, because it stands to reason that those teeth which pass through first will take so much oil, that instead of adhering to the lifting faces of the tooth where it belongs, the oil will run down the tooth pillars and swim upon the bottom, acting there as a dirt trap. It is more advisable to place only a small quantity of oil in the cylinder, then pass the teeth through, and additionally lubricate the lifting face of each third or fourth tooth.

TO TAKE OUT TEMPER OF STAFF.

IN taking the temper out of hard staffs in order to drill without injury to adjacent parts, the following method has been found to work very nicely: Take a small piece of charcoal, as large as a pea, or larger, according to size of staff; make a hole in it, into which the end of the staff is to be inserted; then holding the staff with the pliers, direct the flame of the lamp upon the coal until it is ignited, when it can be kept in a red-hot glow by the blowpipe alone, until all is consumed. This will not even blue the rest of the staff, and will usually take out the temper sufficiently to drill. If once will not do, it may be repeated several times till the end is accomplished.

TO BROACH A HOLE VERTICALLY.

A HOLE in a plate, as, for instance, that in a barrel, is seldom maintained at right angles to the surface by young watchmakers when they have occasion to employ a broach. By adopting the following very simple method success may be assured: Take a long cork or a diameter rather less than that of the barrel or other object operated upon, and make a hole in the length of the cork through which the broach can be passed. When the cork has been turned quite true on its end and edge, the broach is pushed through and used to enlarge the hole; by pressing against the back of the cork it is always kept against the barrel, and the verticality of the broach is then maintained.

THE USE OF SHELLAC IN HOROLOGY.

SHELLAC, says J. Beau, in the *Revue Chronométrique*, is used in two forms, in rolls, and dissolved in alcohol or phenyl, as will be specified farther on. Solid shellac is suited best for fastening parts that either have much shake between each other or are badly fitted together, while the fluid is used for cementing closely fitted pieces; for instance, anchor pallets, because, owing to its fluid condition, it can penetrate better into smaller interstices.

When shellac in rolls is used it is advisable to draw it out, an operation that should not be performed with the fingers; it is to be warmed over an alcohol flame, and drawn out with two pair of tweezers, in which manner it can be drawn out as thin as desired, at the same time protecting it against the perspiration of the hand.

This drawing out is really not the best method, although, perhaps, the large majority of watchmakers employ it; the roll of shellac loses thereby part of its rigidity, and will no longer give results as perfect as those obtained by the following method: The shellac is to be heated, and a part of it is taken upon the point of a pegwood sufficiently strong to manipulate the shellac, with which it is placed upon the pieces to be cemented.

Again, the pieces to be cemented should never be warmed directly, but they are to be placed into a chuck or other suitable utensil, which is heated, the shellac placed upon the point until it becomes soft; when in this condition, a small quantity is taken away with the pegwood; in this way, there will never be any danger of overheating.

Shellac dissolved in alcohol would comply with all the demands of horology, if the solutions were not open to the following objections: If a drop of the solution is only for a few seconds exposed to the air, a pellicle, analogous to boiling milk, will form on its surface and prevent the spreading of the drop, so that it can enter into the interstices, especially if very small, as in the case of pallets. For this reason, I preferably have used for some time the solution effected in phenyl. Phenyl, also called phenylic alcohol, has properties placing it between alcohol and acid; it exerts no injurious effect upon the metals used in horology, and, therefore, no objections to its employment exist. The only disagreeable characteristic is, that it etches the skin when coming in contact with it. The watchmaker may therefore use it to advantage, guarding, of course, against its cauterizing action.

TO SHARPEN FINE FILES.

AFTER the files have been liberated from the adhering dirt and filth with a fine wire scratch-brush, and a hot, fairly dilute solution of crystallized soda, or, what is still better, warm soapmakers' waste lye, place them alongside each other in an earthen vessel, upon the bottom of which two strong wires were laid, so that the files can come in contact from below with the following fluid. This fluid consists of a careful mixture of 8 parts of cold water and 1 part concentrated nitric acid, to be prepared in another vessel. Sufficient of this is poured upon the files that they are just covered. The acid is left to operate upon the files for about twenty-five minutes. After the lapse of this time, they are taken out of this bath, treated with the scratch-brush in clean water, similar to the first time; they are then immersed a second time in an acid bath of the same strength (8 parts water and 1 part nitric acid), for twenty-five minutes, during which time they are occasionally changed about. The files are then again treated with the scratch-brush, and returned to the same bath, to which one-half part of English sulphuric acid has been added. The bath heats, and reddish-brown vapors escape, during which time the sharpening of the files by corrosion progresses. Care must be had to keep the vessel (the best is an earthen) in a rocking motion, so that the acid operates equally upon the files, which are not to be left longer than five minutes in this bath. They are then withdrawn, again treated, as above stated, with the scratch-brush and clean water, and again placed in a new bath of the same composition, in which they must not remain longer than five minutes.

This ends the operation. They are then treated with the scratch-brush, first with clean water, and finally they are for a few minutes laid in a bath to which a little lime water was added; this is for the purpose of neutralizing every trace of acid. They are then well rinsed in clean water, wiped with a dry rag, and heated to dry the moisture. Finally, rub a little oil on them.

IMPROVED BENZINE JARS.

I. Take a circular piece of finely perforated metal—a copper strainer answers well. Then fit it inside your benzine glass, rivet in five or six wire feet, not more than one-quarter of one inch long, so that you will have a small space between the perforated metal and the bottom of the benzine jar; half fill the jar with the purest of benzine—the spirit must be at least one-quarter of one inch above the perforated metal; lay the watch plates, etc., on the perforated metal, and the benzine, which holds the thick oil and other impurities in solution, will speedily precipitate them to the bottom, and their further contact with the work is prevented by the perforated plate, and, when dried, they are perfectly clean.

II. Take a small wide-necked bottle, fit in a cock, and insert a brass wire; turn up the end like a fish-hook, so that it will dip half an inch into the benzine, hook on the wheels, balance, and small pieces, and immerse them in the spirit, which will operate as before described. A little attention to small tools is often the difference between a quick workman and a slow one. Workmen of equal industry and ability often produce widely differing results from the neglect of a small outlay in useful tools.

THE FOOT WHEEL.

I HAVE a 40-pound Webster foot wheel, says a correspondent in an exchange, which runs true and perfectly noiseless. I altered my wheel, balancing it by putting shot in the hole left in the inside of the rim. This hole was left so as to make the wheel heavy-sided, so that it should not stop on centers. For my part, I do not want a heavy-sided wheel that will, every time I stop my lathe and take my foot out of the stirrup, run backward and forward several times before remaining at rest. I can run my lathe very slow and it will not stop on me like a heavy-sided wheel does, unless you are on your guard. Sometimes, one wants to slow up to examine work, and a heavy-sided wheel will stop on you sometimes as the heavy side starts up. A heavy-sided wheel will run with a jerking motion. My wheel now occasionally stops on centers, and when I go to start and find that such is the case, I simply touch the rim of the wheel with my foot, and it is easily thrown off. Poise your wheel, and if you do not like it better, I will pay for the time.

CARE OF THE BRUSH.

A WATCHMAKER'S brushes are a constant utensil in his hands and on the workbench; nothing except pliers, screwdrivers, and tweezers being in more constant use; and how few treat them properly, or rather, how few keep them in proper use. A soft brush for rough work is quite useless, a hard one for fine work is ruinous, and a dirty brush of either kind is a nuisance. The methods adopted for cleaning them are nearly as varied as the workmen that use them, and there are some who never even make the attempt. Some clean the brush with dry bread; some lay a piece of tissue or other paper across the wide open bench vise, the sharp corners formed by the jaws taking off on the paper a little of the dirt; others, brush a piece of clean cork vigorously, and one man we knew who used his knuckles for the same purpose. All these various methods are imperfect, while some of them can be called slovenly. The only good way to clean a brush is with soap and water—warm water, if convenient, being preferable. Wet two brushes, soap them, and rub them together in plenty of water, and the job is done. The only objection to this way is the delay by drying; but this need not be, for six brushes assorted will give you three clean ones to use, while the other three are drying; and the workman who cannot afford half a dozen of brushes had better seek some more lucrative occupation. More damage to the appearance of the movement is done by injudicious brushing than by any other means. The watch may not be injured in its quality as a timepiece, but it grows prematurely old in looks by such severe treatment.

TO MAKE A GOOD DRILL.

IF we wish to make a drill that will act to satisfaction, we must be particular about getting the point exactly in the center; but this is just what is often neglected. Now, it will not be difficult for the youngest reader to understand that when the point is out of the center, one side of that point has to cut a larger share of the metal under operation than the other does; hence, the side that is cutting its smaller share does not do all it might and could, if working under different circumstances. This, of course, is detrimental to the speedy action of the drill, and if the reader would verify this statement, he should make two drills alike in every respect, except that one shall have its point central and the other not, and temper both alike. Then let him drill through a sheet of brass, and notice the time it takes in each case, when he will find that the result will be considerably in favor of the centrally pointed drill.

THE TEMPERING OF SMALL DRILLS.

MUCH has been written on this subject, and still it is never exhausted; new methods for hardening this small tool, so useful to the watchmaker, are recommended every little while.

Small drills for drilling holes in arbors, staffs, etc., which are frequently very hard and difficult to be perforated, are tempered in the following manner: After the drill has been filed to its proper size (the cutting face must *not* be flattened with the hammer), it is only moderately warmed; avoiding that it does not become red when it is run into borax. The drill is thereby coated over with a crust of borax, and secluded from the air. It may now be hardened by heating it only cherry-red, after which it is inserted into a piece of borax, or what is still better, plunged into mercury; care is to be taken in the latter case, however, not to breathe the mercury fumes. The borax accommodates itself to the heat of the drill, melts, and cools it off. Various experiments made by cooling in water, petroleum, etc., after the drill had been coated with borax, were not followed by results as favorable as when the drill was plunged into borax or mercury; it becomes exceedingly hard without being brittle, and the watchmaker is able to drill articles which cannot be perforated with a drill tempered in the ordinary manner.

GOOD STEEL FOR DRILLS.

MANY watchmakers make use of broken broaches for their small drills, in the belief that they are made of the best steel, which is not always the case, however, because the steel used for them is frequently burned, and, of course, the steel is thereby rendered unfit for such small tools. In order to be certain of the quality of their drill, let them take a new piece of round steel.

TO TEMPER A DRILL.

SELECT none but the finest and best steel for your drills. In making them, never heat the steel higher than a cherry-red, and always hammer until nearly cold. Do all your hammering in one way, for if, after you have flattened out your piece, you attempt to hammer it back to a square or round, you will ruin it. When your drill is in proper shape, heat it to a cherry-red, and thrust it into a piece of resin or into mercury. Some use a solution of cyanide of potash and rain water, but the resin or mercury will give better results.

TO TEMPER STEEL.

A PREPARATION is used for the purpose, consisting of one-half a teaspoonful wheat flour, 1 do. salt, 2 do. water. The steel to be hardened is to be heated sufficiently, dipped into this mixture, to be coated therewith, then raised to a red glow, and thrown into cold soft water.

BROKEN PILLAR SCREW.

SHOULD a broken pillar screw be so rusty that it cannot be taken out with a graver or other tool, use a countersink. Make a center at the opposite end of the pillar, take a drill a little smaller than the screw, so as not to weaken the pillar too much, and drill a hole, until the broken screw is reached; then make a punch to go through in the hole, and drive out the screw with a hammer, by laying the pillar by its shoulder on a stake.

CARE OF CHUCKS.

THE watchmaker who values true chucks must never force a wire into a chuck that is too small to receive it, as it will spring the chuck open, and when it is drawn into the mouth of the spindle, it is liable to be sprung at the cone or shoulders. It is just as liable to be damaged at some point by holding a piece of wire that is too small for the chuck. Keep your chucks in a block under glass cover, or in a box kept in your drawer; and occasionally brush them out with a stiff brush, dipped in benzine. A couple of stiff tooth-brushes are nice things, say one for alcohol and the other for benzine.

ISOCHRONISM.

IT will have happened to the repairer and adjuster that when a ruined or badly mounted balance spring was straightened and set in order by him, the rate of the watch differed materially, and the spring had to be reset; a proof that a spring of equal length and thickness, but of another curve, requires another adjusting; the power of resistance or tension of the spring is virtually altered. Generally, when a watch retards it is presumed that its spring is too weak, or, what is the same, too long, and every watchmaker knows that by further drawing through the spiral stud, its vibrations are accelerated. The cause of the acceleration, however, does not lie in the immediate shortening and approach of its two ends, but in the alteration of its curves, whereby the proportion of the curve dimension to the length, and thereby to the weight of the balance, becomes another, and favors a greater power of resistance. If the proportion of length alone were to decide, then the same quantity of shortening of the balance spring would produce the same effect, which, as every one knows, is not so. By shortening the spring on its inner end, its power of resistance is sensibly augmented, because the operating power of the balance upon the spring is less ened by the change from the center of the inner curve. For this self-same reason, the inner curve should be treated with all possible consideration.

TO MAKE A DIAMOND-POINT TOOL.

A USEFUL little tool for the repairing watchmaker is a diamond-point tool, which he can easily make himself. In *bort*, such as he buys for jewel-grinding, he will find small splinters of diamond, which, by careful setting, will form a point by which the pallet stone itself can be marked with a fine scratch. But in grinding, the scratch must be cut away, as, if left, it would be constantly cutting the teeth of the scape wheel. In breaking up old diamond cap jewels, it is quite easy to select a fragment which can be set up. For such a tool, take a bit of steel wire about one-tenth of an inch in diameter, and turn it up to a conical point, and drill a hole in the end to match the size of your diamond splinter; into this, the fragment can be burnished in, and, if necessary, can be still further secured by brazing. That is, if brass filings and borax be applied at and around the diamond splinter, the brass can be fused without injury to the bit of diamond. Such a diamond splinter can be used to reduce the size of hole jewels.

TO CLEAN WATCH CASES.

VERY dirty or oxidized silver or gold watch cases can be restored by brushing them with a soft brush and a little rouge and oil. The case is afterwards cleaned with another brush and a little (best is lukewarm) water and soap, and finally laid in alcohol to remove all traces of the soap. The case, after being taken from this bath, is dried with a clean rag. It is evident that the movement, and, if possible, also the case springs, have been taken out. Clean, dry sawdust may be used in place of alcohol; leave the case in them until thoroughly dry.

DRILLING BOWS.

GOOD bows are necessary complements to good turns, and the watch repairer cannot dispense with less than four, varying in length from 12 to 24 inches, and in strength from that sufficient to make a balance pivot, with horse or human hair, without slipping on the ferrule, when turning with a fine pointed graver; and the others increasing in strength to what is required in turning barrel arbors, stoppings, and the larger drilling operations in watch work.

TO POLISH PIVOTS.

THERE are a number of ways to polish pivots. After turning the pivot down about to size, it is ground with oil-stone dust and oil till the marks of the graver are removed, and a smooth "gray" or dead-white surface is obtained—the pivot now being of a size to barely enter its hole and perfectly shaped. It is then polished with sharp or hard rouge. Both the grinding and polishing are best done with slips of bell-metal filed to shape and used like the old-fashioned pivot burnishers. Many workmen finish off with Vienna lime or diamantine to give a fine gloss, but this is hardly necessary if the polishing with sharp rouge is well done, as that gives a splendid black luster that is the ideal of perfect polish for steel. The polishing should not be continued too long, or the surface will become a sort of brown color and of inferior appearance. If the "gray" has been well done, a very little further manipulation will be sufficient to produce the polish, and, as soon as it is reached, the process should stop. But if the brown shows itself, the surface should again be stoned off and the polishing repeated. Some workmen take the trouble to finish the pivot in the Jacot lathe with the pivot burnisher, in order to harden the surface and make it wear better, and less easily scratched and marred. The foregoing refers to working with the live spindle lathe, but if the repairer uses the old-fashioned steel verge lathe or "turns," he is, of course, confined to the pivot file and burnisher for finishing the pivots.

TO STRAIGHTEN A PIVOT.

SOME watchmakers will object to the straightening of a pivot, and rather break it off and put in a new one. Some may try to avoid the labor and expense, and sometimes a pivot can be straightened and act as well as a new one, in the following manner: I put it in a pivot lathe, with or without screw collet, place in a rest just a little smaller than the pivot, first springing it as near straight as I can see or tell, then carefully run a small steel burnisher over the pivot, pressing sufficiently hard to spring it straight; the wheel will revolve under the pressure (if it does not, use collet and bow). Great care is necessary to keep the pivot from rolling out of the rest.

TO FIX A CAP JEWEL.

TO fix an end-stone, the cap must be held by its edge in the sliding tongs and shellac carefully applied round the edge of the hollow. It is advisable to hold the cap in a small tool formed of two parallel blades, as, when reversed so as to press the stone on a flat surface, the shellac will be spread over the end-stone, from which it will be removed with difficulty.

TO MAKE A PIVOT FILE.

DRESS up a piece of wood, file fashion, about one inch broad, and glue a piece of fine emery paper upon it. Then shape your file as you wish it, of the best cast steel, and, before tempering, pass your emery piece several times heavily across it diagonally. Temper by heating to a cherry-red and plunging it into linseed oil. Old worn pivot files may be dressed over and made new by this process. At first glance one would be led to think them to be too slightly cut to work well, but this is not so. They dress a pivot more rapidly than any other file.

THE LENGTH OF A BALANCE SPRING.

THE length of a balance spring is important, especially in flat springs, without overcoil. By varying the strength of the wire two flat springs may be produced, each of half the diameter of the balances, but of very unequal lengths, either of which would yield the same number of vibrations, as long as the extent of the vibrations remained constant, yet if the spring is of an improper length, although it may bring the watch to time in one position, it will fail to keep the long and short vibrations isochronous. Then, again, a good length of spring for a watch with a cylinder escapement vibrating barely one full turn, would clearly be insufficient for a lever vibrating one turn and a half.

TO SOLDER A STAY SPRING.

STAY or lifting springs are often broken, and the watchmaker has frequently none of the right size nor the time to make a new one. In such a predicament, he can mend the old one, and have it just as good as new, by placing the broken parts together and binding them firmly to a piece of coal, then soldering them with 18-karat gold. It requires a strong heat and plenty of borax; then finish off, nicely harden and temper in the usual manner.

THE INFLUENCE OF CURB PINS.

IF the balance spring is not entirely equidistant from both the curb pins in a state of repose, or, what is still worse, if it touches one of the pins, it will, when it makes smaller vibrations, be more subject to the influence of these curb pins, and consequently its vibrations will become quicker. It will often happen that with a certain extension of the vibrations, it leaves one of the pins, and vibrates free from all impediment, therefore with less power, for a certain time.

TO CUT THE SCREW TO THE FAN OF A MUSIC BOX.

THE country watchmaker will be requested to do many a job of repairing, for which there are specialists in any large city. This is the case also in the present instance. Select a piece of steel wire a little larger than the entire diameter of the screw, and turn up a flank for your screw and staff. Of course, the reader will understand that the piece of wire should be hardened and tempered to a spring temper. Now take a piece of fine iron binding wire, and wind it on a wire a trifle smaller than the size of the screw. Wind the coils close together, and when you have an inch, say, wound, remove from the large wire and stretch it out like a spiral spring until the spaces between the coils exactly correspond to the spaces of the teeth which are to work in the screw; a gradual stretching is the best—stretch and try. Cut off three-eighths of one inch of the fine wire spiral, slip it on the screw blanks, on which it should go easily, not too tight, but so that the coils touch the screw blank. Soft solder this fast, and you have a guide that, with a double safe edge-file you can quickly file out to a screw. Finish with emery, polish with rouge or diamantine.

D PALLET ACTION.

THERE is a class of trouble in pallet action, in the way of scape wheels which are not round. Frequently this is so much, that part of the teeth of the scape wheel hardly pass the pallets, while the other side will trip; that is, the teeth will not securely catch on the locking face. Usually, in such cases, the scape wheel has been badly set on the pinion. This can generally be told by inspection of the pinion at the point where the scape wheel is set. Sometimes it arises from the scape wheel pinion having been pivoted. If the last cause is the one, a new pivot will cure the trouble; but if the pinion is all right we must seek for the cause somewhere else. We will first find out where the fault is, and then tell how to correct it. If we put the scape wheel and pinion into the double calipers and revolve it, we can readily determine which is at fault—the scape wheel or the pinion. If a pivot is the fault, we answered this above; if it seems to be in the wheel, knock the pinion out, and test the wheel if it is round. Usually, in such cases, the trouble is in the manner in which the scape wheel has been set on the pinion. The seat or place where the scape wheel goes on the pinion was turned too small, and when the wheel was riveted on, the riveting was done in such a way as to throw the shake or play all to one side. Such a condition is quite serious, as we cannot well put the pinion again in the lathe and true up the seat, as it is already too small; and it is impracticable to bush or close the hole in the scape wheel. The correct way to proceed is to test the scape wheel for round, and see if it is true; if not, it is easy to open the hole in the center to one side, so that the wheel will be true if the pinion is true. Now, there are two ways to go about correcting the trouble: First, and best, put in a new pinion; next, use the old pinion if it is long enough.

REPAIRING CHEAP CLOCKS.

THERE are few things that tax a workman's patience and ability more than the repairing of common clocks. The low prices that are paid for repairs and the exacting demands that are made for their performance render it increasingly difficult. Among the most troublesome that I have found is the French drum clock with short pendulum. The most frequent cause of stopping is this: the back pivot, just above the pendulum, soon wears flat, which increases friction and stops the clock. The cheapest and best remedy is to file up the pivot to a knife edge or V-shape, which will give it a light action.

TO MAKE A DRILL.

IT is quite a difficult piece of work to make a true running drill in the drilling spindle of the chuck lathe. To do this well do not turn the drill between the lathe center, but fit the steel direct into the spindle and turn the spoon on. It will receive the proper form and size in the lathe, after which it is filed flat in front. Such a drill requires a little more labor, but it is far stronger than the hammered ones, and it is really a piece of downright carelessness if the repairer breaks it. Moreover, a drill made in this manner must unconditionally run true. It is best to make it as short as possible. Every drill should have only two cutting edges—one on each side; this will expedite work not alone in the foot lathe, but also with the drill bow.

BOWS.

WHALEBONE can be reduced in strength or rendered more uniform by being filed with a fine rasp, or by scraping its surface with a piece of broken glass. If, instead of fixing a brass end with a hook to the bow, it is desired to form a hook of the whalebone itself, hold the extremity in boiling oil for a short time, when it will soften; then form the hook, maintaining the whalebone in the required position until sufficiently cool to set. A form of bow has been introduced that consists of a brass handle, into which slides a steel wire bent into the requisite form; the strength, of course, depending on the thickness of steel wire used.

POLISHING THE FOURTH PINION.

THE best pivoters generally polish the fourth pinion like any other arbor, but if nervous or heavy-handed, a special brass center with half of its diameter filed away, and a convenient slit for the pivot to rest nearly all its length in may be used, but it is not to be recommended, as a careless slip will destroy the pivot, which otherwise in the turns would have a certain amount of elasticity. The resting of the little finger on a convenient part of the turns, and letting it move with the polisher, is an item in polishing pivots, the fingers being used to regulate the pressure of the arm and hand; the most troublesome pinion to pivot is the Swiss scape pinion, owing to its having no arbor.

AUDIBLE UNROLLING OF THE MAIN-SPRING.

IT happens occasionally that the mainspring will make a peculiar grating noise in the barrel while in the act of unrolling. The repairer should, if possible, correct this, because it may occasion other errors, and the power exerted by the mainspring must necessarily be unequal. It is most generally caused by the scant room in the barrel; the spring in the act of unfolding in the contracted barrel space must naturally scrape on the cover or bottom. The spring may also, when it grates in one of the common clocks, where the barrel wheel supplies the place of cover, catch on the dial, especially when this is too thick or shaky. Burr inside the barrel may also cause the audible development of the spring.

TO PREPARE SHELLAC FOR USE.

SHELLAC can be dissolved in alcohol, and kept in a liquid form, in a close stoppered bottle, to prevent evaporation. To use it, it is only necessary to apply it, where required, with the pointed end of pegwood, or small camel's-hair brush, and gently heat over a lamp, when it will quickly harden. Or it may be used in chips, as received from a drug store; a good way to do, when setting pallet jewels, ruby pins, etc., is to heat a piece over the lamp and draw it out to a long, slender thread, then break the thread into small particles of suitable lengths for cementing the jewel; by this means, the shellac can be placed just where it is needed, and it will not run all over the pallets or table roller.

TO MAKE A COMPOSITION FILE.

THESE files, which are frequently used by watchmakers and other metal workers, for grinding and polishing, and the color of which resembles silver, are composed of 8 parts copper, 2 parts tin, 1 part zinc, 1 part lead. They are cast in forms and shaped upon the grindstone; the metal is very hard, and therefore worked with difficulty with the file.

DIAMOND FILES.

SHAPE your file of brass, and charge with diamond dust, as in case of the mill, grade the dust in accordance with the coarse or fine character of the file desired.

CLEANING-PITH.

THE stalk of the common mullen makes the best pith for cleaning pivots. The best time to gather it is winter, when the stalk is dry. Some use cork instead of pith, but it will hardly answer the purpose.

VERDIGRIS SPOTS.

A CORRESPONDENT of the *D. Uhrm. Ztg.* inquires how to remove verdigris spots from gilt parts of a large clock, to which some one responds by saying that they are easily removed with a few drops of spirits of hartshorn upon the offending spots; or wet a small ball of silk paper with it and pad them until removed, afterward drying the spots thoroughly with a like pellet of dry paper. If the spots do not disappear at once, repeat the process. If the spots have shown themselves for a length of time, of course, the gilding has been ruined and must be touched up again, after removing the spots, with a fine camel's-hair brush and shell gold.

PALLET LOCKINGS.

IN respect to the pallet lockings, the equality of sharpness of draught inward is readily judged to be about equal by trial—some persons try them by placing the guard pin against the round edge of the roller, and gently putting the peg on the escape wheel. But the equality of their draught inward does not quite prove their equal resistance to the reciprocated force of the balance, nor does the writer know of any way to prove when they are so, strictly, but he will make some remarks about them. It is to be observed that the two lockings are at unequal distances from the center of the pallet, and also that with deeper depths the wheel drops further under the inside locking, so that in unlocking the wheel has to be moved further back to get the locking out from under the tooth; still, as the radius to the inside locking is the shortest, therefore the long arm of the lever bears a greater ratio to that shortest pallet radius, and although the inside locking of itself may be a trifle the hardest, yet it may not subtract any more velocity from the balance in unlocking than the outside one; and, indeed, if the inside locking of itself was as easy to unlock as that of the outside we should then be certain that the resistances to the force of the balance would be unequal, as the two radii to the lockings were unequal. Unequal radii must have unequal resisting lockings to subtract equal portions of velocity from the same reciprocated force of the balance.

In light pallet depths the wheel has only to be moved back in the locking a mere trifle, but in very deep depths or long run to the bankings, the wheel has to be moved back a good bit. It is the moving back of the wheel to get the locking out from under the tooth that causes the principal resistance to the force of the balance, for if there were no motion backward of the wheel the unlocking would only be a frictional resistance, like in a regulator clock; but this is impossible in watches, for there must be a detachment by draught inward sharp enough to free the guard pin without any hesitation, or else there is danger that the vibration of the balance is frequently interfered with, which, in some cases, will stop the watch.

All pallets that make equal arcs by the two workings have, and must have, the deepest hold of the outside locking. Suppose the depth hold to be such that each of the pallets make an arc of 3° in the unlocking, it is easily seen that 3° of the larger outer circle which the pallets describe is a greater space than 3° of the smaller inner circle, and the piece of stone which must enter the wheel is the greatest on the outside locking—and if pallets were made to draw off equally, that depth at which they would do so must be planted precisely or they would be unequal in the draw off. As a rule, it will be found that if the wheel just catches a tripping hold of the outside locking and just ships the inside locking, when tried in a depthing tool before closing the tool to the depth, the unlockings will draw off pretty nearly equal when in at the depth, provided the depth is not very deep.

THE MOVABLE STUD.

THE great objection to the ordinary balance spring lies in the distance of the center of the balance cock from any one of its points of fastening; this causes the body of the spring to crowd to one side in vibrations of any extent. A change of form takes place, which opposes the progress of the isochronal development.

This defect may be overcome by not fastening the spring to the bridge, but to the end of a straight spring screwed with a foot upon the plate. This construction is known by the name of "spring stud," or " movable stud." By the vibrations of the balance the stud bends, and when the balance spring closes, its end approaches towards the center, while in the opening of the former it withdraws. This disposition favors the isochronal development of the spring to a high degree.

The difficulty is to find the exact proportions. It is evident that by a given balance spring the spring stud must comply with certain conditions of length, thickness, flexibility, etc., which until now could be established only by experiments. Besides this, strictly considered, the head of the stud must have almost no weight, so that its elasticity alone would operate, and its weight would not enter into account as a different power, between the vertical and horizontal positions.

This arrangement, says Cl. Saunier, is still too new to express an opinion on its merit. C. Frodsham, of London, introduced a flat balance spring with a spring stud in a marine chronometer, and it has been shown that this chronometer was one of the best he ever made. Raby, of Paris, also used the spring stud in watches, and expressed great satisfaction as to their performances.

TOOL FOR FASTENING ROLLER JEWELS.

HAVING been benefited so much by the many good suggestions appearing in THE CIRCULAR, I deem it but right that I should add my mite toward the fund of information. For fastening a roller jewel I have made a little tool which I find very convenient. It is made of a small piece of brass plate, say one inch long by one-quarter of an inch wide, with a slit lengthwise. Fasten this plate to a handle three inches long, made of iron wire, with a rivet. To use, heat the brass plate, then lay your balance on with the table roller flat on the plate, the end of staff and the roller jewel extending though the slit. When the shellac has melted see that the roller jewel is in correct position before the shellac hardens.

THE ADJUSTING OF LARGE AND SMALL WATCHES.

WHEN we speak of adjusting watches, we are generally understood to mean adjusting to temperature and position or isochronism, whichever may be the proper term. In what I am going to say about the adjusting of large and small watches, I mean to speak only of position, adjustments, or adjustments to isochronism, and I will have nothing to say about the adjustment to temperature, though the latter may, perchance, be the most important of the two.

In adjusting watches to position, or in isochronizing the vibrations of the balance to all the conditions which a watch may be subjected to, we have to deal pre-eminently with the following factors, while there are others which it may not be necessary to mention in discussing the subject from the proposed standpoint:

1. The escapement.
2. The balance spring.
3. The momentum of the balance.
4. Friction.

The most perfect isochronism could, no doubt, be produced, could we have a balance which could vibrate without any friction whatsoever, but in all watches made the balance can only vibrate on resting points or pivots, and its vibrations can only be kept up by its receiving an occasional impulse by means of the escapement; and here we encounter at once one of the worst enemies to a perfect isochronism, *i.e.*, "*friction*." This friction is, therefore, twofold. 1. The friction of the pivots, and 2. The friction caused by the balance coming in contact with the escapement. Of these frictions, the first is constant and the second is intermitting.

What means have we to overcome these frictions?

1. The momentum of the balance.

What is momentum? Momentum is weight multiplied by velocity. A steamship weighing 3,000 tons and moving at the rate of 2 miles per hour, has double the momentum of a steamship weighing 300 tons moving at the rate of 10 miles per hour, because 3,000 tons weight multiplied by 2 miles velocity is equal to 6,000, while 300 tons weight multiplied by 10 miles velocity is only equal to one-half, or 3,000. In a watch balance, momentum is represented by the weight of its rim near its outer edge, multiplied by the velocity at which a given point in this rim moves in a given time and at a given distance. The proportions of the size, or, rather, of the weight, of the arm or arms of a balance, have a good deal to do with the momentum of a balance, as will be readily understood.

2. The balance spring. The balance spring is to the balance what gravity is to the pendulum, and it exerts a continuous influence which tends to bring the balance back to a point of rest, and it overcomes the inertia of the balance in this respect, and in so doing becomes instrumental and auxiliary to unlocking the escapement, overcoming with the co-operation of the momentum of the balance, the pivot friction and the intermitting friction of the escapement.

It will be seen at a glance from the foregoing, that the most perfect isochronism attainable can only be had by reducing the pivot and escapement friction to a minimum, by the greatest mechanical skill and by the most intelligent manipulation. And the larger the machine the more perfectly we can carry out the details of its construction. (Of course, there is a limit to everything.) Hence the size of a ship's chronometer.

When we consider that in making the best 18-size pocket watch movements, we make the balance pivots often as small as 0.004 of an inch and escapements to match, and we present the question whether we can reduce sizes and frictions proportionately to a 6-size watch, the answer must be an emphatic "No." The pivot and escapement friction in so small a watch, therefore, becomes such a preponderating factor, that the isochronizing of the vibrations of the balance thereof must be at best but a crippled job.

In speaking of small watches, we must include in the list some of the complicated watches, such as repeaters, etc., where the want of space and a limited motive power admit of only a small train and escapement and balance to match, and it was with one of these that I had my first experience.

I cannot conclude my communication and convey the impression that what I have said is all that ought to have been said; and, if circumstances will permit, I hope to be able to refer to the subject again incidentally, treating it from an entirely different standpoint.

REGULATION OF WATCHES.

THE accurate time-keeping qualities of a watch, presuming the works to have been properly constructed, depend in the main upon the regulation; while it is a well-known fact that the great majority of people judge the quality of a watch solely by the accuracy of the time it keeps.

To move the regulator to the right or to the left, thus lengthening or shortening the hairspring and thereby causing the watch to run slower or faster, as the case may be, is a very simple matter in itself, but the science of regulation lies much deeper than this, since accuracy can only be obtained when all the parts are in proper order. It is therefore necessary at all times to be assured that certain faults do not exist, because their presence unperceived might render accuracy absolutely impossible; hence, to summarize some of these defects briefly may not be inappropriate. In this article the treatise will be confined to the anchor watch, elbowed spiral, and compensated balance; attention being directed hereafter to the regulation of the cylinder watch.

A subtle defect, and one which inexperienced workman do not readily perceive because they occur almost solely in fine watches, is a too great precision in the performance of the escapement, but which, however, is not noticeable upon the vibrations of the balance. In order to remedy this it is sometimes necessary to remove the gilding at the place where the pallet rests while it is locked. To ascertain if the action is too strict, all the teeth of the wheel should be made to pass by using a small wooden point, in order to push the pallet of the anchor to the locking point on each side of the escapement wheel. In the great majority of cases the teeth will not pass equally well on both sides, to rectify which it is often only necessary to raise the bed of the gilding on one side. This defect does not exist in anchors in which the locking is made on the stem of the wheel, though but few escapements of this kind are met with on account of the greater care required in their manufacture.

The ruby holes, also, should not be too constricted, there being no danger in allowing a little play to the pivots in the holes. In the better grade of watches the ruby holes are usually of a fair size, well oiled and well set, with the exception of the center holes, which are often too exact, the factory workman imagining that to make them well only little play must be allowed. The consequence is that the oil does not remain upon the pivots, entailing a rapid alteration in the rate of speed of the movement owing to the pivots wearing rough, and getting cut. Too often these holes do not receive from the manufacturer the attention which their importance demands.

The axis ought to be well tempered so as to have the pivots as hard as possible, and which, conical and well burnished, should not be too large, but ought to be of such a size as not to leave any chance of breaking. That the pivots should be well rounded is of prime importance, since oval pivots produce the same effect as a balance of bad equilibrium, and occasion much trouble in establishing the isochronism of the positions. Let the ends of the pivots be well burnished and slightly rounded, and better still, that that part of the pivot which works in the hole should be perfectly cylindrical, so that it may leave the axis just play enough between its counter-points.

The balance spring requires particular attention; requiring to be very upright, and to turn well round. Many watchmakers have been surprised, after having well rounded a balance to discover, when the watch is brought back to them six months later, that the balance is no longer round, and that the regulation is changed. To avoid this, warm the balance on a metal plate to a temperature of 60° or 70° Cent., make it round and warm it afresh until quite certain that it is in the same condition as at first. Care should be taken, if it is held in the fingers during very warm weather, to place it each time upon a plate of cold metal, as it may happen that the heat will close it up, and that a moderate temperature will change the diameter and of course interfere with the regulating. It is usual also to obtain its diameter and height by that of the barrel and mainspring. Its size should be the diameter of the cover of the barrel, and the height of the rim just half that of the spring. It should be furnished with fourteen screws of gold, rather less than more.

The practice of regulating at different temperatures is already well understood, yet for the sake of perspicuity it should be remembered that when a watch goes slower in heat the screws are carried toward the end of the blade of the balance, and if that does not suffice, then change the last gold screw for one of platina; but this latter course is very unusual, owing to the length of the spiral now in use. If the watch gains in heat the screws should be set back; and if after they have all been put back the watch still gains, the arms of the balance must be shortened, and two additional small screws added. With a little practice the desired result will be obtained.

For the sake of convenience, regulating the balance has been considered prior to that of the spiral, but it should be borne in mind that the former can in actual practice only be regulated after the isochronism of the latter has been accomplished; because if any change is needed in the spiral, the balance must then be regulated again.

Often it becomes necessary to put in a new spiral altogether, in the selection of which those of moderate size are preferable, since with the small ones considerable difficulty is met in finding the isochronism; while with the large ones, although this is much easier accomplished, yet they are not safe for a pocket watch, the movements of the wearer, especially when the coils are close, causing them to touch each other, or to touch the balance. Many watchmakers have met instances in which larger spirals almost caught the center wheel, and to prevent which have been obliged to put in an accessory piece; and besides this, a long spiral is more susceptible of shocks which might interfere with regulating, especially in watches that are liable to receive rough treatment, as for instance those worn by railroad men, and those engaged in similar pursuits.

It is usual to take for the diameter of the spiral the radius of the balance and the number of turns fifteen; this size and this number permit the separation of the coils, and avoid the danger of their touching each other through shocks. The spiral should be hard and the blade high—as high as the watch will permit. Generally the spiral of low blade produces a noise which the accustomed ear detects, and which indicates something wrong with the regulator. This may be produced by an uneven steel wire, and, in order to discover if the wire is equal throughout, observe attentively its workings; if it is uneven, a slight vibration of the thickest part will be perceptible, upon discovering which the spiral should be immediately changed, for it will only be loss of time to try to make it isochronal. The requisites of a perfect flat or elbowed spiral are that it should not wriggle, and if it is of fifteen turns, the eighth should not leave its place, though this is contrary to the opinions of some watchmakers who have confined their observation to the helicoid spiral, in which all the blades are equally displaced.

REPAIRING OF ENGLISH PATENT LEVER WATCHES.

WHENEVER an English patent lever watch is offered for repair, the watchmaker well understands that a difficult and tedious job is before him. Very often the cap has been hammered out by some botch, and evidence may be visible that the top bridge has been pressed this way and that, while the heavy and clumsy expansion balance wheel with its lazy motion, which becomes still slower when held in different positions, presents in itself a hard problem. Before taking the watch to pieces the banking should be carefully examined by guiding, to determine whether or not the escape wheel has a safe rest upon the anchor pallets. Should the banking be safe, but wide, close one, or, if necessary, both of the banking pins; bearing in mind, however, that very little play is needed. Friction is thus reduced, and the impulse power of the pallets thereby increased; which is in turn transferred to the balance wheel, increasing its curve of vibration. Should the fork pin squeeze against the roller, thus clogging the motion of the balance wheel, the banking is insecure, and after the watch has been taken to pieces and the escapement reached, the fork pin should be bent a trifle forward.

Supposing the watch to be in pieces, examine each piece separately and thoroughly. First, put the center wheel between the plates and notice if its motion is free and easy; if it has the right play, or if it is rubbing on the bottom of the out-cut. A small supply of ordinary pins, with heads filed gradually thinner to the end, should always be kept on hand to be used in place of the usual pillar pins, a handy substitute which admits of easy insertion and ready withdrawal without pliers. If the center wheel moves freely and the pinion is well fastened, observe whether the cannon pinion has made a hard impression on the front of the dial plate, and if so, take it off by making a flat counter-sink—the bottom of the cannon pinion must never touch the plate.

The fusee wheel next requires attention, and more than ordinary pains must be taken with this; because this wheel causes more trouble in an English lever than all the other wheels together. Test the wheel between the plates, and in a great majority of instances it will be found to be out of order, and sometimes so badly as to absorb more than half the power of a strong mainspring. Examine the stop-piece situated in the stud, to see if it squeezes against the fusee. This piece, generally furnished with a stiff spring, reaches too high up; if so, make the spring softer and stretch the lower end with the hammer so much that the front end touches the plate; take the screw-driver or penknife, squeeze it under the stop-piece close to the stud, and bend it carefully up a little, just enough to give the stop-snout of the fusee a free passage, and nothing more. If the edge of the lower end does not give out enough when stretched (sometimes it gets too thin), put a new stop-piece in the watch. Again place the fusee-wheel between the plates and carefully note that the stop-snout passes freely between the stop-piece and plate, forward and backward. When this is corrected, proceed to the stop-snout of the fusee. Here a neglect is met, curiously enough, which has been carried on for hundreds of years, and perhaps longer. The snout is invariably too short to secure a safe stopping, after winding up. Fusee, staff, and snout are in one solid piece, making the job of filing it out very difficult for an ordinary watchmaker. However, it can usually be accomplished if the snout is not too thin, by placing it upon a suitable anvil, and with a hammer stretch it as much as possible and then bend off the stop-piece from the fusee. Place the fusee in the upper plate only, to see that a safe counter-stemming is produced. If so, there is no danger of chain-breaking on account of an imperfect stop-work. Put the wheel again between the plates, and if the work has been done properly, the fusee wheel will be found to move with perfect freedom.

Examine the chain on its track; if it runs off, file the turns a little deeper with a sharp and well-fitting screw-head file, bearing in mind that the chain should be only one inch longer than actually necessary, to prevent running one turn over another. Now place the two wheels together between the two plates, center and fusee, and examine the pitchings or depth, and when traces of hard wear are observable on the front side of the teeth, the wheel must be worked over, a job requiring both skill and experience. Close below the teeth is generally a little cornice, which must not be destroyed. Place the teeth—and only the teeth—upon a sharp-edge anvil, fastened in a bench vise, and hammer them out, one after the other, until all are done; but the hammer must hit no other places. The marks of the blow must be removed with fine emery paper without touching the gilding, while with a small rounding-up file (entirely smoothed on the oil-stone) the front side of the teeth must be polished.

Assuming the depth to be right, observe that the wheels do not touch each other, and that the pin of the maintaining spring reaches out far enough to catch the teeth of the center wheel. Then try the click-work by turning the fusee around the wheel. If the rattling of the double click is heard plainly, all is right; otherwise, take off the wheel and remedy what is necessary by putting in either a new click-work or a new ratchet wheel. The correction of the mainspring click-work yet remains to be done. The point of the click must be sharp and the click itself level with the ratchet wheel. The click-spring is invariably too stiff, absorbing too much power, and must be made softer. If the spring is small and curved, file it thinner at a point about half an inch from the stud—never at the front end; while doing the job support the spring upon a cork, placed in a vise, or in some other safe way. If the spring is a broad, band-shaped one, cut in with a shoulder file a quarter inch from the front end, and file out half, or a little more, of its whole width, close to the stud. In filing this spring thinner, the broad side presents the difficulty, on account of its hardness and brittleness, yet the spring must not possess more stiffness than is absolutely necessary for working the click properly. The two wheels, maintaining click-work and stop-work, are now in perfect order. The third wheel now requires attention. Place it between the plates, and if it works free and easy, do the same with the fourth; then put in both together and examine depth and freedom. The rule is, *examine each wheel singly, then in pairs.*

If the watch is jeweled, holding the plate firmly in your hand, put each pivot in its pivot hole, and observe that the fall is equal on all sides; if not so, roll the pivot a little thinner, irrespective of how free it seems, otherwise when oiled the pivot will stick. If the watch is working in metal bearings, put a pivot broach in each hole to see if it is straight; in many cases it will not be, in which case a few chips must be taken out with the broach very carefully, in order to straighten the hole as much as possible. If the hole is getting too large, bushing will be necessary.

Examine the escape wheel as to freedom and pitch in the same manner as before, and if the pinion is too large, it must be re-turned to its proper size, the edges smoothed, and the teeth of the fourth wheel well polished with a smoothed rounding-up file.

The escapement next requires attention. The arbor-pin has been bent already a little forward, but by doing so, frequently the free passage through segment of the roller-plate will be destroyed; therefore take off the roller, hold it in the cuts of a watch-hand tong, or some other suitable way, and file the segment straight down to its bottom; the two edges are mostly in the way. If there is left plenty of material between the surface and the hole in which the roller-pin is fastened, hollow out the newly-made surface with a bird's-tongue file to restore the segment form again. In no other way must the proper hold of the roller-pin be destroyed; better the fork-pin be bent a trifle back.

Next comes the hairspring roller. Take off the hairspring and roller, fasten the latter upon a fitting turning arbor, and turn both sides of the roller down as much as possible, the front side even a little under-cut, without endangering a safe hold of the hairspring.

The balance wheel is now reached, the weight of which must be in proportion to the motive power. "A balance wheel too heavy does not admit a good curve of vibration; a balance wheel too light would act as a fly, but not as a regulator." The balance wheel is almost invariably too heavy, to rectify which, the arms or spokes must be filed much smaller, and made to incline a little toward the center. To do the job with security, put a good sized piece of wire perpendicular in the vise, bend the top end outward nearly in a right angle and furnish it with one or two cross cuts deep enough to give the balance wheel a firm support when filing the spokes; afterward file away all unnecessary metal around the staff, taking off as much as possible without interfering with a safe hold of the center-staff. Then file the drums a little slanting so as to cut the air well, and after cleaning put the hairspring and roller in their proper places. If the hairspring roller is somewhat loose, squeeze it a little, but not without having a piece of wire held loosely in the middle, or it is apt to break. Some slight improvements still remain to be made in the anchor-fork. If the outside of the fork reaches far outward, cut off enough to make the banking just safe and poise the inner end by filing and shaping it into a small bar from close behind the fork-pin to the anchor (pallets). Should the extreme inner ends of the fork be very stiff, file them straighter, but never touch the inner edges, and carefully remove all burr. Sometimes when they are too steep, they are apt to catch the roller-pin from behind. In fine Swiss watches these ends are hollowed out.

Last, but not least, the mainspring and barrel requires attention. See that the arbor has the necessary play and how many rounds the mainspring makes—generally 3¾ rounds, and if so, span the ratchet wheel about ⅜ of a whole round—just enough not to allow the chain to fall off. Clean the watch properly in the ordinary way, and if the job has been done conscientiously, the result cannot fail to give perfect satisfaction.

ADJUSTMENT TO ISOCHRONISM.

THE manipulation of the hairspring so that the long and short arcs of the balance are performed in the same time. The theory of isochronism advanced by Dr. Robert Hooke, and more commonly known as Hooke's law, "as the tension so is the force," is an axiom in mechanics with which everybody is, or should be, familiar. This law has, like nearly all others, its exceptions, and it is only partially true as applied to hairsprings of watches; "otherwise," says Glasgow, "every spring would be isochronous." Pierre Le Roy says that there is in every spring of a sufficient extent a certain length where all the vibrations, long or short, great or small, are isochronous, and that this length being secured, if you shorten the spring the great vibrations will be quicker than the small ones; if, on the contrary, it is lengthened, the small arcs will be performed in less time than the great ones. Glasgow says that a hairspring, of whatever form, to be isochronous must satisfy the following conditions: Its center of gravity must always be on the axis of the balance, and it must expand and contract in the vibrations concentrically with that axis. When these conditions are secured in a properly made spring it will possess the quality of isochronism, that is, its force will increase in proportion to the tension, and it will not exert any lateral pressure on the pivots.

The recognized authorities conflict considerably in their various theories in regard to adjustment to isochronism, and particularly in regard to the length of spring. Immisch says that mere length has nothing to do with isochronism. Glasgow contends that length has everything to do with it and that a spring too short, whatever its form, would make the short arcs of the balance vibration be performed in a less time than the long arcs, and a spring too long would have just the contrary effect. Charles Frodsham advanced the theory that every length of spring has its isochronous point. Britten declares that the length is all-important. That a good length of spring for one variety of escapement is entirely unfitted for another variety. Saunier says that the discussion of the question whether short springs are preferable to long ones is a mere waste of time and can result in no good. In horology everything must be relative. Whatever be the escapement under consideration, it requires neither a long nor a short hairspring, but one that is suited to its nature and mode of action, that is to say, the length must bear a definite relation to the extent of the arcs of vibration, etc.

Owing to this conflict of opinion, it is advisable that the student read the various arguments set forth in the works referred to above and form his own conclusions.

ABOUT GAUGES.

IN working in a new pinion when the old one is at hand, no trouble will be experienced as to height, and when the old pinion is removed from the wheel, all the measurements can be taken from it by the millimeter gauge. This gauge is much lighter in its action than the douzieme gauge, and altogether more suitable, having finer and cleaner divisions. About two-tenths of a millimeter are equal to one douzieme. The jaws of this tool are frequently not fitted closely, and on account of their hardness can only be corrected by grinding. A piece of flat brass, similar to a barrel cover, is fixed on an arbor and adjusted to run true in flat; a little emery and oil or oil-stone dust is applied on each side of it. The turns having been put in the vise sideways, so that the gauge can hang freely, the jaws should be allowed to close on the lap. A few revolutions will grind both jaws true and perfectly parallel. After this operation it is not unlikely that the pointer will pass beyond the index; if so, the end of the pointer must be gripped in the vise, with a piece of card inserted between it and the vise, to prevent marking, and pulled gently, until it indicates correctly.

ANNEALING AND HARDENING.

COPPER, brass, German silver, and similar metals are hardened by hammering, rolling, or wire drawing, and are softened by being heated red hot and plunged in cold water. Copper, by being alloyed with tin, may be made so hard that cutting instruments may be made from it. This is the old process of hardening copper, which is so often claimed to be one of the lost arts, and which would be very useful if we did not have in steel a material which is far less costly and far better fitted for the making of edge tools.

WATCH REPAIRING.

ALTHOUGH broaching in the mandrel is not a bad way of opening a hole, it is always better to open it to nearly the required size by running a cutter through it, if the hole is large enough to admit of this being done; but, as these cutters are easily broken, in consequence of their being so small, turning out holes is not often resorted to by watch jobbers.

The half-round or triangular pieces of steel sold with a mandrel to make cutters of are seldom made from the best steel, and are only fit for cutters for rough turning, and making a cutter of one of these involves considerable labor; therefore it is much better to make one into a cutter-holder by drilling a good-sized hole in one end of it, and after broaching the hole, fitting several pieces of small steel to the hole (they should be turned and fitted accurately); these pieces are easily made into cutters of any size or shape required, and if one gets broken it is easily replaced.

Watch jobbers do not seem to like the mandrel, but the more they use it the better will their work be done, and it will certainly save their time to do so. If the fusee requires new holes and the center wheel holes are right or have been renewed, the teeth of the great wheel will often be found worn and sometimes bent from the wheel having been softened in gilding—the teeth being much longer than is necessary and the spaces cut square at the bottom—and in the case of the teeth being worn from the center pinion being a wrong size and the depth too shallow. A new wheel would, of course, be the proper remedy for this; but if this may not be done, the teeth should be hammered carefully; the depth tried in the depthing-tool, and when the stopping in the pillar plate or bar is pushed out, the depth marked across the hole. The hole should then be *drawn* until the mark is in the center of it and a new stopping put in. The great wheel depth should always be as deep as possible; it is a mistake to make it shallow, because it will then run more smoothly. But, supposing the lower fusee hole does not require any alteration, and a new top hole only is required (a repair often wanted), if the old stopping in the plate is removed or —in the case of a ¾-plate watch—the fusee piece is broached large enough for a stopping, if a piece of brass is broached to nearly the size of the pivot and then turned to fit the hole in the plate of fusee piece and riveted; if the hole is again broached to fit the pivot and the fusee put into its place in the frame, the chances are twenty to one against its being upright; whereas if the method I have described, of pegging the lower hole and turning out the upper one, be adopted, the upright of the fusee will be secured without further trouble; and, if it is not perfectly upright, the stop-work is most likely to be wrong, and the acdetantant will require bending to get it to act in the steel wheel, which, of course, is botching.

If the barrel holes are worn, and the barrel is, as it often is, out of truth, it may be better to put in a new stopping in the barrel and get it true by the cover; but generally it will be sufficient to close the holes by laying the barrel on a small round stake and hammering up the boss from the inside of the barrel. This boss is usually left large, and if it is hammered on the outside edge the hole will be closed, when it can be made to fit the pivot by broaching with a round broach, and it will be good enough to last for years; this repair is often an improvement, as it lessens the rubbing surfaces of the shoulders of the barrel-arbor pivots. If the hole in the barrel cover is too large and the cover too small, from the expansion of the barrel from the breaking of strong mainsprings, the best remedy is a new cover, which any one can make without any telling; but in the case of a new cover being made, the barrel is not likely to be true, and the cover should be snapped into the barrel before it is brought to the right thickness; if when the end-shake of the arbor is adjusted, the arbor and barrel are put into the calipers, it will be seen if the barrel is true—if not, the cover should be marked on the high side, taken off and turned until it fits easily, and then hammered carefully on the outer edge of the side that is marked until it fits the groove in the barrel; and this, if done the required amount, will bring the barrel true. When a barrel cover is hammered on one side until it is out of round, the barrel and cover should be marked in order that the cover may always occupy the same place.

THE BREGUET SPRING.

THERE is no doubt that the Breguet or overcoil spring is one of the best forms, in fact the best form, of spring under certain conditions; and if the watch be of such a character in construction and finish as to justify or require its application—this fact being known and acknowledged gives a character to a watch worthy of imitation, and therefore it is something for a manufacturer or agent to point to—and as the action of the spring is easy and uniform the retailer or shopkeeper is taken with it and points to it in his turn as an excellence in the cheap watch he is recommending to his customer, and in which he probably believes. As to his consideration for the comfort or convenience of the jobber into whose hands the watch may afterward come for repairs, the thing is too absurd to be thought of; his business is to sell the watch. The Swiss have hitherto been the chief sinners in this affair of Breguet springs, and as they claim that great man Breguet as their countryman, they may be excused for having a prejudice in favor of his invention; but it is useless to rail against the manufacturers of any article for making what they can sell. However great the excellence of a spring having the inherent quality of giving isochronal vibrations to the balance of a fine watch, it is no help to a watch with machine-made pivots and jewel holes, and such escapements as these watches generally have, especially when the overcoil is badly and unscientifically made so that each move of the index pins gives the spring a different form. But it is the business of the watch jobber to take things as they are, and to that end he should learn to make the best of them.

The manipulation of the balance spring is really the most important function of the watch jobber, and but for the fact that these springs can be bought ready to his hand, he would be under the necessity of learning to handle them with greater certainty and less trouble to himself. It is rather humiliating to be obliged to acknowledge that *nearly* all the balance springs applied to English watches are of foreign make.

Although the watch jobber is an all-round man, he ought to be able to pin in a spring flat and true and to correct or repair an injured one, as, no matter how perfect all the other parts of the watch may be, if the spring is bent or constrained in its action no correct time will be obtained from the watch. A flat or spiral spring should never be larger than half the diameter of the balance, that is, if the spring has the coils close together, such as are generally in use at present; but if a new spring is required for a job watch it must be of a size to suit the stud and index pins, and therefore if larger than this prescribed size the coils should be more open. If the old spring is only distorted, and not broken, a ready way of finding the strength of the new one is by lifting a small weight attached to the inner coil of the spring while the other end is held in the tweezers. This weight should consist of a small disc of brass having a pin about an inch long projecting through its center; the pin should be tapered so as to make it as light as possible at the top, and have a small hook filed in it close to the disc sufficient to hold the inner coil of the spring while the weight is being lifted. It is easier to judge of the strength correctly if the weight be sufficient to draw the spring down the whole length of the pin, and for this purpose a few thin pieces of brass, that will drop over the pin and increase the weight to what is required, should be kept ready; by this means the strength of the old spring is easily gauged and a new one of the same strength as easily chosen. A very common and very uncertain method of finding the strength of a spring is by lifting, in a similar manner to what I have just described, the balance itself; the almost uselessness of this method is seen when we know that the diameter of the balance has as much to do with the time of the watch as its weight, and the diameter in this case counts for nothing. A spring should be chosen that will be rather smaller than the circle of the stud hole and index pins; that is, the spring should look small when the balance is at rest, as a spring this size has more freedom of the coils or at those parts of the coils that lie between the stud and the balance staff, and therefore assists in quickening the short arcs of the balance.

I think it is pretty well known that almost all ordinary watches go slower in the short arcs of the balance than in the long ones, or slower when the watch is hanging up than when it is lying down (this is especially the case with full-plate watches, and they, as a rule, have the balance springs too large). A spring collet should be as small as possible, and the inner coil of the spring just large enough to be free of the collet. If the hole in the collet is not straight, that is, tangential, it should be broached until it is so, and from the side from which the spring is inserted, as, if this is done, it will not be found necessary to bend the spring to suit a hole that is drilled anyhow; and, if the spring has to be unpinned, it must be bent again to suit another position.

If, when the spring is pinned to the collet, it stands away from it at the points where the pin is inserted, it will be useless to attempt to bring it closer to the collet by bending it on the collet; therefore, it must be unpinned, and the eye bent in a little, so as to get the center true. When the spring runs true, the collet can be put on an arbor, and there is then very little trouble in getting it flat. I am now speaking of hardened and tempered springs, or those springs that are hardened by chemical process, and are more difficult to handle: soft springs can be bent to any shape or form. Some years ago a prize essayist on the balance spring gave a few diagrams of springs, showing how they grew shorter as they grew older, and the way these springs were made to *do* was by a process known as white throating, that is, by scraping with a graver about an inch of the inside of the outer end of the spring to reduce its strength. This is complete botching, and the workman who resorts to it can have no respect for himself, and need not look for respect from others.

A GOOD WAY TO CLEAN A MAIN-SPRING.

THERE are several methods for cleaning and mounting a mainspring, but the following ranks with the best in use among good watchmakers. Let us suppose we have a watch that has run twelve months or more. After taking the watch down, first examine the mainspring by taking off the cap of the barrel, carefully removing the arbor, then holding the barrel in the thumb and fingers of the left hand, lift out the inner end of the spring with small round nose pliers, holding the thumb and fingers in such a manner as to allow the spring to uncoil itself from the barrel in a gentle manner into the hand, and if sound and of the right strength, proceed to clean it with a piece of domestic (a clean soft rag is preferable, as it is free from starch and other foreign matter calculated to injure steel). Holding the cloth or rag in the left hand and the spring just as it has come out of the barrel in your right, gently move it back and forth, holding two or three of the coils between the thumb, first and second fingers, pressing the coils slightly over with the ball of the thumb (not nails), so as not to materially change the natural curvature of the spring in any way during the operation. In this way the entire spring can be cleaned, with the exception of a small portion of the inner coil, which can be cleaned by using a corner of the rag, applied with a piece of pegwood, or by a slight brushing with a brush used for this purpose. A first-class spring (and no watchmaker should use any other if he values time and reputation) thus cleaned, with proper space in the barrel, and with the arbor free, of proper size, and a *liberal* application of watch oil, but not flooded with it, turned up to its proper capacity, will give out its full force for one or two years, at least, without breaking, rusting, or becoming gummy and foul.

BALANCE.

THREE things cause a loss of the balance velocity, viz.: the resistance of unlocking the escape wheel, the friction of the pivots in the holes, and the stress of the reciprocating spring on the pivots. If the mass of the balance is unbalanced, the pivots will suffer an additional stress from the centrifugal force in revolving.

PRACTICAL METHOD FOR LENGTHENING A BALANCE SPRING.

THE repairer is occasionally compelled to regulate a watch with too short a balance spring, because the owner does not want to pay for a new spring, or else, if a country watchmaker, he may not happen to have the exact size on hand. Let us imagine that he has withdrawn the spring to its utmost, and still the watch advances. Apparently something is to be done, and in this extremity the most objectionable means are employed. A repairer recently asked the question in a German horological paper, and received all kinds of replies. One recommended to dip the spring in acid; another to scrape it thinner with a graver; and still another to make it weaker by grinding with an oil-stone. The most heroic treatment was proposed lately in another horological paper. The scientist says: "When I find that a spring is too short and cannot be made longer by pinning, I employ a method that will invariably do it: I make the balance a trifle heavier with tin solder. I cut off two very small pellets of solder, put a little soldering fluid on the lower side of the balance, lay a pellet of the solder upon it, and then hold the balance rim on the edge of the alcohol flame until the solder has run.

"It does not require a great heat to do this, and it suffices to hold the rim on the edge of the flame, whereby it is prevented at the same time that the cylinder or one of the pivots is annealed, by carelessness. I then make the opposite side heavier in the same manner, and finally buff the rim, after which no trace of the work can be seen."

For what use, we ask, are the prize essays "on the balance spring," by Excelsior, Immisch, Sandoz, and others, who have wasted their talent and ill-spent lives by writing on timing and isochronism? Make a pyre of their writings!

A Mr. Barthelemy, of St. Ménéhouldt, a skillful watchmaker, recently published his method for obtaining satisfactory results in the *Revue Chronométrique*. He says:

"My method, which I have employed with excellent results for the last fifteen years, is, that in place of the graver I use a burnisher, with which I rub over the balance spring, the thickness of which is reduced by this means; its pores are closed and the quality of the spring is not whatever impaired; besides this, it is easy, with a spring treated in this manner, to restore it to its original coils.

"It requires only a moderate amount of practice to accomplish the purpose, and it is only necessary to hold the spring flat. I made the first trial with a spring that advanced 20 minutes per day. After I had smoothed a length of about 3 centimeters with the burnisher, I had produced a difference of 40 minutes—that is, the spring now retarded 20 minutes, while formerly it had advanced 20 minutes."

The country repairer who may occasionally be called on to do this, might by practice seek to acquire the necessary skill.

WOOD ROD AND LEAD BOB FOR PENDULUM.

A CHEAP and good compensated pendulum may be made with a wood rod and lead bob. For a seconds pendulum, the rod should be of thoroughly well seasoned, straight grained deal, 44½ inches long, measuring from the top of the free part of the suspension spring to the bottom of the bob, and of an oval section .75 inch by .5 inch. This size of rod allows of sound fixing for the attachments at the ends. A slit for the suspension spring is cut in a brass cap fitting over the top of the rod, to which it is secured by two pins. A bit of thin brass tube is fitted to the rod where it is embraced by the crutch. The rating screw, .25 inch in diameter, is fixed to a short piece of sheet brass, .75 of an inch wide. A saw cut is made at the bottom of the pendulum rod, into which the brass plate is inserted, and fixed with a couple of pins. Wooden rods require to be coated with something to render them impervious to the atmosphere. They are generally varnished or polished, but painting them answers the purpose well. Mr. Latimer Clark recommends saturating them with melted paraffine. The bob, 2¼ inches in diameter and 11 inches high, with a hole just large enough to go freely over the wood rod, rests on a washer above the rating point.

Many pendulums made on this plan have been all that could be desired. Several correspondents have borne testimony to their high efficiency, but nearly all say that the bob, 14 inches, advised in a former article, is too long for a seconds pendulum, and a length of 12, 11, 10, and even 8 inches is advised. For this reason, 11 inches may be taken as a mean.

It is essential that the grain of a wood pendulum should be perfectly straight, for if the grain is not straight the rod is likely to bend, causing the clock to go irregularly.

CLOSE OBSERVATION NECESSARY.

CLOSE observation is necessary when taking down a watch for repairs. If it has a strong mainspring and a bad vibration and the train free, it may be assumed that the escapement is at fault. A very common fault by which the vibration is spoiled is too much run on the pallets, and the escapement pitched too deep; all run is a serious evil, and no more than sufficient for freedom should be allowed.

If, on closing the banking-pins, the pallets escape freely and the roller and lever are not free, first try if the guard-pin is free with the banking closer, and has fair shake when the end of the lever is moved. If tight, the guard-pin must be bent back, or the roller edge turned away and repolished to give the guard-pin freedom, care being taken that the pin, though free, is not so free as to pass the roller or to stick; reducing the size of the roller insures its safety, though an impression to the contrary seems to prevail among some foreign makers of common lever escapements, judging by the large radius of roller outside the ruby pin, which is seen in all cheap levers of English, Swiss, and German make. Both time and trouble are saved by making the guard roller as small as possible. True theory requires it smaller than the roller-pin radius, hence the double roller escapement.

Should the ruby pin be unable to leave the lever notch, with the motion of the lever curtailed to that given it by the pressure of the pallets only, the necessary freedom must be obtained by more legitimate means than wasting the motive force in pallet motion and extra locking friction—an evil, in its best form, to be kept within the smallest possible limits in all escapements. If the lever notch is very deep, removing sufficient with a piece of oil-stone will give freedom, but much care is desirable in making a radical alteration, and repairers should think twice before removing parts they cannot restore. Putting the roller on a wire and warming it sufficiently to allow the ruby pin to be moved nearer the center of the roller, to make a more shallow depth, and, if the pin is circular, replacing it with one flattened on the surface, will allow the pin to leave the lever notch with more freedom; and experiments with a brass pin in the roller should also precede any serious alterations. Exchanging a small roller pin for a large oval or flattened one, will diminish the labor required in unlocking and improve some escapements by changing the engaging friction at the line of centers to a disengaging action.

THE ROUNDING-UP TOOL.

THIS most ingenious tool is one of the most useful to watch repairers. By its aid the wheel may be almost instantly reduced in diameter; corrected, if out of round, or have the form of its teeth altered as may be required. The cutters are a little over half a circle and terminate in a guide. While one end of the guide meets the cutter, the other angles a little, so that instead of meeting the other extremity of the cutter, when the circle is completed, it leaves a space equal to the pitch of the wheel to be cut. By this means, after the cutter has operated on a space, the wheel is led forward one tooth by the time the cutter arbor has completed its revolution. Some little practice is required to select exactly the cutter required. Care must be taken not to select one too thick, or the teeth will of course be made too thin, and the wheel probably bent. When the guide is adjusted to the pitch, it will be well to see that it enters the space properly before rotating the tool quickly. The wheel should be fixed firmly, but not too tightly, between the centers, which should rest well on the shoulders of the pinion. The rest piece for the wheel should be as large as possible to keep the wheel from bending, to give it firmness and to insure a clean cut.

CONICAL PIVOTS.

THE cone should be an easy curve tapering off into the pivot proper, which runs in the hole; this part must be perfectly straight and parallel. The pivot having been turned to a little over the required size, its end is laid on a bed formed in a manner of the turns. Every time the work is examined the bed of the runner must be cleared and the runner adjusted to a slightly different length, so that it does not bear on the same part of the pivot. If this is neglected, the pivot is sure to be marked. A soft steel polisher, made to suit the pivot, is then used with either oil-stone dust or red-stuff. It should be used with a backward and forward as well as a rolling motion, till the pivot is reduced so that it will just fall off the hole. The pivot is then finished with a very smooth burnisher and oil.

Instead of the soft steel polisher, some prefer to use a hard steel burnisher roughened, or a piece of lead with emery, which makes an equally good pivot. For rounding the end of the pivot, a thin-edged runner, to allow the end of the pivot to come through, is used. The pivot is rounded by passing the burnisher from the body of the pivot over the end. If the burnisher is used *from* the point toward the body of the pivot, a burr may be formed. There is a little difference of opinion as to the proper direction of the stroke to be imparted. Opinions will differ.

THE MOTIVE FORCE IN WATCHES.

FOLLOWING a recent controversy in an English horological paper, a contribution from the pen of Mr. Oscar Perret, of St. Imier, in the *Journal Suisse d'Horlogerie*, will be read with interest: "It should appear that this question [the motive force in watches] were worthy of meriting the attention of all those engaged in watchmaking; nevertheless, this is far from being so, because it is the most neglected part, to such an extent, even, that many watchmakers do not trouble themselves at all to study the important works which this force produces, nor the parts that consume a portion of it. It appears that the mounter has no other duty to perform than that of imprisoning the spring within the barrel, lubricating it with a little oil of an inferior quality, without further troubling himself whether it runs without being cramped, or whether its force can develop as it should. This is due to the fact that the motive force labors under one disadvantage. Its motions cannot be seen and studied like those of the other movable parts; were this so, one can be certain that it would be the object of greater care, and it would be more highly esteemed.

"It is rarely the case that the mainspring is examined; this fact is left to the good faith of the spring manufacturers, who may employ either steel of a bad quality or badly tempered; nor is any rigorous exactitude exerted as regards the height or thickness of blade, etc. Such as the spring is, it is delivered to the mounter, whose duty simply is to put it in place, regardless of the condition in which he receives it. It is not astonishing, therefore, that the greater part of these springs cannot but very imperfectly comply with the functions they are to discharge, and they become a source of imperfection to the watch, even when all its other parts are in fair order.

"We have said that the mainspring performs a very important part; it produces a force which must be preserved as nearly intact as possible. The barrel being actuated by this force must, in its rotary motion, actuate an entire mechanism, and its energy experiences a diminution from one wheel to the other, so that when it arrives at the escapement a large part of the original force has been consumed by the many frictions of the depthing and pivots. Theory can with precision calculate this loss. To this may be still added the imperfections of construction, bad proportions, etc., which augments the intensity of the frictions, and consequently requires more force.*

"In order that the mainspring may comply with its functions passably, it must be capable of exerting a uniform traction force for at least twenty-four hours; and it would thereby favor the regularity of the amplitude of the balance vibrations, which is very important for the adjustment. But experience has taught us that it is not always an easy thing to attain this result, because it is well known that the manufacturers of steel have not yet been able to produce it with a regular force, and, consequently, springs without a uniform action in the same conditions are the result. Nothing, indeed, is more interesting than experiments on their action, to prove the irregularities produced by them, as far as their traction is concerned, even with springs of the same height and thickness of blade; this irregularity is a great defect.

"I would like to call the attention of young watchmakers to one point: it is better in order to have more force to augment the breadth of the blade rather than its thickness, because less is lost of development,

* Experiments instituted have demonstrated that the train (wheels, pivots, depthings), when in proper condition and lubricated with fresh oil, absorbs about 20 per cent. of the motive force.

and the traction is much more regular from the beginning to the end of the performance—that means that the differences are not so great in the extremes; we have been able to observe this fact in a number of instances, and it is easy to prove the truth of the assertion by instituting experiments.

"The friction produced between the coil blades during the activity of the spring is also of great importance, and becomes so much more injurious as the spring is out of truth, that is to say, when it unfolds to one side. It is fairly difficult to ascertain the origin of this, and the inquirer frequently loses much valuable time in ascertaining it. In the common watch, where the price does not, naturally, permit any very exhaustive inquiry, much could nevertheless be done toward ameliorating this evil.

"The barrel must be free upon its arbor, like any other movable piece in the watch; the spring must be unconditionally free to develop with the greatest ease. The pivot holes and spring must be lubricated with a suitable oil of good quality. The repairer will frequently find a bad oil which rusts the steel and produces very injurious friction. One grave error very often found is that the core is too large.

"We might say much on the question of the stop-work, because it must be acknowledged that many watchmakers do not at all inquire into the utility and duty of this little mechanism. It is often the case that repairers take it out altogether because they do not understand its functions. The stop-work has its well-defined utility, if it is kept in good order, and especially if it is made to comply with its functions, to wit, of utilizing the turns which give the greatest equality in the tractive power. By barrels for which no stop-work is used, different stop systems are employed, and they are oftenest in bad condition, either by the space they occupy, the little quantity of solidity which they possess, or the disagreeable friction produced by them. We have been able to observe frequently that in many cases the collar-stopping contrivance hinders the spring from unfolding; although certain kinds of collars do not produce this effect, and thus enjoy an advantage over other kinds.

"As regards the quantity of force to be employed, there are laws governing this question in a rational manner. Generally speaking, there is more force than is necessary, but by reason of the want of care this excess is completely absorbed.

"It is often asserted that the Americans use springs which are too strong. It is necessary to do them this justice, however, that their springs are proportioned to the barrel, and that if they employ large barrels their trains and escapements are in the same proportion. One difference to be noticed is that they have employed a much smaller but much thicker balance than we. In Switzerland the principle governs that the watch must go with the least possible force. It is an old principle which exerts its full value, especially for fine grade watches; but when it concerns watches 'by the thousand,' which must be manufactured at a very low price, the question is no longer the same. We must admit that the Americans have abandoned this principle for a very simple reason: Their watches, as well as our own, possess imperfections which would cause them to stop, and, above all, to go badly. Now, it must be acceded that these defects are compensated to a certain extent by the resistance of the motive power, which is much stronger than in our watches."

BROKEN BALANCE PIVOT.

IF a balance pivot is broken I generally replace it by a new staff, as I think that by far a better way than to drill and put in a new pivot, as it is nine chances out of ten that the job is not done without some harm to the watch. I can take a blank staff and turn up and finish the pivots in less time than I could drill and pivot, and I always feel satisfied with my job. Of course there are always cases where we have to pivot and then make the best of it. In the train wheels I always pivot, as there is less wear and tear and more stock to work on.

ATTRACTION OF GRAVITATION.

ONE law governing the pendulum is this: The action of gravity or the mutual attraction of bodies varies with their masses, and inversely as the square of their distances. Following from this, a pendulum will vibrate seconds only in a given place. Our standard of measurement is taken from a pendulum vibrating seconds in a vacuum at the level of the sea. It also follows that the further a pendulum is removed from the center of the earth the less it will be attracted in its descent toward the vertical. This explains why a pendulum loses on being transferred from the sea level to the mountain, or from one of the earth's poles toward the equator, as the earth is a spheroid slightly flattened at the poles.

WATCH MAINSPRING.

VERY little is generally said in the horological press on the subject of mainspringing; while some writers appear to have "isochronism" on the brain, others treat *ad nauseam* of the pallet draw and locking, while mainspringing is but occasionally mentioned, and treated with a step-parent's affection. We recently read in a horological publication where the writer advised to substitute the hook on the barrel for one on the spring; not to make it of steel, but of the softest and best of iron; for instance, an American clock pendulum rod or a horseshoe nail. To use iron, because it is more easily and more firmly riveted, and easier to cut off and finish.

These are apparently weighty reasons, although not many practical watchmakers would agree with the writer in substituting a hook on the barrel for that on the spring in a watch with fusee and chain. The trial has occasionally been made, but the inevitable result is that the first time the chain breaks the barrel is bulged out on the side, caused by the recoil of the spring against the hook, and in all probability ruined beyond redemption. He next recommended that the workman should always shape the hook on the spring and polish its face before it is put in the barrel. This style of work may be possible to do, but it is certainly neither practical nor customary.

A practical method of fitting this kind of hook would be about as follows:

A piece of soft iron is held in a pin vise and filed to fit the hole in the barrel, round or square, whichever it may be, giving it as little taper as possible; pass the wire so fitted into the hole in the barrel from the outside, in giving it the same slant as the hole, and make a scratch with a sharp point across it and on the inside of the barrel; withdraw the wire and turn it end for end in the vise, bringing the end faces of the jaws even with the scratch. You now place this vise, with the wire in it, in a perpendicular position in the bench vise; first shorten the wire and then proceed to fit it to the hole in the mainspring, which has been previously punched, countersunk and pointed, as already described, allowing the jaws of the pin vise to act as a gauge for the scratch made on the wire, remove the wire from the pin vise and grip it firmly in the left side of the bench vise, close up, but not so as to injure the part which is to form the hook.

Put the spring in its place and rivet up carefully and solidly; have the spring so countersunk as not to permit any of the rivet to project above the surface of the spring. Take it out of the vise and cut off, leaving just enough to form the hook. Try if the hook fits by putting it backward into the hole in the barrel from the outside, for it is possible to distort its shape in riveting, etc. Being satisfied, and not having the hook excessively long, wind it in and ship the hook.

You now take the barrel between the thumb and point of the middle finger and slap it on the bench, first on one side, then the other, till you see that the hook is well home to its place. Put the arbor and cover—presuming that the spring was oiled before winding it in. All that remains to be done now is to finish the hook outside the barrel, which is done by carefully filing it down till you come close to the gilded side or edge of the barrel; you then take a piece of thin writing paper and lay over it, and go on filing both paper and hook together till you touch, but not deface, the barrel. It is well now to grip the square of the arbor in a pin vise, and set the spring up to test the efficiency of the hook, and, if possible, to force it further through the barrel, in which case you repeat the filing through a fresh piece of paper. You now finish the job by passing a clean flat burnisher over it a few times, also through a piece of paper. I consider it quite impossible for a hook on the spring that is properly fitted to fail to hold securely.

It is easily seen that the hook on the spring is preferable to having it on the barrel, because box chronometers of all nations have it on the hook. We may readily conjecture that when we see the hook of a watch with fusee and chain altered from the spring to the barrel, that it was the work of one who was either too lazy or incompetent to do the job, but it is not to be accepted as evidence that the hook-on-the-barrel style is more reliable.

SCAPE WHEELS OF SWISS WATCHES.

IN the case of a very bad wheel it would be much easier to change, than to attempt to correct it; there is such facility now for doing this—wheels of very good quality can be got for such a low price, and in such a variety of sizes and heights, that it is rarely a difficult matter to get one of a correct size. If the country watchmaker has no large stock on hand, and must send for a new wheel, it is always best to turn a sink in a piece of brass in the mandrel, as a gauge for size; and if the wheel is not sent, a notch cut for the height also. The removal of the wheel from the pinion should be done on a pinion-riveting stake, in a hole that just fits the pinion loosely; a pointed hollow punch, preferably of brass, fitting freely over the pivot, or in the hollow of the rivets, should be used and a light hammer. The size of the hole in the wheel is the next consideration; it will most probably be considerably smaller than the old. The common way of opening this hole is to broach it, and as the wheel as obtained from the material dealer is generally too hard to broach, it is usually put on a wire, and the wire in the flame of a lamp, until sufficiently softened.

This is rather a risky way of doing; the wheel is liable to be got out of flat, or broken in the operation; a far safer and better plan is to grind out the hole without softening the boss. A long and soft arbor is filed lengthways; it should not be too taper, and used with either fine emery or oil-stone dust, the wheel having previously been cemented by its back to either an old fourth wheel or some light, circular piece of brass, to protect the teeth and handle it by. Particular care should be taken not to run the arbor dry while grinding, but to keep it liberally supplied with oil, so that it does not stick. Should the boss be too thick, leaving insufficient rivet, it can be turned down with a hard graver. To turn down the seat, if the watch is flat, would be rather a difficult matter; but if it is at all high, it can be done, supposing that the slot in the cylinder will admit of it. The hole having been ground out until it fits firmly on to the pinion, it should be riveted lightly with a hollow steel punch, revolving the wheel a little between each blow of the hammer, which should be very light. Its truth in flat should be examined from time to time by means of the brass calipers and straight-edge; if the riveting is carefully done the wheel will be true. It will rarely be necessary to bump the arms of the wheel if carefully riveted. The size of the punch should be such that it just goes easily over the shoulder of the pinion, and its face should be perfectly polished.

HOW TO REPLACE A BALANCE STAFF.

IN the event of a broken staff a new one is to be made as follows:—In the first place the old balance staff should serve as a model, unless it has decidedly radical defects. The balance is knocked off the brass collar on the old staff and a rough staff selected of approximate dimensions. These staffs are generally sold in the rough by material dealers, but one may be made by driving a steel arbor into a collet of hard brass. The steel should be hardened and tempered just sufficient to allow it to be turned with the graver. A screw ferrule is fixed to the staff, and it is mounted in the turns; the length is reduced to a trifle over the finished size, paying due attention to the relative size of the staff that projects both above and below the brass. The brass is then turned to fit the balance and the balance spring collet, and the length is made right. The staff is then turned down to fit the hole in the roller. The pivots are then made, gauging the position at the shoulders by means of the pinion gauge, using the old staff to measure by. The diameter is made by trying in the jewel holes. The body of the staff is polished, as are the pivots, with crocus on a bell-metal burnisher, English workmen generally using the turn bench with specially made centers, but the Jacot tool is far more convenient. When the staff is finished the balance is riveted on true, and should be at the precise height, so that it will not be necessary to use a punch to raise or lower it. Very careful handling and constant gauging are the principal requisites for making a balance staff; failing the former, the partly finished staff is likely to be broken, and by not paying sufficient attention to the latter, some part will be made too small.

IS THE STOP-WORK INDISPENSABLE.

THE question whether the Maltese cross or stop-work in medium and low grade watches is indispensable or not was some time ago debated in a meeting of watchmakers in Germany. Those in favor of dispensing with it proposed a number of other devices, among which is the brace. One of them published his views on the matter subsequently in the *Deutsche Uhrmacher Zeitung*, from which we translate the following:

"I am not at all opposed to the stop-work; on the contrary, I consider it to be one of the best and most secure devices—if well executed and hardened, and the square of the spring arbor upon which the stop sits is sufficiently long and well-conditioned. Every repairer, however, knows the condition of the stop-work in the ordinary cheap watches. . . . It is an ordinary occurrence that already in the first four weeks the man who recently bought a cheap watch from you will come back to the shop with his watch over-wound, and from that time forward misconfidence against his time-keeper and yourself is fully established. Frequently, also, does it happen that after the mainspring is broken the owner also ruins the stop-work by winding, when he is a sort of a Jack-at-all-trades and tries to remedy the evil himself.

"Some repairers urge that when an ordinary brace stop is used, more springs break than by the use of a stop-work. I cannot say that this is my experience, although I have been a repairer for a number of years. If ever it should be true that the breakage of springs is greater by 10 per cent., surely watchmakers cannot call this a great misfortune! Nor does the assertion hold good that the small end of a spring (the brace) forms a separate spring power, as this force lasts barely one minute.

"Another advantage of the simple brace stop in the interior of the barrel is that this is rendered much more secure, as the cover does not require to be turned down and out, and the spring arbor can at its lower end be made with a nice and long pivot. All the repairers know how terribly shaky some barrels are in consequence of the pivot hole being too thin in the barrel cover, and also in this particular a decided defect would be remedied. The time which the workman spends upon the repairing or re-making of the stop-work may, by the employment of the simple brace, be spent to a far better purpose upon the other parts of the watch. . . . For better grade watches, which have from the start been constructed with more care, and on which more time is spent in repairing, they may be employed profitably.

"Three methods are known to me for using the brace as a stop. The first consists in riveting a small piece of watch spring to the end of the spring and of beveling its free side a little; by the second, the end of the spring is bent into a small hook, in which is laid a small piece of spring with beveled ends; by the third, the spring is bent outward at a length of from 5 to 10 millimeters near the end, which must be done, however, while the spring is red hot, so that it will not break in bending. The diameter of the spring core can, in general, be taken as the length of the brace. The latter method is the simplest and easiest, and I have successfully employed it for a number of years. The hook in the barrel is unnecessary, and a very small pin slightly projecting within is all that is required; even this fear is not necessary; simply raise a burr with a sharp graver on the inner side of the barrel."

In conclusion the writer solicits the opinion of other watchmakers on this question.

THE BAROMETRICAL ERROR.

A PENDULUM is affected by the density of the atmosphere, but to a degree that would only be of importance in a precision timepiece, where all the errors are reduced to a minimum. An increase of density in the air is equivalent to reducing the action of gravity, while the inertia of the moving body remains the same. The rule is, that the velocity of the pendulum varies directly as the force of gravity and inversely as the inertia, and it follows then that an increase of density diminishes the velocity and shortens the time of oscillation, causing the clock to gain time. The barometrical error can be reduced to within three- or four-tenths of a second in twenty-four hours for each rise or fall of the barometer. Short axes of oscillation are also essential in reducing the barometrical error. An apparatus is sometimes attached to the pendulum to assist in reducing the error.

PENDULUMS.

A PENDULUM required to vibrate seconds, says a lecturer, must be of such a length as to make the distance between the centers of suspension and oscillation 39.14 inches; and it must farther satisfy the condition here indicated, namely, the expansion of steel downward must equal that of brass upward. The co-efficients of expansion of steel and brass are respectively 0.0000124 and 0.0000188 per 1° centigrade, and it can easily be shown that the smallest number of rods that can satisfy this condition, keeping the pendulum symmetrical, is nine. The arrangement of the rods and the mode in which they effect the required object need but little explanation. The outer steel rods are firmly pinned at right angles to the upper brass cross-piece, but they are only held loosely by the pins in the lowest cross-bar. This carries two brass rods expanding upward, and each pair is loosely held by pins in the same way. The innermost steel rod hangs from a pin at its upper end, passes freely through the lower cross-piece, and supports the pendulum bob by a nut at its extremity.

The necessity for so many rods has always been regarded as a serious objection to this form of pendulum, and many attempts have been made to avoid the difficulty. Troughton suggested a very elegant arrangement, in which the four brass rods are replaced by two brass tubes, the five steel rods being joined in a manner corresponding to that above indicated. The bulk of the pendulum rod is thus diminished to a tube 0.6 of one inch in diameter, an important point, since the center of oscillation is thereby lowered, and a shorter pendulum can be employed. Zinc has a much higher expansibility than brass, and attention was, therefore, directed toward the employment of this metal. By increasing the length of the pendulum, and placing the bob some distance above the lower end of the pendulum, supported by a short cylinder of zinc, Berthoud succeeded in obtaining sufficient compensation with only two brass rods and three of steel; and, even with a brass cylinder in place of the zinc, the compensation was at times found to be complete. This is a compact form of gridiron pendulum, but long, and the excessive friction between the rods is a serious objection. Berthoud constructed them about 13 inches long, beating half-seconds, and the center of oscillation comes very near the center of the bob.

Reid, Tiede, Jacob, Ward, Dent and others, invented pendulums in which zinc and steel are employed in conjunction, and in an interesting arrangement suggested long ago by Robert, zinc is associated with platinum as being at the opposite end of the scale of expansibility. The form adopted by Jacob is worthy of notice on account of its extreme facility of adjustment. The central rod is of steel, and terminates in a screw bearing a locking nut, which supports a rectangular zinc frame. A screw thread is cut on the upper portion of this, and a nut on it supports the frame that carries the bob. Assuming the pendulum to be under or over compensated, it will only be necessary to elevate the upper screw and depress the lower, or *vice versâ*, and the effective length of the zinc will thus be altered as required. The expansion of zinc being more than double that of steel, a single zinc rod less than the length of the pendulum will suffice for the compensation.

The only other combination of these two metals that need be specially referred to is the pendulum employed by Dent & Co., of London, England, for astronomical clocks, in which the bob is of lead, and the steel and zinc are two concentric tubes, the rod also being of steel. A zinc tube resting on the rating nut supports, at its upper end, a steel tube by which it is enclosed; to the lower end of the steel is fixed, by its center, the lead bob covered with a brass jacket. Holes are drilled through the steel and zinc tubes in such a manner that each portion of the pendulum is equally influenced by thermometric variation.

The pendulum by Mr. Robert, above referred to, is a light platinum tube passing through a zinc bob and terminating in a steel screw, which carries the rating nut. The bob extends to half the height of the rod, and its upward expansion is sufficient to neutralize the downward expansion of this latter.

Numerous other combinations of two or more substances have been suggested from time to time, but detailed reference to them is unnecessary since the principle of all is identical. J. L. Smith employed a vulcanite tube surrounding the lower extremity of a steel rod, in a manner somewhat analogous to Berthoud's pendulum, only that the tube passed within the (copper) bob; Ley used zinc and glass similarly arranged, and Callaud proposed a combination in which steel, brass, and platinum (wire) are used. The brass tube resting on the timing nut supports a plate at its upper end, through which pass two screws attached to the extremities of a platinum wire. This passing round a groove in the pendulum bob raises it as the brass tube expands, and the adjustment for compensation somewhat resembles that of Jacob's pendulum. Benzenberg's pendulum, as modified by Kater, consists of a lead tube traversed by an iron wire, the bob being suspended by two iron wires from the upper end of this tube. By employing steel and zinc, Kater succeeded in reducing the length of compensation metal so as to conceal it within the bob; and Bailey proposed a cheap construction that has been much used, in which the upward expansion of a cylindrical lead bob neutralized the downward expansion of a deal rod.

It is unquestionable that a carefully made wooden pendulum is to be preferred in all clocks, other than the very best astronomical timepieces; in conjunction with a well-made train, it can be relied upon to give a more uniform rate than any unadjusted compensation pendulum. Indeed, such a pendulum may give rise to a very great irregularity, if, as is perfectly possible, the arrangements for compensation tend to produce an opposite effect to that which is required.

An immense variety of devices have been proposed for correcting this error of temperature, but they may all be classified under four heads:

1. Two or more solid and rigid substances employed in conjunction, and so arranged that the vertical downward expansion of one is neutralized by the vertical upward expansion of another.

2. Two metals of different expansibilities actuating levers, and thus maintaining the length of the pendulum invariably.

3. Two metals of different expansibility, rigidly joined together by soldering or otherwise, employed to vary the distance of a weight from the center of suspension whenever the temperature varies.

4. Pendulums in which mercury is employed.

The earliest attempt to correct the variations of temperature was made by Harrison, in the construction of his "gridiron" pendulum, consisting of nine vertical rods—five of steel and four of brass.

RULES GOVERNING COMPENSATION PENDULUMS.

THE compensation pendulum is to the astronomical clock exactly what the compensation balance is to the chronometer, and whatever facilitates the narrowing of the margin that borders the central line of absolute accuracy, reduces the space demanded by final adjustment. It may never become possible to produce, by mechanical means, either a balance or a pendulum absolutely correct and requiring no adjustment. There are means of closely approximating to that condition, and these I propose to impart.

In the first place, the conditions of the manufacture of Graham's mercurial pendulum, the one adopted by both the artist and the astronomer, require careful consideration. The rod and the stirrup should, after all mechanical work is completed, be annealed down to the simplest softness, and all subsequent bending avoided, as well as any large amount of friction, for the sake of polish; no part of the stirrup should be left on the strain; everything should fit without shake, but still without bind. Here we arrive at the point of the closest approximation to the proportion nearest mechanically achievable—perfect compensation for temperature. The ordinary glass jar and mercury being the simplest, is amongst, if not absolutely, the best; and the result of a great number of experiments has proved that a glass jar of exactly two inches internal diameter, containing eleven pounds eight ounces (avoirdupois) of mercury will be so near to absolute compensation as seldom to require any correction when tested in heat and cold. The mercury should be carefully relieved from all admixture of atmospheric air, and this is by no means an easy task. In addition to the careful removing of any visible air bubbles, time and the application of heat should be given in order to facilitate the decomposition of such remaining portions of air as cling with great tenacity to mercury that has been recently shaken. For this purpose a piece of bladder neatly tied over the top of the jar will enable the maker to aid this decomposition by keeping the jar for a week or so in a temperature of (say) from a hundred to a hundred and five, and the jar should not be put into the stirrup until all the manipulations of the clock and its pendulum suspension are completed.

During the ovening of the pendulum, the addition or subtraction of mercury from the jar should be effected by a dipping-tube. The most convenient form of this latter tool is a piece of glass tube half an inch in diameter, drawn out at one end for a couple of inches to a nose about two inches long, and of about a quarter of an inch in diameter. The top end of the dipper should also be drawn out a little, and the end of the drawn-out part rounded where the orifice is about one-tenth of an inch in diameter. The plane in which the pendulum swings should be east and west, and the suspension should always be of such a form as will enable the pendulum to oscillate by its own weight, making the suspension of itself from all restraint of friction.

The fulfilment of the foregoing conditions will give in all cases good practical results.

NEW METHOD OF HARDENING DELICATE STEEL PARTS.

THE warping of very delicate or long steel parts by tempering is one of the most disagreeable occurrences that can happen to a watchmaker, and many remedies have been proposed and are in use to counteract it, with more or less satisfactory results—tempering in animal charcoal, smearing with soap, tempering in the lead bath, etc. The latest method is that of the very able watchmaker, Mr. P. Gabriel, published in the *Revue Chronométrique*. He says:

"Take an earthen or metal crucible, pour in a proper quantity of cyanide of potassium and place it over a grate fire to fuse. Into this fusing mass enter the steel article to be hardened, and, as soon as red hot, dip it quickly into cold water. The article will not only have obtained a very good temper, but it has also not become warped in the slightest degree. Another advantage of this method of hardening is that the polish of the article is not injured whatever—in case it has already been polished. The polish becomes slightly gray, which color, however, is easily removed by a few retouches with wood and a little fine steel rouge.

"As regards the warping of the article to be hardened, it must be stated that before hardening it must not be injured by hammer taps or careless glow heating, so that the interior texture of the steel is damaged. Well treated thus, turning arbors of from four to five centimeters long remained perfectly true, when hardened by this method. This is also excellent for hardening the detent springs of chronometers, by which the foot must always be much larger than the very delicate, flexible part of the spring. All the parts are equally heated in the cyanide bath, in consequence of which they experience no warping."

TO REPAIR A YANKEE CLOCK.

THE ordinary Yankee clock is so very cheap now that it "hardly pays" to repair it; yet it stands the *wary* watch and clock repairer in hand to look out even in this particular. We will suppose a customer has an old Yankee clock which has done service in the kitchen for years; he brings it in to you and you see it is well worn and needs a considerable amount of repair; now, sell him a new one if you can; if not, do not let him take it away and get some other man perhaps not half as skillful as yourself to tinker it up for him, for if you do it will be more than probable that he will give him his watch to clean and repair, and you will not only lose a customer, but have a man saying: "Oh! B.'s no good; I took my clock to him to fix and he said it was all worn out, and C. took it and fixed it, and it runs as well as ever." In every case either sell a new one or fix up the old one. It is a very bad clock that one who knows how cannot put into shape so it will run. Another thing to be looked to is the regulation; be sure it is running right before you let it go out of the store; do not trust the purchaser with timing his own clock, as it is only in rare instances that you will find one who can do it properly. Nine cases out of ten, if the clock goes too fast, he will turn down the nut, but it never occurs to him to pull the bob tightly down on to it. All words aside, it is best to make sure of the regulation yourself while you have the clock in your possession. The great secret in clock work is to know exactly what you want to do and have the proper tools to do the work with. In three cases out of four it is not necessary to take a clock down to insure its running. Put on plenty of fresh oil and take off the verge and let it run down, wiping off the oil as it exudes from the pivot holes, leaving enough on finally to ensure its running for the next twelve months. When it comes to repairs, clocks need but two things (as a rule) done to them; these are closing a hole or two and grinding out pits in the pallets. It needs no expensive punches to close a hole nicely, just a crescent-shaped punch of two or three sizes is all that is required. The largest punch should be of No. 5 steel wire and the smallest of No. 14 steel wire. Holes are in every instance worn on one side; close up from this side only, but be sure you do not overdo the matter and force the hole over too far—this, like everything else around a watchmaker's shop, is a matter of nice judgment. A few words to my old friends, the apprentices, for whom these articles are supposed to be written: Learn to take down and put together a clock quickly; don't sit and dread a clock and be afraid you cannot get it to strike right again; go at it manfully, and say, "I am going to get so I can put any striking clock together in five minutes," go at it and stick to it until you can be as good as your word. When you find it is necessary to take a clock down, out with the pins or screws and down with it; do your repairs and slap it together again. But for mercy sake don't sit and dread it. Get (when you have an idle half hour at your disposal) an old clock movement and take it down and mix up the wheels, and learn to put every part of it in place as quickly as you can set the men on a checkerboard. When you have a hole to close, notice how it is to be closed, and on the side where the wear is, so as to restore it to as near the original condition as possible. Judgment is essential in regard to the distance from the hole at which you should set the punch. This in a great measure depends on the thickness of the plate; if the plate is quite thick the punch should be set back farther from the hole than in a thin plate. It should be our endeavor to close the hole the entire thickness of the plate, and this can generally be done from one side; but in some cases it is necessary to close from both sides. A round broach should be used to smooth out the hole after it is closed, putting the wheel in place and the plates together, and trying if the wheel runs free and with the proper amount of side-shake. A smooth-faced stake of pretty good weight should be used for punching on.

HANDSOME FROSTING OF WHEELS, ETC.

FREQUENTLY we see stem-wind wheels frosted, that is, they have a dull, gray, matted look. This is usually done with sifted oil-stone dust and benzine on the end of a block of wood, giving the wheel or piece to be frosted a short circular motion. Such frosted wheels, when well and nicely done, are very pretty; but where one perfectly satisfactory finish of this kind is accomplished there will be a dozen failures. I mean to a greater or lesser extent. A beautiful frosting can be made, dissolving clear white rosin in alcohol. The solution does not want to be thick, as the thinner the solution is the finer the grain or finish produced will be. Take two wide-mouthed bottles, holding about two ounces each, and fill one about half full of rosin broken into dust and small pieces, then fill the bottle with 95 per cent. alcohol and let it stand, with an occasional shaking, for two or three days; after this pour the fluid portion into the empty bottle and fill up with alcohol. When we wish to frost a wheel, put piece of sharpened pegwood into the center hole (to handle it by); dip the wheel into the solution of rosin and alcohol and set the wheel on a riveting stake to dry, letting the point go into one of the holes so that the wheel will lay flat and quiet until dry. The wheel is now to be dipped into dilute nitric acid prepared by mixing fifty drops of acid with an ounce of water. The wheel is allowed to remain in about two minutes, when it is removed and well washed with water. After this the rosin is dissolved off with turpentine and well washed in soap and water. If the first etching is not satisfactory repeat the rosin coat, dipping in acid, and the frosting will be found very even and a little coarser than the grain made by grinding. By rubbing the wheel on a bit of flat cork with oil-stone dust and benzine, the dark coat produced by the acid is removed and the surface has a beautiful steel-gray appearance. A mixture of ¼ of an ounce of alum and ¼ of an ounce of corrosive sublimate in half a pint of water, makes a good acid solution into which to dip the wheel after the rosin coat has been applied. It is to be understood that the process of frosting by acid is not attempted until the wheel is ground smooth and flat, and free from any deep scratches. The solution of alum and corrosive sublimate acts much quicker than the dilute nitric acid, a few seconds answering. Before I leave the subject of cheap chatelaine watches it is well to speak of the stem-winding works. These are, as a rule, very badly made and tax the ingenuity of the workman to the uttermost to remedy the countless ills to which (like flesh) they are heir to. The American plan of a tilting yoke for changing over the action from the winding to the hand setting, is usually kept in place by a spring struck out of sheet metal with a die. This method is to be deprecated, as the die breaks up the strength of the steel. Springs cut out in this way should be struck out much larger than needed, and worked down with a file or milling machine to the correct size. For such springs we need sheet steel softened in charcoal annealing box from which to cut them. Every watchmaker should keep an assortment of such sheet steel of different thicknesses ready softened for just such jobs. In making such a spring, about the best way is to select a bit of softened sheet steel of the proper thickness and soft solder the old spring fast to the steel. The hole is drilled and the whole spring given shape while the old spring is attached. A jeweler's narrow saw can be used to saw the soft steel into shape almost as readily as if it were of brass. After it is cut out with the saw it should be brought nearly to shape with a file, and then hardened by placing it between two plates of thin sheet iron formed by folding one piece together like the covers to a book. The spring is embedded in a paste of Castile soap between the folds of the sheet iron, heated red hot, and thrown into cold water to harden. It should now be tempered by laying on another piece of sheet iron with a little beeswax, and heated until the beeswax burns off. This device of heating to harden can also be used for wheels.

TO COLOR IRON AND STEEL BROWN.

DISSOLVE in four parts water, two parts crystallized chloride of iron, two parts chloride of antimonium and a trifle of tannic acid, and apply this mixture with a cloth or sponge upon the surface; then let it dry. Repeat the application according to the depth of color desired. This coating fully protects the steel against humidity. The chloride of antimonium should be as little acid as possible.

HARDENING GOLD SPRINGS.

TO gold detent, thermometer, suspension and balance springs can be imparted a high degree of elasticity. Rolling hardens them, but they are rendered very brittle thereby. They can be made pliable and elastic, not by hardening, as in the case of steel, but by annealing, care being taken not to exceed a certain degree of heat. The spring may be coiled on a block and placed in a tube, with a smooth steel lid; then heat the tube in the flame of a spirit lamp, and as soon as the steel is of a blue temper, remove the flame and allow the whole to cool.

FLATTENING AN ORDINARY BALANCE SPRING.

REMOVE the collet and stud, and clamp the spring by a central screw between two plates, which are then placed on a bluing tray and gently heated. A small piece of whitened steel is laid on the plate in order to see that the heat does not exceed what is needed to give a blue temper. Allow the plates to cool and separate them. Ordinary springs being made of rolled steel and subsequently coiled, always open out on heating; it is therefore necessary, before resorting to the above method, to coil up the spring, as otherwise the outer turn will be found to have opened beyond the stud.

TO FIT A BOUCHON.

AFTER repairing the pivot, a bouchon is selected as small as the pivot will admit. Open the hole of the plate or cock so that the bouchon, which previously should be lightly draw-filed at the end, will stand with a slight pressure upright in the opened hole of the plate or cock; then, with a knife, cut it across at the part where it is to be broken off so that it may break very readily when required to do so. Press it in the plate on the side the pivot works, break off, and then drive it home with a small center punch. In every repair of this nature, notice should be taken of the amount of end-shake of the pinion, and allowance made by leaving the bouchon so that any excess may be corrected. To finish off the shoulder end, a small chamfering tool should be used. It has a hole smaller than the pivot one to receive a fine brass wire, serving as a center to prevent the tool from changing its position while being used; or the wire may be put through the bouchon holes, and then the hole of the tool may be left open. The above is a far more expeditious way than using the turning lathe.

THE USE OF BENZINE FOR WATCH CLEANING.

IN a period at the workbench extending over fifty years, I have used benzine for the last fifteen—of course, the purest. A piece of brass dipped into it will not have a particle left on it one-half minute after, and if my experience in this line will be of any use, I am glad to offer it to my fellow-workmen.

On taking a watch down, removing all screws and cap jewels, I place all the parts in an alcohol glass one-half full of benzine; I then put the cover on and let it soak for an hour or so; two or three can thus be in operation at the same time. Then I turn all out into a small white porcelain plate, and with tweezers and a small, stumpy camel's-hair brush, wash all the parts while covered with the benzine; on removing, dry off with an old fine cambric rag; then place in alcohol and dry off with another clean rag; this can all be done easily in ten minutes. I do not let it remain in the alcohol longer than I can help, putting the balance and pallets in last, and taking them out first. I very seldom find it necessary to use either peg or (watch) brush; thus the gilding even on a cheap watch will never get rubbed off. Of course, you want to keep clean rags, especially for the alcohol. In my opinion, there are so few watches that will do without a little oil on the pallets, that it is best to put it on all. Often when I have left them over night without oil, they have stopped before morning (of course, alcohol makes them very dry), and this has happened with good American watches too.

TO REPAIR A PINION.

AT the present prices of material, it is economy to buy the parts as nearly finished as possible. Then take your measures and bring them to sizes required in your lathe. Then stake the wheels to their place with a good true staking tool. With a good tool, you are bound to do good work. The balance staff, when broken, requires a staking tool and roller remover to do a good job properly. Fit your new staff to the jewels, then stake on the balance; place in position and take a blow-pipe and blow against its edge, and see if it runs easy in all positions. This is the very best test. Let it run lively and listen, and see if there is any tremble or jar; if you hear this, the balance is out of poise or out of truth. Always get a good polish on your pivots.

TO STRAIGHTEN THE CYLINDER WHEEL.

THE cylinder escape wheel, if it does not run flat, may be straightened upon a nice little brass anvil, which has a hole for the pinion in the center; it can be placed either upon the workbench or fastened in the vise; a small punch, in the shape of a rounded-off chisel can be used, or else taps are directly given upon the wheel with the pane of a small hammer. Care of course is necessary.

THE PROPORTION OF AN ESCAPEMENT.

THE most effectual test of the correctness of the proportions of an escapement is supplied by the bankings. Assuming that the depths are right, the "run" of the pallets ought to be the same as the shake on the bankings, and if the wheel has been so planted that the lever lies straight along the pallet the proportions may be used as the basis of future operations, assuming always that the angle of the pallets are the same.

TO MAKE A WHETSTONE.

IT is easy to make a stone for sharpening tools and to make it sufficiently hard, and give it the "bite" desired. Take gelatine of a very good quality, which melt in an equal quantity of water. The operation should be performed in darkness, as daylight is injurious to gelatine. When melted, add one and one-half per cent. of bicarbonate of potash previously dissolved. Then take about nine times, by weight, the quantity of gelatine employed of very fine emery and pulverized flint-stone, which mix intimately with the dissolved gelatine. Mould the obtained paste according to the desired form, and press it in as hard as possible to consolidate the mass well. After it has been dried in the sun, you will have a first-class stone for sharpening.

HOW TO DRILL HARD STEEL.

HAVING to put a pivot in a pinion wheel, on attempting to drill, I found no drill I could make would cut it. I thought of trying the same lubricator as for cutting or drilling glass, viz., turpentine, and to my great surprise I found the same drills cut freely and enabled me to get over the difficulty. In a long experience and with many men, I never heard of it being used before, and if not generally known, if tried I am sure will remove a difficulty that I know has existed with many repairers.

MEASURE FOR THE LENGTH OF BALANCE STAFF, ETC.

AN exchange contains a practical process for exact measure. The brass instrument is composed of a brass pendant with two points placed one over the other, exactly similar to the point of the depthing-tool, with the exception that the inside ends are flat. Both points will be pressed by side screws, similar to the depthing-tool. The outer end of the upper point is furnished with a screw, on which is a strong adjusting nut. It has to be used as follows: The tool with the situated piece is pressed into the vise, and after the cover-lids or end-stones have been taken off from the jewel holes of both balance staff or cylinder cocks, the whole is brought with the left hand between the points of the instrument, of which the lowest will be established by the side screw, while the upper one remains previously loosened. The last point is afterward pressed softly down, until it reposes on the outer surface of the upper jewel hole. The upper point is also pressed by the side screw and the nut screwed down, so as to pose firmly on the body of the tool. By this process is the corrected measure given. To take the plate out with both cocks, it is necessary to screw the upper side looser and to lift the point, by which motion the whole is free and easily taken away. The point is to be pushed back until the nut reposes firm on the body of the tool, being also pressed by the side screw. The distance of both points given is the exact one between the outer surfaces of both side holes, which shows the right length of the arbor to be finished.

CLUB TEETH.

ONE of the grave objections to the club tooth is that, no matter how perfect the machinery for cutting the teeth, error will creep in; and these errors are much more difficult to detect than with the ratchet tooth.

CYLINDER PIVOTS.

ALL cylinder pivots should be of a conical shape, since they are then much stronger; and their making does not require more time and skill than ordinary cylindrical pivots. They are made with a three-cornered pivot polishing file, the edges of which are correspondingly ground off. The file must be well sharpened, to be done with medium fine emery upon a flat piece of lead.

THE TRAIN OF A WATCH.

THE first condition for the construction of the train of a watch, says M. Grossmann, is to make it of as large dimensions as the diameter of the movement will admit of. The very limited space allowed by the reigning taste for the movement of a portable time-keeper is already an impediment to the attaining of a high degree of perfection in the gearings; and if it is possible to execute the wheels and pinions of a clock with a satisfactory degree of accuracy, it gets more and more difficult to do so, according to the smaller dimensions in which the work is to be executed. If we had the means of verifying easily the accuracy of the division and rounding of our small pinions, even of the best make, we would soon come to the conclusion that it must necessarily diminish with the dimensions. The inequalities and alterations of shape by the stoning and polishing will be nearly the same with a large pinion as with a small one, only the small one suffers proportionally much more under them. This applies to the manufacturing of the pinions; but before the pinion runs in the train it has to pass through the finishing process. The finisher first of all will have to verify whether the pinion runs perfectly true, and to set it true in case of need. In all operations of this nature the operator has to rely on his eye for distinguishing whether the state of the piece is satisfactory. But the eye, like all the senses of man, is reliable only within certain limits, and if a good workman pronounces a pinion to be true, this statement must not be taken mathematically; it can only be understood so that an experienced eye can no more detect any deviations from the truth of running. There are, then, in any piece of workmanship, some small defects escaping the most experienced eye, and their absolute quantity is about the same for the large pieces as for the small ones. Let us suppose, for instance, that a careful workman when turning a pinion of 3 millimeters diameter, cannot perceive any defect of truth beyond one hundredth of this size—say 0.03 millimeter. The same defect, indistinguishable to his eye, with a pinion of one millimeter diameter, will be not one but three hundredths of it; consequently it is of threefold more importance with the small pinion taken proportionally.

The same considerations will, to their full extent, apply also to the correctness of the depths or gearings; and it will be clearly seen that it is of the greatest importance to construct the acting parts of the train as large as the diameter of the watch will admit of.

Another matter of great importance is the uniform transmission of motive power from the barrel through the train to the escapement. This uniformity can only be attained by good depthing; and, as it is well known that the depthings are more perfect with the higher numbered pinions, it is advisable never to have the center pinion with less than 12 leaves, the third and fourth wheel pinions with 10, and the escape pinion with 7 at least. The difference resulting therefrom in the cost of manufacturing is so very trifling, that it could not be an obstacle to making even low class watches with these numbers.

The center pinion, it must be admitted, will be more delicate, apparently, and more liable to injury by the sudden jerk resulting from a rupture of the mainspring, or by the pressure occasioned through careless winding. The teeth of the barrel, too, being necessarily thinner, will be more apt to bend from the same causes; but this is partly remedied by the fact that with a pinion of twelve there are in almost every moment two teeth of the barrel acting at the same time on two leaves of the pinion, while in the lower numbered pinions one tooth alone has to lead through a more or less extended angle. Thus, any sudden shock will be divided between two teeth of the pinion of twelve, and sustained in the same way by two teeth of the barrel belonging to it, whereby the same apparent danger is greatly diminished. Besides, the finer toothing produces a better transmission of power, a weaker mainspring may be used, and, in case of its rupture, the shock will be less violent.

One of the chief conditions for a good and regular transmission of power is a good and suitable shape of the wheel teeth; and it is astonishing to see in what an indifferent way this important matter is treated. It is a well-known fact that the wheel teeth, in order to act properly, ought to have an epicycloidal rounding, and no engineer would suffer any form for the teeth of star wheels. Berthoud treated this subject in a most elaborate way about a century ago; Reid and others have also explained the principles of the construction of toothed wheels most explicitly, but in vain. It seems that the greater part of the horological community have resolved to view the shape of their wheel teeth as a matter of taste. All the wheels of English and other makers have, with very few exceptions, their teeth of a shape defying the rules of Berthoud, Reid, and other masters—a shape of which nothing can be said, except that they look very nice in the eyes of those who make them, or those who use them, and say, "They look much better, indeed, than those ugly pointed teeth."

There is no possibility of being successful against arguments like these, and I have known many a respectable and good watchmaker who declared that he could not bear the sight of epicycloidally rounded teeth. This is a subject, however, which cannot be more amply entered into in the present essay.

The respective proportions of the wheels of a train ought also to present a certain harmony, attainable by a regular progression in the diameters of the wheels and the fineness of their teeth.

With respect to the escape pinion, at least for the larger watches, I would strongly recommend to have it of eight leaves, with a fourth wheel of 75, and an escape wheel of 16 teeth. The last depthing, the most sensitive of all to any irregularity of transmission, will be found greatly improved by so doing.

The following are the sizes of a train which, according to my opinion, would answer perfectly to the above conditions, for a watch of 43 millimeters = 19 lignes Swiss = 14 lines English size.

Diameter of barrel. . $43 \times 0.485 = 20.85$	mm.
Center wheel 15.4	mm.
Third wheel 13.0	mm.
Fourth wheel. 11.8	mm.

The numbers would be:

Barrel.	90	teeth.
Center wheel.	80	"
Third wheel.	75	"
Fourth wheel.	75	"
Escape wheel.	16	"
Pinion.	12	
"	10	
"	10	
"	8	

The sizes of teeth are accordingly:

Barrel. 0.345	mm.
Center wheel. 0.30	mm.
Third wheel. 0.27	mm.
Fourth wheel. 0.24	mm.

It is easy to see that this progression is a very regular one.

The train ought to be arranged in such a way as to have the seconds circle at a suitable place on the dial. This circle, of course, ought to be as large as possible for the sake of distinctness of the divisions, and, on the other hand, it ought not to be so large as to cover entirely the VI. of the hour circle. It may be recommended as a good disposition to have the center of the circle of seconds exactly in the middle of the distance from the center of the dial to its edge. The general observation of this rule would be a decided step toward a greater regularity of construction, and besides it would prove a great boon to all the dealers and manufacturers of dials, and to all the repairers who have to replace broken dials.

A greater circle of seconds might be obtained by approaching its center nearer to the center of the dial, but this subordinate advantage would be too dearly purchased at the expense of the commodious arrangement of the wheel work.

The height of the moving arbors ought to be restricted only by the height of the frame. The longer the distance between the two bearings of an axis can be, the better it will prove for the stability of the moving part as well as its performance. The same amount of side-shake required for free action will influence the pitch of a long pinion less than that of a short one.

The diameters of the pivots in the watch work could not be made according to the generally established rules in the construction of machines, for if we should attempt to make the dimensions of our pivots in a theoretical proportion to the strain which they have to resist, we would obtain pivots of such extreme thinness that they would be very difficult to make and handle, and it would be doubtful whether the cross-section of such a pivot would not come into an unfavorable proportion with the molecular disposition of the steel. Besides, it ought always to be kept in mind that the pivots of the train must not be calculated to bear with safety the mere pressure of the mainspring, but also the sudden strains resulting from rupture of the spring or from rough winding. Thus, there will be very little to say against the way in which the pivots of watch work are generally made.

SCREW PLATES AND TAPS.

THE lathes employed in the manufacture of screws, says Mr. Saunier, are of two kinds; those intended for polishing, and, where necessary, modifying the form of screw heads much used by watch examiners and repairers, and those specially designed for cutting the threads, which are mainly in use among mechanics. Before discussing them, however, we will give some account of the screw plates and taps in ordinary use.

COMMON HAND SCREW PLATES.

The use of these is much facilitated by providing a seconds plate perforated with holes of such sizes that a spindle which just passes into a hole of any given number will be of the size most convenient for forming a screw in the hole of the same number in the screw plate. For a long time we had made use of two Latard screw plates, so made that a rod which would enter into one hole without play was of the most convenient size for forming a screw in the next smaller hole but one. (Thus the plate perforated with plain holes can be replaced by a second screw plate, or by using the successively larger holes on a single plate as gauges.)

In order to form a screw that is clean cut and even with the least possible straining of the metal, the holes in the screw plates should have notches; they should be carefully hardened and well polished on each side of the notch, and this system is now even applied in the case of the smallest jewel screws.

SCREW DIES.

The ordinary plate in which notches are not cut at the sides squeezes up and strains the metal. This effect is less marked when separate dies are used, and disappears entirely if only a small quantity of metal is removed at a time and the cutting edges of the dies are smooth and in good order. In addition to possessing other advantages, this form of screw plates enables us to obtain at will screws of the same thread and different diameters, or of the same diameter and different threads. The dies must be carefully fitted to the sides that receive them. Dies cannot be employed for cutting very small screws.

FINE THREADED SCREW PLATES.

At the present day these can always be obtained at the tool shops; but thirty years ago it was not so, and the watchmaker was obliged to make them for himself. The following method was adopted: Take a screw formed with an ordinary plate in which the thread is broad as compared with the hollow. If the screw does not satisfy this condition, it must be modified thus: Having ascertained that it runs true on its points, and that it is larger than will be ultimately required, attach a ferrule to the screw and place it between the centers of the lathe. The T-rest must carry a smooth horizontal rod of hardened steel. Rotating the screw with a bow, hold a slitting file in the hollow; the file should fit into this hollow accurately and should be smoothed on its two sides, only cutting with one edge. The bar of hardened steel will determine the depth to which the file is allowed to cut. By this means a screw is obtained that has a thread thick at the bottom. With the graver remove the top of this thread, round off its corners and harden the screw, filing three facets along its entire length that make it taper. The tap having been thus prepared is employed for cutting a thread in a piece of steel, not too thick, that has been previously annealed, and in which a hole is drilled of the proper size. The thread of this internal screw will be thin and the hollow proportionately broad.

The plate is now hammered cold with care, until the thickness is so far diminished that the thread and hollow are as nearly as possible of equal thickness. Harden it and chamfer the ends of the hole with a conical steel point and oil-stone dust. Then clean it and cut a thread on a piece of soft steel which may be formed into a tap. If the operation has been properly conducted this tap will satisfy the prescribed conditions and, when hardened, it is to be employed as a screw plate; for that first formed must, in consequence of the hammering to which it was subjected, present irregularities in the hole, and can only be used to cut one or two taps cautiously. It is useless for making screws or tapping brass.

TO CLEAR A STOPPED HOLE IN A SCREW PLATE.

DRILL a hole through the center of the piece of metal that fills up the hole, taking care to maintain it central, and to employ a drill that is sufficiently small to avoid all risk of contact with the screw thread. Pass a broach through this hole, and, after tightening it with a few gentle blows with the hammer, turn it in such a direction that it tends to unscrew the broken screw, which will, in nearly every case, be removed without difficulty by this means.

THROW AWAY BAD SPRINGS.

THE vibration of the balance and the time-keeping qualities of the watch are more frequently destroyed by untrue and badly put springs. Repairs to springs, except of a trifling character, are generally false economy. An hour may be spent trying to reshape and flatten a bad spring in vain, which can be replaced in a few minutes by an expert hand possessing a good stock of springs, and nothing pays so well for keeping.

THE CUTTING OF HOLLOWS, ETC.

THE cutting of hollows in pinion faces and rivets is perhaps the finest test of skill with the graver, as a sharp, well-pointed, yet strong, graver must be used, and the graver cutting clean without burr or roughness, leaving the hollow a bright gray. It was the practice years ago to polish hollow, but there is no skill in the operation, and it has gone out of fashion. The value of hollows to rivets and pinions, when the pivots are close to them, is very great, as they prevent the oil running away from the pivots and shoulders.

LOSS OF ESCAPE WHEEL.

SHOULD an escape wheel and pinion be lost, they can be replaced by sectoring the fourth wheel for the size of the pinion, or a pinion whose leaves are rather smaller than the same number of teeth of the wheel may be tried in the depthing-tool, taking the depth from the fourth and scape holes. The scape wheel corresponds in number on the gauge with the hole in the cylinder gauge, in which it fits; but before using it will be as well to see if the cylinder passes freely between two teeth of the wheel, and that one tooth of the wheel has shake sufficient for freedom in the inside of the cylinder.

BANKING ERROR.

A NEW hairspring will sometimes cause the banking error. There is a tendency of late years to put too many turns in the hairsprings of cylinder watches. A large number of turns in a lever balance spring is a great advantage, owing to the greater vibration necessary and desirable; but when the arc of vibration is small, as in cylinder and vertical watches, long springs do not have all their turns properly in action, and offering not sufficient resistance to the balance, allow it to travel greater distances too easily. A balance without the balance spring strikes the banking at every vibration, and the number of turns and tension of the spring are the means to be used to prevent this.

TO FIT IN NEW SCAPE WHEEL.

THE old wheel was defective, the teeth being bent and too short, so that the action was not safe; the effect being that the scape tooth, instead of dropping on the locking face of the pallet jewel, and drawing the fork over to the banking pin, dropped on the impulse face, and thereby caused the fork to travel the opposite direction and bring the guard pin up against the roller, which would either cause the watch to stop or vary. No doubt some of my readers have often, in listening to a watch ticking when in the case, heard an occasional scraping noise, and an accompanying dropping off in the motion, and perhaps it would run on again for some time before another *scrape* would take place. If you have, you can in all probability trace the trouble to a very shallow depthing or an untrue scape wheel, which caused the guard point of fork to rub against the tail roller. Pick out a new wheel that you think is about the correct size and run it on a small turning arbor, and insert it with pallets in depthing tool, and examine the action very carefully. If the inside edge of the entrance pallet catches against the back of a scape tooth, the wheel is too large, as it sticks on the inside and would consequently have too much drop on the outside. If the outer edge of disengaging pallet jewel catches against the back of a scape tooth the wheel is too small, and there would be too much drop on the inside; if correct the tooth should drop just nicely safe on the locking faces of the pallet jewels, and the *drop* should be about equal, that is, when the scape tooth leaves the impulse face of the entrance or engaging pallet jewel, the distance the wheel has to travel before coming in contact with the locking face of the disengaging pallet jewel should be the same practically as it is when the tooth leaves the edge of impulse face of disengaging pallet, and the wheel again comes in contact with locking face of engaging pallet.

THE MEANING OF "ADJUSTED."

CATALOGUES and lists of prices frequently speak of "adjusted" movements, which term is also applied frequently to cheap watches. The term is a very elastic one, and can be stretched so as to cover a multitude of sins. It varies, according to whether it is applied to the balances, the movements, etc. An adjusted balance means a chronometer, or expansion balance, which is adjusted for changes of temperature, so that it will keep the same rate in warm or cold weather. This adjustment is made more close or perfect in fine watches than in cheap ones. A great many are sold as "adjusted," that have never been adjusted at all.

But there are other adjustments besides that for heat and cold—as the adjustment for the positions, which enables the watch to keep the same rate whether hanging up or lying down, or in any other position, while carrying, etc.; the adjustment for isochronism, which is an adjustment of the balance spring to secure isochronal vibration of the balance; the rating or timing is often called the adjustment for rate, etc. An adjusted *movement*, or one "fully adjusted," should have all of these adjustments, but an adjusted *balance* is only adjusted for heat and cold.

An expansion balance, the rim of which is not cut entirely through, is certainly not adjusted, and cannot be. This is a simple test for some kinds of cheap bogus "adjusted" watches. But the methods of testing cut balances, and also for testing the other adjustments, are too numerous and too lengthy to be condensed into one simple article, but will be given more fully in detail.

TO REGULATE A FINE WATCH.

SOME time ago a correspondent desired to know how to regulate a very fine watch made by a certain favorably known English watchmaker. He said that although he "had tried altering the hairspring by taking up and letting out, yet could never obtain the desired effect."

When a watch has no regulator, it is regulated by the timing screws in the balance rim, at the end of the center bar. They are turned very slightly inward, to make the watch gain, and outward, to lose. Both screws must be turned exactly the same quantity, or the balance will be thrown out of poise, and regular running will be impossible. Should the amount of regulation wanted be too much to be easily corrected by these screws, it shows that there is some fault in the movement, which should be looked after and repaired. This may be in the escapement, or elsewhere. It is sometimes caused by the balance rim having become bent by the careless handling. But the hairspring should never be disturbed in a fine watch, unless in some very exceptional circumstances. Its length and curvature have probably been carefully adjusted to secure isochronal vibration of the balance, and taking it up or letting it out will at once damage or destroy the isochronism. Even taking up a hairspring and afterward putting it back where it was in the beginning will often spoil it for fine running, because the shape of the spring and the condition of the metal have been so altered by the pressure of the pin in the hole, the bending or straightening of the coil, etc., as to unfit it for isochronal action. It is difficult, in fact, for a workman who is not fully posted in fine watch work, to handle a fine movement without injuring it in some way, although he may not know how he did it, or discover the fact till the owner complains of its inferior performance.

TO PUT AN ADJUSTED WATCH IN ORDER.

WE have heard so many complaints coming from members of the trade in regard to this matter, that we thought perhaps the pointing out of the difficulty concerning the remedy therefor would be of profit to all concerned. Ten years ago we hardly sold one adjusted watch a year; now a large portion of the watches we sell are adjusted movements, I having sold eight the past month (April), and they are the best advertisement that a jeweler can have.

If a watch was going immediately into the hands of a customer without any preparation except what it received at the factory, I would rather risk a well made medium-priced watch than a fine adjusted watch. The reason of this is that the adjusted movement is usually three times as long in stock as the medium grade that they have calls for every day, and it may have been out on approval and have been monkeyed with more or less by some knowing ones. If the following rules, which I practice on every adjusted watch I receive, are carried out, I will guarantee satisfaction not only to the buyer, but to the seller, for it is a satisfaction to sell a good time-keeper.

1st.—When you receive the movement, look it carefully over outside to see that it has received no apparent injury; then taking out the slip under the balance, observe the motion in different positions and see that it has not only the same, but a good motion in any and all positions, with the mainspring one-half wound up.

2d.—Place a bristle or fine broach in the train so as to stop the motion; see that neither pallet hits against the scape wheel so as to hold the fork to one side; then with your strongest glass, observe that the hairspring, just where it goes through the pins, is exactly in the center, with about the thickness of the hairspring each side, or perhaps less. Also observe whether it is true in the round or flat; if everything is all right apparently, you can proceed to the first test. If the hairspring is not in the center of the pins when the balance is at rest, the stud must be turned until it stands so, but the pins must not be stirred under any consideration, and the banking pins must not be moved. If the watch is not adjusted to position, the first test should be made with pendant up (don't put the movement in the case yet). Wind it entirely up, set the seconds hand exactly with the seconds hand of the regulator, and let it run for 12 hours; make an observation and set down just how much it has gained or lost; leave it in the same position and set it again with the regulator; in 12 hours more observe the variation. Say in the first 12 hours it gained 30 seconds, and in the next 12 hours it only gained 20; 10 seconds difference between the first and last coils of the mainspring. If the hairspring is isochronized, 5 seconds is as much variation as should be allowed, if the observations on the works and hairspring have found them correct.

In a movement costing over $15.00 I should send it back if I had found in these preliminary trials the variation between the first and the last observations exceeded five seconds, or if the movement was running fast or slow to exceed one minute either way per day, for if the regulator has to be moved much the isochronism of the spring will suffer.

If the watch is adjusted to position it should be tried in different positions, each time setting it exactly with the regulator and using the same strength of mainspring for different positions, and if in a 6-hour trial in each position, it should not vary more than three seconds from the standard or vertical adjustment, I should retain it.

Some may consider these conditions rather severe, but if the movement was in the condition described before being tested, I have not had to return but three out of hundreds tested and sold.

CARE OF THE EYES.

IT happens occasionally that, while turning, a splinter of the metal will fly into the eye. Never try to expel it by rubbing, as it simply irritates the eye and drives the chip still further into it. It is better to raise the upper lid or draw it over the lower, so that when returning to its place, it slides over the lower eyelashes, which will thereby sweep it clean, as it were. This process will, in the majority of cases, suffice to remove the chip or other foreign body; if not, the object may be gotten out with a strip of white paper or a camel's-hair brush. Never, however, let any one use a hard instrument; if this is necessary to be done, it is most advisable to send for or go to a physician.

TO LUBRICATE CLICK-WORK, ETC.

WHEN putting together the barrel parts, never forget to lubricate the click-work, more particularly that of the going-barrel, as the injury occasioned by its working, while dry, would soon show itself. The mainspring is to be lubricated only slightly. The stop-finger should always be fastened with a steel pin; it is more securely retained thereby. The barrel is mounted in the plate, and the spring is wound a few teeth to apply oil to the escapement.

THE KNACK OF PIVOTING.

THE repairer who is the happy owner of an American lathe (and right here let me say the scope of usefulness of this tool is so much greater than that of any others I have ever used, that the latter simply drop clear out of sight) will readily echo the opinion expressed to me by a brother repairer. When asked how he liked his new lathe, he ejaculated, "Like it! I do not think that a better tool exists; I am prepared with it to do any kind of turning, from a cambric needle to a sheet anchor." Supposing, however, that we do not get an order for a sheet anchor every day, and only have a balance staff of a low-grade American with the upper pivot broken, and our customer not willing to pay for a new staff, requires the insertion of a new pivot. Before proceeding farther, I will devote a little space to the explanation of a small device for holding pivot drills, which I think is ahead of some found in material stores, as no set screw is required and the drill is always centered.

This drill chuck is made by securing a ¼-inch brass chuck in your lathe, and turning the end down to fit snugly in the taper hole in the spindle of the tail stock, but should fit tighter near the shoulder, so it will close on the drill, when pressed in tightly; the principal being the same as that of the American lathe chucks.

After it is fitted and cut off, place it in tail spindle and drill a hole through it just to fit the wire you intend to use for pivot drills. Mark the relative positions of chucks, spindle and tail stock by little dots so that they can be replaced in the same position to bring the drill true. Now, with a fine saw, split the chuck as indicated by the heavy line in the center, and it is complete, and will pay you for your trouble a thousand times.

I now take a No. 6 chuck and put it in my lathe, insert the staff and stone off the stub of the broken pivot, down to the shoulder. Try the truth of its running by sliding the T up close, and resting a small screw-driver on it so that the point will just touch the lower side of the staff near the end, rotate and see if it runs true; if any light can be seen between the screw-driver and the staff at any part of the revolution, it is not true, and must be loosened and turned in the chuck a little. Keep on trying till it runs perfectly true. If there is no point at which it can be set to run true, the only remedy is wax, but I seldom find one that will not run true when set in the proper position in the chuck. When you get it true, tighten it up for keeps. Take the measurement with a height gauge from the balance arm to the top of the pivot, making allowance for the part broken off. Few staffs are so hard that a properly made and tempered drill will not cut them; if it will not, draw the temper in the staff slightly, with a wheel protector covering the wheel, being careful not to blue the balance arms. Nothing makes a much more unsightly job than having the balanced arms blued or almost blackened as I have seen them, half way to the rim. If they should become slightly colored by heat it may be removed by dilute hydrochloric acid, cleaning thoroughly with alcohol after, to prevent its rusting. Insert the drill in the little chuck previously described, press the chuck firmly in the spindle, and all is ready to drill. Take hold of the rubber button at the end of tail-stock spindle, and press the drill against the work. If the chuck and drill have been made with proper care, one can center and drill a staff with his eyes shut. If the tail-stock spindle should not be true, it might be prudent to have a little dot on the spindle, and also one on the little chuck to correspond with it to necessitate its coming true every time. Drill the hole about one millimeter in depth, although this may be varied to suit circumstances. Now take a needle in the pin vise, a trifle larger than the hole you have drilled, and draw the temper in it, never beyond a blue, then file it down by the thumb and finger motion, till the end will just start in the hole. It should be tapered a very little, but if too much, it will loosen and work out in turning. Drive it in tightly with a light hammer, and cut it off with a sharp-pointed graver, a little longer than is indicated by the height gauge previously referred to, so that it may be shortened to the exact length by stoning. Great care should be exercised in cutting it off, and in the first turning of the pivot, to keep the graver sharp, and not use too much pressure or the pivot will become loosened in the staff. Turn and polish the pivot the same as you would on a new staff. In turning the back slope at the base of the cone, cut away a little of the metal of the old part of the staff, to be sure that the shoulder of the new pivot is even with the old, making an invisible joint. When I say that I use needles for drills, pivots, etc., I do not mean to say that I am partial to them; they are good, and so is Stubb's steel or other wire of equal quality; but as they are cheap and easily obtained, of any size, I mostly use them. If the hole you drill for a pivot breaks out at the side, or you find the hole is much out of true, discard it entirely and make a new staff. Any attempt at soldering or botching should not be indulged in if one ever wishes to be a master of the art.

THE MOTIVE POWER OF CLOCKS.

CLOCKS not propelled by springs are actuated by weights fastened to the end of a cord, which is wound around a barrel. The power of the weight increases or decreases according to the diameter of the barrel. The radius of the barrel is a one-armed lever, but by its union with the barrel wheel it becomes two-armed. For this reason the power with which the barrel wheel depths into the pinion is proportioned to the drawing power of the weight or its ponderosity, as the length of the radius of the barrel, multiplied with the ponderosity of the weight, to the length of the radius of the barrel wheel.

If, for instance, the ponderosity is 2 kilograms, the radius of the pinion 2 centimeters, and the radius of the barrel wheel 6 centimeters, then the power with which the latter depths into the pinion is $2 \times 2 :: 6 = 2/3$ kilogram.

In the clock train the power decreases with each wheel that depths into a pinion by so much as the radius of the pinion is contained in the radius of the wheel depthing into it. We may also say "diameter" in place of "radius," as the proportion remains the same. When, for instance, the barrel wheel depths with a power of 750 grams into a pinion of 8 millimeters in diameter, and this arbor carries a wheel of 50 millimeters in diameter, then this wheel exerts a force of only 120 grams upon the next pinion. Because $750 \times 8 :: 50 = 120$ grams. In this manner the power may be calculated up to the scape wheel.

If, however, the original power were to be retained, it then would become necessary that each wheel should depth into the next, having the same diameter; in this manner, however, the time necessary for the scape wheel to make its required number of revolutions, while the barrel wheel makes one revolution, could be obtained. This power may, indeed, be increased, if the actuation of the wheels upon the pinions be reversed, so that the latter act upon the former. For instance: A weight of 1 kilogram draws on a barrel of 72 millimeters in diameter; a pinion of 16 millimeters in place of the barrel wheel depths into a wheel of 48 millimeters diameter; the arbor of this wheel carries a pinion of a diameter of 8 millimeters. The power with which this last pinion depths into the next wheel is $1 \times 72 : 16 \times 48 : 8 = 26$ kilograms.

With such an arrangement, naturally, it would be possible to lift a heavy body by the expenditure of a little power, but it would go increasingly slower, the lighter the ponderosity would become; because the weight of 1 kilogram would have to sink 679 millimeters to revolve the pinion of 8 millimeters only once. In the case of clocks it does not so much depend upon the loss of time to increase the power, but rather upon the gain of time, even if this cannot be effected in another manner than at the expense of power. Neither is it desirable to wind the clock every few minutes, nor yet to make the cord unnecessarily long; and for this reason the train is constructed in such a manner that, as already observed, the scape wheel has to make many revolutions while the barrel wheel rotates only once.

CALCULATION OF THE TIME.

Every timepiece, with regard to the purpose of its wheels, may be divided into three parts. The first part of the wheels, from the barrel wheel to the center wheel, solely conditions the length of time during which a clock can go without being rewound.

The center wheel, upon the arbor of which sits the cannon pinion with the minute hand, must, since the hand has to accomplish its revolution in one hour, also revolve once in an hour. When, therefore, the pinion of the center arbor has 8 leaves and the barrel wheel 144, then the 8 pinion leaves, which makes one revolution per hour, would require the advancing of 8 teeth of the barrel wheel, which (8 : 144) is equal to the eighteenth part of its circumference. But when the eighteenth part in its advancing consumes 1 hour, then the entire barrel wheel will consume 18 hours to accomplish one revolution. If, now, 10 coils of the weight cord were laid around the barrel, the clock would then run $10 \times 18 = 180$ hours, or $7\frac{1}{2}$ days, before it is run down.

Question.—How long will a clock run with 8 coils of cord around the barrel—the barrel wheel having 144 teeth, the first wheel 84 teeth, with a pinion of 12 leaves, the second wheel 80 teeth, with a pinion of 10 leaves, and the center wheel having a pinion of 8 leaves?

Answer.—$\frac{144}{12} \times \frac{84}{10} \times \frac{80}{8} \times 9 = 9{,}072$ hours, or 378 days.

The clock would therefore run 378 days.

As will be seen from above example, the number of wheel teeth are multiplied with each other, and the same thing is done with the number of pinion leaves, after which the product of the former is divided by that of the latter, the result being the number of given hours of the clock with one coil of the cord. This number multiplied with that of the coils of the cord gives the entire time during which the clock will go until run down.

CALCULATING THE TIME OF OSCILLATION, LENGTH OF PENDULUM, AND NUMBER OF OSCILLATIONS.

The second part of the wheel work, from the center wheel to the escape wheel, is in the number of its teeth controlled by the length of the pendulum, and the reverse; the length of the pendulum is controlled by the proportion of the number of wheel teeth and pinion leaves of this second part. For instance, a seconds pendulum is to be used in a clock; the center wheel can then be made with 64 teeth, the third wheel with 60 and a pinion of 8 leaves, the escape wheel with 30 and a pinion of 8. The scape wheel, each tooth of its 30 teeth being dropped by the anchor after two beats (or 1 tooth every 2 seconds), accomplishes its revolution in 60 seconds, or 1 minute. The third wheel has meanwhile, as it gears into a pinion with 8 teeth, only progressed (8 : 60) the $7\frac{1}{2}$ part of its circumference, and consequently would accomplish its entire revolution only in $7\frac{1}{2}$ minutes. While the third wheel (the pinion of which has also 8 leaves) has made one revolution in $7\frac{1}{2}$ minutes, the center wheel has advanced only by 8 teeth or (8 : 64) the one-eighth distance of its circumference, and would therefore consume $8 \times 7\frac{1}{2} = 60$ minutes, until it accomplishes one revolution.

With a proportion like the above, to wit, providing the scape wheel of a seconds pendulum with 30 teeth, a seconds hand can be mounted upon the arbor of the scape wheel, since the wheel makes one revolution in 60 beats of the pendulum. Still, the proportion of the number of teeth can also be changed according to desire; for instance, center wheel, 60 teeth; third wheel, 50 teeth and a 10 leaf pinion; scape wheel, 60 teeth and a 10 leaf pinion; so that in this proportion, when the center wheel has made one revolution, the third wheel has already (10 : 60) = 6; the scape wheel, however, at one revolution of the third wheel (10 : 50) could have made 5 revolutions; consequently $(5 \times 6) = 30$ revolutions, while the center wheel has made one; to reduce this to time would be equal to 30 revolutions in one hour. Naturally a seconds pendulum would have to be used for this arrangement, but no seconds hand could be mounted because the scape wheel would accomplish one revolution only in two minutes.

Example.—To find the length of a pendulum when the center wheel has 72 teeth, the third wheel 60 teeth and a 6 leaf pinion, and the scape wheel 30 teeth and a 6 leaf pinion.

Since we know that the lengths of the pendulum are proportioned to each other inversely as the squares of the numbers of oscillation, we calculate first how many oscillations the clock makes per hour, which we ascertain as follows:

The center wheel makes one revolution per hour; the third wheel 6 : 72 = 12 revolutions; the scape wheel makes for each one revolution of the third wheel 6 : 60 = 10 revolutions, or with 12 revolutions 10 × 12 = 120 in one hour. Each tooth causes two beats, therefore the entire wheel 2 × 30 = 60; consequently 120 revolutions cause 60 × 120 = 7,200 oscillations.

The entire calculation can be made shorter as follows:

$$\frac{72}{6} \times \frac{60}{6} \times 60 = 7{,}200.$$

As is well known, the length of a seconds pendulum is 994.07 millimeters, and makes 3,600 oscillations per hour. Consequently is proportioned the square of 3,600: to the square of 7,200 = x: 994.07; reducing this we have the square of 1 to the square of 2 = x: 994.07; or 1 × 1 : 2 × 2 = x: 994.07; consequently, 1 : 4 = x : 994.07, whereby we find that x = 248.51 millimeters.

In place of the center wheel, any other wheel may occupy the center of the movement, and the seconds hand may be in the center of the dial. For instance, the center wheel has 64 teeth; the first third wheel has 60 teeth with an 8 leaf pinion; the second third wheel, upon the arbor of which the seconds hand is mounted, and which, therefore, has its place in the center, has 60 teeth with an 8 leaf pinion; the scape wheel has 8 teeth with an 8 leaf pinion, and the number of oscillations is:

$$\frac{64}{8} \times \frac{60}{8} \times \frac{60}{8} \times 16 = 7{,}200.$$

The pendulum, therefore, as its time of oscillation is only one-half that of the seconds pendulum, has $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ the length of the seconds pendulum, or 248.51 millimeters.

The second third wheel, which here is the fourth wheel, makes in one hour (64 : 8 × 60 : 8) = 60 revolutions; therefore, one revolution per minute. The wheel must have 60 teeth in order to divide the revolution more equally into seconds. The wheel progresses one tooth per second.

A table of the pendulum lengths is to be found in every work treating on horology, and therefore need not be reiterated here.

TO FIT IN A SCAPE PINION.

The next consideration is the scape pinion. Choose one that has been truly cut and well polished, notice particularly that the leaves are all of the same thickness; if not throw it away, it is of no use. Without discussing how to pick out a pinion theoretically correct with relation to the 4th wheel (which I will do in a subsequent article), I will just say, place the new pinion in the depthing tool, also the 4th wheel and pinion, and set the tool so that the points of the two centers are exactly the distance apart that the 4th and scape holes are, revolve the wheel and pinion, keeping a slight friction on scape pinion to be able to notice well the action, and see that when one tooth has finished its lead, the following one comes into action with the following leaf without a *drop*, and also that a butting action does not take place between a tooth and leaf by their coming in contact too soon before the line of centers. If such is the case the pinion is too large; if there is a drop, the pinion is too small.

Insert the pinion in a chuck either by the arbor part, or by the pinion leaves, if the pinion will not run true when chucked on arbor part, in which case be careful in tightening up the chuck not to draw it up or tighten as you would on a plain piece of wire for bushing, as there would be the danger of flattening the edges of the pinion, at the same time it can be chucked sufficiently tight to remain as placed, and without damaging the leaves. Turn the bottom end of arbor true, and finish the bottom pivot first, having its shoulder at such a distance from the face of the pinion that the 4th wheel will be about in the center of the leaves, considered lengthwise, then reverse the pinion in the chuck, and mark the point in the upper shoulder. This distance can be gotten several ways; an inside measuring tool may be bought or made; if you possess a little ingenuity, one of your own make would be the best, or you could make it to suit all cases, while the one made for sale will not always enter sufficiently far between the plates. Another way is to take a piece of brass wire, filed perfectly flat, and make it of the requisite length, so that when introduced between the plates and resting on the scape jewels or surfaces the shake will be of the desired extent, and then measure with ordinary calipers from that; or the old pinion can be used as a guide by making the necessary allowance if the end-shake is too great, and still another way will sometimes answer, namely, measuring the length of the pallet staff, which occasionally is the same as the scape pinion. Of course these are only make-shift ways, and the proper way is to have a carefully made measuring gauge. Measure the total length and finish top pivot and the upper end of arbor for the scape wheel collet to fit on; this must be *slightly* tapered, and turned very smooth and true and well polished, and great care must be taken not to get it so small that the scape collet will go down too far or be loose; this very defect often is the cause of poor motion and stoppages in English levers, and in examining such watches for repairs, never neglect to grasp the scape pinion tightly and see that the scape wheel is not loose. Sometimes I have found that the hole in collet has been closed to one side, thereby causing the wheel to be out of true in the round, thus making a serious defect in wheel and pallet action. The proper way in such a case is to make a new collet.

THE USE OF THE CUTTING BURNISHER.

FOR the ordinary every-day watch, pivots and shoulders are sufficiently well finished with a cutting burnisher, one side of which is rubbed on a board or strip of lead charged with emery, or a few rubs on the small stone used by shoemakers to whet their knives for leather cutting, is a handy substitute, and gives the requisite cutting power; and then a few rubs with a burnisher, polished on a well-used burnishing board, on which smooth emery has been distributed, will give a perfectly smooth and black pivot. The best Clerkenwell pivoters finish their pivots with the smooth burnisher in this way to harden them, though they have been previously highly polished with a soft steel polisher which leaves the shoulder perfectly square and highly polished.

SCREWED JEWELS.

THE screwed jewel, against which several well-founded objections may be urged, may be improved in such a way as to make it much less liable to failure. There is not the slightest necessity for countersinking the screws in the upper plate; they might, without the least detriment to their functions, have flat heads, rounded at the top, as they merely serve to hold the jewel down in its place, thereby reserving the whole thickness of the plate for the hold of the screws. The jewel setting might be dotted, as usual, for always having it in its same place in its sink, which is not without importance; and if it should be thought necessary to insure this position of the jewel, even against careless repairers, who might not pay any attention to the dotting, this might easily be attained by drilling a very small hole in the bottom of the countersink, into which a pin might be driven, and for the reception of which the jewel setting ought to have a small groove.

JEWELS IN WATCHES.

A MOVEMENT with plain set jewels is in no way inferior to one with screwed jewels, even in the very exceptional case of the replacement of a jewel hole. The movement with screwed jewels has a more elegant appearance, but it implies, if not done with the greatest care and discernment, a vast deal of trouble in the manufacturing, and still more so in the repairing. Not only must all the screws and jewels be taken out for thoroughly cleaning a watch and put in again, but the very little thickness in which the screws have to take their hold is a great source of annoyance to the repairer, especially in the English watches, with their thin upper plates of brass, rendered quite soft by gilding, and with screws of rather coarse threads. Any screw failing in its hold has to be replaced by one of the next number of threads having by its greater thickness still less chance of a sound hold, and very often it is necessary to make other holds at fresh places. If, now, the screwed jewel presents the advantage of easy replacement of a broken jewel without leaving any lasting mark of the operation, this small advantage may be considered to be neutralized by the above-mentioned drawbacks.

RULES FOR DEPTHING.

IT may be accepted as a rule that the following conditions are necessary for a good depthing: 1. That the pinion be well proportioned to the wheel. 2. That both parts run true. 3. That this division be mathematically correct. 4. That the wheel teeth as well as the pinion leaves be shaped properly and in proportion to each other.

TO INSPECT DEPTHINGS.

THE depthing of watches, as they are invisible, are generally examined by the touch. This sort of examination, however, requires practice of years, and even the experienced repairer may occasionally be deceived by a shallow depthing. Whenever it can be done, small holes should be opened for inspecting, to bring both the senses of sight and feeling into play. The examination of the depthing in the depthing-tool cannot be recommended or relied on in all cases.

VISIBLE DEPTHINGS.

WHEN the depthing can be seen pay attention to the following points: 1. The wheel tooth must enter the pinion undisturbed and with sufficient shake between the back of the wheel tooth and the next pinion leaf. 2. The first engagement, or the exact point of beginning of the driving, must take place on the line of center. This, however, is possible only with the center pinion in cylinder watches, and with ten or more leaf pinions. Those with a lower number of leaves will always have driving before the line of centers, which increases with the decrease in the number of leaves. If the driving occurs too far before this line of centers, it may either be caused by an unduly large pinion, or pinion leaves of unduly pointed rounding, and, finally, by too shallow a depthing.

CARE IN REPAIRING.

WHEN you clean a watch, see that the holes are well pegged out and the pinions free from all foreign substances. Many watches of good construction fail to give satisfaction because some trifling fault has been overlooked by the over-quick workman. A man may clean a watch in half an hour, and it may stop from the fact that the pinions are clogged with the abundance of chalk used in the process, or in the inconsiderate haste a loose jewel may be overlooked, or a screw left not fully turned in. Carelessness in adjusting the hairspring leaves the watch in such a condition that its owner cannot depend upon it.

RECOURSE IN TIMING A WATCH.

ALTHOUGH first-class watchmakers do not admit of the process explained below, still, when the repairer is timing a medium or low-grade watch, he may have recourse to the following: When the watch gains in a horizontal position, and loses with pendant up, the ends of the pivots of the balance wheel may be flattened to increase the friction while lying down, so as to make the friction the same in that position as when the pivots are rubbing against the sides of the pivot holes while the watch is in a vertical position.

THE ART OF TURNING.

THE art of turning with the bow and common turns is so valuable to the watch repairer, says M. Ganney, that no opportunity should be lost by young watchmakers to acquire facility in this branch of the business, as advancing years render it almost impossible to atone for any neglect of this subject in early youth. A certain amount of daily practice is the only sure means of acquiring it, and it was at one time the usual plan of teaching a youth his business to let him have at least two hours a day at turning, as the ordinary watch repairing business, unlike escape making and finishing new work, does not give the opening for turning talent to be developed; and the supply of material now being so prevalent, instead of making new pieces as required, it behooves all having apprentices to make provision in this respect by making the learner produce himself all screws, arbors, plugs and stoppings, and rough out, for the other workmen, the pieces that they finish and put into the watches. The spectacle, now too common, of young men who have served a number of years and quite unable to replace a broken piece of watch work, would become rare. The usual routine of large and small clock work to commence with, and finishing with coarse and fine watches, is admirably adapted to develop the mechanical ideas of the learner; but the turning must be supplemented with more than what is required ordinarily in the course of the business of watch repairing.

Almost any sort of turns will do good pivoting, the only requirement being rigidity of centers when fixed, and firmness in the rest, which must be brought as close to the work as possible, and the center that holds the pivot that is turning must be as close as possible to the hole in the turns. For this reason many pivoters prefer the plainest possible turns with a piece of brass for a rest, having another piece of brass riveted on it, which is simply put against the turns, and the two screwed up in the vise, the work being brought close to the rest by the centers. This primitive and despised plan is better than using the Swiss turns, which being made to elongate so as to take in all sizes common to the various jobs in use, is deficient in the prime element of rigidity, and the rest that usually accompanies them is three times the width it ought to be, and should be filed away to allow the shortest possible amount of center to be used. When a long center projects the work invariably becomes loose, as the pressure on such a long lever is more than the binding screw can counteract. What are known as English pivoting turns, when the rest is shortened, answers all the requirements of fine turning, as the centers are held firm by the split hole in which they fit, being closed throughout its length on the center by a screw working from the back, and not liable to accidental disturbances by a touch in working, and all parts very strong and rigid. The centers usually supplied with turns are not of much use, as all the holes are made in the center of the steel, and this prevents the work coming close to the rest and renders good or fine turning impossible, besides breaking both fine graver points and pivots by the vibration of the graver. Ordinary round steel must be fitted rather loosely, or, as dirt accumulates in the holes, there will be an amount of force required in moving the centers difficult to apply and dangerous to the work in hand, as the center must be moved lightly in all directions with one hand whilst the work is held lightly in position for fixing with the other. The back center must be a pointed one with only one hole or chamfer in it, made with a fine punch as near to the outer edge of the steel, when full size, as convenient. The surrounding steel must be all filed away with a half-round potence file, forming an irregular hollow cone for a quarter of an inch; this may be considered the finest or finishing back center, and should have a hole in which the finest pivot point can rotate without side motion. The other end of the center should be made a center of the same kind, but much stouter and larger, to hold an arbor, when the pinion is first commenced on for turning. The fine point to the center is to allow it to pass freely up any ferrule in which the work is held, and all strength compatible with freedom should be obtained, and the hole at the center being at the side or eccentric allows the work to be raised or lowered or brought close to the rest as may be desired, and also in a straight line with the holes in the other center at which it is being turned. The right hand center is simply left full size and both ends filed quite flat, and small dots made around its extreme edge with a sharp punch completes the apparatus for turning. The ends of all centers should be made red hot and plunged in water; if hardened all over they may break when dropped or pulled roughly. One or two holes or dots may be made so close to the edge as to burst, or a slight nick cut, in which the point of a pivot rests, when being polished. As the various holes wear through they may be used for polishing pivots on, and holes that wear too deep and become dangerous thereby to the work by the friction they generate, must be restored to use by grinding the center on the oil-stone. Many neglect to harden centers, but the advantages of hardening are very great—the friction is much less, and the constant wear and change of soft centers prevents the certainty and accumulation of experiences in the use of a tool which insures perfection in such a delicate operation as fine turning. Another center, called a centering one, is quickly made by filing the plain steel center as a right angle on each side with its face and cutting a recess on each side; an arbor or pinion point resting on it, exposing its extreme end, may be truly centered by a very smooth old file; a new one will have too much power over it and push it off the center. Great lightness and rapidity are necessary in centering truly.

HAND TURNING IN WATCH WORK.

IT should be the fixed object of every young man, says Henry Bickley, who wishes to become a watchmaker to master the art of turning; not only because it will enable him, if a jobber, to work in new pieces with skill and precision—in itself an object worth striving for—but also because, in the process of learning to turn, the eye and the hand receive an education unattainable by any other means. A thorough conception of form and truth, as well as delicacy of touch, are the outcome of the art of turning. Think how much the watchmakers' art is dependent on the possession of these qualities, and but what a poor representative of the trade must he be who has them not!

Turning, like all other branches of skill, can only be mastered by slow and patient effort, plodding onward step by step from the beginning. No hurry, no slurring of difficulties, but patiently attacking and vanquishing each as it arises. For want of proper grounding in the preliminary stages many men are never able to turn at all in the proper sense of the word. Badly taught, most likely, in the first instance, with no clear idea of what is required, and deprived of the practice without which they can never succeed, they rush forward, evading the difficulties in their way instead of surmounting them, till the goal of their ambition, a balance staff, is reached. It is unnecessary to say that the staff is usually a very bad one; its merits being quite undiscernible to any but the maker. He, however, is decidedly proud of the job. Has he not gained his ambition, what more is there to learn? And so he quietly subsides. This is no fancy picture. I have come across many such persons, who, when put to the test, have been unable to do anything, even to the making of a screw, in a satisfactory manner.

There is no better mode of learning to turn than to practice first of all in soft steel or even brass till proper command is acquired of the graver and bow. The latter should be tolerably strong to begin with, with good-sized steel wire and a large ferrule and graver. Then let the learner try to make a big screw, taking another screw as a copy. The wire must first be centered quite true, starting on the filing block and finishing on the centering runner, and a pivot turned on it to form the screw top. The graver must be held firmly on the rest at a point slightly above the center of the wire. In this apparently simple piece of work, if persevered in till it is properly done, the learner will take in four valuable lessons. He will learn in the first place to turn straight, as the pivot must be so formed if a proper thread is to be put on it; secondly, he will learn to turn squarely in forming the shoulder for the back of the screw head; thirdly, he will learn to turn to size, if he makes the screw tops, as he should do, to fit a certain hole in the screw plate; and lastly, and most important of all, he will learn to turn true. On this latter point I think it well to make a slight digression, having met with a strange confusion in some minds as to what constitutes truth in turning. We speak of a piece of work as being true when its circumference forms as nearly as possible a perfect circle—in other words, when it is round. Now, as the truth of the work as left from the graver depends entirely on the centers, it follows that if they are not round, neither will the work be; especial care must therefore be taken to fix the centers in the first instance. Lay the end of the piece on the centering runner, giving it a good speed with the bow, then turn along it for a short distance and carefully observe it; if the center and the part turned over do not seem round, turn and center it again. If the piece be much out of round, turn off the extreme point to form a new center before running it with the file, repeating the operation till perfect truth is obtained. This must of course be done to both centers, and frequent observation made of them during the progress of the work. Want of care and observation, even at the last moment, may cause a good piece of work to be spoiled; for if the centers should get but the slightest degree out, the part turned last—which in a finished piece is always the pivot—will be oval, and its effectiveness, in any case seriously diminished, will in a balance staff be destroyed. Thus far as to centers and centering. This little digression will not be lost, as I have met with inexperienced persons who have thought and argued that, because a thing is true to the center it must of necessity be true, a fallacy that in some instances had taken deeper root than I should have thought possible.

But to return to the screw making. From large screws the learner should gradually pass on to small ones, adapting his bow and ferrule to the work as he goes along; and when he can make a jewel screw quite true, with a good thread, and a well-shaped head with the shoulder at the back turned clean and square, without either lump or nick in the corner, he may think, as regards soft metal, that he has done very well. It seems in some respects a pity that material for repairing is now so easily obtained. In days gone by, when screws were wanted for jobbing (and for new work, too, for that matter) they were made by the apprentice, who, by this means, got an amount of useful instruction and practice in turning he does not get now. I know I shall be told that to make screws when they can be bought for almost next to nothing does not pay, that time is money, and so forth. To this I reply that skill must be paid for in some shape or other, that youth is the time to acquire it, when the perceptions are quick and time not so valuable as afterwards, and that if the young watch jobbers of to-day are to learn turning at all, they must do as all the best men in the trade have had to do—begin at the beginning. Besides, to take the matter on its merits, I am not sure that it would not often be cheaper to make screws than to buy them. The screws, as we get them, usually want so much alteration, that to one who can handle his tools the making of a screw would take very little, if any, longer than the fitting of one.

Having so far mastered the making of screws, the learner may now try his hand at tempered steel, following much the same procedure as with the soft metal. A piece of good-sized steel wire should be rough-centered on the filing block, hardened and brought back on the bluing pan till tolerably soft. A light blue color will give about the right temper: if left harder than this it will be liable to glaze easily and give trouble. After centering it in the manner just described, turn a good-sized pivot with the point of the graver, keeping it straight and the shoulder clean and square. Begin with pivots as large as the No. 10 hole in Latard's screw plate, and do not reduce them in size till able to make them of a good shape with the point of the graver, smooth and quite true. Then gradually make them smaller, proceeding by easy stages till the smallest sizes are reached. The same remarks apply to conical pivots as to straight ones—the learner must begin with large ones and gradually work his way, striving in all cases to produce the exact shape required. Not only pivots, but all the different forms to be seen on staffs and pinions, such as back slopes, hollows, etc., should be practiced on rough steel. One of the most difficult lessons for the learner is the turning in of pieces, such as staffs and pinions, to exact height or length to meet an end-shake. It is very mortifying, when the piece is completed, to find that it is too long or too short, and very elaborate and ingenious gauges have been constructed to overcome this among other difficulties. But it is at least doubtful if some of these instruments are not calculated to make the learner's troubles greater instead of less. Gauges, to be really useful, must be simple; and it may be said of them, almost more than of any other tool, that there is as much in the use as in the construction. There is really but one way of meeting these difficulties, and that is by attacking them systematically. It is too much to expect that a youth, so soon as he can hold a graver, should be able to execute work requiring great nicety of judgment, even with the aid of the finest gauges. Let him take an old frame and practice fitting pieces by copying the old staffs and pinions. The pinion gauge, or a space filed in a piece of sheet brass, will be the only gauge necessary at first.

Take one of the pinions that has a proper end-shake in the frame and measure off the distance between the pivot shoulders; if the end-shake is wrong, adjust the gauge to correct it. Then turn pivots on either end of a piece of steel, with the shoulders a proper distance apart to fit the gauge. The correctness of the height will of course be proved by trying it on the frame. Only large pivots should be made at first, and, the height having been struck in the gauge, care must be taken in turning the pivots not to back the shoulders. It is just at this point that learners generally fail: in turning the pivots they cut into the shoulders and get the piece too short, or, anxious to avoid this, they allow for it and leave the piece too long. It is work, as I have said, calling for nice judgment with a keen appreciation of trifles, and must be gone over many times before the worker becomes thoroughly familiar with it. Making a pallet staff to a full-plate lever watch is capital practice in this kind of work. Before knocking out the old staff, take accurate measurement of the height of the top pivot shoulder above the lever, also of the length of the staff between the two shoulders. Take a thin piece of tempered steel wire and turn it down a sufficient length to form the staff, fitting it to the hole in the pallets and keeping it slightly taper; polish and glass-burnish it; then gently drive it tight into the pallets and mark off the height for the top shoulder; remove the pallets and make the pivots, being careful that they fit the holes with very little side-shake. The next step should be to practice making pivots, straight and conical, to jewel holes. The pivots, to be quite true, must be turned the exact shape, and, as nearly as possible, to the right size before being polished or burnished.

All this should be preliminary to making balance staffs, fitting cylinders, and such like ambitious efforts: so that, when these higher parts are reached, the ground round about will be so far cleared as to make their accomplishment comparatively easy. It has been said that no one can claim to be master of an art till he can play with it. As applied to watch-making this can only be a half-truth, as our work is not of a kind to be played with. But, stated in another form, the idea is true enough: for in watch-making, as in other things, mastery only comes with a complete loss of self-consciousness, when, from long and constant practice, the faculties move together in unison without apparent effort. To all, therefore, who would excel in turning, my last words would be:—begin at the beginning, make sure of each step as you advance, and work away.

THE DEVELOPMENT OF THE LATHE.

MR. AMBROSE WEBSTER, the head of the American Watch Tool Co., contributes the following article to the JEWELERS' CIRCULAR on the subject of above heading, upon which he, of all others, is perhaps the best qualified to speak. He says:

There is no tool on the watchmaker's bench that is so expensive, valuable, or attractive as a nickel-plated American watchmaker's lathe. It is expensive because in its construction, though there is a comparatively small amount of material used, a large amount of expensive labor is necessary. It is valuable because it is ready for use at a moment's notice, and furnishes the capability to polish pivots and staffs, and perform any of the numerous operations so constantly required in the repairing of watches. It is attractive through its highly bright appearance and delicacy and beauty of form. Through this attractiveness, the lathe proves of value as an advertisement to the owner, for, when a customer, upon entering his shop, discerns the neat and trim American lathe, instead of the rough-looking affairs he remembers were universally used in his youth, he argues that the possessor of the better tools must perform the better work. The efficiency of the American lathe is undeniable; skilled workmen agree that they can do from 20 per cent. to 25 per cent. more with it than with the old styles. The best manufactures have been copied in England, France, Germany, and Switzerland.

As very few watch repairers ever consider the progressive steps in the development of the lathe from its original form used in prehistoric ages, down to its present perfect construction, I think a review of this step in simple outline, will prove of interest and value. In the first illustration the crude, primitive lathe is depicted. It will be noticed that the article to be turned has both its ends, or bearings, fastened in the fork of two trees, and is revolved by a crank. The operator, or turner, holds the cutting tool against the revolving object, his hands resting on the fork of a tree-branch, which is driven into the earth.

There are several minor stages between the primitive form and the ingenious Egyptian lathe; but, my space being limited, I will hurry to a description of this machine. The Egyptian lathe for centuries was in universal use; and, even at the present moment, in some out-of-the-way places still exists. It was originally made wholly of rough wood, and was composed of a spindle and pulley mounted upon a stand, looking more like the frame-work of the door of a log-cabin than a piece of machinery. The power for driving this lathe was as follows: a cord was at one end fastened to the pulley, the other end being tied to a branch of an adjacent tree, which was bent downward to form a spring. A pressure of the foot in the stirrup produced a forward rotary motion which was reciprocated backward by the release of the foot-pressure and the recoil of the tree-branch, the continual pressures and releases producing a constant reciprocal rotary motion. As years became generations, and generations centuries, the material used in the manufacture of these machines, as seen in the illustration, was to change to iron, the principle of regenerating power remained essentially the same, a springy pole being used instead of a tree-branch. The Egyptian lathe has entirely disappeared in America, but, as I have said, still exists in remote parts of Europe.

Until quite recent days, the fiddle-bow was almost every watchmaker's principal tool, and is now utilized by many mechanics. This was, or rather is, but a modification of the reciprocal rotary motion in the Egyptian lathe. It is too widely known to bear profitably a description at this day.

This final stage, the fully developed machine, is shown in the last illustration, which gives an improved foot-wheel, driving to a countershaft, and from the latter to the lathe.

Every watchmaker's lathe should be set up thus to exercise its full value to the workman.

To consider some of the essentials of a perfect lathe. As is known, every article turned will be of the form of the bearing of the spindle; consequently, if the bearing is not perfectly round, the article cannot be perfectly round; the shoulders of the spindle must be perfectly true, or the truth of the turned article will be affected; the spindle of the lathe should revolve with uniform freedom, and must not have hard spots during the revolution; the general use of spring chucks requires that the mouth and throat of the lathe shall be perfectly true and both hard, and that the chucks shall be hard, and ground true after hardening; the tail-stock spindle should also be perfectly straight and round, and fit accurately in the hole. The process of binding the spindle must not have any effect upon its alignment; it is also absolutely necessary that the fine point of the tail-stock shall accurately match and align with the point of the center of the head-stock, to secure which end very expensive tools and machines have been made, adding largely to the general cost of the lathe. The latter essential, capable of fulfilment in a lathe, proves the lathe to be fairly perfect in construction. Some manufacturers are producing a lathe in which the tail-stock may be reversed upon its bed, and either end perfectly align with the head-stock.

Notwithstanding that lathes possessing the above qualities cost fifteen per cent. more than those built without particular care, the difference in the efficiency of the two varieties is a larger per cent. than that of the difference in cost. Every investor hopes for the return of a good dividend, and experience has proved that a perfect lathe pays an annual dividend of fifty per cent.

TO EXAMINE A WATCH.

BEFORE you take a watch down examine the action of the balance wheel, and you will quite often find it to be rubbing slightly on the center wheel, the stud, or the curb pins; push the balance in several directions with a peg, and freely apply the file to the offending pieces. If center wheel and balance are touching, consider the balance foul, and after taking it out, screw the cock on, and drive it over with a blow on a box-wood peg with the hammer; but be sure that the required freedom is attained, and that the balance is free of both the stud and regulator in all positions.

THE TRAIN OF WHEELS.

EXAMINE the train of the wheels. If the scape-wheel depthing is too shallow, as often happens when there is much side-shake, drive the scape-bridge by pressure from behind, if freedom should allow, the second pivot hole being very shallow. A pivot broach pressed by the finger underneath in opening the hole will cut away one side of the hole, into which a French bouchon must be inserted and riveted, and then we have a depthing as the result of a few moments' work, the wheel being uprighted by driving the cock in the customary manner.

FINAL REVIEWS.

WHEN the repairer has corrected the defects and cleaned the watch, and is about to mount it, let him look to the oil-sinks, that they are thoroughly clean, inspect the jewel-holes to see that they are highly polished and firmly set, that the screws are all securely fastened, and when he finds everything in order, he may commence to mount the pieces.

HOW TO FIT WATCH HANDS.

THE fitting on of a watch hand, although slighted in many shops, is a job deserving of a great deal more care than is generally bestowed upon it, and even repairers who take pains with their work neglect several important points. They leave the pipe of the hour wheel too long and that of the minute hand too short, and when they adjust the end-shake of the hour hand, they lay the boss on the hour wheel and the dial so that the end-shake of the center wheel affects that of the hour hand, sometimes giving it too much, and the hour hand is bent by catching the minute hand either in setting the hands or in the going of the watch. In fitting the hands to a hunting case, the examiner should fit the glass as high as the case will admit; ascertain the space available by placing a piece of beeswax on the dial and pressing the glass down on it, and then turning the cannon pinion until it projects from the dial the height of the beeswax. The hour-wheel pipe should rise perceptibly above the dial, and the end-shake of the hour hand be adjusted by the pipe of the minute hand and that of the hour wheel. If the body of the cannon pinion will not bear turning in fitting it to the hour wheel, then it should be opened in the mandrel, as it cannot be kept true by opening the hole in the fingers.

TO REPAINT THE HOURS ON A DIAL.

THE following system has reference to metallic dials, but the reader will be able to select without difficulty the parts that are applicable to altering and retouching the figures on an enamel dial. We can answer from experience for its being successful, but would at once observe that it cannot be practiced hastily, because some skill is essential in addition to patience and care; with them success is certain. Before removing the hour figures and the division for minutes, mark them with a fine steel point, using a lens and proceeding with great caution. These marks will remain, so that after the dial has been colored or otherwise treated, it will only be necessary to trace over them with a fine brush charged with ink. The short horizontal lines at the top and bottom of each figure, termed "serifs," as well as the two circles that enclose the minute division, can be drawn with a sharpened point of the screw-bar compass.

LIFTING SPRINGS.

LIFTING springs of watch cases are often broken. If the watchmaker has none of the right size on hand, and has no time to make a new one, he can mend the old spring and have it just as good as new. Place them close together and bind firmly to a piece of charcoal; then solder with 18-karat gold. It requires a strong heat and plenty of borax; next finish off nicely, heat, and temper in the usual manner.

SPOTTING.

THE process of finishing chronometer and watch plates, by polishing thereon equidistant patches, is called by different names: spotting, snailing, smoothing, stoning, damaskeening, frosting, etc. The plate to be spotted is fixed to the top of a slide rest, and the marks are made with a small bone or ivory tube, which screws into the bottom of the upright spindle. The material used to produce the pattern is a mixture of oil-stone dust and sharp rouge. The plate when fixed in position on the platform of the tool is dabbed all over with the end of the finger dipped in this composition, which must not be at all dry or thick. This upright spindle carrying the spotter is kept constantly rotating by a band from a foot wheel. A spiral spring round the arbor of the spotter keeps it off the work, and a little pressure on a knob at the top brings the spotter into action. The pattern is made by turning the handle of the slide rest equal amounts after each spot until a row is finished, and then moving the transverse slide an amount equal to the pitch of the pattern.

A wavy or watered spotting is produced with water-of-Ayr stone and oil, carefully prepared, or with a piece of wood charged with oil-stone dust, etc. The oiled corner of an emery buffstick can occasionally be used.

To obtain wavy undulations on a smooth piece of metal, the finger should first be placed at the point of commencement of the undulations. Resting the wood or stone against this finger, it is moved a little in a straight line, and then in a series of semicircular wave lines, from right to left or left to right. The finger is advanced through a definite distance, and the operation repeated, and so on.

A very good watered surface can be produced with soft charcoal. With a view to increasing the regularity in the marks, a rule may be laid on the object, against which the charcoal is brought. Parallel watering is usually done mechanically, in about the same manner.

PRINCIPAL INVENTIONS IN HOROLOGY.

THE JEWELERS' CIRCULAR is frequently asked concerning the dates of the principal inventions in horology, and it has therefore compiled them in a chronological form, which is as nearly correct as patient research can make it. It appears, however, that the old masters were not as eager to obtain a patent for every displacement of a screw or introduction of a pin, as our modern watchmakers are, but were content with the knowledge of having introduced a new escapement, a new arrangement of wheels, etc., without letting everybody know who did it. The invention of the balance spring is ascribed to several; the detached lever escapement is claimed both by Switzerland and England; the duplex escapement is said to have been invented by Dr. Hooke; Pierre Leroy; Dutertre, another French watchmaker; again, that it was introduced into England by Thomas Tyrer, after whom it was also called Tyrer's escapement; and, finally, that it was invented by an Englishman, named Duplex. The reader may choose.

Watchmakers of the past century, aided by advancing education, gradually began to comprehend more fully the power and adaptability of wheels and pinions; new escapements were planned and existing ones improved; no less than one hundred and eight are preserved in our various watch collections. The greatest impulse, however, was given by the introduction of the pendulum, claimed both by Huyghens (pronounced Hoyghens) and Galileo, and the balance spring, most probably by Dr. Hooke. The interesting series of inventions commences with the date of the application of the pendulum to clocks, 1656.

1658. Dr. Hooke invents and applies the balance spring.

1675. Barlow and Quare, of London, construct the repeating timepiece, first for mantel-clocks, next for watches. The former, a priest, furnishing the plans, the latter, a watchmaker, executing the work. Besides this, the invention is also claimed by Tompion.

1680. Dr. Robert Hooke constructs the recoil escapement for clocks.

1691. Daniel Quare applies the minute hand. As watchmakers well know, the timepiece had only one hand until then.

1700. Graham invents the mercury pendulum.

1702. Graham invents the dead-beat or "Graham" escapement, and the cylinder escapement.

1704. Fatio, of Geneva, introduces watch jeweling, *for which he receives an English patent, No.* 371, *May*, 1704.

1720. Harrison, the "extraordinary genius," invents the maintaining power.

1726. Harrison constructs the compensated gridiron pendulum.

1754. Caron de Beaumarchais invents the pin escapement for watches, which is claimed by Lepaute, but after a lawsuit awarded to the former.

1754. Mudge invents the detached-lever escapement.

1760. Ellicott constructs a peculiar compensation pendulum.

1761. Harrison, sixty-seven years old, invents the first marine chronometer.

1765. Pierre Leroy invents the compensated balance.

1770. Stodges constructs the half-quarter repeating escapement, mostly used in English watches.

1770. Duplex, an Englishman, invents the escapement named for him.

1780. Arnold invents the marine chronometer with detent escapement.

1780. Earnshaw constructs the spring-detent escapement and the compensated balance, both substantially as now used in chronometers.

1792. Breguet invents the tourbillon escapement.

It was stated above that one hundred and eight distinct escapements have been constructed. Four of these only withstood the touchstone of time, viz., detached lever, cylinder, chronometer, and verge, the latter of which is fast becoming obsolete. Of the remaining three escapements again, the chronometer is used with but few exceptions for marine timepieces, while the cylinder is used only sectionally for cheap grades of watches. We therefore may sum up by saying that there is only one universal escapement—the detached lever.

TO CLEAN CORAL.

FIRST soak them in soda and water for some hours; then make a lather of soap, and, with a soft hair brush, rub the corals lightly, letting the brush enter into all the interstices. Pour off the water, and replace with clean water. Finally dry in the sun.

CEMENT FOR REPAIRING A DIAL.

SCRAPE pure white wax, and mix with equal parts of zinc white; next, melt the mass in a clean vessel over the alcohol flame, and let get cold. The cold cement can be easily pressed into the cracks of the slightly warmed dial, and adheres firmly, assuming a high polish when scraped with a knife. If the cement has become too hard, add a little wax; if still too soft, a little zinc white. Cleanliness in mixing and a little heat contribute to the production of a very white wax.

THE TREATMENT OF GOLD, SILVER, ETC.

THE MISSION OF THE GOLDSMITH.

THE goldsmith expresses in his works the sentiment and culture of his age. The more exalted this sentiment, the purer are the conceptions, and the more artistic the works of the goldsmith. A sober and ignorant age also produces only a miserable treatment of the precious metals. Depraved taste does not understand to array itself in an artistic manner; its low vanity is satisfied with coarse, unwieldy trinkets, or the glittering ornament of a boastful, pretentious style; it overloads itself with bulk, with which it strives to impose.

The goldsmith was originally only a smith, who fashioned gold and silver into useful shapes, as the latter does iron. Growing culture, however, in individual people not only awakened a desire for the possession of useful articles from the precious metals, but the possessor also wished to have its value augmented by more exquisite work so that, as it were, the possessor would be distinguished among men by his superior ornaments. The kings demanded diadems, the heroes golden shields and weapons, the nobles handsome dishes and vessels for their tables, the priests gold and silver ornaments for the temples, and the ambitious citizen, finally, desired spangles and bracelets, rings and chains, to serve as a noble distinguishing mark of his self-respect. The tradesman of whom all these demands were made exerted his taste and ingenuity to always produce something better and purer. The goldsmith no longer cast his trinkets, but gave them finer forms by hammering according to models; he embellished them by engraving into them and chasing upon them arabesques, flowers, figures, and entire pictures, and still enhanced this style by adorning these designs with jewels; he skillfully added single pieces to form a whole by choosing different substances—silver, gold, ivory, and jewels; he invented enamel. And thus the tradesman became an artist, one of the highest rank. He was called on to adorn architecture, and became the chief auxiliary of the architect, the sculptor, the painter. The Bible and many historians of the Greek speak of this rise of the art of goldsmithing among the old nations of culture. Solomon's temple glittered in the pride of gold adornment. Homer exalts the golden arms of Glaucus, and the inlaid shield of Achilles. Semiramis caused gold and silver statues to be erected, and the greatest of all Greek artists, Phidias, was a goldsmith, who built temples, and in them placed statues of the gods in a hitherto unknown perfection. In Samos, Corinth, and Athens, the most excellent goldsmiths manufactured those vessels, ornaments, and masterpieces for which the Romans afterward paid incredible sums, and which we marvel at to-day, as the proof of the eminence of an art vocation.

As previously stated, the goldsmith characterizes in his productions the grade of culture both of his people and age. During the flourishing period of Greece, we find it upon the highest pinnacle of the art; gradually it declines, commensurate with the increase of ignorance and wars, and finally the sun of culture sets behind them. In Rome, where the conceptions of the ideal languished and perished in the viciousness of the emperors and the brutality of the people, the goldsmith finally becomes the panderer simply for the senseless, boastful lavishness, and his art becomes nothing else than a gradually degenerating imitation of Greek works. Heliogabalus adorned his room with gold, only dined from gold plates, drank out of gold and silver vessels, which he presented to his companions, servants, and the hungry multitude before his palace, after nocturnal orgies; he caused gold dust to be strewn in his path, in order to show that he, as the first of Rome, could waste its possession and blood. But art had no companionship with this senseless waste, until, after a night of a thousand years, a new era began to dawn upon it, and as long as the merciful mission of Christendom shall exist the art of the goldsmith will also not perish.

GOLD AND ITS TREATMENT IN SMELTING AND ROLLING.

WE will here state that it is our desire to go through a kind of apprenticeship in respect to the processes employed in the manufacture of gold. We hope that the information thus afforded, beside being very valuable to the practical workman, by giving him facilities which will result in the more successful performance of his work, will prove useful to the manufacturer also, by imparting to him that with which he has hitherto been unacquainted. We shall lay most stress upon those processes of art workmanship and management in which we venture to believe we have been more successful than most of our compeers.

We shall commence with the first procedures in the course of the manufacture, viz.: the preparation of the alloy and its subsequent treatment in the crucible, in order to describe minutely the processes or methods of working with the precious metals.

When purchasing the materials for alloying, where a fair average trade is being carried on, there is an advantage in buying copper in large quantities; but with gold and silver the reverse is the case. Irrespective of the disadvantage of the cash lying idle, gold being always bought for cash, some of its particles are so fine and minute that every time it is moved about or touched some portion is sure to be lost; the quantity may, perhaps, be very small indeed, but when we take into consideration the extremely valuable nature of gold in the above state, the loss in the course of the year may be something amazing. For these and other reasons which could be adduced, we recommend the purchase of gold at the time it is needed, and sufficient for the purposes required.

In preparing the mixture of gold, silver, and copper for the crucible care should be taken in weighing them accurately in order to prevent improvement or deterioration in the qualities of the gold constantly in use. In melting all qualities it is a wise plan to place the lightest of the metals to be melted at the bottom of the crucible, viz.: the copper first, the silver next, and the gold last; by so doing the melter is more likely to get a perfect amalgamation of the metals, as the gold, being the heaviest, is sure to find its way to the bottom of the pot. When spelter is employed it must not be put in until the other metals are melted; being of so volatile a nature, it would be all evaporated before the mixture of alloy was properly incorporated, consequently the bar of gold would fall short of its original weight, the quality would be improved, and the manufacturer would be unable to compensate himself without remelting with an addition of alloy.

Plumbago crucibles are the best for all practical melting purposes, and with care will last from twenty to fifty times; if new, a very small quantity of charcoal powder should be put into the pot with the mixture of alloy. This coats the surface of it, and prevents the metals from adhering. When the gold is at the point of fusion, fling on it about a tablespoonful of perfectly pure vegetable charcoal. The layer of charcoal which forms upon the surface of the gold in the crucible protects the mixture from the action of the air, which would refine the gold by destroying some of the alloy. When perfectly fused, the mixture must be well stirred with an iron stirrer (consisting of a long round piece of iron sharpened at the point), which should previously be made red hot, to render the whole mass uniform in quality. The pot is then quickly withdrawn, and its contents poured into a suitable ingot-mold, previously warmed and greased, to prevent adhesion. The warming of the mold is quite indispensable; but, if made too hot, the metal, when poured into it, will spit and fly about; besides incurring great loss of gold, dangerous results may thereby happen to the person in charge; the same remark applies when the ingot-mold is cold; this part of the process must therefore not be neglected, but carefully attended to. The ingot-mold, we may state, is hot enough when you can just touch it with the hand for a second or two. In nine cases out of ten, if the gold is properly heated in the melting and cast all right with the charcoal flux we have recommended, the working qualities in its subsequent treatment will be found all that could be desired for any purposes whatever.

When it is desired to produce very tough gold, use as a flux a tablespoonful of charcoal, as before, and one of sal-ammoniac, adding it to the gold on the eve of melting; the sal-ammoniac burns away while toughening the gold, leaving the charcoal behind to perform the functions already indicated. The employment of the mixture of sal-ammoniac will bring the ingots of gold up bright and clear; it will also prevent them from splitting or cracking at the rolling-mill, and in subsequent working; if proper attention has been paid to it, the gold will then be found tough and pliable. This does not, however, apply to every kind of alloy, but it may be affirmed of those we have described, and can be safely and thoroughly depended upon.

The furnace used by most jewelers is the ordinary wind furnace, built of brick-work, which is admirably suited for such purposes; a size convenient for every requirement is of the following dimensions: eight inches square inside, and sixteen inches deep from the grate which supports the fire.

For producing tough gold, the employment of common salt as a fluxing agent is sometimes strongly recommended. There is not, however, much to be said for its use, as it produces a very liquid flux, and is not half so clean as the one we have recommended. In the casting, unless very great care is exercised, it runs into the ingot-mold with the gold, producing a brittle-like substance, and this forces itself into the bar of gold, the surface of which becomes irregular and full of holes; on this account alone it is objectionable, in preparing clean and smooth bars of gold. The same may be said of borax, but that is still largely used in the jewelry trade for melting purposes. Nevertheless we are confident, from long practical experience (the result of many years' study and practice, during which time we have worked up many thousand ounces of gold), that there is no better flux than a mixture of sal-ammoniac and charcoal, for every possible purpose required, in the subsequent treatment of the different qualities of gold; and that for toughness, cleanliness, and producing good workable properties it cannot be surpassed.

In melting scrap gold from the workshop, care should be taken to see that it is quite clean and free from organic matter, wax, etc. To effect this it is a good plan to heat the scrap in an iron ladle until all wax or grease is removed; this should be done before the workman weighs his scrap into the warehouse, and should be a special rule of every establishment. It has a great tendency to reduce the working loss, which is almost unavoidable. This kind of scrap is best remelted by itself, and the same flux may be employed as has been recommended for new gold; if the bar of gold should split in rolling, it is due to the presence of some foreign metal, such as lead or tin, or it may be iron or steel. Then remelt the bar with two parts carbonate of potash and one part of nitrate of potash (saltpeter), the saltpeter will draw the iron or steel into the flux, leaving the alloy of gold free. If lead or tin should get into the gold, very serious results follow—a very small portion being sufficient to split a large bar and render it totally unworkable and exceedingly brittle; when broken, the grains appear close and pale. Bi-chloride of mercury (corrosive sublimate) is the best flux to use when these defects make their appearance, in the proportion of two parts charcoal to one of corrosive sublimate, when all will go right again. Sandiver is also a very useful flux when iron or steel gets into the gold. Such gold, when remelted, always loses in weight, some of the alloy being lost on account of the many small pieces of gold of which the scrap consists. This, of course, improves the quality; therefore it is necessary, in order to keep the gold of one standard, to add some small portion of alloy, either silver or copper; but, as the scrap may contain a little solder, copper will be the best to use. The following calculations may be relied upon for the different qualities:

TABLE OF CALCULATIONS.

Wet-colored scrap..	3 gr. copper per ounce.
12-karat scrap.....	6 gr. copper per ounce.
10-karat scrap.....	9 gr. copper per ounce.
9-karat scrap.....	12 gr. copper per ounce.

Any gold bearing the English Hall-mark make no additions.

All qualities of scrap should be well-sorted and undergo the action of a magnet before remelting, and the greatest care exercised in keeping every quality separate.

Sometimes in remelting scrap gold it is necessary to make some addition, either in fine gold or alloy, for the purpose of improving or reducing the quality. This happens when different qualities of goods are required on the spur of the moment, and it may not be convenient to procure fine gold at the time sufficient for the purpose; this is very often the case with beginners who have embarked in business with a limited capital, which may already be partially invested; to such persons the advice we may give may prove serviceable. There may be possibly existing at the time in the work-shops a large quantity of scraps of the regular quality, and if the proper rules for alloying, in reference to reducing and improving the qualities, were understood thoroughly, use might be made of it in the above direction, not only to the pecuniary interest of the man of business, but also to the advantage of all parties concerned. We shall be as simple and as concise as possible in our modes of calculation, and will employ the usual arithmetical signs. In preparing the scrap for reducing, great care must be taken in selecting it free from solder or other impurities, otherwise the calculation, as regards extreme accuracy, will be thrown out; and sometimes this is of importance, but, more commonly speaking, when the quality is not for some special purpose, the difference likely to result is of little importance. The numeral 20 in the following tables will always be consonant, because it represents the number of pennyweights in one ounce of gold. The multipliers and divisors will be different, and will vary with the quality of gold required.

As an example, suppose we want to find how much pure gold will be required to be added to 1 ounce of 9-karat scrap in order to raise it to 15-karat gold, we should proceed thus:

$20 \times 15 = 300$
$20 \times 9 = 180$
$300 - 180 = 120$
$120 \div 9 = 13$ dwts. 8 grs.

Therefore to every ounce of 9-karat gold we shall have to add 13 dwts. 8 grs. of fine gold to make 15-karat gold. The divisor 9 does not represent the quality of scrap about to be improved, but is the difference between the quality manufactured and the numeral 24, which represents the number of karats in one ounce; consequently, when it is desired to improve the scrap, the divisor will always represent the difference between the quality as improved by the addition of fine gold and 24. When it is desired to reduce the scrap the reverse will be the case; the divisor will always indicate the quality to be made.

Let us take another case as illustration of what we mean. Suppose it is desired to reduce some scrap in quality, no alloy being suitable to be found in the alloy book, we shall have to make a sort of guess-work or haphazard calculation. If we adopt the system we are recommending it will become very simple. To reduce 18-karat scrap in order to make 15-karat gold we shall proceed as follows:

$20 \times 18 = 360$
$20 \times 15 = 300$
$360 - 300 = 60$
$60 \div 15 = 4$ dwts.

To every ounce of 18-karat scrap must be added 4 dwts. of alloy. This case clearly illustrates the difference in the divisor between reducing and improving the quality. If it is of importance to know how much mixture of alloy should be added to one ounce of fine gold, in order to produce qualities of inferior standard, the numeral 24 becomes consonant, thus to produce 18 karats:

$20 \times 24 = 480$
$20 \times 18 = 360$
$480 - 360 = 120$
$120 \div 18 = 6$ dwts. 16 grs.

Therefore, in making 18-karat gold, to every ounce of fine gold a mixture of alloy consisting of 6 dwts. 16 grs. must be added. The above examples represent almost every case, and any others which may arise out of them may be safely calculated, taking these as basis or starting point.

THE MELTING OF GOLD.

THE melting of gold is a work performed nearly every day in the goldsmith shop, and would hardly be considered as one occasioning great difficulty. Larger quantities are melted in a crucible, either in a coal fire or in a gas furnace. This method, where gas is cheap, is to be highly recommended, on account of great convenience and cleanliness.

MELTING ON COAL.

It is really a cause of astonishment that there are so many shops into which the melting of gold on coal has not yet been introduced, although it will be seen at a glance that it must be very convenient—of course when a small quantity only is to be melted; from 25 to 30 grams (16 to 19 dwts.) may be melted on a piece of coal. The round branch coals are to be preferred. See that they are thoroughly charred, and contain no cracks. Cut one end obliquely and in it make a medium deep hole, into which lay the gold. In order to keep out the air and confine the heat within, put on a small covering coal. As in the procedure when using a crucible, add the alloy only when the gold is in a fusing state; the labor of the operation may be facilitated by adding a small piece of borax.

BORAX AND SALTPETER AS FLUXES.

Borax has the property of slightly dulling the color of the gold, and, if a lively color is desired, add also a little saltpeter —but only a little, as this agent attacks the copper as alloy, especially when preparing red gold. This effect might be prevented by adding a little charcoal dust. The warmed ingot-mold is placed in a convenient position, with a piece of sheet tin underneath; it may happen when least expected that the coal splits, or, that, in shaking in place of stirring, a little gold flies or runs over. When the gold has been melted well expose it to a soft flame for one moment longer, and when it shows a nice button, pour it, but not with too great haste.

THE BEST MOLD FOR CASTING.

An open ingot-mold should never be used in casting; the gold cast in it invariably labors under the disadvantage of being impure, or cracked upon the entire surface; such a bar will never have as regular a form as when cast in a closed mold. The goldsmith may himself manufacture such a mold very readily and in a simple manner.

MALLEABILITY OF THE INGOT.

Freshly alloyed gold is best suited to stand further working; its not being easily workable is frequently due to the lack of care exercised in the melting and casting. In spite of all patience in the repetition of the melting and the most painstaking care, however, it will have happened to some of my readers that the gold proved to be brittle. It is to be supposed that an annealing fluid would contribute to its toughness. Most suitable for this is perhaps the ordinary nitric acid, as it cleans at the same time the surface, and perhaps creates a thin film of pure gold. It is perhaps best not to anneal it while too hot. Much is also contributed to the ductility of the gold by hammering it; strike it a few times on all sides, and only then bring it between the rollers. Both 8- and 14-karat gold must be glow-heated very often; but 18-karat is best worked up to finishing without glow-heating it, as it is almost sure to crack in this process. If, however, it will not stand at all melt it again, and when liquid add a small quantity of corrosive sublimate. This has the property of expelling the air, for which 18-karat gold has a great affinity; in other words, it assists it in becoming compact. The expert workman will know by the very sound whether gold is ductile or not. If it gives a clear ring when thrown down it is good; if, however, the sound is dull, count on its being brittle.

TO CORRECT CRACKED GOLD.

Should the gold crack only at a few places, the defect may be corrected by welding. Coat it with borax and lay it upon the coal in such a manner that it lies upon it everywhere. Then heat it until it almost melts; it will then be found that the jagged places have run together again, and will not reopen in the succeeding working processes. This, of course, applies only to 18-karat gold. If, however, it will not become tough in spite of all endeavors, it is best to use the particular piece for 14-karat, and try another alloy. It is a first indispensable condition to use only the finest kind of copper for alloying.

THE USE OF SCRAP GOLD.

The use of scrap gold, when used for 14-karat, sometimes occasions great difficulties. It is best to dispense with the many remeltings and refine it well at once, for which the following method can be highly recommended. The gold to be refined is weighed exactly, and with a corresponding quantity of saltpeter placed into a crucible. Upon this invert a smaller crucible with a hole through its bottom, and then lute the joint well with clay. Place the crucible in the furnace, and at first heat slowly; when the vapor issues quietly from the air-hole the gold is melted; keep it in this condition for one-half hour longer; you may then be sure that the saltpeter has operated well, and has refined the gold. When cold, break the lower crucible carefully, so as not to injure the perforated one, which may be used again at some future time. Then weigh the button, add the wanting quantity, melt together, and cast. It will then be malleable.

MELTING WASTE.

In most shops only the entirely clean gold filing dust is melted. Everything else is added to the waste, which is melted together once about every two months, and sent to the assayer for refining. This method is under all circumstances the most convenient, as the jeweler works thus only with good gold and is seldom called upon to refine. In many establishments, even, when it is ascertained that a purchased lot of gold is not as pure as it should be, it is thrown into the waste. Before melting, heat this waste well in a pan, draw a magnet through the pile and take out all the iron. Then mix it well with potash or fluxing powder, place everything into a good-sized crucible, strew upon the surface a layer of salt, which prevents the boiling over, and place the crucible into the furnace. Since, especially in the melting of waste, the crucible bursts easily, great care is to be exercised in regulating the heat well, and that the charcoals lie always compact during the melting. To prevent the crucible from sinking down to the grate when the coals underneath have been burned away, it is well to place it on the lower half of an old one. When the waste begins to behave more quietly, and emits a whiter, beady vapor, the metal has been melted; either cast at once, or else let the crucible get cold, and melt clean. When doing the latter, and a clean button with rounded edges and smooth, arched surfaces is found, the melting is successfully performed; but, if it is flat and sharp-cornered, it still contains foreign metal. Preserve and add it to the next melting of scrap. It will decidedly not pay to attempt to refine the scrap, as the assayer can do it much cheaper and better.

TO ALLOY GOLD.

IT is not always convenient to obtain pure gold to modify our alloys; consequently gold coin is used which is 900 fine, and as our books and instructions I believe without exception only give the rules for pure or fine gold as it is termed, I will give the rules for compounding alloys of any fineness less than $\frac{9}{10}$ from standard American gold coin. The rule for calculating the proportions is the one known in the arithmetics as alligation. There is a feature of the calculations which should be taken into consideration, and that is the absurd usage of a 24-karat standard. All our alloys should be on a decimal basis. If we look for a composition of brass or bell-metal in any work on metallurgy we find the proportions invariably given in hundredths, and so in the present case, as our coin standard is in one thousandths, let us use the same standard in all gold alloys and call 18-karat gold $\frac{750}{1000}$ fine. I presume most of my readers are familiar with the rules of alligation; still one would be very excusable for not recollecting them, as in business life, except to jewelers, they are seldom called into use. The method of working the rule is as follows: We will first, however, give the decimal equivalent for the different alloys in one thousandths:

Fineness in Karats.	1000ths.	Fineness in Karats.	1000ths.
24 =	1000	12 =	.500
23 =	.958	11 =	.458
22 =	.917	10 =	.416
21 =	.875	9 =	.375
20 =	.833	8 =	.333
19 =	.792	7 =	.292
18 =	.750	6 =	.250
17 =	.708	5 =	.208
16 =	.667	4 =	.167
15 =	.625	3 =	.125
14 =	.583	2 =	.083
13 =	.542	1 =	.042

The reader need not be told that to convert the karat expression into decimals, he should add cyphers to the karats fine given and divide by 24; as, for instance, what is the decimal of 18-k.? Add 000 which reduces it to thousandths and divide by 24; 18.000 ÷ 24 = .750. The alligation method is worked as follows: Suppose we have some 10-k. scrap we wish to raise to 14-k.; by adding gold coin 900 fine we would work it thus: Write the desired fineness in decimals to the left (14-k. in decimals being 583) thus:

$$583 \begin{cases} 416 = 317 \\ 900 = 167 \end{cases}$$

then to the right put the decimal of 10-k., 416 (see table), and below this put the gold coin decimal of 900. Still farther to the right we write the difference between 583 and 900, not opposite to the 900, but opposite the 416 or 10-k. decimal, while opposite the 900 we write the difference between 583 and 416. Now, the meaning of this is, if we take 317 parts of 10-k. gold and add 167 parts of coin gold, we will have a mixture (alloy) of 14-k. gold. To prove this let us suppose the 317 and 167 represents dwts. of gold, the first of 10-k. fine is worth say 40 cts. a dwt., and the second, coin gold worth 86 cts., 4 mills a dwt. Now, 317 and 167 added together as 14-k. alloy will make 484 dwts., and this at 56 cts. a dwt. (4 cts. a karat fine), amounts to $271.04. To form this 484 dwts. of 14-k. alloy, we used 167 dwts. of coin gold worth 86.4 cts. a dwt. and 317 dwts. of 10-k. worth 40 cts. a dwt. The first amounts to $144.28 and the latter $126.80; added together they amount to $271.08, the 4 cts. discrepancy arising from the decimals on the 10 and 14-k. as will be seen by taking a series which have perfect decimal expression. Even the slight loss noticed could be reduced to a fraction of a cent by carrying the decimal expression out two figures farther. The truth or accuracy of the rule will be demonstrated by taking such an expression as the following which give perfect decimals, when we will raise some 12-k. to 18-k. stated thus:

$$750 \begin{cases} 500 = 150 \\ 900 = 250 \end{cases}$$

In this case every 150 parts of 12-k. will require 250 parts of coin 900 fine. We will suppose we have 30 dwts. of 12-k. we raise to 18-k.; we make the statement of 150 parts of 12-k. require 250 parts of 900, what will 30 parts require—thus:

150 : 250 : : 30 : the required amount.

We work it out as follows:

$$250 \times 30 = 7{,}500 \div 150 = 50,$$

the required dwts. of coin gold 900 fine. Now, to see how this will pan out by values as above where no loss from decimals will occur. We have 80 dwts. of 18-k. from the 30 dwts. of 12-k. and 50 dwts. of coin gold; now, 50 dwts. at 72 cts. is $57.60. And 30 dwts. of 12-k. at 48 cts. is $14.40, and 50 dwts. of coin gold at 86.4 cts. is $43.20, which added to $14.40 gives us $57.60, the same result as before. In calculations it is as well to use grains; as, for instance, we had 26 dwts., 14 grains of gold, we would express it thus, 534; it would make no difference with the method of stating the question as in illustration of the last proposition of 30 dwts. only we would say 720 grs.; thus:

150 : 250 : : 720 : 1,200 (grs.).

It is almost needless to say 1,200 divided by 24 gives the dwts.

GOLD AND ITS ALLOYS.

EIGHTEEN-karat gold, from the peculiar nature of its alloy, can be wrought into almost any article of exquisite beauty and delicate workmanship; if properly cast, it is both malleable and tenacious. It is also exceedingly ductile. A hardness is imparted to this quality of gold, which admirably adapts it to the manufacture of jewelry of the highest order. There is, perhaps, a difficulty in preparing eighteen-karat gold, not experienced in some other alloys; this defect soon shows itself when subjected to the breaking-down mill, by little cracks all over the surface of the bar of gold; and when this appearance presents itself, it is by far the most economical plan to remelt it at once than to go on with the breaking-down; for when the process of slitting is attempted, the gold will all fly into little fragments, and the probability is that some will be lost. The prevailing opinion in the trade is, that this want of unity or amalgamation of the particles of the gold and alloy is due to the copper which is employed. Our experience teaches us—having tried every kind of copper, from the bean-shot down to the best refined Swedish wire, for the purpose of producing eighteen-karat gold rather cheaper—that we have invariably found that there is not so much in the quality of the copper as in the quantity used. This we wish to state for the benefit of the goldsmiths' trade. Formerly we used a rather large proportion of copper, in order to effect a small saving per ounce, but the misfortune to which we have just alluded sometimes presented itself, and after trying all sorts of copper, with no certainty of permanent success, we thought of the plan of alloying with more silver and less copper. In this we succeeded, and now never meet with a bar exhibiting the defects after rolling just described.

It is the most economical plan, when these defects appear, to reduce the bar to the regular nine-karat quality. It is only right to say that we always found eighteen-karat gold alloyed with bean-shot copper, a more difficult and harder alloy to work with than when the refined wire was used. One great drawback in shot copper (which is very injurious in alloying, particularly in this quality), is that it may contain lead or tin; and half a grain of either in an ounce of this gold will prevent it from working. This quality of gold is now always manufactured fully up to the standard fineness.

COLORS OF GOLD.

Yellow gold—pure or fine gold, 24 parts.

Red gold—fine gold, 18 parts; copper, 6 parts.

Green gold—fine gold, 18 parts; silver, 6 parts.

Blue gold—fine gold, 18 parts; iron, 6 parts.

White gold—fine gold, 12 parts; silver, 12 parts.

Platinum, or fine silver, may be employed for white gold. Red and white are generally employed for flowers, green for leaves, while the stems or sprays may be made of yellow or fine gold. Blue gold may be used for special purposes of ornamentation. This latter alloy requires great practical knowledge, as it presents many difficulties in its preparation; these are best overcome, first, by melting the gold, and then introducing some iron wire into the molten mass, until the proper quantity of alloy is formed. Then the crucibles must be withdrawn, and the composition poured out into an ingot-mold prepared for its reception. This alloy must not be quenched in water, but allowed to cool; the ingot of gold to be perfect should exhibit no signs of porosity; if it turns out of the ingot-mold in proper condition, it must be well hammered upon the edge, and annealed in order to render the grain more close and prevent it cracking in the rolling-mill. This process may be wisely repeated upon the surface, and the ingot again put through the fire. The gold is then ready for the breaking-down mill, and may be safely wrought into wires or sheets of different sizes.

Fifteen-karat gold is another alloy largely used in the manufacture of colored jewelry. This quality, to our mind, is second to none with respect to works of art in jewelry, both in regard to taste and appearance as well as durability. It can be made to look quite equal to the finest gold, and in addition it is easy of manipulation; almost any article can be easily made from it, whilst the hardness which nine parts of alloy impart, is not such as to prove a hindrance or a difficulty in the manufacture, but unites with it that amount of strength and durability which is so essential in costly articles of jewelry. These advantages make articles of this gold wear much better than when made of a softer material; they also keep their form and shape a considerable time longer.

Thirteen-karat gold is called common when speaking of colored goods, for the reason that it is about the lowest quality that can be conveniently colored to look rich and beautiful. A slightly inferior quality (12½-karat) can be colored, but thirteen-karat is about the usual kind employed in all respectable colored-gold houses. In Birmingham a very large quantity of gold is weekly employed in manufactures of this kind.

Twelve-karat gold is the best of the bright golds, and is so called to distinguish it from the colored; although any of the qualities that are described in speaking of colored gold may be made bright by a little variation in the mixture of alloy. No gold inferior to twelve-karat will color to present that appearance which characterizes the higher qualities. Twelve-karat gold finished bright has a fine, rich, sparkling appearance, and when the workmanship is good is very imposing; it is a good quality to work upon, being tolerably soft and ductile, as well as possessing good malleable properties.

Ten-karat gold sustains all the characteristics of the former quality, both as regards facility of manufacture and finish. A large quantity of goods is made of this quality in Birmingham.

Nine-karat gold is regularly manufactured into all kinds of bright goods, and this quality, when made fully up to the standard of fineness, is of a good appearance. After all, the quality which is most extensively employed in every possible description of manufacture, is usually below this standard, probably it is about 8½ karats; and if alloyed according to the appended table will stand the aqua test perfectly well. Nine-karat of the mixture of alloy given in the table will stand more than ordinary treatment from the hands of the workman, and may be touched and removed from the annealing pan while still red hot, without injury to any subsequent manipulation of it; it may also be quenched at any degree of heat in pickle or water, if any advantage is likely to accrue from it; but we strongly object to the continuous quenching of gold alloys at every subsequent process of annealing, partly because every time the metal is quenched in sulphuric acid pickle, a portion of alloy in these low qualities is dissolved. This improves the quality of the gold, by which the manufacturer does not receive any benefit, but is actually a loser. Moreover, we shall see that, when we come to the processes of soldering, this pickling or boiling-out is perfectly indispensable.

Nine-karat alloys, if alloys with too much spelter, will not present the characteristics we have just named in respect to treatment; if shaken or touched while hot, they are very brittle and difficult to work; consequently they take longer in working, and therefore the same quantity of goods cannot be produced in a given time with these alloys as with those we have just described. The great point in the manufacture of gold articles should be to get the greatest amount of real work out of the smallest amount of material, so as to make the least possible waste or scrap for remelting; for this reason we say that the alloys which mostly tend to this object are the best for jewelers to use in their manufactures.

Eight-karat gold is sometimes used in the manufacture of jewelry, and is often styled nine-karat No. 2, in some of the workshops where this quality is somewhat extensively employed. In order to stand the aqua test it must be alloyed with more silver than ordinary nine-karat gold, and when finished appears rather paler to the eye; this may be a partial guide as to quality, but not always a sure one; if properly alloyed it works exceedingly well in any process of preparation, from the ingot-bar down to the finished articles; but, of course, judgment must be used by the workman as to the proper periods for annealing; if this be neglected the gold will become hard and brittle, and, as to the process of preparing proceeds, it will break and fall to pieces.

Seven-karat gold is generally termed common gold, and is about the lowest quality manufactured; it requires extra care in working on account of the very large proportion of silver it contains, which increases the fusibility of this alloy. Care must necessarily be taken in annealing and soldering. The increased proportion of silver is requisite to enable the articles manufactured from it to stand the gold test of aqua fortis. Gold chains of this quality are now very seldom made. The common alloys of gold have much lower fusible point than those of a superior quality.

Pure silver has a brilliant white color, and is the whitest of all the metals; none surpass it in luster; and in hardness it ranges between pure gold and pure copper. It is more fusible than copper or gold, melting at a bright red heat or at 1,873° F. It is commonly used for the purpose of alloying gold in its pure state, but if too much be added it makes the gold pale.

Pure copper has a reddish appearance, and is the only metal of that color; it is both malleable and ductile, hence it is used as an alloy for gold. In fusibility it stands between silver and gold. It is a very useful metal, a large number of cheap alloys being manufactured from it.

Composition is a mixture of copper and zinc, and is used by jewelers in alloying. Some of them profess to have secrets with regard to color, which is produced by different proportions of the composition.

When it is necessary to form hard gold, this metal may be safely employed, although it will not be wise to use too much, about four dwts. to the ounce of fine gold being ample; if, as we have already observed, too much be added, it will make the gold brittle and unworkable. With less silver and more composition an alloy is formed equal in appearance to one, two or three karats higher, but it is very difficult to work, and after being some time in wear it changes color. This alloy cannot be attempted in very inferior qualities, as it will not stand the acid.

TABLE OF ALLOYS.

For 23 karats—23 parts gold, ½ part copper, ½ part silver.

For 22 karats—22 parts gold, 1 part copper, 1 part silver.

For 20 karats—20 parts gold, 2 parts copper, 2 parts silver.

For 18 karats—18 parts gold, 3 parts copper, 3 parts silver.

For 15 karats—15 parts gold, 6 parts copper, 3 parts silver.

For 13 karats—13 parts gold, 8 parts copper, 3 parts silver.

For 12 karats—12 parts gold, 8½ parts copper, 3½ parts silver.

For 10 karats—10 parts gold, 10 parts copper, 4 parts silver.

For 9 karats—9 parts gold, 10½ parts copper, 4½ parts silver.

For 8 karats—8 parts gold, 10½ parts copper, 5½ parts silver.

For 7 karats—7 parts gold, 9 parts copper, 8 parts silver.

For composition—16 parts copper, 8 parts spelter (purified zinc).

The above table represents the full standard quality of alloy (used in England); if it be needful to make an inferior alloy, which is often the case in the manufacture of jewelry, the same calculation in respect to the inferior metals will do, but a small portion of fine gold must be deducted till it brings the alloy down to the value required.

VARIOUS GOLD ALLOYS.

The following mixtures will answer all the ordinary purposes of the manufacturing jeweler for his gold alloys:

Gold, 22 karats, for wedding rings or medals: 22 parts fine gold, 1 fine silver, 1 copper.

Gold, 18 karats, bright: 18 parts fine gold, 4 fine silver, 2 copper.

Gold, 18 karats, colored: 18 parts fine gold, 4 copper, 2 silver.

Gold, 15 karats, bright: 15 parts fine gold, 6 fine silver, 3 copper, or 15 parts 18 kt. bright gold, 2 fine silver, 1 copper, or 15 parts 18 kt. colored gold, 2½ fine silver, ½ copper.

Gold, 15 karats, colored: 15 parts fine gold, 6 copper, 3 fine silver, or 15 parts 18 kt. colored gold, 2 copper, 1 fine silver, or 15 parts 18 kt. bright gold, 2½ copper, ½ fine silver.

Gold, 12 karats: 12 parts fine gold, 8 fine gold, 4 copper, or 12 parts 18 kt. colored gold, 4 fine silver, 2 copper, or 12 parts 18 kt. bright gold, 3 fine silver, 3 copper, or 12 parts 15 kt. colored gold, 2 fine silver, 1 copper, or 12 parts 15 kt. bright gold, 1½ fine silver, 1½ copper, 3 parts fine gold, 12 parts of 9 kt. gold, or 3 parts 18 kt. colored gold, 6 parts 9 kt. gold, or 3 parts 15 kt. colored gold, 3 parts 9 kt. gold.

Gold, 9 karats: 9 parts fine gold, 8 fine silver, 7 copper, or 9 parts fine gold, 7 fine silver, 5 copper, 3 brass, or 9 parts 18 kt. colored gold, 6 fine silver, 3 copper. 9 parts 18 kt. colored gold, 5 fine silver, 2 copper, 2 brass, or 9 parts 18 kt. bright gold, 5 fine silver, 4 copper, or 9 parts 15 kt. colored gold, 4 fine silver, 2 copper, or 9 parts 15 kt. colored gold, 3 fine silver, 1 copper, 2 brass.

HARD GOLD ALLOY.

A very hard gold alloy which may be used for many purposes, is obtained by melting together three parts gold, two parts silver, four parts copper, and one part palladium. The mixture is of a brownish-red color and assumes a high polish. We should think that it would be excellent for jewel holes; a good hard alloy would be preferable to colored glass jewels seen in many low-grade watches.

NOTES ON ALLOYS.

Mr. Guthier, in his work on "Metal Alloys," gives a few suggestions on the subject of fusing the metals: 1. The melting pot should be red hot (a white heat is better), and those metals first placed in which require the most heat to fuse them. 2. Place the metals into the melting pot in strict order, following exactly the different fusing points from the highest degree of temperature required, down to the lowest, in regular order, and being especially careful to refrain from adding the next metals until those already in the pot are completely melted. 3. When the metals fused together in the crucible require very different temperatures to melt them, a layer of charcoal should be placed upon them, or if there is much tin in the alloy, a layer of sand should be used. 4. The molten mass should be vigorously stirred with a stick, and even while pouring it into another vessel, the stirring should not be relaxed. 5. Another hint is to use a little old alloy in making new, if there is any on hand, and the concluding word of caution is to make sure that the melting pots are absolutely clean and free from any traces of former operation.

GOLD SOLDERS.

As it is difficult to procure, at the time when most wanted, alloys for solders that are the most suitable and advantageous for the various kinds of work without no little inconvenience in effecting a proper composition, we here append a list suitable for all the qualities of colored gold work as manufactured by jewelers and goldsmiths:

GOLD SOLDER SUITABLE FOR 18-KARAT WORK.

	oz.	dwts.	grs.
Gold, fine	1	0	0
Silver, fine	0	6	0
Copper wire	0	4	0
	1	10	0

Or 3 dwts. of copper and dwt. of composition instead of all copper.

GOLD SOLDER SUITABLE FOR 18-KARAT WORK.

	oz.	dwts.	grs.
Gold, fine	1	0	0
Silver, fine	0	7	0
Copper wire	0	5	12
	1	12	12

Or 4 dwts. of copper and 1½ dwts. of composition instead of all copper.

GOLD SOLDER SUITABLE FOR 16-KARAT WORK.

	oz.	dwts.	grs.
Gold, fine	1	0	0
Silver, fine	0	8	0
Copper wire	0	7	0
	1	15	0

Or 5 dwts. of copper and 2 dwts. of composition instead of all copper.

GOLD SOLDER SUITABLE FOR 15-KARAT WORK.

	oz.	dwts.	grs.
Gold, fine	1	0	0
Silver, fine	0	10	0
Copper wire	0	10	0
	2	0	0

Or 7½ dwts. of copper and 2½ dwts. of composition instead of all copper.

GOLD SOLDER SUITABLE FOR 14-KARAT WORK.

	oz.	dwts.	grs.
Gold, fine	1	0	0
Silver, fine	0	12	12
Copper wire	0	12	12
	2	5	0

Or 9½ dwts. of copper and 3 dwts. of composition instead of all copper.

GOLD SOLDER SUITABLE FOR ANY COLORED WORK.

	oz.	dwts.	grs.
Gold, fine	1	0	0
Silver, fine	0	15	0
Copper wire	0	12	12
	2	7	12

Or 9½ dwts. of copper and 3 dwts. of composition instead of all copper.

EASILY FLOWING YELLOW HARD SOLDER.

A yellow solder is frequently required in country shops; it must flow at a low heat, and be a hard solder at the same time. Of course, each shop contains its own recipe, each one possessing its own merits, but the following will be found as good as the best: For an easy flowing 5-karat solder, take 5 dwts. gold, 13 dwts. silver and 6 dwts. copper. Melt and cast into bars; as soon as it can be handled, break into pieces and throw into the melting pot; while the pot is hot add 15 grains of brass and melt again; when thoroughly mixed, cast into a bar and roll it out thin for use. Another solder, much used for low grade gold, is made as follows: 3 dwts. gold, 2 silver, ½ copper; melt as above, and at the second melting add, when fused, ½ dwt. zinc in small pieces, and as soon as mixed pour into the mold. This solder runs at a dull red heat; three-fourths dwt. zinc in place of one-half would flow sooner, but would be apt to eat into the work if too high or too low heat was used. But that would be of little consequence if the article to be soldered was of brass.

SOFT GOLD SOLDER FOR 14 KARATS.

Melt equal parts of 14-karat gold and silver solder, and hammer it into thin sheets upon the anvil. This solder will satisfy all the demands of a watch repairer. It is advisable to use silver solder for a low-grade, say 6- or 8-karat gold goods, which consists of 2 parts fine silver and 1 brass, with the addition of a gram of tin.

SOFT GOLD SOLDER FOR 8 AND 14 KARATS.

A nice soft solder for 8- and 14-karat gold consists of 1.5 parts fine silver, 0.5 part fine copper, 1.6 parts 14-karat gold, and 0.4 part zinc; the first three metals are well melted and mixed together, and when well in a fluid state, the zinc is added, the whole left for a few moments in fusion, until it melts, not volatilizes, and then cast.

GOLD SOLDER.

To make a gold solder, instead of reducing the quality of your gold with copper, silver, or brass, use a silver solder composed of three dwts. coin silver and one dwt. English pins. I never keep gold solder by me; when I make a piece of jewelry, as soon as I get the gold worked out, I take a piece of it, and reduce it with about its own weight of the silver solder, with the blow-pipe on charcoal. It matters not if the work is to be bright or colored, it always comes out satisfactory. I, however, make colored work always of at least 15 karats. By what I have said, my solder will be, say, 8 karats. Some will say, perhaps, that such solder will not color; neither will it, but it must be borne in mind that when pieces of gold are soldered together, the surface melts and combines with the solder, thereby improving 8 karats to 12 karats. This, of course, will be a very easy running solder, intended for light work, and where a large number of pieces are to be joined; for a heavy job, do not reduce it quite as much.

SOFT-SOLDERING ARTICLES.

MOISTEN the parts to be united with the soldering fluid, then, having joined them together, lay a small piece of solder upon the joint, and hold over the lamp, or direct the blaze upon it with the blow-pipe, until fusion is apparent. Withdraw them from the blaze immediately, as too much heat will render the solder brittle and unsatisfactory. When the parts to be joined can be made to spring or press against each other, it is best to place a thin piece of solder between them before exposing to the lamp. When two smooth surfaces are to be soldered one upon the other, you make an excellent job by moistening them with the fluid, and then having placed a sheet of tinfoil between them, holding them pressed together over your lamp till the foil melts. If the surfaces fit nicely, a joint may be made in this manner so close as almost to be imperceptible. The bright looking lead which comes as a lining of tea boxes, is better than tinfoil.

SOLDERING FLUID.

AN exchange gives the following recipe for making a soldering fluid for soft-soldering jewelry. Dissolve sheet zinc in hydrochloric acid until the acid will take up no more zinc. Turn off the clear liquid and dilute it with alcohol in place of water. When diluted with water, it must retain acid enough to rust, but with alcohol the dilution can go on until the acid is not perceptible by the tongue.

SOLDERING A RING WITH A JEWEL.

IN order to prevent the bursting of the jewels of a ring, when soldering the latter for repairs, take a juicy potato, cut it into halves, make a hollow in both portions in which that part of the ring with the jewels fits exactly, so that that part of the ring to be soldered protrudes. Then wrap the jeweled portion in fine silk paper, place it in the hollow, and bind up the closed potato with binding wire. Now, solder with easily-flowing gold solder—not upon a coal, but by holding the potato in the hand. Another good way to do the same job is to fill a small crucible with wet sand, bury that part of the ring with jewels in the sand, and then solder.

TO REMOVE SOLDER STAINS.

THE removal of solder stains, to a certain extent, depends on the nature of the article you are soldering. If you are soldering gilt metal, German silver or silver, you may scrape it off. If you use pickle, you will leave a stain that will require to be polished off. If soldering bright gold you can use pickle rubbed on with a cork. With colored gold, it would be better to use a little color. Pickle is merely nitric acid and water, in the proportion of half a gill of acid to a pint of water.

TO REMOVE SOFT SOLDER FROM GOLD AND SILVER WORK.

THE following method is given by Mr. A. Watt: Place the soldered article in a hot solution of perchloride of iron—made by dissolving crocus or jewelers' rouge in muriatic acid—diluting the solution with four times its bulk of water, and there leaving it until the solder is removed. A formula recommended by Gee for this purpose is composed of protosulphate of iron (green copperas), 2 oz.; nitrate of potassa (saltpeter), 1 oz.; water, 10 oz. Reduce the protosulphate of iron and nitrate of potassa to a fine powder, then add these ingredients to the water and boil in a cast-iron saucepan for some time; allow the liquid to cool, when crystals will be formed; if any of the liquid should remain uncrystallized, pour it from the crystals and again evaporate and crystallize. The crystallized salt should be dissolved in muriatic acid in the proportion of 1 oz. of the salt to 8 of acid. Now take 1 oz. of this solution and add to it 4 ozs. of boiling water in a pipkin, keeping up the heat as before. In a short time the most obstinate cases of soft solder will be cleanly and entirely overcome and the solder removed without the work changing color.

RESTORING THE COLOR OF GOLD AFTER HARD SOLDERING.

THERE are different ways, according to the effect desired, as for plain or mat gold, Roman or Etruscan, etc. To describe all would make quite a good-sized book. The simplest and easiest way is to expose all parts of the article to a uniform heat, allow it to cool, then boil it until bright in a pickle made with about ⅛ ounce of sulphuric acid to one ounce of rain water. Another way is to first pickle, then color. Anneal and boil in a pickle made of nitric acid and water, then again anneal black and dip in a coloring mixture made as follows: Put into the coloring pot or a No. 10 black-lead crucible 9 oz. 12 dwts. of saltpeter, and 4 oz. 15 dwts. of table salt. Heat it up without water, then add hot water enough to make a thick paste; let it boil, add 6½ oz. of muriatic acid and stir it up well. In using, keep up a quick and lively fire, and the mixture should boil up till it fills the crucible—which should have been previously well annealed to avoid breaking. The mixture removes more or less of the gold, and the operation should therefore be performed as quickly as possible. With good gold 1½ to 2 minutes will be long enough to expose it to the mixture. The article should be constantly stirred about, taking care not to let any of the surface get out of the color, as the vapors will affect the work. Then rinse it in a pickle, dip in hot water, wash well in ammonia, again dip in hot water and dry thoroughly in hot sawdust. This color may be used with gold ranging between 12 and 20 karats fine, but the finest coloring can be got with about 15-karat gold. If not thoroughly dried the work is liable to become spotted. Much practice is needed to be successful.

WHEN WRONG SOLDER IS USED.

WHEN colored gold-work intended for coloring has, by mistake, been soldered with silver solder, which renders it unfit for the purpose, it can be prepared again for the operation by being placed in tolerably strong nitric acid, of good commercial quality and free from muriatic acid, as the latter would cause the mixture to be decomposed, with liberation of chlorine and dissolution of the gold. The nitric acid solution, if chemically pure acid is employed, will entirely free the work from all traces of the wrong solder, breaking it up and dissolving it without injuring in any way the articles operated upon. After the solder has been removed, and the work taken from the solution or acid, it should be rinsed, annealed and boiled out in dilute sulphuric acid—commonly called oil of vitriol—before re-soldering again with the proper solder. The nitric-acid solution should be of good strength, although not too strong; a good mixture consists of one part of acid to four of water. It should be used hot, and the necessary heat can be kept up to the point required by means of a gas jet.

TO REMOVE SOFT SOLDER.

HOW to get rid of soft solder on such jobs as one has to hard solder. Boil the job in a mixture of crocus and muriatic acid. Take 4 ounces of muriatic acid and add ½ an ounce of crocus in a bottle; shake the mixture well. Take of this mixture 1 ounce and add 4 ounces of hot water, and keep it hot over a lamp or gas flame; put your article in, and in a short time the soft solder will be dissolved off.

SEPARATING GOLD FROM GILT ARTICLES.

IRON and steel articles, says A. Roseleur, are ungilt without any injury to themselves, by dipping them into a bath of 10 parts of cyanide of potassium and 100 parts of water, and connecting them with the positive pole of a battery. A wire or foil of platinum is fixed to the negative pole. This is inverting the position of the poles, and in this case the gold applied upon the iron or steel is dissolved in the solution of cyanide, and partly deposited upon the platinum anode, from which it is removed in a regular gold bath. When there is only a film of gold upon iron or steel, it may be removed by the cyanide alone without the aid of electricity, but the method is slow.

Silver, copper, and their alloys, may also be ungilt by this process, but the cyanide dissolves, at the same time, the gold and part of the other metals; it is, therefore, preferable to operate as follows: For ungilding silver, it is heated to a cherry-red heat, and immediately thrown into a pickle of more or less diluted sulphuric acid. The gold scales off and falls to the bottom in the shape of spangles. The operation is repeated until gold no longer appears upon the surface of the silver, which is then white and frosty. This process is not adapted to light and hollow articles, for which the preceding process is better. For copper and its alloys, in small articles such as false jewelry, thinly gilt, either by battery or by dipping, use the following bath: sulphuric acid, 10 parts; nitric acid, 1 part; hydrochloric acid, 2 parts.

The large quantity of sulphuric acid allows of the solution of gold, whilst it does not sensibly attack copper or its alloys. The sulphuric acid is put alone into a stoneware jar, and the mixture of hydrochloric and nitric acids, kept in a stoppered bottle, is gradually added to it as the operation proceeds. The same sulphuric acid may last a long time if it is kept well covered, and its dissolving action promoted by successive additions of nitric and hydrochloric acids. The articles should be often withdrawn to watch the operation, which is terminated when no gold is seen, and when the copper has acquired a uniform blackish-gray coat; or, by plunging the objects into the compound acids, they will be perfectly cleansed when the gold has all dissolved.

Saltpeter and common salt may be substituted for nitric acid and hydrochloric acid; the salts must be finely powdered and stirred with a glass rod.

For large objects, such as clocks or chandeliers, concentrated sulphuric acid, 66° Beaumé, is put into a glass or stoneware vessel supporting two brass rods. One of these rods is connected by a conducting wire with the last carbon of a battery of two or three Bunsen's inserted elements, and supports the objects to be ungilt, which are entirely covered by the sulphuric acid. The other rod supports a copper plate, facing the object, and is connected with the last zinc of the battery. The electric fluid traverses the sulphuric acid, and carries the gold from the positive to the negative pole; as the copper plate is not prepared for retaining the gold, it falls to the bottom of the bath in a black powder, which is easily recovered. So long as the sulphuric acid is concentrated, and even under the action of the galvanic current, it does not sensibly corrode the copper. As it rapidly absorbs the dampness of the atmosphere, the vessel in which it is contained should be kept perfectly closed, when the ungilding process is not in active operation, and the pieces for ungilding should be put in perfectly dry.

If it is intended to sacrifice the gilt articles of copper or silver, let them remain in pure nitric acid, which dissolves all the metals except gold, which either floats on the surface of the liquid as a metallic foil, or falls to the bottom as a blackish powder. If the liquor is diluted with distilled water and filtered, all the gold will remain in the filter and the solution will contain the other metals.

STRIPPING GOLD FROM GOLD-PLATED WARE.

ACCORDING to the following process the gold may be stripped from a gold-plated article, no matter whether it was fire—or electrically gilt. When stripping with the battery do as follows: Suspend the article in place of the anode in an almost exhausted bath, previously warmed. In place of the goods a piece of sheet copper, insulated in some manner, is best. After the current has been active for a short time the gold will be found to be entirely stripped from the article. The gold is recovered by diluting the stripping fluid with double the quantity of water and adding a solution of sulphate of iron. The gold will be precipitated in powder form, and may then be melted.

The gold may also be stripped by means of a mixture of 200 parts sulphuric acid, 40 parts hydrochloric acid, and 20 parts nitric acid, in which it will gradually dissolve. The articles must always be entered in this mixture in a perfectly dry condition. To recover the gold, dilute this acid mixture with from 10 to 12 times its quantity of water, and add a solution of sulphate of iron. The gold will also in this instance be precipitated in the form of powder, and may then be smelted in the well-known manner.

If the article is of a shape to be scraped, the gold may also be stripped in this mechanical way. The copper of the scrapings may be eaten out with nitric acid, after which the gold can be smelted.

REFINING GOLD THAT WILL NOT WORK.

IT is known to those who work in gold that there are times when a piece of that metal cannot be got to work; so, after having tried all the usual methods of refining and re-alloying, etc., only to find that our time has been wasted, and the gold as obstinate and unworkable as ever, that we are compelled to resort to a chemical process; we accordingly refine it once more, giving it lots of saltpeter, a good heat, plenty of time—throwing in a pinch of table salt when the crucible shows a disposition to boil over. The result is an alloy composed of gold and silver. Nitro-muriatic acid will not dissolve this, because, after eating the gold off the surface, further action is prevented by a coat of silver that remains. In like manner, nitric acid will not act upon it. Under such circumstances it is customary to melt about eight times its weight of silver with it, and when really hot, to pour it into a large vessel of water while an assistant agitates it briskly with a stick, so as to cut it up into small shot. (Some roll it out.) It is then dissolved with nitric acid, which leaves the gold in the form of a black sediment, which, on being dried, turns to a beautiful brown powder, and on being melted with a little borax runs out fine gold. So far there is nothing new. We will say that we have two ounces of this alloy. This will require about sixteen ounces of silver. By the way, I have known people to borrow old silver from their neighbors in the trade, to be returned after having used it for this purpose. This is the predicament I was in. I had no old silver; no neighbors to borrow from, and did not care to melt so much coin, especially as I had no use for it afterward; and still I had urgent use for this troublesome gold. I thought over the difficulty, and determined, although I had never known of such a thing being done, to use pure copper in the place of silver, with the most gratifying result—in fact, consider it much better than silver, for while copper only needs cold nitric acid and to be set aside where the fumes can escape, silver requires heat and constant attendance. The solution must now be decanted off the sediment into another vessel, and table salt added to it to throw down the silver; both these precipitates must be well washed in several changes of water, allowing them plenty of time to settle each time, and dry them well before putting them in the crucible to melt. The copper is recovered by putting a couple of iron bolts or pieces of iron into the remaining solution, upon which it will be found to deposit, and is pure, suitable for alloying gold.

HOW TO UTILIZE GOLD SCRAPS.

AMONG the old scraps of gold which accumulate in a jewelry store are many pieces which are more or less contaminated with soft solder, and as a very small amount of this material will render gold unfit to work, it stands one in hand to look out that none gets in with the scrap we melt. It is well to put all such bits as show any trace of this precious substance into a box by itself and treat it in the following manner: Take 4 ounces of muriatic acid and add ½ an ounce of crocus; put these two ingredients into a bottle and shake them well together. Put 1 ounce of this mixture into 4 ounces of boiling water in an ordinary teacup; put the scrap gold contaminated with soft solder into the teacup and keep the mixture hot over a lamp or gas jet, and in a few minutes all the soft solder will be dissolved off, leaving the scrap fit to be melted with other scrap gold. In a former article the writer gave a method of melting, and promised some future time to give additional methods for refining scrap and gold which worked badly. It is a business of a lifetime to be a proficient in gold melting, so many details have to be mastered; trifles in themselves, but still going a long way in making up the sum of knowledge necessary to the gold worker. Economy is one essential thing in all jewelry repair shops. Save your scraps and filings; pick out all the scraps large enough to be picked up with the tweezers and put into your scrap to be melted. In regard to filings you should have a good-sized steel magnet to pass through your filings to remove all iron and steel filings and chips. The manner of using the magnet is to simply run the two poles of the magnet back and forth through the pan of the bench at which you work, brushing off the particles of iron as fast as they accumulate, letting the iron filing go into the sweep, as they will mechanically carry away some gold. The sweepings of even a small place is far more valuable than most persons would imagine, and should be carefully saved. The floor of a jewelry repair shop should be carefully laid to avoid cracks and corners. The best way, if a floor is to be laid new, is to have the plank of which the floor is to be laid well seasoned and quite narrow. After the floor is laid it should be well oiled with boiled linseed oil or painted with oil paint, and the cracks puttied with hard putty composed of white lead and coach varnish—the kind of coach varnish known as rubbing varnish—the puttying should be done after the oil is applied or the paint put on. The varnish putty is difficult to use, as it dries very quickly; keep it under water except as fast as you use it. If you have an old floor full of cracks, put sheet zinc over the whole floor where you work; let the sheets lap well, and if a hole wears through, put a piece over it as soon as seen. A common soft wood floor will hold an unbelievable amount of scrap and filing, to say nothing about the cracks. This is true also of oilcloth, and an old oilcloth which has been on the floor for any length of time should be burned and the ashes put into the sweepings. Scraps of paper and old match sticks lying on the floor should all go into the sweepings. These sweepings should be put in a tight box or barrel until enough have accumulated (say a barrel or two) to pay for burning. The way to burn sweepings is, if you use a stove, clean it out when you are going to burn a lot of sweepings, and put the dirt with the scraps of paper in a little at a time until all is reduced to ashes. A barrel of sweepings will be reduced in this way to two or three quarts; this reduction is another economy when you come to send it to the sweep smelters, which it is better to do than to try and recover the precious metals it contains yourself. Such a melting furnace as the writer described in a former article is a good place to burn sweepings in. The residue of three or four barrels of sweepings can be put in an old paper flour sack, and the flour sack, which will not permit a particle of anything it contains to escape, can be put in a quite small box and shipped to your sweep smelter, whom you will notify of the shipment and mention how you treated your sweep. After burning such a lot of sweepings you, of course, will be careful to remove every particle from the stove or furnace, as the gold being heavy will fall to the bottom. A person working gold or silver should brush his clothes and apron with a bristle clothes-brush kept for this purpose before leaving his work. Treat filings as follows: They should be melted by themselves with a flux composed of 2 parts of carbonate of potash (*sal tartar*) and one part of nitrate of potash (*saltpeter*). This flux will remove the iron and steel particles which escaped the magnet. The button of gold should be remelted with sal-ammoniac and charcoal powder and cast in the ingot-mold. If, on attempting to roll it, it cracks, it is a pretty sure indication that some lead or tin is present; but if the precaution given above is taken of treating the suspected scrap with the muriatic acid and crocus, there is very little danger but the gold will come out in condition to roll and work well; but if it does crack, remelt it with a flux of charcoal and corrosive sublimate, two parts (by weight) of charcoal to one of corrosive sublimate. This treatment will destroy the last trace of lead or tin. Sometimes one will get hold of old gold pens with iridium points; these points should be carefully removed, as they are pernicious things to get into gold you have to work, being so hard that a file will not touch them, and they will also indent the hard steel rollers. If only one or two such points get into an ingot, they should be instantly cut out with a small cold chisel. But if quite a number of such points should get into a lot of gold, the way to proceed is to remelt the lot in a crucible which has a strongly marked hollow conical bottom. The heat should be raised (using fine charcoal as a flux) until the gold is rendered very fluid. The crucible should now be removed from the fire and allowed to cool. On removing the button from the crucible, all the pen points will be found to have settled to the bottom of the crucible, and now are congregated at the very apex of the cone of the gold button. The reason for this is that iridium being heavier than gold (and not melting as easy), when the gold was in a melted state settled to the bottom. The part of the button containing the iridium points can now be cut off with a cold chisel and treated as follows: The gold can be dissolved in *aqua regia*—composed of two parts of muriatic acid to one of nitric acid; after the gold is dissolved the acid can be poured from the points (now visible and separated); to the gold solution add oxalic acid crystals until the brown deposit ceases; this brown deposit is pure gold and can be melted into a button with a blow-pipe, using carbonate of potash as a flux.

TO WORK GOLD SCRAPS.

The following process is very useful for working up filings and scraps of gold, gold-plated jewelry, etc. It does not, of course, refine the gold as in the usual process of quartation, but merely destroys the filings of copper, silver, German silver, brass, and other metals acted upon by the acid. It will "eat" the solder or brass out of hard-soldered or plated goods, leaving the thin shell of gold. The iron filings are thoroughly separated from the mass by the repeated use of the magnet. All pieces of soft solder and lead should be picked out, and if there is much soft solder in any of the plated articles, it should be melted out, and the residue then placed in a shallow glass or china vessel, and rather more than covered with good nitric acid. When the bubbles cease to agitate it, the acid should be poured into another cup, and if there is any base metal left, more acid added, and the mass stirred occasionally with a glass rod. When no bubbles appear on adding new acid, it may be poured off, and the filings, scrap, etc., washed two or three times, or until perfectly clean, letting them stand a minute or two to settle before pouring off the water. They are then dried and melted. The filings and scraps treated in this manner seldom require more than one melting to make them easily worked and fit for jobbing. There is no skill required, only considerable care in the handling. The silver remaining in the acid may be precipitated in the ordinary manner with common salt. The chloride obtained may be melted into a button, and, being pure silver, used as an alloy for other gold.

TO REDUCE JEWELERS' SWEEPINGS.

THE fire for burning the sweepingsto reduce the bulk should be a smoldering one, with as little direct draft as possible, as a strong flame has a tendency to carry more or less gold up the chimney. The safest and most economical method is to put the sweep into an iron pot, with an iron cover, and put the pot into the furnace and burn the contents out by a slow combustion. But, if the process is conducted in a workmanlike manner, with the precaution of making the combustion as slow as possible, very little gold will be lost. The acids used in coloring and pickling should not be thrown away until treated to recover the gold. All wet coloring acids and muriatic acid pickle after using should be thrown into a stoneware jar, and when nearly full treated as follows: A saturated solution of green copperas (*proto-sulphate of iron*), in the proportion of 8 oz. of hot water to 1 oz. of the sulphate. In getting the sulphate it is best to get such as is used for medicinal and chemical purposes, as it is essential to be pure; also avoid all such pieces as are air slacked or present the look of rusty iron; such pieces are chemically changed to such an extent as to be deleterious to the process. The solution of sulphate should be added to the acids in the stoneware vessel until it fails to produce any effect. Allow the precipitate to settle (after stirring well), when the acid can be poured off. The precipitate is nearly pure gold, and if of sufficient quantity can be directly recovered by melting with a strong flux. By a strong flux I mean one which will resist a high temperature, as the complete reduction of the gold will require intense heat. After the precipitate is thoroughly dried, to every 4 oz. of precipitate add 2 oz. of sal tartar (*carbonate of potash*), 1 oz. of common salt, 1 oz. of green glass (any glass which contains no lead). All the ingredients should be reduced to a fine powder and well mixed, when it can be put in a crucible. While the melting is going on a little saltpeter can be added occasionally to aid the process. But in small quantities the precipitate can be thrown into the burnt sweep; as also the old sulphuric acid pickle used in jobbing. The true course to pursue, as far as scouring is concerned, is to look sharp to all the filings of gold on plated jobs. There is more gold wasted here than in any part of the job shop. And as I remarked in a former communication, the gold derived from filings seldom or never works well; and for this reason it is best to melt it into a button, so as to get at the fineness, and sell it to the refiner. The best course to pursue with filings ("*lemel*," it is termed) is to first pass it through a fine sieve to remove all pieces of gold of any size; these should be put in with the scrap. After all the coarse particles of gold and silver are removed, the magnet should again be employed to remove any iron or steel particles which may remain. In refining and melting filings, for every 12 oz. of filing take 2 oz. of sal tartar (carbonate of potash), 1 oz. of common salt. Mix the filings and flux together well, and put them into a crucible and cover the mixture with common salt. The crucible should now be put into the furnace and a continual high melting heat kept up for 30 or 40 minutes, adding a little saltpeter from time to time. Care must be taken to add the saltpeter sparingly, as it may cause the mixture to rise and flow over. A little very dry common salt if added, as indications of rising too high occur, will check it.

BRITTLE GOLD.

THE goldsmith is often puzzled to soften gold so that it can be forged out thin without cracking or breaking. Some gold can be forged out easily, while other varieties are very hard and brittle, because the impurities or alloys, such as a little lead or zinc, tend to make it so. Melting over a stone coal fire would do the same. Gold should be melted over charcoal or coke, and if of low grade, should not be exposed to the heat too long. If it has no "grain," melt again. If it does not take grain, then melt again, and add a little saltpeter, and, a little later, some borax. For ordinary melting, fuse with borax, stir well and add a little sal-ammoniac just before pouring. In forging gold, it must be annealed as often as it begins to get hard and brittle. Low grade gold needs annealing oftener than fine gold. Heat red hot and cool without tempering.

TO TOUGHEN BRITTLE GOLD.

If the gold ingot shows sufficient ductility to withstand the first two or three annealings without cracking, it may be considered as sufficiently tough for being worked; if, however, it cracks, recourse must be had to a sort of mold casting, what the French call "brassage." This process is performed by taking a soldering coal sufficiently large to receive the ingot. It is prepared for the purpose by working with a file, a half round hollow in it. The ingot is then heated upon a coal to nearly white heat, is laid in the hollow of the prepared coal, and covered with borax everywhere to facilitate the melting; direct the flame of the soldering lamp with a heavy wick upon it, using a long blow-pipe; maintain the flame until the surface begins to melt, whereby all the cracks disappear, without raising the temperature sufficiently, however, to either shorten the ingot or separate it into several pieces. The necessary degree of heat will be recognized as soon as the bar begins to give way and conforms to the smaller angles of the coal, as well as by the rainbow hues that begin to appear upon its surface, and finally by the disappearance of the cracks. When the ingot has reached this degree of heat throughout, the operator may be assured of its malleability.

DISSOLVING AND PRECIPITATING GOLD.

TWO processes frequently occur in goldsmithing and electro-plating, viz., the solution and precipitation of gold, and the operator often meets with difficulties or is in doubt; so valuable a material as gold cannot be treated with levity.

As regards the dissolving, the nitro-muriatic acid is generally used in too concentrated a state. The workman most generally goes by guess work and takes as much as he considers about right, now nitric acid, then muriatic acid, and finally he is in difficulties to remove the excess of acid, especially nitric acid. How easy it would be for him to compound an *aqua regia* according to the following formula:

4 parts by weight of crude muriatic acid,
1 part by weight of crude nitric acid,
5 parts by weight of pure water.

Of this mixture generally will suffice 10 parts to 1 part of gold.

It is enough if the gold is in a passable state of division. With thick pieces a little more mixture is subsequently to be added, until a perfect solution has ensued. It is well to weigh also the subsequently added portion.

The writer performs his solutions in a weighed porcelain dish or glass retort in a water bath, and is not in any manner troubled by the evolving of red vapors. That the solution takes place can be seen from the outside by the yellow color of the fluid and the bubbles arising from the gold.

A water bath is easily made; take an iron or earthen pot, upon the rim of which the dish or the glass retort rests, fill this pot with water and heat it. The gold hereby receives simply the heat necessary for effecting of the solution from the arising steam, and no fear need be entertained that something may go wrong. One-half of the solution having evaporated, which can be ascertained by weighing—for instance, you used 10 grams gold and 100 grams *aqua regia*, there must be left 50 to 51 grams; dilute this solution to 100 or 200 grams, and you will have a solution, each gram of which contains $\frac{1}{10}$ or $\frac{1}{20}$ gram of gold.

The writer always found such a solution to be free from nitrate, and it may safely be used for every recipe.

THE PRECIPITATION OF GOLD.

The gold from galvanic baths is easiest precipitated with the galvanic current upon a smooth copper plate; the gold which does not precipitate as a powder is scraped off and purified, as well as that which precipitated as powder. Impure gold, which chiefly consists of gold, however, is dissolved in the indicated proportions in the *aqua regia* specified above; it is then evaporated to one-half, diluted with water, filtered and washed out with large quantities of water. This washing is continued until the escaping fluid is water, clear and no longer colored by sulphate of iron.

Meanwhile a solution of handsome crystallized sulphate of iron has been prepared, as follows: To 10 grams (6 dwts. 10.32 grains) sulphate of iron, 100 grams water and 10 grams muriatic acid.

For precipitating the gold suffices the 4½ fold quantity of crystallized green copperas of the impure gold used.

In order to precipitate the gold, pour its solution into the copperas solution. The gold will very quickly fall down in this diluted fluid; decant the clear liquid, and first wash with water acidulated with muriatic acid, afterward simply pure water. Collect the gold in a porcelain dish, drain off the wash water as closely as possible, and let it dry in a moderately warm place.

LAPPING.

THIS is a distinct process of finishing jewelry work. It is not much resorted to in colored work, and when it is employed, it is sometimes performed before the articles are colored, and sometimes after, according to choice. It is distinguished from scratching, by the evenness of surface and the luster it leaves upon the parts to which it has been applied; and this can be ascertained by an examination of the work after this operation. It is principally confined to bright gold chains and earrings, a class of jewelry to which its adaptation is most suitable, as it enhances the beauty of their appearance very much. The lapper produces the plain and diamond-shaped surfaces by the rotary action of the lapidary's wheel, which consists of a specially prepared composition disc, secured in the lathe vertically upon a horizontal spindle. This has a shoulder in the middle, against which the disc of metal is firmly held by a nut and screw from the other side. This lap or disc weighs about five pounds, and is made of a mixture of two parts pure grain tin to one part of pure lead; to which, for edge-laps, may be judiciously added one pennyweight of fine copper to every pound of mixture. To effect a complete amalgamation of the component parts, the lead, being the least fusible metal, should be first melted and the tin afterwards added, first well heating, to prevent too sudden a chill of the lead. If necessary to add the copper, it should be melted separately, and added to the other ingredients when in the liquid state, and be well stirred. Care should be exercised in the casting, in order to prevent waste.

The lap having been properly adjusted by skimming, it is then "headed in," a process performed by the application of flour emery, by means of a brush, to the right-hand side of the lap, and pressed in with a hard flint stone. In heading in a lap, the emery is used in the wet state. This done, the gold-cutter, as he is familiarly called, takes his work, and submits it to the revolving lap or disc; but before doing so, he submits it to a preparation he has by the side of him, which is used for protecting the gilding or surfaces not subjected to his particular work. He dips the articles into a liquid mixture of gum arabic, two parts, and gamboge, one part; they are then well dried, but must not be overheated; this has a tendency to protect the gilding whilst under the manipulative skill of the gold-cutter. This gum or cement is soluble in hot water; consequently, in washing out, it parts from the gold, and leaves a color upon the work. The lapping process is a curious one, and it is truly marvelous to see the skillful and practiced workman turning the links of gold chains between his thumb and finger with great dexterity and accuracy; and while to all appearance it seems as if they are being presented in a haphazard fashion to the lap, the most perfect-shaped diamonds are being produced. This is called faceting.

Square-lapping is now extensively practiced; it adds a sharpness and luster to the work not equaled by any other means. The gold taken from articles during the process of lapping remains—the greater portion of it at least—upon the lap. The emery cuts and retains the gold upon it; this, however, is prevented from interfering with the process by wiping the side of the lap with a tow of cotton waste, dampened with oil. This cotton waste must be strictly preserved and subjected to a special mode of treatment for the recovery of the metal.

ACID COLORING.

COLORING gold articles is a process for dissolving out more or less of the alloy, to give them a surface having a different quality or fineness from its previous surface. For good gold, that is, 18-karat or finer, melt in a common pipkin the following articles: No. 1.—Alum, 3 ounces; nitrate of potassa (saltpeter), 6 ounces; sulphate of zinc, 3 ounces; common salt, 3 ounces. When melted, mix well together, and immerse the articles to be colored in it, removing occasionally to examine the color. When the color appears satisfactory remove the articles, place them on a piece of sheet iron and allow to cool, then immerse in dilute sulphuric or acetic acid, which will remove the flux, after which they may be rinsed in warm water, to which a little potash or soda has been added, and finally brushed with hot soap and water, again rinsed in hot water, and dried in clean warm boxwood sawdust.

For inferior qualities of gold, that is, from 18-karat down to 12-karat, use the following composition: No. 2.—Nitrate of potassa (saltpeter), 4 ounces; alum, 2 ounces; common salt, 2 ounces. Add warm water enough to make the whole into a thin paste, place it in a small pipkin or crucible, and boil. Attach a thin wire to the article to be colored, and hang it in the paste, allowing it to remain from ten to twenty minutes. Then remove it, rinse in hot water, treat it with the scratch-brush, rinse again, and replace in the coloring pot for a few minutes. The length of time it is subjected to the action of the coloring bath depends of course on the amount of alloy to be removed. When the color suits, the article is removed, rinsed and scratch-brushed as before, then brushed with soap and hot water, again rinsed in hot water, and dried in the sawdust.

When the articles are of as low quality as 12-karat, if they are slightly made, great care must be used or the coloring process will eat away so much of their substance as to destroy their strength. The coloring paste should not be used on articles lower than 12-karat.

Electro-plated articles are often colored, but they must have a good thick plate on in order to stand it. The following is considered a good composition: No. 3.—Sulphate of copper, 2 dwts.; French verdigris, 4½ dwts.; chloride of ammonium (sal-ammoniac), 4 dwts.; nitrate of potassa, 4 dwts.; acetic acid, about 20 dwts.

Reduce the sulphate of copper, sal-ammoniac and saltpeter to a powder in a mortar, then add the verdigris, and finally pour in the acetic acid, a little at a time, stirring it well all the while, till the whole becomes a bluish-green mass. Dip the article to be colored in this, then place on a piece of sheet copper, and heat over a clear charcoal or coke fire till it becomes black. Then let it cool, after which put it into a tolerably strong pickle of sulphuric acid and water to dissolve off the flux, rinse well in hot water containing a little potash or soda, brush with soap and hot water, and dry in the sawdust. If the article is scratch-brushed being colored, it will come out of the pickle perfectly bright.

Another preparation for coloring either gold or plated articles is: No. 4.—Nitrate of potash, 5 ounces; alum, 2 ounces; sulphate of iron, 1 ounce; sulphate of zinc, 1 ounce. Mix well together, then add water to form a thin paste. Dip the article in this, gently shake off any superfluous paste, place on a piece of sheet copper and heat till dry. Then increase the heat for two or three minutes, plunge into cold water, and finish as before described.

Preparation No. 1 may also be used for coloring plated goods (heavily plated), by dipping the articles in and heating, etc., as described under No. 4, till nearly black, then plunge into cold water and finish as there directed.

Gilt articles of poor color (as well as gold articles) may be improved by the use of gilder's wax, No. 1; beeswax, 4 parts; verdigris, 1 part; sulphate of copper, 1 part. Melt and mix well together. No. 2.—Beeswax, 5 parts; alum, 1 part; verdigris, 1½ parts; red ocher, 1 part. Melt the beeswax and mix well together.

This wax is used by heating the article, rubbing the compound over it, then placing it on red-hot charcoal till the wax is all burned off. Place in very dilute sulphuric acid to clean it, scratch-brush it, wash, etc., as before.

Nearly every manufacturer has his own secret process for "coloring" gold, which they are not at all likely to give away. But the foregoing processes are considered good, and will doubtless meet all the cases.

ACID COLOR FOR 14-KARAT GOLD.

Saltpeter, 4 parts; salt, 2 parts; muriatic acid, 3 parts. Put the first two ingredients in the pot and heat strongly; add a little water; let boil up and when it becomes a thin paste add the muriatic acid; stir and put in the work, taking care to completely submerge it in the color; let it boil two minutes, then add as much water as you did muriatic acid, make it boil quickly again for two minutes, take out the work, boil in hot water, then in another pot of hot water to which a few drops of muriatic acid have been added, and afterward rinse in hot water and dry in sawdust.

ACID-COLORING SOLID GOLD.

Saltpeter, 2 parts; salt, 1 part; muriatic acid, 1 part. Put saltpeter and salt into the coloring pot, and heat it without water, then add hot water sufficient to produce a thick paste, let it boil, add the muriatic acid and stir it up well. As soon as the brown vapor arises, plunge in the work quickly, being careful to submerge it completely (since the vapor will affect the work if exposed to it). Let the work boil over a quick and lively fire (and preserve it during the whole process) for about three minutes, stirring it about constantly, taking care not to let any part of it come to the surface of the liquid. Then rinse the work in a light pickle, and thereupon plunge it into hot water. Quick and careful handling in dipping in and taking out the work is important. This done, the acid color should be thinned by adding hot water, or one-half old color, which is preferable. Submerge the work again, let it boil two minutes, and should some pieces require it, such should boil one minute longer. Now boil the work in a pickle, two thimblefuls of muriatic acid to one gallon of water, then again in a pickle containing only a few drops of acid, then dry off the work carefully in hot sawdust. Remember that work not properly dried will draw spots.

ACID-COLORING SMALL ARTICLES.

For acid-coloring on gold for small articles, a very good plan is to place them on a lump of charcoal, and make them red hot under the blow-pipe flame, and then throw them into a pickle composed of about 35 drops strong sulphuric acid to one ounce of water, allowing the article to remain therein until the color is sufficiently developed; washing the article in warm water in which a little potash has been dissolved, using a brush, and finally rinsing and drying in boxwood sawdust, completes the operation.

PREPARING FOR WET COLORING.

THERE are several methods of preparing work for wet coloring, each operator adopting the one which suits him best and appears to claim an advantage over the others. We do not intend to assert that there is any particular advantage in the adoption of any particular process. The main principles are thorough polishing (this need not be so much the case as for dry coloring, though it is of great importance) and cleanliness, the latter element being very essential in the production of a good color. The operator cannot be too careful in enforcing these two conditions.

Some persons prefer to color from the black anneal; others to boil for a time in nitric acid pickle; others, again, after the work has been well annealed, boil out in sulphuric acid pickle, and afterward in clean water. In adopting any of these plans, the method is that after the work has been well polished by means of the finest materials and washed out, it must be placed upon an iron or copper pan and heated to redness over a clear fire, the latter proceeding being of importance. If it appears greasy in the interstices and it is desired to color it black, it should be boiled out again and annealed; it may then be placed aside to cool, and afterward suspended upon the wires usually employed for this purpose. In the work of re-coloring articles it is by far the best plan to anneal them. Where this can be done, boil them out and again anneal them, which is easily performed. It is an economical plan to re-color goods of this sort in old color, which should always be preserved for the purpose. If this appears dry, or nearly so, when put into the pot, add one ounce of acid and one ounce of water; if tolerably liquid make no addition whatever, for, in some instances, and especially where the alloys contain a great proportion of copper, the weaker the preparation the better and brighter is the color produced upon the work.

FINISHING THE WORK.

After the process of wet coloring, it is absolutely necessary that the work should go through another operation, that of "scratching," which consists of submitting it to the revolving action of a circular brush of fine brass wire, mounted upon a lathe after the manner of the round hair brushes used in polishing, and upon which a weak solution of ale is allowed to run from a small barrel with a tap to it. This removes any dull color that may be upon the work and gives it a perfectly bright and uniform surface. Frosting is effected by keeping the points of the wires of the brush quite straight and running the lathe very fast, just letting the ends touch the surface of the work; to do this accurately requires great practice. After this process has been performed, the work must be well rinsed in either hot or cold water, and finally dried in warm boxwood sawdust, which must not be allowed to burn or char in any way; if so, the color of the work will be much damaged and its beauty marred. A soft brush will remove all traces of sawdust from the interstices of the articles which have passed through this operation.

WET COLORING BY THE GERMAN PROCESS.

TIE up your work in small bunches with fine silver or platinum wire; then, for 3 ounces of work, take a black lead pot 6 or 7 inches high, and having previously placed your work in hot water, put into it 6 ounces of saltpeter and 3 ounces of common salt; stir them well with a wooden spoon, and when thoroughly dried fine and hot add also 5 fluid ounces of hydrochloric acid. When boiling up, put in your bunch of work, having previously shaken the water from it, and keep it moving for three minutes, taking care to keep it well covered all the time of the operation. At the end of this time take it out, and plunge it into a vessel of clean hot water, and finally into a second vessel of the same. Then add to your color in the pot 6 fluid ounces of hot water, and when it boils up again after having been thus diluted, put in your work for one minute longer, and again rinse it as before directed, when it will be found to be of a beautiful color. Too much clean hot water cannot be used for plunging the work into each time.

If the work is hollow and bulky, not as much as 3 ounces should be put in, as it is not effectually immersed in the pot.

In wet coloring, it sometimes happens that the color is rather dead, or it may happen that the "color" burns, which causes the work to look brown; this is a precipitation which may be removed by scratch-brushing at the lathe with stale beer, using a fine brass wire brush similar to the round hair brushes used for polishing.

In coloring, a large stone jar should also be provided, into which should be emptied your "color," when done with, because the pot should be worked out each time, so as to be ready when wanted again; also the wash-water used, as it contains quite a percentage of gold. All things in connection with the process should be kept clean and free from grease of any kind. Do not keep iron near this wet color in the pot, as it is most injurious.

AN EXCELLENT WET COLORING.

A MIXTURE for wet-coloring, such as the following, may be applied with advantage, and if a moderate amount of skill be employed during the operation, certain success is sure to follow the process when red eighteen-karat gold jewelry is treated with it. The ingredients employed are as follows, when small work is to be heightened in color:

Saltpeter	6 ounces
Common salt	3 ounces
Alum	3 ounces
	12 ounces

A color pot or crucible is provided with straight sides, into which is put the salts, which should have been previously well pulverized and mixed together with the hands. Now place the color pot upon the fire (a gas jet is by far the best substitute, as the power of the heat can be regulated at will, without the removal of the color pot from the position in which it was first placed), and dissolve the mixture very carefully and slowly so as not to burn the coloring composition. Stir occasionally during the dissolution of the salts. When the latter have dissolved, the mixture will rise somewhat in the pot, and then it is time to place in the work, which must be superseded by a wire of platinum of suitable dimensions to the work in hand. The work should be gently moved about while in the pot, and occasionally withdrawn to inspect its color. Dipping in acid water removes any color that adheres to the surface of the work, and which occasionally prevents a proper and satisfactory inspection of it. The acids used mostly for the purpose are nitric, muriatic, and sulphuric acids; either one may be used in the proportion of one of acid to twenty of boiling water. Be careful in adding the sulphuric acid to the water, as it will fly about and scald or burn, if it comes in contact with the flesh or clothes of the operator. The water hanging to the work after each rinse should be well shaken from it before re-dipping in the color pot. The time occupied in the process, if the alloy and other particulars absolutely necessary to the true performance of it are in accord, will be about four or five minutes.

After the dissolution of the coloring salts, the heat kept up should not be too intense during the period occupied in coloring; if so, the paste or composition is not at all unlikely to become devoid of the necessary moisture before the allotted time has expired, which, practically, is required to the termination of the treatment. A very slow fire, or still better, a gas jet is best for the purpose of accomplishing the common object in view, viz., the highest and richest color to the work under treatment, and that in the simplest and easiest manner possible.

The coloring mixture may be employed for 16-karat, and also for as low as 15-karat gold if the alloys are red gold. But for such a purpose its preparation and application is somewhat different to that just described, as well as to the length of time occupied in the process.

For a small batch of work the quantities may be the same as those already stated, although larger quantities can be used with the same success that attends the smaller ones, taking extra work in proportion to increase the color. The best relation between the work and the color would be as one to three, four and five; that is, the mixture given will be sufficient to color four ounces of solid work, such as chains, three ounces of hollow work, or two ounces of light work, with large surfaces. Always remember that it is in proportion to the surface of the work that you have to provide a coloring mixture, and not to its absolute weight, to be accurate and correct in your results.

In coloring with the too inferior qualities named above, it is necessary to add water to the salts in the pot, in order to keep them moist during their period of action, which takes a much longer time than the one we have already given the details of to produce a color intense enough for the trades. Two ounces of water will be sufficient to put to the mixed salts, which must be allowed to boil. When this takes place, take the batch of work encircled with a wire of platinum or silver, and put it in the mixture, and there let it remain for about fifteen minutes, when it should be withdrawn and instantly plunged into boiling water provided in a pan for the purpose. The work during the above period may occasionally be withdrawn and rinsed in order to inspect its progress, and sometimes this is found to be an advantage, as the right color is produced more quickly at times than others.

ELECTRO FIRE-GILDING AND SILVERING.

COMPLAINTS against the durability of the ordinary electro gilding and silvering by contact or limited battery, and of the abrasions, when exposed to wind and weather, or friction, as compared to the good old fire-gilding, are very frequent, although the former is generally acknowledged to have a richer appearance than the latter. The reason for these complaints are based upon the facts that the deposit of the precious metals by the galvano-electric system are not of a solid and compact nature. Experience has taught that electro-gilt ornaments attached to church-yard monuments, lightning conductors, crosses, balls, eagles, and other ornaments on church steeples and public buildings, very soon tarnish, which is fully proved to be the cause of the unsolid and porous deposit of the gold on the metal forming the base of the articles.

To effect good substantial deposit of gold or silver by electricity, we are compelled to take recourse to batteries of great capacity, dynamo-electric apparatus worked by steam power arrangements which to purchase and to maintain entail expenses too large to be borne by the jeweler or watchmaker who conducts his business on a limited scale, and who, if even in a position to purchase and maintain these extensive appurtenances, in very rare instances has sufficient work to realize a profit to warrant and encourage the outlay.

In order to overcome the instability of the deposit by electro-gilding, and to avoid the heavy expense of costly apparatus, while securing at the same time a good deposit by electricity, the following procedure is recommended as practically good and satisfactorily effective.

To the ordinary gold solution for electro-gilding add some mercury previously dissolved in nitric acid; this solution, diluted with water and neutralized of the acid by adding small quantities of spirits of ammonia until immersed litmus paper does not change its blue color into red. Previous to dissolving the mercury in the acid, it is necessary to free it from the lead, with which commercial mercury is generally contaminated, and this is effected simply by passing the mercury through a piece of wash-leather, which will allow the mercury to pass through on squeezing it and retain the lead.

This prepared gold solution will be a mercurial-gold amalgam of a fluid or watery nature, and should not be mixed in larger quantities than required for immediate use. The articles to be gilt are immersed in this solution appended to the wire in connection with the cathode (zinc) of any battery, and will receive a gold deposit of a quicksilver appearance, after the article has remained sufficient time in the solution. It is then withdrawn, rinsed in water, and laid on a fresh fire made of small pieces of charcoal, until the mercury has evaporated, which takes place very soon, as the quantity of mercury is very small in proportion to the gold deposit, although the color of the former predominates. After the evaporation of the mercury, the article has all the characteristics in color and toughness of fire-gilding—pale yellow and dead surface. The article is then scratch-brushed in beer and will assume a fine luster. If a heavy deposit of gold is required, the operation may be repeated after each scratch-brushing. By weighing the article before the first immersion into the gold solution, and again after the last scratch-brushing, the weight of the gold deposited can be ascertained very accurately. In the last evaporation, the article is left for about half a minute or so longer on the fire than necessary for driving off the mercury, which will deepen the color of the gilding. After a final scratch-brushing, the article may be gilded in an ordinary gold solution without the addition of mercury, by which the richness of color of electro-gilding and the durability of fire-gilding are combined.

This kind of gilding is accomplished with much less trouble, and what is of great importance, attended with less, or no more, danger than fire-gilding on the old method, which requires the continual handling of a large quantity of mercury so injurious to health, as the deposit of mercury in combination with the gold deposit in electro fire-gilding is so slight as to evaporate almost instantly, and affords the great advantage of a regular deposit of gold, not only on the surface, but in the hollows and interstices of the articles to be gilt. If any places or portions of the articles do not require gilding, these places can be prevented from receiving the deposit by a coating of copal varnish mixed with a little rouge powder, and drying in a warm place before immersion in the gold solution.

The same method may be advantageously applied to electro fire-silvering, by employing silver solutions, and the results are excellent.

Care must be taken that the mercurial gold or silver solutions are carefully kept apart from the ordinary gold and silver solution.

Silvering by fire has been very much neglected, and preference given to electro-plating, but fire-gilding is still practiced to a considerable extent, and the careful perusal of the above cannot fail to convince the practical man that the combination of electro fire-gilding not only fully replaces the ordinary and antiquated process of fire-gilding, but effects at the same time a great saving of precious metal, which would unavoidably be lost in fire-gilding, while at the same time presenting all the advantages to be derived from that method.

REPAIRING JEWELRY.

PROBABLY there is nothing which builds up the reputation of a jeweler more easily than the neat and substantial repairing of the jewelry of his patrons. The intrinsic value of a filled ring may be almost nothing, but to the owner it is surrounded by a halo of associations which give it priceless worth, and if broken by accident, its neat repairing is very highly appreciated. So also the cleaning of jewelry, which, through discoloration, has lost its beauty, is often looked upon with delight as marvelous; therefore, a few hints on this subject may be of use to some who have met with difficulty in making to their satisfaction such repairs to articles of jewelry that are almost of every-day occurrence.

It is of first importance that the use of soft solder be avoided as far as possible in repairing articles of gold or silver, and even filled and plated jewelry may be repaired with hard solder.

To repair a ring, the shank of which requires soldering, bury the head in a crucible of wet sand, place a small piece of charcoal against one side, coat the break, previously cleaned by filing or scraping, with borax, and charge with solder; blow a flame against the ring and charcoal until the solder runs in. For articles which require to be protected from discoloring in the process of soldering, coat them with a mixture of burnt yellow ocher and borax, adding a little dissolved gum tragacanth to make it lay all over, allow it to dry, then charge with borax and solder and heat sufficiently; boil out in weak pickle made of nitric or sulphuric acid. One important point is to wash the piece well in hot water with a little ammonia in it before attempting any repairs; this removes all dirt and grease, which, if burned on, cannot be removed.

If the article be of colored gold, boil out in pickle made of muriatic acid, and never coat with any protecting mixture. The solder must vary in regard to fusibility according to the quality of the article. For repairing most filled work, very easily melted solder is required, which may be made of one ounce fine silver, ten pennyweights hard brass wire, adding two pennyweights zinc just before pouring; or, to make it more fusible, use bar tin instead of zinc; or, for strong silver solder, use only the silver and brass. For repairing most bright gold work, use gold coin, three pennyweights; fine silver, three pennyweights; fine copper, two pennyweights. For colored work, fine gold, one pennyweight; silver, seventeen grains; copper, twelve grains; hard brass wire, two grains.

A good solder for repairing spectacles or other steel work is made by melting together equal parts of silver and copper. In soldering steel, plenty of borax should be used.

Very often the want of a rolling mill is a great obstacle to the making of solder, but it may be flattened very thin, although not with great regularity, by pouring into a flat piece of wood, and putting the flat surface of a piece of iron, while it is still in a melted condition; a piece of cigar box is good to pour it on, as the odor emitted is not very disagreeable, and the solder may be melted in the hollow of a piece of charcoal, by using gas and a blow-pipe.

For cleaning colored gold, a mixture of one pound sal soda, one pound chloride of lime, and one quart of water will be found useful; it should be placed outside the building after mixing, and when settled, the liquor poured off and the sediment thrown away; with great care this may be used for cleaning gilt bronzes, and cheap gold, and plated jewelry, but caution is necessary, as it will corrode brass very rapidly.

To remove lead solder from badly repaired jewelry, place the piece in muriatic acid and leave it till the lead is eaten away. It is always best to heat the piece gently and brush off the lead, while melted, before subjecting the piece to the action of the acid, as too long a steeping is not desirable.

Set pearls, which have become discolored by wear, may often be improved by placing in a covered vessel with a mixture of whiting, ammonia and water, and permitting them to remain a few hours.

A good powder for cleaning jewelry, silver watch cases, etc., is made by mixing about four parts of whiting with alcohol or water; this, it will be found, is easily brushed out of crevices, engravings, etc. Many are not aware of the fact that the gold and the jet jewelry, which has been worn so much for years, can be hard soldered with easy running solder without removing the jets, but it is easily accomplished by coating the gold with ocher, and laying the piece with the jets up while soldering, care being taken not to smoke the jets; an alcohol lamp is perhaps preferable to gas for this purpose, but in most cases gas answers best for soldering.

THE ART OF ENAMELING.

WHEN an enameler lives at a convenient distance, it is better to send your work to him; this, however, is not always possible, as these artisans are generally to be found only in large cities, and for obvious reasons, a certain piece of work requiring his assistance, cannot always be sent to him. In such cases, it is well if the country jeweler knows how to help himself, and any intelligent workman will, by the exercise of a little common sense, soon attain the necessary skill. This article is intended to give him simple and practical instruction in the method.

Enamel is a glass which fuses at a lower degree of heat than the ordinary kind; it is manufactured in so many ways and of so many different compositions that to give all the formulæ would lengthen this article inordinately. The basis consists generally of silica (quartz powder or white sand), carbonate of soda, and oxides of tin and lead, and the different colors are produced by metallic oxides; consequently enamels are of a metallic nature.

The colors of the enamel are liable to change on silver, and on copper they will generally turn bluish and greenish around the edge; to prevent this, a ground of white enamel is fused on first. The colors do not change on gold, and this metal is therefore suited best for the purpose; reddish gold is the handsomest of all alloys.

To prevent the chipping of the alloy, always prepare a fresh alloy of gold, to be of at least 14 karats. To prevent the chipping of the enamel on hollow articles, strengthen them from behind with so-called counter-enamel.

CLEANING THE SILICA.

The silica best suited for the basis (the frit or fritz) is colorless quartz (rock crystal), which is heated and thrown into water, to make it vitreous; it is next pulverized finely. If the operator desires to use white quartz sand, it must be cleansed first. This is done by pouring over it equal parts of hydrochloric acid and water; it is left to stand for several days and then washed with water ten to twenty times. In a test melting of a sample, with the other necessary ingredients, a pure white mass that shows no shade of green must result; if such is not the case, the sand still contains traces of iron.

The sand may also be purified by mixing it with one-fourth of its weight of table salt, and glow-heating it in a plumbago crucible. The peroxide of iron present and the table salt decompose each other and form chloride of iron, which evaporates, while the soda enters into combination with the silica.

MAKING THE FRIT.

The glow-heated mass may, by mixing with red lead and smelting, be reduced at once into a frit, which represents a glass of lead, soda and silica. Take: Quartz sand, 100 parts; table salt, 25 parts; and smelt with red lead, 25 parts. The soda (carbonate of soda) used in enameling must also be free from iron. The chalk used for the same purpose must be perfectly white; yellow spots betray the presence of peroxide of iron, and a product made with it would be useless.

PREPARING THE PEROXIDES OF TIN AND LEAD.

The white coloring substance in the base or frit is, as already stated, generally peroxide of tin, to which peroxide of lead is also added occasionally. This peroxide of tin is on a large scale generally prepared by smelting 2 parts tin and 1 part lead in a very flat porcelain dish over live coals, and heating the alloy beyond the point of fusion. This alloy will soon be coated with a white (yellow in heat) skin of peroxide, which is with a glass rod pushed to one side, when a new film is formed, and this is continued until all the metal has been oxidized. The oxide is then separated by washing it from the metallic parts. It is more advantageous, however, to do as follows: The tin and lead, reduced to small pieces, are treated in a porcelain dish with concentrated nitric acid; the metals are violently affected thereby, and evolve brown vapor; the lead is dissolved, while the tin is changed into a white powder—the peroxide of tin. Corrosion being finished (no more brown vapor must evolve, on the addition of nitric acid), the whole is slowly evaporated to dryness, and the white pieces of the mass are glow-heated in a crucible; the nitrate of lead dissociates and forms peroxide of lead, and in this manner a mixture of pure peroxide of tin and peroxide of lead is obtained. If the operator desires to produce peroxide of tin alone, he can treat the tin with nitric acid, and after the development of the brown vapor has ceased, heat the fluid to boiling,—finally obtaining the powder of the tin peroxide, which he dries.

Useful mixtures for the production of frit can be composed in the following proportions:

I.

Tin (oxidized), 2 parts; lead (oxidized), 1 part. Of this mixture take 1 part, melted with crystal glass 2 parts, and saltpeter, 0.1 part. The saltpeter is for the purpose of converting any traces of very strongly (green) coloring protoxide of iron into the much less strongly (yellow) coloring peroxide of iron.

II.

Crystal glass, 30 parts; antimoniate of soda, 10 parts; saltpeter, 1 part. This frit contains no peroxide of tin.

The above specified substance, obtained by the smelting of table salt, quartz sand, and minium, is a colorless glass; in order to change it into white enameling mass, the weight of the glass of peroxide of tin is added. If a frit of an especially high coloring capacity is desired, the quantity of the tin is still increased 5, 10, or 20 per cent.

SMELTING THE FRIT.

In the melting of the frit, blistery lumps of an unequal color are obtained first; some places are highly transparent, while others are perfectly white, being charged with the peroxide. In order to correct this inequality, the substance is to be powdered and smelted; repeating this operation until the color is uniform. The greatest cleanliness is necessary in these various remeltings; neither ashes nor fire gases must in any manner be permitted to enter into the crucible, as the result would be a miscolored enamel.

By pouring the fusing mass of enamel in a thin stream into cold water, it will by the sudden cooling off become so brittle that it can be pulverized readily. As above stated, the enameling mass is to be fused repeatedly, until the color is perfectly uniform. Only when this is produced, it is pulverized as finely as possible, and by crushing reduced to an impalpable powder.

The frit produced by the above detailed formulæ is either used by itself or else as a basis for certain other colors. In the former case, it is frequently used as smelt for the manufacturer of watch dials or used on articles of copper, silver, and gold, which receive thereby the appearance of porcelain. Beautiful specimens of art objects of this kind, especially bonbonnieres and jewelry boxes, were in the 17th century manufactured by French artists; they are still sought and purchased at high prices by collectors.

If the frit is to be smelted upon sheet silver or gold, it is necessary only to apply enough to just cover the metallic ground. When copper or bronze plates—and for larger enamel pictures copper is almost always used—are to be coated, a thicker coating of the frit is to be applied.

CHARACTERISTICS OF FRIT.

By comparing a sheet of gold and one of copper, on both of which the frit was applied equally thick, the latter metal will appear only bluish or greenish white. By chipping off a corner of the coating, this will be found green on the side to the metal, because when fused on, it dissolved a little of the copper. This may be prevented by making the frit coating a little heavier. This is applied upon the well polished metal surface, moistening this, and dusting the frit powder, tied in a linen rag, very uniformly upon it. This done, the spots which are not to be enameled are cleaned from the frit, and this is fused.

FUSING.

It is best to perform this operation at once; if it cannot be done at the time, the article must be very carefully protected against dust or accidental rubbing off of the loose powder. The fusing is always performed in the muffle; if the article has curved surfaces, great care is necessary, because the readily fusible mass will soon be so fluid that it leaves the higher places, and the metallic face will show at these places, while at the places where the coating is thicker, it is apt to chip off.

VARIOUS FORMULÆ FOR COMPOUNDING FRITS.

Certain colors can at once be applied upon this basis; they are those which fuse at a high temperature, without altering their color; these are especially blue (protoxide of cobalt), dark red (peroxide of iron and alumina), black (protoxide of iron), and brown (peroxide of iron). The other colors, however, cannot stand the high temperature necessary for smelting the frit, and change their hue. If, therefore, enamel paintings are to be made upon the white frit, a colorless covering frit, consisting of an easily fusible glass, has to be applied first. Such a covering frit, suitable for every color, is compounded according to the following formula:

Frit No. 1.

	Parts by weight.
Quartz powder	60
Alum (free from iron)	30
Table salt	35
Minium	100
Magnesia	5

This mixture, which in its composition is equal to a lead glass, can be made still more fusible by decreasing the quantity of the alum one-half; the degree of fusibility is still increased by leaving the alum out entirely.

For very sensitive colors, especially those produced with purple of cassius, from rose to deep purple, it is better to use the following covering frit, which smelts easily, and exerts no influence upon even the most delicate hues.

Frit No. 2.

	Parts by weight.
Quartz powder	3
Washed chalk	1
Calcined borax	3

Many enamel painters work in such a manner that they fuse upon the basis the covering frit, and execute the painting upon this; the work, however, may be simplified by melting the covering frit at once with the color, and painting with this mixture. The frit then fuses together with the color, and adheres to the basis.

For producing these painting colors, the pulverized covering frit is, by washing, changed into a very fine powder, mixed with the corresponding color in very definite proportions, and the whole is smelted in small crucibles. The fused mass is then pulverized and washed again, and can be used for painting. It is evident that in this manner the fused color is only of one deep shade; in order to have graduation the composition is to be toned down by an addition of colorless covering frit, and it is advisable to prepare an assortment of ten shades, calling the unadulterated substance No. 1; a somewhat lighter shade is obtained by smelting 90 parts of No. 1 with 10 parts of the colorless frit; No. 3 is composed of 80 parts; Nos. 1 and 20 of the latter, etc. In order to be certain of the effects produced by each number, it is well to prepare a sample plate with the ten numbers. The painter must often have more than these ten grades, and he must then rely on his skill and practice to prepare intermediate ones, to be produced in the same manner as the first.

The colors ground, with lavender oil, are applied upon the covering frit with a brush. The picture, when finished, is next subjected to fusing, and the greatest amount of care must be exerted in this process, because by a slightly incautious treatment, at the last moment when about finished, the whole work may be utterly ruined. The muffle, in which the enamel picture is to be fused, must be only warm enough to smelt the covering frit; the article is first gradually warmed, because by a precipitate heating the enamel layer might crack on account of the unequal degree of expansion of the latter and of the metal. The pre-heated article is then inserted into the muffle, and left in it until the covering frit arrives at a state of fusion, and unites with the base frit. By an unduly strong heating the covering frit becomes so highly fluid that the individual colors merge into each other, and the picture does not have any clear and plain contours, but looks blurred, which, of course, deteriorates the value of the small delicate pictures which are occasionally used as ornaments on jewelry.

THE ENAMELING WITH ENAMEL PASTE.

From above details of the work necessary for enamel painting, it will be seen that this art is very laborious, and requires considerable amount of attention; it is, therefore, appropriate only on high-class jewelry. It is often desirable, however, to use enamel on lower-grade jewelry, and this may be done by using the so-called enamel paste. This consists of a covering frit, which, by a suitable variation of mixture proportions, has had imparted to it a lower degree of fusion; for instance, according to the following proportions:

	Parts by weight.
Silicious (quartz) sud	60
Chalk	30
Calcined borax	60
Minium	10–30
Tin oxide	5–90

This charge, after having been smelted, is powdered coarsely and again smelted with the addition of such pigments as stand a high degree of heat. Colored masses, which, according to the pigment used, show a superior or inferior degree of intensity, for instance, protoxide of cobalt produces shades from light forget-me-not blue to the darkest pansy-blue; sesquioxide of iron and alumina dark red; a large quantity of protoxide of iron makes a black, etc. These color pastes are in a smelted condition poured into water, powdered, and for large surfaces they are fused in the muffle, while for smaller ones, they are simply fused with the blow-pipe. Before applying the enamel paste, the previously brightened surface is moistened with borax solution; the mass is then applied, first heated over live coals, in order to evaporate the water, and then fused. The entire work of enameling is performed at one operation.

THE ENAMEL COLORS.

The enamel painter has at his disposal quite a large list of colors, and by suitable mixtures he is able to compose any shade desired. His paints are:

For white: Oxide of tin.

For yellow: Oxide of antimony, antimonious potash, antimoniate of potash, antimoniate of lead, oxide of silver, oxide of iron, oxide of uranium.

For red: Oxide of iron and alumina, sodium and chloride of gold, chloride of tin and chloride of gold, purple of Cassius.

For orange: A mixture of yellow and red; brown pigments.

For green: Oxide of copper, oxide of chrome or protoxide of iron.

For blue: Protoxide of cobalt, silicate of cobalt (so-called smalt), zoffre.

For violet: Oxide of manganese.

For brown: Oxide of iron.

For black: Protoxide of iron in larger quantities.

We omit describing the processes used for compounding colors with these oxides and other chemical combination, their manufacture not being the work of the enamel painter or goldsmith, but of the chemist. If, however, there are those who desire further information, THE JEWELERS' CIRCULAR will most cheerfully furnish it on application.

The writer closes with a few remarks concerning the proportions to be observed between the covering frit and the different colors, and these apply specially to these colors prepared from gold preparations.

The gold preparations are distinguished by their great affinity for being reduced into metallic gold. If in consequence of an incorrect treatment a gold-containing enamel color should be reduced into the metal, the enameler will have, in place of the light red or dark purple, according to the color, a more or less dark brown spot with metallic luster, consisting of finely divided gold. It is necessary, therefore, to fuse gold preparations at as low a degree of heat as possible, and they must never be applied immediately upon a base containing lead or tin, nor must they be brought into contact with a covering mass containing lead. If, consequently, the enameler desires to make the most of his gold color, he must coat the white covering mass with a covering free from lead, and execute the painting with gold color only upon this; the latter, as above said, is to be fused on only at a very low heat.

Pigments, such as oxide of cobalt, oxide of chromium, and all iron colors, which withstand any degree of heat with impunity, are very easily treated; the composition of both base and covering frit, as well as the temperature used for fusing them, has no influence on them. Copper pigments are more sensitive, and antimony and silver are more so, being altered by an unduly strong heat. Silver colors also are easily reduced into the metal, and in this condition form a gray spot with a metallic luster.

If, therefore, easily reducible preparations are to be fused together with the glass charges which are to be colored with them, it is evident that great care is necessary. Gold purple is in small quantities mixed most intimately with highly fine pulverized borax 3 parts, chalk 1 part, and pulverized quartz 3 parts; the mass is filled into a glazed and covered porcelain crucible, which is placed into a larger one, equally covered; these two crucibles are used for the sake of keeping out the fire gases, and fused at as low a temperature as possible. The dark red mass is pulverized, washed and made of a corresponding lighter color by a suitable addition of frit of the last mentioned composition (3 quartz flour, 3 borax, and 1 chalk).

For the antimony and silver preparations, mixtures are composed of easily fusible lead glasses, and the preparations, together with one-half their weight of the whole mass of sal-ammoniac, and very gradually heated to the fusing point. The addition of the sal-ammoniac is only for the purpose of not raising the degree of heat too high; when the temperature has risen to the point at which the sal-ammoniac volatilizes, it remains at the point at which the latter evaporates, this salt making use of all the heat for volatilizing it.

The preceding is about the description of the process, together with the formula as employed on the continent, France and Italy. We next append that employed in England.

ENGLISH ENAMELING.

Enamels are vitreous or glassy substances, used by metal workers for producing various designs for useful or ornamental purposes. Enamels as applied to metals have a transparent colorless base, and when required for use, a color is readily given to it by the addition of metallic oxides, of which the following formulæ have been selected as the most useful:

Frit No. 1.

Red lead	10 parts.
Flint glass	6 parts.
Saltpeter	2 parts.
Borax	2 parts.

CONCLUSION.

Frit No. 1, in English enameling, is composed of red lead 10 parts, flint glass 6 parts, saltpeter 2 parts, and borax 2 parts. Fuse this mixture well in a crucible for some time, then pour it out into a jar of water, collect the residue, and afterward reduce it to a powder in an agate-ware mortar and preserve for future use.

Frit No. 2.

Metallic tin	8 parts.
Metallic lead	2 parts.

Fuse this composition in an iron ladle at a dull red heat; carefully remove the oxide which will form upon the surface, taking care also to obtain it quite free from the pieces of metal which have escaped oxidation, and reduce as before to a fine powder. Then take of this, calcine 4 parts, silica 8 parts, saltpeter 2 parts, common salt 2 parts. Well mix and partly fuse in a clay crucible; the fewer number of times this is fired the firmer it will be.

Frit No. 3.

Broken crystal goblets	12 parts.
Calcined borax	4 parts.
Glass of antimony	2 parts.
Saltpeter	1 part.

Melt this mixture after the manner recommended for No. 1. Break up and again melt, as the flux improves by repeated melting. The above enamel fluxes are admirably adapted to form the basis of enamels for gold work. They may be made more fusible by increasing the proportion of borax; and by the latter substance the fusibility of all enamels may be increased at pleasure; but too free a use of it is an obstacle to the work of the artist.

Frit No. 4.

Flint glass, powdered	16 parts.
Pearl ash	6 parts.
Common salt	2 parts.
Calcined borax	1 part.

Let the ingredients be well melted together, and afterward finely broken into powder; and pre·erved ready for the additional coloring mixture of enamel.

Frit No. 5.

Silicious sand	12 parts.
Calcined borax	12 parts.
Glass of antimony	4 parts.
Saltpeter	1 part.
Chalk	2 parts.

Mix and fuse as before explained; grind into very fine powder and re-melt; this operation may be judiciously repeated several times.

We have only so far described enamels, and given directions for the bases of them; variety of design in color is produced by the addition of some metallic oxide, which effects the change according to the kind employed. These oxides should be used as sparingly as possible, because some of them will not stand the chemical process of coloring or even boiling without a bloom coming over them. A good black enamel may be made by taking the following ingredients:

BLACK ENAMEL.

Frit No. 5	14 parts.
Peroxide of manganese	2 parts.
Fine Saxony cobalt	1 part.

BLUE ENAMEL.

Frit No. 4	24 parts.
Fine Saxony cobalt	5 parts.
Saltpeter	1 part.

RED OR CRIMSON ENAMEL.

Frit No. 3	8 parts.
Purple of Cassius, or	1 part.
Red oxide of copper	1 part.

WHITE ENAMEL.

Oxide No. 2	1 part.
Fine crystal	2 parts.
Peroxide of manganese	$\frac{1}{16}$ part.

GREEN ENAMEL.

Frit or flux No. 1	36 parts.
Oxide of copper	2 parts.
Red oxide of iron	$\frac{1}{10}$ part.

YELLOW ENAMEL.

White lead	2 parts.
White oxide of antimony	1 part.
Sal-ammoniac	1 part.
Alum	1 part.

For the last mentioned, pound each of the ingredients separately in a mortar and mix well together; then carefully submit them to a heat sufficient to decompose the sal-ammoniac (chloride of ammonia); this color can be tested in the melting, and will do when the yellow is properly brought out.

Enamel may be made deeper in color by a further addition of oxide than that given for producing the respective tints. For instance, if a very intense blue is required add half a part of zaffre to the other ingredients. For black, the same protoxide of iron, zaffre or black oxide of copper; but the latter is not so good as the others. For red, the red oxide of copper may be employed; and in yellow, the oxide of lead must be used. For green, the protoxide of iron and oxide of chromium may be sparingly added to the transparent flux.

GENERAL REMARKS.

Enamels may be prepared and kept ready for use by grinding them in an agate mortar, and then placing them under water in a covered vessel. Or if preferred, they may be preserved until required, in the lump, as they are formed after the crucible operation; if the last-mentioned plan is adopted, then they must be broken with a rather sharp-faced hammer, and pulverized by means of the previously mentioned pestle and mortar. When this has been done, they are washed in clean water until all extraneous matter has entirely disappeared.

The work which has to receive enamel must be specially prepared. This is done in the following manner: The pattern desired is first drawn on the work by the graver, the ground work or part to receive the enamel is cut down very evenly, and this helps to heighten the effect; in the case of transparent enamels, the ground work should be extremely smooth and bright. After the work has been well cleaned by washing in a hot solution of soda, soap and water, and dried, the enamel is applied. In very delicate cases the point of a pen is used for this purpose; in others, a knife or spatula may be substituted with advantage; the work is then fired and the enamel is laid on as many times as is required.

When the enamel is sufficiently fused the surplus part is rubbed off, the article is rinsed and again fired in order to close the pores. Great judgment is required with regard to this operation, as too long an exposure to the heat of the furnaces would completely ruin the entire work. Different shades of color require different degrees of heat, and a knowledge of this can be acquired only by continual practice; such knowledge, however, is of the highest importance, because in some of the lower qualities of gold, the fusing point of the enamel is so near that of the gold that there is great danger of fusing the one along with the other. As we have said before, when the workman finds himself beset with these difficulties, a small addition of borax to the enamel will remove these defects in the operation.

Opaque colors require a slower and longer continued heat than transparent ones, because the base generally contains lead, tin, or antimony. In transparent colors a sharp, quick heat is most suitable, which must be proportioned to the extent of brilliancy required. Opaqueness may be given to black enamel by heating the work to a dull red after it has passed through the usual process of cleaning; the oxide which forms upon the surface being black imparts a kind of darkness to the color.

In the case of transparent enamels, the ground work must be clean, smooth, and quite bright; the grooved surface being commonly run over with a polished, half-round scorper, to make the effect more intense and beautiful, the latter quality depending to a considerable extent upon this being properly performed.

By varying the alloys of gold, a great alteration may be made in the brilliancy of enamel; for example, in transparent yellow and green, the alloy of gold should be rather pale; in the case of red, the reverse should be the case.

The vertical lapidary's wheel is now much used by the artificer for the purpose of removing the surplus enamel; and by the application of wet emery it is rendered clear and smooth; this is much quicker and better than the old method. It is finished upon the buff by an application of putty-powder (oxide of tin), as it is both smoother and cuts faster than most other polishing mixtures. In England enameling is a separate and distinct craft, and is altogether an art in itself; it has never been found to answer well where tried by ordinary manufacturing goldsmiths, the designs and colors having in their hands too much of sameness when compared with those produced by the professional enameler. The enameler, to take high rank in the order, must have some knowledge of designing, engraving, and chemistry; he must likewise understand the alloys of gold and their points of fusion, and the effects of coloring the work; he must also be tolerably conversant with the nature of the workmanship that is continually coming under his charge; and all this knowledge may be considered quite sufficient to raise the art to a distinct branch of study and practice.

In closing our remarks on the preparation of enamels, colors, and fluxes, and their mode of application to gold alloys, we desire to say that the rules or directions here given have been selected from very high authorities in the trade, and we trust they will be found equally serviceable to those desirous of gaining information concerning enamels and the art of enameling. The exact work cannot well be described, and thorough success is to be achieved only by the exercise of good taste, and by long-continued practice and attention to the craft.

Where diamonds and other precious stones are employed as well as enamels, work pertaining to the latter is performed first. Engraving, chasing, coloring, and lapping are subsequent processes of the goldsmiths' art.

TO RESTORE LUSTER OF GOLD ARTICLES.

HIGH quality gold articles, when their color has deteriorated, can be restored to their primitive beauty by the application of the following mixture. It is thus composed:

Sesquioxide of iron	3	oz.
Calcined borax	2	"
Chloride of ammonia	1	"
Water to form paste	2	"

Well mix the powdered ingredients together until a thick and even paste has been formed, then take the work and either dip it into the mixture or otherwise brush it over with it, care being taken to see that it is well covered with the color. The articles to be brightened are then taken and placed upon a copper pan, and heated over a clear fire, until all hissing sound has ceased and the articles have received a moderate amount of heat, when they are withdrawn, placed aside to cool, and afterward boiled out in weak muriatic acid to dissolve the coloring salts adhering to the surface. Well rinsing, scratching, and drying completes the process. This produces a fine and high color to rich gold, if the alloy is of a deep hue. It may also be used for restoring the color to repaired places of gold chains, which have had to be mended after the color has been given to them, and when it is not safe or economical to put them through the acid process again. After the soldering has been completed take a little of the above composition, prepared as stated, and apply it to the soldered parts, then heat the parts only very gently with the gas jet by means of the mouth blow-pipe, allow to cool; next dissolve the adhering flux by the means before stated, slightly scratch-brush the places recolored, rinse, and dry, after which the evenness of surface will be completely restored.

Another mixture that may be used in the same manner, consists of the following ingredients:

ANOTHER RECIPE.

Sesquioxide of iron	3	oz.
Acetate of copper	3	"
Calcined borax	1	"
Water to form paste	2	"

The acetate of copper should be well dried before using it, to free it from the vinegar, or it will probably corrode the work. In this recipe the sesquioxide of iron should be the red, whereas in the other it may be the yellow. The treatment is exactly the same as that in the one above described.

CASTING.

THE goldsmith or watchmaker often has the occasion to make a casting, which is easily effected in the following manner: Make a model of the article desired out of lead or wood, but a trifle larger than necessary, as the casting will lose somewhat in shrinking and hammering; take two pieces of cuttlefish, and fit them smoothly together; then place the model between them, gently press equally on both, whereby you will receive a good imprint of the model, and to prevent a possible displacement, fasten them with three or four pins. Take them apart, carefully remove the model, make a funnel-shaped cut-in for casting, and bind them together with wire. Put the brass into a crucible, strew borax over it, and if you are skillful, you will obtain a nice casting.

GILDING WITHOUT A BATTERY.

OBJECTS which are not exposed to much handling may in a short time be gilt in the following manner without employing the electrical pile. In boiling distilled water, dissolve one part of chloride of gold and four parts of cyanide of potassium. The objects will in a short time be covered by a handsome gold film, by leaving them in the still hot bath for a few minutes, and by having them attached by a fine copper wire secured to a strip of clean zinc.

FUSING GOLD DUST.

USE such a crucible as is generally used for melting brass; heat very hot, then add your gold dust mixed with powdered borax. After a while a scum or slag will rise to the surface, which may be thickened by the addition of a little lime or bone ash. If the dust contains any of the more oxidizable metals, add a little saltpeter, skim off the slag or scum very carefully; when melted, grasp the crucible with strong iron tongs, and pour immediately into cast-iron molds slightly greased. The slag and crucible may be afterward pulverized, and the auriferous matter recovered from the mass by cupellating by means of lead.

TO KNOW PURE GILDING.

A SOLUTION of chloride of copper will show the difference between gilding for which gold has been used and gilding with alloys of inferior metals. If the gilding is imitation gold, a touch of the solution gives a black mark, copper separating out through the zinc in the yellow metal; with pure metal no discoloration occurs. The test can also be effected with a solution of chloride of gold or nitrate of silver, the first of which gives a brown spot, the second a gray or black spot, neither, of course, having any effect on gold. Common gold goods of 14-karat gold do not change their color with nitrate of silver. Leaf gold is tested by being shaken up in a stoppered bottle with sulphur chloride. Beaten gold shows no alteration, while "metal" leaves grow gradually black.

TO MAKE CHLORIDE OF GOLD.

TAKE five pennyweights of fine gold, and after rolling out to a thin plate, cut it into small strips or pellets. Get an olive flask and clean it well with a warm and saturated solution of soda and water. Half fill the flask with water, and set on a sand bath over a heat that will slowly bring the water to boiling, which will both temper and test the flask; if it stands this test, it is fit to be used. Put the gold pellets into the flask, then mix in a small bottle half an ounce of pure nitric acid and two ounces of muriatic acid, and pour some of this into the flask to cover the pieces of gold; place it on a sand bath over a gentle heat, and put over the mouth of the flask a small piece of glass to prevent the solution from spurting out, while in action. As soon as the acid ceases to act on the gold, and if any remains undissolved, add a little of the mixed acid, and continue to add little at a time as often as it stops acting on the gold until all is dissolved; remove then the flask from the sand bath and let it cool, after which pour in it about the like quantity of water, and boil over a heated sand bath until about half of it is evaporated; remove and pour the solution into a glass or porcelain dish, and rinse the flask several times with small quantities of warm water, which add to the solution.

NEW INGOT MOLDS.

NEW ingot molds to prevent the gold adhering to them, should be well greased before using. It is much better to close them and pour in a solution of salt and water, letting them remain so for a day or two before using them; this causes oxidation, or rust, of the surfaces, and is an excellent preventive to the gold sticking, which is sometimes found to be so obstinate as to cause chipping of the mold, thus rendering it thereafter useless.

HOW TO DISTINGUISH REAL GOLD.

A TINY drop of mercury rubbed on some corner of the surface to be examined will produce a white, silvery spot if the gold is pure or if there is gold in the alloy. If this silvery spot does not appear, there is no gold in the surface exposed. To prove the correctness of this result, a drop of the solution of nitrate of mercury can be dropped on the surface, when a white spot will appear if the gold is counterfeit, while the surface will remain unaltered if the gold is genuine. After the operation, heating the article slightly will volatilize the mercury and the spots will disappear.

WHITE COLOR AFTER PICKLING.

THE white color after pickling may be due either to heating the article too much or too long, or to keeping it too long in the pickle. In the former case, the alloy or copper is oxidized deeply into the article, and when removed by the pickle it leaves only the silver on the surface. In the latter case, keeping the article too long in the pickle has the same effect, by eating away the copper too deeply. The color may be restored by scouring and polishing till the silver coating is removed and the solid metal is brought to the surface. Then, if the natural color of the gold is too light, it must be colored either by plating with gold, or by the coloring process.

TO MAKE GOLD AMALGAM.

EIGHT parts of gold and one of mercury are formed into an amalgam for plating, by rolling the gold into thin plates, heating it red hot and then putting it into the mercury, while this is also heated to ebullition. The gold immediately disappears in combination with the mercury, after which the mixture may be turned into water to cool. It is then ready for use.

GOLD FRICTION POWDER.

THE following is an advice given by an expert: I use a gold friction powder, which I find very handy in removing or covering over spots on gold or plated articles where the plate is worn off, and where I do not care to dip the articles in a solution. I dissolve twenty-four grains of fine gold (coin) in one-half ounce of nitro-muriatic acid, and then absorb the acid with a clean blotting paper. When the paper is thoroughly dry I burn it and pulverize the ashes, which I rub on the bare spots with chamois skin moistened with water. The spots should first be well cleaned, the same as for plating with a battery, to resist the deposition of gold upon them.

TO REMOVE TIN FROM THE STOCK.

JUST previous to pouring the gold, throw a small piece of corrosive sublimate into the pot, stir well with a long piece of pointed charcoal, and allow the pot to remain on the fire for about half a minute afterward. This will take tin from the alloy; gold containing tin will not roll without cracking. To remove emery or steel filings from gold, add a small piece of glass-gall while melting; it will collect them in the flux.

TO SEPARATE GOLD FROM SILVER.

THE alloy is to be melted and poured from a height into a vessel of cold water, to which a rotary motion is imparted. By this means the alloy is reduced to a finely granulated condition. The metallic substance is then treated with nitric acid, and gently heated. Nitrate of silver is produced, which can be reduced by any of the known methods, while metallic gold remains as a black mud, which must be washed and smelted.

TO POLISH GOLD ARTICLES.

EIGHTEEN karat articles and upwards from *bright alloys*, will present a bright, mirror-like appearance by well polishing all over, inside and out, with pumice and emery, then with oil and rotten-stone, and finally finishing upon the buff with a little rouge of the best quality, and a touch or two of grease. Work high in quality finished in this manner, requires no gilding or coloring to put a superior surface to it; and when it is well washed out with soap in a hot solution of potash or soda it looks very beautiful and rich. The bright alloy for 18 karats is composed as follows: Gold, fine, 15 dwts. 3 grains; silver, 2 dwts. 21 grains; copper wire, 3 dwts. Add 2 grains of copper per ounce for loss in melting. The two grains of copper added for melting loss will be found to be an advantage, since it keeps the alloy more uniform as to its original weight, and the cost per ounce is more certain and regular.

FROSTING AND COLORING GOLD.

FOR 15- to 18-karat gold the work should be well polished, first with glass paper, then with crocus and oil used on a circular brush revolving on a lathe spindle. Wash out clean with soap and hot water with soda, and dry in hot boxwood sawdust. Take 2 parts saltpeter, 1 part alum, 1 part common salt; reduce them all to powder, place them in a rather large crucible or a proper color-pot of plumbago and set over a gas jet; add a very little water to moisten and allow the whole to dissolve, stirring occasionally to prevent burning. While this is dissolving, set a kettleful of water on the fire to boil. Take the gold articles out of the sawdust; dust away any particle of the latter and anneal the articles, attaching each one separately to a silver wire (which may be thin), and twist all the articles up into a bundle and tie the ends of wires on to a stick of cane or firewood, allowing the goods to be colored to be spread out slightly. By this time the ingredients will have boiled up into a froth. You must so arrange that this effect is produced, regulating the heat to produce that effect by the time you are ready.

Now, dip the bunch of goods into the color-pot, thoroughly immersing them, and keep them moving gently for five minutes; then withdraw and pour boiling water from the kettle over them to rinse, holding them at the same time over a pipkin to catch the rinsing.

Now, pour about 1 ounce of boiling water in the color-pot, allow that to froth up, dip the bunch again, move about for four minutes and rinse as before; add 2 ounces of water, dip again for three minutes and rinse; add now 3 ounces of water, let it froth up, dip for two minutes and rinse; add 4 ounces of water and rinse as before; then 5 ounces of water, re-dip for one minute and rinse for the last time.

The operation of coloring is now complete. Remove the goods from the wires, and boil them in a pickle of nitric acid and water for a few minutes and afterwards in plain water, throwing away the water when it boils and replacing it with cold. The goods are now ready for frosting.

Have a very fine scratch-brush mounted on the lathe, with an arrangement for dropping size water on the front or top of the brush; set the lathe going and hold the article so that the ends of the wires of the brush just touch it; drive it fast and turn all parts of the work to the action of the revolving brush.

TO CAST IN FISH-BONE.

HEINRICH SCHULTZE says in *Die Goldschmiedekunst* that the manner of casting in fish-bone has been explained repeatedly in that and other technical journals. It will, however, have happened occasionally that the cast has not turned out well, a circumstance readily induced partly by the way of pouring and again by the condition of the mold. Brass foil is sometimes recommended for producing a compact cast; indeed, it is very good, but the copper percentage of the alloy is increased unnecessarily, since the zinc only influences the compactness of the ingot. For about 80 parts 14-karat gold, or 50 to 60 parts 18-karat gold—the same proportions hold good for silver—1 part good pure zinc sheet rolled together, dipped in sal-ammoniac water or soldering fluid, heated and immersed into the clear molten metal, does the same services, and does not alter the nature of the alloy as it evaporates again.

A bad cast is caused both by pouring when too cold or too hot, as well as by a bad mold. After the mold has been made ready and provided with air ducts and hole for casting, and when ready to be laid together, take a camel's-hair brush and coat everything with a concentrated solution of borax or boracic acid; after the lapse of a few minutes, when the surface has become fairly dry, repeat the coating, this time, however, taking a concentrated solution of water gloss, either diluted one-half with water or borax solution; do it as carefully as possible, so that no small lump remains adhering anywhere, or in order not to injure the sharp corners; then dry over a small lamp, place together and lay the mold where it is warm. If wood cores are to be laid in, they are each separately laid into the water-gloss solution, and after drying, are placed into the mold.

It may perhaps not be known to everybody how it is possible to cast holes in a certain object; for instance, the bezel hole of a ring. The pattern for it is fully finished, and the more perfectly it is smoothed and burnished the nicer will be the cast. When the corresponding holes have been cut in, fit into it a wooden mold of the requisite shape—round, square, oval—but in such a manner that it projects a few millimeters so that the plug, after the ring or model has been removed, may again be laid exactly into the imprinted place; these projecting parts are then slightly rounded off in order to be inserted and withdrawn readily. Now bind the mold together and carefully close the casting hole with silk paper; drive also some of it between the sides in case they should stand together with only little hold; then place the model obliquely into a small vessel filled with fine sand, so that the former is filled nearly as far as the opening. The sand may also be heated previously, or else the vessel may be heated afterward to a degree borne by the fish-bone, both for the purpose of drying them and expelling the air as much as possible. When the metal is clear and ready for coating and the operator is certain that the mold is thoroughly dry, pour. Experience makes the expert, and experience is necessary to know the right time when to pour. If the metal is too cold the cast is faulty; if too hot, it becomes blistery; it may also occur that the cast looks to be nice and smooth, but when worked places cave in caused by holes and blisters within. Therefore, remember: first, a good heat, next, have the crucible closely before the mold, and as soon as the brightness of the molten metal disappears and a film is about to form on it, cast quickly, and my word for it you will cast with as much success in fish-bone as you will in sand. The placing of the mold in sand is for the purpose of preventing the running through of the metal.

TO RECOVER THE GOLD LOST IN COLORING.

DISSOLVE a handful of sulphate of iron in boiling water, then add this to your "color" fluid, and it will precipitate the small particles of gold. Now draw off the fluid, being very careful not to disturb the auriferous sediment at the bottom. Then proceed to wash the sediment from all trace of acid with plenty of boiling water; it will require three or four separate washings, with sufficient time between each to allow the water to cool and the sediment to settle, before pouring off the water. Then dry in an iron vessel by the fire, and finally fuse.

RECOVERY OF GOLD FROM SOLUTION.

AN easy method to recover gold from solutions, particularly from old toning-baths of photographers, has been made known by Fr. Haugk. It consists in filtering the solution into a white glass flask, or bottle, making it alkaline with sodium carbonate, and then adding, drop by drop, a concentrated alcoholic solution of aniline red (fuchsine), until the liquor is of a deep strawberry color. The flask is then exposed to the sunlight for six or eight hours, at the end of which all the gold still present will have been precipitated as a dark violet color, and the liquor will have become colorless. After pouring off the liquor the flask with the precipitate is kept until a fresh quantity of solution has to be precipitated, and this is continued until the deposit in the flask is sufficiently large to make it worth while to remove it. It is then transferred to a filter, washed, dried, and burned with the filter. The residue, containing the filter-ash, is dissolved at a gentle heat in aqua regia, filtered, and the solution evaporated to dryness. The quantity of impurity caused by the simultaneous solution of the filter-ash is too insignificant to be objected to.

TO CLEANSE GOLD TARNISHED IN SOLDERING.

THE old English mode was to expose all parts of the article to a uniform heat, allow it to cool, and boil until bright in urine and sal-ammoniac. It is now usually cleaned in dilute sulphuric acid. The pickle is made in about the proportion of one-eighth of an ounce of acid to one ounce of rain water.

FACETIOUS GOLD.

IT is averred that the following recipes will produce alloys of metals so nearly resembling genuine gold as to almost baffle goldsmiths without a resort to thorough tests. Fuse together with saltpeter, sal-ammoniac, and powdered charcoal, 4 parts platinum, 2½ parts pure copper, 1 part pure zinc, 2 parts block tin, and 1½ parts pure lead. Another good recipe calls for 2 parts platinum, 1 part silver, and 3 parts copper.

TO COLOR SOFT SOLDER.

THE following is a method for coloring soft solder so that when it is used for uniting brass the colors may be about the same: First prepare a saturated solution of sulphate of copper—blue stone—in water, and apply some of this on the end of a stick to the solder. On touching it then with an iron or steel wire it becomes coppered, and by repeating the experiment the deposit of copper may be made thicker and darker. To give the solder a yellow color, mix one part of a saturated solution of sulphate of zinc with two of sulphate of copper; apply this to the coppered spot and rub it with a zinc rod. The color can be still further improved by applying gilt powder and polishing. On gold jewelry or colored gold the solder is first coppered as above, then a thin coat of gum or isinglass solution is laid on and bronze powder dusted over it, making a surface which can be polished smooth and brilliant after the gum is dry.

CYANIDE OF GOLD.

CYANIDE of gold is formed by cautiously adding a solution of cyanide of potassium in six parts of water, to a neutral solution (that is to say, not containing any free acid) of terchloride of gold, as long as a yellow precipitate settles down; if more cyanide of potassium is added, the precipitate becomes dirty yellow, and is more quickly deposited; a still larger quantity renders it orange-yellow, and re-dissolves it. It is a crystalline powder, permanent in the air; by ignition, it is resolved into gold and cyanogen gas; it is not decomposed by sulphuric, hydrochloric, or nitric acid, or by aqua regia, unless freshly precipitated, and then only slowly. It is not decomposed by sulphuretted hydrogen; hydrosulphate of ammonia dissolves it slowly but completely, forming a colorless solution, from which, by the addition of acid, sulphide of gold is precipitated. It dissolves in aqueous solution of ammonia, hydrosulphite of soda or alkaline of cyanides, but not in water, alcohol, or ether.

RECOVERING GOLD FROM COLORING BATH.

DISSOLVE a handful of sulphate of iron in boiling water, and add it to your "color" water; it precipitates the small particles of gold. Now draw off the water, being very careful not to disturb the auriferous sediment at the bottom. You will now proceed to wash the sediment from all trace of acid with plenty of boiling water; it will require three or four separate washings, with sufficient time between each to allow the water to cool and the sediment to settle, before passing off the water. Then dry in an iron vessel by the fire and finally fuse in a covered skittle pot with a flux.

TO MAKE GOLD TO ROLL WELL.

TO cause gold to roll well, melt with a good heat, add a tablespoonful of sal-ammoniac and charcoal, equal quantities, both pulverized, stir up well, put on the cover for two minutes, and pour.

MELTING AND REFINING.

IN melting brass gold urge the fire to a great heat and stir the metal with the long stem of a tobacco pipe, to prevent honey-combing. If steel or iron filings get into gold while melting, throw in a piece of sandiver the size of a common nut; it will attract the iron or steel from the gold into the flux, or, sublimate of mercury will destroy the iron or steel.

TO RECOVER GOLD FROM GILT METAL.

TAKE a solution of borax water, apply to the gilt surface, and sprinkle over it some finely powdered sulphur; make the article red hot and quench it in water; then scrape off the gold and recover it by means of lead.

TO REMOVE GOLD.

GOLD is taken from silver by spreading over it a paste composed of pulverized sal-ammoniac with aqua fortis, and heating it till the matter smokes and is nearly dry, when the gold may be separated by rubbing with a scratch-brush.

CLEANSING MAT GOLD.

TAKE 80 grams chloride of lime, 80 gr. of bicarbonate of soda, and 20 gr. table salt; pour over this about 3 liters distilled water, and fill in bottles, to be kept well corked. For use, lay the dirty articles into a dish, pour over the well shaken fluid, let it submerge them, leave them in it for a short time, and in extra cases when very dirty warm them a little. Next wash the articles, rinse them in alcohol, dry them in sawdust, and they will appear like new. The fluid is of no further use.

PURE GOLD.

THE *Journal de Pharmacie* specifies the following method for preparing pure gold: Commercial gold is dissolved in a mixture of 4 parts hydrochloric and 1 part nitric acid, of 20° B.; the obtained white-colored pasty chloride of silver is filtered off, and the filtrate is mixed with an aqueous solution of antimony chloruret, to which so much hydrochloric acid has been added, that no turbidity is produced at the mixing of the solution. The reduction is effected in a few hours, especially if a little heat is used. The gold is filtered off, washed with dilute hydrochloric acid, next with water, and fused with a little saltpeter and borax. The mother liquors, which contain antimony chloride, can, boiling with metallic antimony, be again reduced to antimony chloruret and again used.

ACCIDENTS IN POURING.

MOST jewelers, at some time or other of their experience, may have met with accidents in the melting and pouring of their alloys, such, for instance, a pot cracking, the spilling or the upsetting of a portion of the metal from the crucible into the fire. The following mode of recovery of lost metal we have found the best and most practical in the workshop, with the ordinary appliances usually at the command of jewelers and gold workers. Collect the whole of the burnt coke, ashes, and other refuse used in the smelting operation and, first of all, well wash it several times with water, to remove the dust and other extraneous matter; the sediment left behind is then well dried and pounded as fine as possible in a cast-iron mortar; it is afterwards put through a sieve as fine as is convenient to prevent the small particles of gold from going through the meshes with the powdered dust. The gold is now picked at this stage from the refuse in a sieve; and if there be any solid particles of refuse still unpounded, it is put through the process again. It is very seldom that the whole of the gold can be collected when once split into the fire, but the larger portion of it can be recovered by these means. The remainder goes into the scraps to be treated by the refiner.

JEWELERS' PICKLE.

THE usual jewelers' pickle is made of 5 parts of water to 1 of sulphuric acid. When something is wanted that will "take hold" more than this, a little muriatic or nitric acid is added to it. For Roman colored goods, especially, muriatic acid is added. If the jeweler has trouble with a gold article, and it looks green or white after being in the above sulphuric acid pickle, make a pickle of strong sulphuric acid and saltpeter, equal parts, heat it boiling hot, hang the article on a hook made of copper wire and dip in the boiling liquid, then wash. If the color is not good, repeat.

COLORING TIN SOLDER YELLOW.

ACCORDING to the *Metal Arbeiter*, prepare a saturated solution of sulphate of copper in water; into it dip a pegwood and with this touch the soldered place. Then take an iron or steel wire, and with it touch the same place, whereby it will become coppered at once. The precipitate will be increased by repeating the operation. For coloring the place of soldering yellow, prepare a saturated mixed solution of one part of sulphate of zinc and two parts sulphate of copper; with this touch the coppered place, and then touch with a zinc rod, whereby a precipitate of brass is produced; in order to improve the color, the place may be rubbed with gilding powder and burnished with a steel. On gilt or colored gold articles, the coppered soldering place is furnished with a thin coating of mucilage or isinglass solution, over which bronze powder is strewn which can be brushed nice and smooth after the mucilage solution is dry; or else the article may be galvanically gilt again, whereby a uniform color is produced. The coppered place is, on silverware, rubbed or brushed with silvering powder; it may then be carefully scratched and polished.

PREPARATION OF GOLD SALTS.

TERCHLORIDE of gold is formed by dissolving metallic gold in a warm mixture of one measure of nitric acid, and from two to three measures of hydrochloric acid; the mixture is called aqua regia. The gold dissolves slowly with evolution of gas. When it is all dissolved, evaporate the solution by gentle heat, with stirring, until it is reduced to a small bulk and solidifies on cooling. The residue should be entirely soluble in water. If it contains a white substance which will not dissolve, it is chloride of silver, derived from traces of silver in the metal. If there is a small amount of yellow or brown residue, one of the salts has been overheated. Such residue should be redissolved in a little aqua regia and evaporated to dryness again. One ounce of gold, if it is in small fragments or thin sheets, will require about four ounces of aqua regia to dissolve it. Chloride of gold is a yellow salt, and dissolves in one and a half its weight of water. If it is properly made, it contains one atomic weight (196.6 parts) of gold and three atomic weights (106.5 parts) of chloride, and its composition is represented by the formula $AuCl_3$. One troy ounce of gold will make one ounce 164½ grains of the chloride.

Oxide of gold is obtained by digesting a solution of the chloride with an excess of calcined magnesia, washing the precipitate first with dilute nitric acid, and then with water only. If caustic potash or soda be used instead of magnesia, the oxide is liable to contain some of the alkali.

The terbromide of gold may be formed by digesting oxide of gold in hydrobromic acid, and evaporating the solution by gentle heat, stirring until it solidifies on cooling.

The oxide of gold forms, on addition of aqueous ammonia or of solutions of carbonate sulphate, or chloride of ammonia, a dark olive-brown substance, called fulminate of gold, aurate of ammonia, or ammoniuret of gold. The same substance is also formed on adding ammonia or a solution of a salt of ammonia to a solution of terchloride of gold. It is an extremely dangerous substance when dry, and detonates with the least friction or percussion. To form ammoniuret of gold, which is sometimes used in electro-gilding baths, convert ten parts by weight of gold into the solid chloride. Dissolve that salt in water and add to the solution fifty parts, by weight, of the strongest aqueous ammonia and stir the mixture; an abundant precipitate of the ammoniuret, otherwise called fulminate of gold, is produced in the form of a yellowish-brown powder. When it has subsided, pour .off the supernatant liquid and fill up again with water, and repeat this several times, until the precipitate no longer smells of ammonia. The water contains a little gold, and is reserved for recovery of that metal. As the yellow-brown precipitate, when in a dry state, is highly explosive, it should never be allowed to get dry, and ought not to be prepared until the time of forming a gilding solution with it. Particles of it should not be allowed to dry upon the edges of the vessels nor upon filters through which the wash-liquids have been passed. To remove the solid salt from articles we may dissolve it in a solution of cyanide of potassium. Freshly precipitated wet oxide of gold dissolves in a solution of caustic potash, to form aurate of potassium; the solution is yellow, and may be used for electro-gilding.

Sulphide of gold is obtained by passing a current of sulphuretted hydrogen gas through a solution of chloride of gold, as long as a precipitate occurs; it is a blackish, brown powder.

WHY GOLD IN JEWELRY CHANGES COLOR.

IT is well known that the human body contains humors and acids, similar in action to and having a like tendency toward baser metals, as nitric and sulphuric acids have, namely, to tarnish or dissolve them, varying in quality in different persons. Thousands wear continually, without any ill effects, the cheaper class of jewelry, with brass ear-wires, while if others wore the same article for a few days they would be troubled with sore ears, or, in other words, the acids contained in the system would so act on the brass as to produce ill results. Instances have occurred in which articles of jewelry of any grade below 18 karats have been tarnished in a few days, merely from the above-named cause. True, these instances are not very frequent; nevertheless, it is as well to know them. Every case is not the fault of the goods not wearing well, as it is generally called, but the result of the particular constitution of the wearer.

WHITE METAL ALLOYS.

AS so much depends in plating on the quality of the metal on which the outer stratum is deposited, both with respect to the appearance of the goods when new and their durability in use, the importance of its homogeneity can hardly be over-estimated.

A good deal of misapprehension seems to exist as to the meaning of the term "nickel," which is commonly applied (even by those who are well aware of the misnomer) indiscriminately to all kinds of white metal alloys. The principal alloy of nickel is German silver, a triple compound or admixture of nickel, copper, and zinc; although another alloy, composed of nickel and copper only, is also in use, chiefly for purposes of foreign coinage, which, however, does not call for special attention here. An instructive article dealing with the above subject appears in a recent issue of a contemporary, an abstract of the principal part of which will be of interest to our readers:

The casting of German silver is, in many respects, similar to the same operation with brass; but there are certain important differences. It is found impossible in practice to make German silver by one melting in the pot, the high and sustained temperature necessary to bring about liquefaction of nickel causing excessive loss of the low melting and volatile zinc (spelter). For this reason the nickel is always alloyed in one operation with a portion of the copper, and the zinc and the remainder of the copper, in the form of brass, are added in a separate melting. It is the invariable rule of English casting shops to make one-and-one "mixing" and one-and-one brass; "mixing," it may be explained, is the name given to the alloy of copper and nickel. This alloy is made in 80-lb. plumbago crucibles heated in a wind furnace, similar to the square section furnaces employed by brass casters, and fed by the best hard coke. It is necessary to use a good coke, since nickel alloys are much deteriorated by contamination with sulphur. About an hour is required from putting in the pot to pouring the metal, and the temperature must be very high. To diminish oxidation, and also to refine the ingredients, more particularly the nickel, borax is always added as a flux. This substance, though possessing many of the properties of an alkali when in aqueous solutions, has powerful acid properties at temperatures beyond redness. The boracic acid it contains is, like silicic, a feeble acid; but being, like the latter acid, fixed in the fire, it manifests important properties at these higher ranges of temperature, and borax, chemically speaking, contains a more than *normal* quantity of this acid. It will, therefore, be understood how the flux, by inducing a kind of scorifying action, brings about a partial refining of the contents of the pot. Mixing is run into pigs of a few pounds weight, and each of these should, when cold, present an upper surface somewhat concave and covered with transverse wrinkles. If the metal shows a smooth and bloated convex surface, the presence of impurities, and more particularly of sulphur, may be inferred. The casting of the brass for German silver making differs in no important respect from the ordinary manufacture of the same alloy for sand caster's use. The actual making of German silver begins when the mixing and the brass have been obtained. For pig metal, that is, German silver intended for remelting and casting in sand molds, it is sufficient to mix together the ingredients, fuse under a layer of charcoal, and pour into pig molds; sometimes a little tin is added, to give increased whiteness and hardness. It is in the casting of strips for the rolling-mill that the special skill of the German silver maker comes in. Many a good brass caster has tried his hand at German silver strip casting and failed, although, to a superficial observer, the two operations are identical. Both alloys, when required in the form of sheets or wire, are cast into strips, or, in the case of wire, into rods, and these are then reduced to the finished form by mere mechanical manipulations. But a German silver strip, or wire rod, treated exactly as a brass one, would, in ninety-nine cases out of a hundred, result in a sheet or wire, good, perhaps, at one end, but unsound through half of its dimensions. The reason is to be found in the greater shrinkage of the nickel alloy during solidification, and the remedy for this is in the careful "feeding" of the ingot during cooling. To compound German silver, of whatever quality, certain weights of mixing and of brass, together with a smaller quantity of copper, are necessary; and to allow for loss of zinc by volatilization during the melting, about 2 lbs. of spelter per heat for low qualities, and 1½ lbs. for the better qualities, are allowed, the heat being about 80 lbs. The ingredients are weighed out mixed with a certain quantity of scrap, and placed in the pot, which has been already heated to redness. The lumps of new metal are introduced with a pair of tongs, and the scrap by means of a long sheet-iron funnel reaching into the furnace. A few pieces of charcoal are now introduced, and the pot covered with a lid. When the charge has melted, the crucible is stirred with an iron rod, and the zinc allowed for waste is added, the pot being again stirred. Meanwhile the ingot-molds have been prepared and placed in position. The molds are similar to those used for brass and are of two halves, clamped together by rings and wedges. The molds are cleaned, rubbed inside with oil, and dusted with powdered charcoal (blacking). The caster raises the crucible from the furnace, and, holding it in position, pours the metal into the receptacle, while an assistant keeps back the floating pieces of charcoal with an iron rod. The mold is now full of German silver, and as the portion in contact with the cool surface solidifies, considerable shrinking takes place, and a hollow core begins to appear at the upper central part of the ingot. The skill of the workman is now brought to bear in supplying a fine stream of metal to prevent the formation of such a core. This stream is continued for some time, and the ingot is thus fed until the last portions form a projecting button at the center of the upper extremity. Mixing, it may be mentioned, is always made in plumbago crucibles, the charge being diminished in each successive heat, to prevent the corrosive flux acting successively upon the same zone of the pot. German silver is melted in plumbago pots, or in the best fire-clay crucibles; the latter are, perhaps, better for the purpose, since they radiate heat with less rapidity, and remain hot for a longer time, a point of some importance when the pouring takes a considerable time, as in filling ingots for wire rods. If the ingots are intended for rolling into spoon strips, the nickel need not be of the very finest quality, because such strips are thick, and destined to undergo only a moderate amount of mechanical strain. Into metal of this kind a little inferior scrap, filings, etc., may be introduced; but, of course, it must not be supposed that any rubbish will answer the purposes of the spoon and fork manufacturer. German silver that is destined to undergo the trying operations of raising, deep stamping, or drafting, must be compounded of the best brands of spelter, such as "Upperbank," "D. & Co.," and of best selected copper; the nickel should be either grain nickel or the cake nickel made by the Nickel Company. A brand of nickel containing varying quantities of copper, imported from Sweden in the form of powder, also gives very good results. Only a limited quantity of the best "raising metal" scrap should be introduced; but this little, if good, has a tendency to improve the working properties, although the reason is not very evident. The ingots of raising metal are now planed on the flat faces, in order to remove the hard skin and the inequalities which would impair the surface of the finished sheets; spoon metal is usually not planed. When the metal reaches the rolling-mill it is treated cold, in a similar manner to brass, the first operation being known as "breaking down." The ingots are passed diagonally between very powerful rolls, until they have attained to rather more than the breadth of the required sheet (to allow for trimming), and have, at the same time, of course, increased in length. This treatment is followed by passages longitudinally through smaller rolls. From time to time, and from the outset, the metal is annealed by heating it in a furnace and cooling with water; after each annealing the scale must be removed by pickling in dilute sulphuric acid, assisted by scouring with fine sand. Sometimes bright sheets are ordered, and when this is the case, the final pickling is done with aqua fortis (nitric acid). The following table gives the composition of the various qualities of German silver; "hollow-ware" or "raising metal," it will be noticed, contains proportionally less zinc and more copper than spoon metal or sand caster's pig. The mixtures of the various makers vary a little, some using more copper than others per unit of nickel; the former qualities are somewhat reddish, while the latter have a yellowish tinge.

TABLE I.—*G. S. as weighed out.*

Quality.	Lbs. per heat.			Percentages.		
	Copper.	Mixing. (1 & 1.)	Brass. (1 & 1.)	Copper.	Zinc.	Nickel.
"Best best"	8	34	27	55·79	19·56	24·64
"A," "hollow-ware"	6⅝	33¼	26⅛	54·97	20·07	24·95
"A"	9⅝	27⅛	33¼	56·87	23·73	19·38
Special 1st (spoon)	10	29	30	57·23	21·73	21·01
1st spoon	11	24	30	58·46	23·08	18·46
1st hollow-ware	18	24	21	64.28	16·66	19.05
2d spoon	8	18	40	56·06	30·30	13·63
2d hollow-ware	15	18	29	62·10	23.38	14·51
3d spoon and 3d hollow-ware	8	14	42	56·25	32·81	10·93
4th spoon and 4th hollow-ware	8	12	48	55·88	35·30	8.82
5th spoon and hollow-ware	10¾	8½	50	57·76	36·10	6·13
"Portland"	7½	6	54	55·58	39·98	4·44

TABLE II.—*As analyzed. Results in per cent.*

Quality.	Copper.	Zinc.	Nickel.	Iron.	Lead.
Qual. spec. 4th	56·48	33·11	9·57	·39	·49
" " "	56·08	33·55	9·56	·39	·36
Sp. 1st spoon	48·17	29·28	21·66	—	—
"B.B."	51·44	24·47	23·51	—	—
"B.B."	52·90	20·38	26·06	—	—
3d	64·32	23·98	11·21	—	—
2d "H."	63·34	22·64	13·58	—	—
"A 1"	54·70	20·25	23·67	·75	·26

ALLOYS OF COMMON SILVER AND IMITATION ALLOYS.

THE undermentioned white alloys have their various uses in the industrial and mechanical arts, some being employed as common silver, whilst others are manufactured as near as possible in imitation of it, and used as a substitute, for many purposes. In melting the alloys in which nickel and several other compounds enter into combination, unless very great care be exercised, it is a difficult matter to maintain the true and definite proportion of each metal of which the alloy proper is composed, owing to the loss of the more fusible metal by volatilization, if allowed to remain too long in the furnace. The best method of preparing the compound for the crucible is to mix the copper and nickel together. The latter is produced from the pure oxide of nickel; therefore it is taken in this form and placed in the crucible with the copper at the commencement of the operation. When these ingredients are well melted, and incorporated by stirring, add the zinc or other fusible metal required to make up the compound, previously heating it thoroughly over the mouth of the crucible, to prevent the chilling of the already molten metal which it contains. When silver forms a component part in any of these alloys it should be added at the beginning of the process along with those of high degree of fusibility, and reduced under the protection of a suitable flux; charcoal being the best for the purpose. This also tends to preserve the fusible metals, upon their addition to the melted compound in the pot, from too suddenly flying away in the shape of fumes. The best zinc of commerce should be employed in these alloys, which is sold under the name of spelter.

Common silver alloy:—

Fine silver, 1 oz.; shot copper, 17 dwts.; nickel, 13 dwts.

Another: fine silver, 1 oz.; shot copper, 1 oz.; nickel, 15 dwts.

Another: fine silver, 1 oz.; shot copper, 1 oz. 3 dwts.; nickel, 17 dwts.

Another: fine silver, 1 oz.; shot copper, 1 oz. 6 dwts.; nickel, 19 dwts.

Another: fine silver, 1 oz.; shot copper, 1 oz. 9 dwts.; nickel, 1 oz. 1 dwt.

Another: fine silver, 1 oz.; shot copper, 1 oz. 12 dwts.; nickel, 1 oz. 3 dwts.

Another: fine silver, 1 oz.; shot copper, 1 oz. 15 dwts.; nickel, 1 oz. 5 dwts.

Another: fine silver, 1 oz.; shot copper, 2 oz. 2 dwts. 12 grs.; nickel, 1 oz. 7 dwts. 12 grs.

Another: fine silver, 1 oz.; shot copper, 2 oz. 10 dwts.; nickel, 1 oz. 10 dwts.

Another: fine silver, 1 oz.; shot copper, 16 dwts.; nickel, 10 dwts. 12 grs.; spelter, 3 dwts. 12 gr.

Another: fine silver, 1 oz.; shot copper, 19 dwts; nickel, 12 dwts.; spelter, 4 dwts.

Another: fine silver, 1 oz.; shot copper, 1 oz. 2 dwts.; nickel, 15 dwts.; spelter, 3 dwts.

Chinese silver.—Shot copper, 1 oz.; spelter, 6 dwts.; nickel, 4 dwts.; cobalt, 3 dwts. 18 grs.; silver, 18 grs.

Imitation silver.—Shot copper, 1 oz.; nickel, 6 dwts. 12 grs.; spelter, 4 dwts. 18 grs.

Another: shot copper, 1 oz.; spelter, 12 dwts.; nickel, 8 dwts.

Another: shot copper, 1 oz.; spelter, 8 dwts.; nickel, 4 dwts.

Another: shot copper, 1 oz.; spelter, 10 dwts.; nickel, 10 dwts.

Another: shot copper, 1 oz.; nickel, 8 dwts. 8 grs.; spelter, 6 dwts. 16 grs.

White alloy.—Shot copper, 1 oz.; tin, 10 dwts. 6 grs.; brass, 2 dwts. 12 grs.; arsenic, 18 grs.

Clark's patent alloy.—Shot copper, 1 oz.; nickel, 3 dwts. 18 grs.; spelter, 1 dwt. 22 grs.; tin, 12 grs.; cobalt, 12 grs.

White alloy.—Shot copper, 1 oz.; tin, 10 dwts.; arsenic, 1 dwt.

Alloy with platinum; fine silver, 1 oz.; platinum, 5 dwts.

Alloy with palladium; fine silver, 1 oz.; palladium, 5 dwts.

The platinum and palladium of which the last two alloys are composed, although very difficult to use in combination with any other metal, readily unite in any proportions with silver; and it has been found that such alloys are not so easily tarnished as the ordinary ones, or even as fine silver itself. These various alloys serve to effect the several purposes for which they are employed in manufactures; wires prepared from any of them will supply the place of silver, as brooch tongs, stems for pins, catches and joints, etc., for articles of common quality and cheap workmanship. They are also employed for preparing the ground for "electro-plate" for which they are very serviceable. When, however, these alloys are employed by the regular silversmith, care should be taken not to get the scraps of metal in any way mixed with those of the better material, otherwise difficulties will soon begin to present themselves, which will materially interfere with the regular and proper working of the best silver alloys; and in fact, with all qualities that have originally been prepared free from nickel. Those prepared from nickle are much more infusible than those made without it; consequently, if a piece of the nickel alloy, either by accident or design, gets intermixed with the other quality, in a subsequent melting, it will be found to float on the surface of the molten metal for some considerable time and thus retard the process. Alloys prepared in imitation of silver are harder and much more difficult to work than those of the true metal; therefore it can easily be imagined what alteration the latter undergo upon the addition of some of the former compounds. The hardness and toughness which these alloys possess admirably adapt them for such purposes as we have described.

SILVER SOLDERS: THEIR USES AND APPLICATIONS.

SOLDERING as applied to silversmith's work is an art which requires great care and practice to perform it neatly and properly. It consists in uniting the various pieces of an article together at their junctions, edges, or surfaces, by fusing an alloy specially prepared for the purpose, and which is more fusible than the metal to be soldered. The solder should in every way be well suited to the particular metal to which it is to be applied, and should possess a powerful chemical affinity to it; if this be not the case, strong, clean, and invisible connections cannot be effected, whilst the progress of the work would be considerably retarded. This is partly the cause of inferior manufactures, and not, as might be frequently supposed, from the want of skill on the part of the workman who makes them.

The best connections are made when the metal and solder agree as nearly as possible in uniformity, that is, as regards fusibility, hardness, and malleability. Experience has proved, more especially in the case of plain and strong work (or work that has to bear a strain in the course of manufacture), that the soldering is more perfect and more tenacious as the point of fusion of the two metals approaches each other; the solder having a greater tendency to form a more perfect alloy with the metal to which it is applied than under any other conditions. The silver or other metal to be operated upon by soldering being partly of a porous nature, the greater the heat required in the fusion of the solder the more closely are the atoms of the two metals brought into direct relationship; thus greater solidity is given to the parts united, and which are then capable of forming the maximum of resistance. It is thus obvious that tin should not be employed in forming solders possessing the characteristics we have just described, for being a very fusible metal it greatly increases the fusibility of its alloys; but when very *easy* solder is required, and this is sometimes the case, especially when zinc has been employed in the preparation of the silver alloy, its addition is a great advantage when it comes to be applied to the work in hand. Solders made with tin are not so malleable and tenacious as those prepared without it, as it imparts a brittleness not usually to be found in those regularly employed by silversmiths; for this reason it is advisable to file it into *dust*, and apply it in that state to the articles in course of manufacture.

The best solders we have found to be those mixed with a little zinc. These may be laminated, rolled or filed into dust; if the latter, it should be finely done, and this is better for every purpose. Too much zinc, however, should not be added under any conditions, as it has a tendency to eat itself away during wear, thus rendering the articles partly useless either for ornamental or domestic purposes earlier than might be anticipated. Solders thus prepared also act with some disadvantage to the workman using them, for they possess the property of evaporating or eating away during the process of soldering, leaving behind scarcely anything to indicate their presence; consequently the workman has to keep on repeating the process until the connection is made perfect, which is always done at the expense of a quantity of solder as well as loss to the workman as regards time.

Solders made from copper and silver only are, generally speaking, too infusible to be applied to all classes of silversmith's work.

Solders are manufactured of all degrees of hardness; the hardest of all being a preparation of silver and copper in various proportions; the next being a composition of silver, copper, and zinc; and the easiest or most fusible being prepared from silver, copper, and tin, or silver, brass, and tin. Arsenic sometimes enters into the composition of silver solders, for promoting a greater degree of fusion; and we have heard of workmen actually refusing to work with any other solder. The employment of arsenic has, however, a tendency to slightly endanger the health of those persons using it in large quantities; and of late its employment has not been persevered in.

In applying solder of whatever composition, it is of the utmost importance that the edges or parts to be united should be chemically clean; and for the purpose of protecting these parts from the action of the air, and oxidation during the soldering process, they are covered by a suitable flux, which not only prevents oxidation, but has also a tendency to remove any portion of it left on the parts of the metal to be united. The flux employed is always borax, and it not only effects the objects just pointed out, but greatly facilitates the flow of the solder into the required places. Silver solder should be silver of a little inferior quality to that about to be worked up. The various degrees of fusibility of the several solders are occasioned by the different proportions of the component parts of the elements which enter into their existence. For instance, a solder in which tin forms a component part will flow or fuse much sooner than one in which copper and silver alone enter into composition, or of one wholly composed of copper, silver, and zinc, or of silver and brass; therefore it must be understood that tin is the best metal for increasing the fusibility of silver solders, and for keeping up their whiteness. Nevertheless it should always be used sparingly, and even then drawbacks will present themselves such as we have already alluded to.

It is our intention to give a list of the various solders which have been usually employed with more or less success, so that the silversmith and the art workman will be enabled to select the one most suitable to the particular branch of his trade; and we contend, from experience in the craft, that success of workmanship mainly depends upon this point.

HARDEST SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	0	16	0
Shot Copper........	0	4	0
	1	0	0

HARD SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	0	15	0
Brass..............	0	5	0
	1	0	0

EASY SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	0	13	8
Brass..............	0	6	16
	1	0	0

HARDEST SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper........	0	5	0
	1	5	0

HARD SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Brass..............	0	6	16
	1	6	16

EASY SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Brass..............	0	10	0
	1	10	0

The silver solders here given are not such as we can confidently recommend to the general silversmith, having proved them to be very unsatisfactory in certain classes of work. For example, the first solder, except in the case of plain, strong work, would be far too infusible to be generally used by the silversmith; the second, although much more fusible, cannot safely be applied to very fine and delicate wire-work, because the brass in its composition is so uncertain; unless specially prepared by the silversmith, it probably, if purchased from the metal warehouse, contains lead; the latter is injurious, and in process of soldering it burns and eats away, much resembling the application of burnt sawdust to the work. No really effective work can be produced when the above symptoms present themselves. The same remarks apply to No. 3, which is the most fusible, and when free from lead or other base metal it may be classed as a tolerably fair common solder. In the preparation of the solders to which we are alluding, it is preferable to employ, instead of the brass, a composition consisting of a mixture of copper and zinc, in the proportion of two parts of copper to one part of zinc; the operator then knows of what the solder is composed, and if it should turn out bad he will partly know the cause, and be able to supply a remedy.

The solders that we have found to answer our purpose best are composed of the following elements. The first is described again as *hard* solder, but it is not nearly so hard as the one previously described.

BEST HARD SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	0	16	0
Shot Copper	0	3	12
Spelter	0	0	12
	1	0	0

BEST HARD SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	4	9
Spelter	0	0	15
	1	5	0

MEDIUM SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	0	15	0
Shot Copper	0	4	0
Spelter	0	1	0
	1	0	0

EASY SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	0	14	0
Shot Copper	0	4	12
Spelter	0	1	12
	1	0	0

COMMON SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	0	12	12
Shot Copper	0	6	0
Spelter	0	1	12
	1	0	0

MEDIUM SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	5	8
Spelter	0	1	8
	1	6	16

EASY SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	6	12
Spelter	0	2	4
	1	8	16

COMMON SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	9	15
Spelter	0	2	9
	1	12	0

The whole of the above-named solders will bleach or whiten properly if applied to silver of the suitable quality for such purposes. We have used copper and spelter in our silver solders because we have found from experience that the fewer number of times a solder is melted the better it is for all purposes. This result of our experience is in direct opposition to those authors who have professed to treat upon this subject, and who can have had but a small amount of real practical knowledge; for it is argued by them that the oftener a solder is melted the more properly does it become mixed, and consequently the more fit it is for the workman's use. To such arguments we are prepared to give a blank denial, and our reasons for so doing we will state further on in this treatise.

There are various other silver solders used by silversmiths, some few of which it will be as well, perhaps, while we are on the point, to enumerate:

SILVER SOLDER FOR ENAMELING.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	5	0
	1	5	0

EASY SILVER SOLDER FOR FILIGREE WORK.

	oz.	dwts.	grs.
Fine Silver	0	16	0
Shot Copper	0	0	12
Composition	0	3	12
	1	0	0

SILVER SOLDER FOR CHAINS.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	10	0
Pure Spelter	0	2	0
	1	12	0

COMMON SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	12	0
Pure Spelter	0	3	0
	1	15	0

SILVER SOLDER WITH ARSENIC.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	3	0
Yellow Arsenic	0	2	0
	1	5	0

EASY SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Composition	0	5	0
Tinsel	0	5	0
	1	10	0

SILVER SOLDER FOR ENAMELING.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Shot Copper	0	10	0
	1	10	0

QUICK RUNNING SILVER SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Composition	0	10	0
Pure Tin	0	2	0
	1	12	0

EASY SOLDER FOR CHAINS.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Composition	0	10	0
Pure Spelter	0	2	0
	1	12	0

COMMON EASY SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Composition	0	12	0
Pure Spelter	0	3	0
	1	15	0

SILVER SOLDER WITH ARSENIC.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Composition	0	6	0
Yellow Arsenic	0	1	0
	1	7	0

COMMON EASY SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Tinsel	0	10	0
Arsenic	0	5	0
	1	15	0

ANOTHER COMMON SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Composition	0	15	0
Arsenic	0	1	6
	1	16	6

A VERY COMMON SOLDER.

	oz.	dwts.	grs.
Fine Silver	1	0	0
Composition	1	0	0
White Arsenic	1	0	0

The solders here given will be found amply sufficient to select from for every operation of the silversmith, and will answer the several purposes for which they have been described. When tin and arsenic are employed in the composition of solder, either together or separately, they should be withheld until the more infusible metals with which they are to be united have become melted; the tin or tinsel should then be added, and when this is well melted with the mass, fling on the top the arsenic, let it melt, stir it well together, and pour it out quickly into an ingot-mold already prepared for its reception.

When silver and brass, or silver and composition, alone form the component parts of the solder, these metals may be put into the melting-pot together, well fused, stirred, and poured out as before.

Solders into which volatile metals enter, upon repeated meltings, become hard, brittle, and drossy, and are therefore not so good as when the metal has received only one melting; it is for this reason that we have always preferred to manufacture our solders from metals which have not been melted before, or from those which have gone through the process as few a number of times as possible.

The mode of soldering gold and silver is as follows: Take the solder and roll it out thin between the flattening rollers, or file it into dust, according to the kind of work in hand. If filed into dust, it is all the better if done very fine; and if reduced to a flat state, which should be tolerably thin, cut it into little bits, or pallions, which may easily be performed with a pair of hand-shears, lengthways, and afterwards crossways. When this is done, take the work which is to be soldered, join it together by means of fine binding-wire (very thin iron wire), or lay it upon the pumice so that the joinings can come close together and will not be liable to move during the process; wet the joinings with a solution of borax and water mixed into a thick paste or McLane's Anti-Oxetyn, applying it with a small camel's-hair pencil; then lay the bits or pallions of solder upon the parts to be united, and having placed the article upon some suitable object, take your blow-pipe and blow with it, through a gas-jet, a keen flame upon the solder in order to melt it; this will render the unification of the parts complete and compact.

When filed solder is used, the process of charging the article is rather different from the above. In the latter case the filings are commonly put into a small cup-shaped vessel, in most cases the bottom of a teacup, or some other similar vessel being used for the purpose; a lump of borax is then taken and rubbed upon a piece of slate, to which a little water is occasionally added during the rubbing; when this solution attains the consistency of cream it is put into the solder-dish and well mixed with the solder. This is then applied to the article to be soldered by means of a charger, consisting of a piece of round metal wire, flattened at one end, and shaped for the purpose it has to serve. The joinings, when this kind is employed, require no boraxing with the pencil, as described under pallion solder; the borax being intermixed with the solder flushes with it through the joinings to be united, thus rendering any further application unnecessary. The process to which we are alluding is called "hard soldering," and cannot be applied to metals of a fusible nature; neither must it be attempted in the case of goods bearing the name of plated, which are put together with soft or pewter solder, similar to that used by tinsmiths and gasfitters. If there should be any soft solder about the article to be soldered by the means we are describing, it would be almost certain to destroy it, the soft solder having such an affinity for entering into combination with metals more infusible than itself when overheated.

There is an art in soldering greater than some people would believe. The heat required is of various degrees, some articles requiring a broad rough flame, others a smooth one, and others again a fine pointed one. All these circumstances connected with the process, together with others which we could detail, proving that it is an art only to be acquired by practice, must be considered enough; and we proceed to observe that the skillful jeweler in soldering a large piece of work will direct the flame of the gas-jet to all parts of it, until it is tolerably hot, and then return to the spot to be soldered, and by a very dexterous movement of the flame, produced by the blow-pipe, increase the heat at the spot until the solder has flushed and the parts are rendered thoroughly secure. So far as some of the work of the silversmith is concerned, the process of soldering is a very delicate operation, and ought not to be undertaken by an unpracticed hand.

The method of preparing solder for filigree work is worthy of a passing notice. It is called by the Germans Lemaille solder. In the first place it is reduced to very fine filings, mixed with burnt borax powdered fine, and in this state it is sprinkled from a spouted grater over the work to be soldered. The English filigree workers commonly use clean filed solder, and by means of the camel's-hair pencil apply a solution of borax to the work, and then sprinkle the dry solder upon it from the grater.

In Vienna a kind of powdered borax is employed, called *Streu borax*, or sprinkle borax. It is composed of the following ingredients, which should be gently annealed to expel their water of crystallization, the whole well pounded and mixed together, and sprinkled over the parts to be joined from the spouted grater as before:

	oz.	dwts.	grs.
Calcined borax.......	0	17	12
Carbonate of soda...	0	1	12
Common salt........	0	1	0
	1	0	0

The object of this mixture is to prevent the rising of the solder, and to facilitate its flushing. Too much of it should not, however, be put with solder in the grater at one time, as it is as objectionable as too much borax applied in the ordinary way; but every workman will learn from experience concerning these matters. We have tried this mixture, prepared with filed solder in the ordinary way, and found it advantageous at first; but its greatest drawback is the turning of the solder yellow if not quickly used upon the work after mixing, thus rendering the solder permanently injured. For this reason we have had to abandon its employment in the wet state. But, in its dry state, to the silversmith for filigree purposes it is likely to be of advantage. It may be remarked that this preparation encumbers the work with a great deal more flux than borax does, and consequently it requires to be more often boiled out during the period of soldering together the component parts. This is effected by boiling in a weak pickle of sulphuric acid and water, composed of the following proportions: one part of acid to thirty parts of water

TO SOLDER SILVER.

THE best solder for general purposes to be employed in soldering silver consists of 19 parts (by weight) of silver, 10 parts of brass, and one part of copper, carefully smelted together and well incorporated. To use this for fine work, it should be reduced to powder by filing; the borax should be rubbed upon a slate with water to the consistency of cream. This cream should then with a fine brush be applied to the surfaces intended to be joined, between which the powdered solder (or pellet) is placed, and the whole supported on a block of charcoal to concentrate the heat. In the hands of a skillful workman the work can be done with such accuracy as to require no scraping or filing, it being necessary only to remove the borax when the soldering is complete, by immersing in a jeweler's pickle.

SILVER SOLDER.

TEN pennyweights of brass and one ounce of pure silver melted together makes a good silver solder for plating.

SILVER SOLDER.

THREE dwts. coin weight, one dwt. English brass pins. Melt the silver alone with borax, bend the pins up double, and wrap them up into a compact little parcel in thin paper, so as to be readily dropped into the molten silver, and not bristle up and stick to the sides of the crucible; as soon as they melt, give your crucible a shake or two and run into the ingot; if you leave it long in a molten state after the pins melt, the zinc burns out and impairs the quality of the solder. Have a good heat on before you drop the pins in, especially the lip from which you intend to pour off. It is not owing so much to any peculiarity in the brass of which these pins are made, although its excellence and their convenient size recommend them, as witnessed by their general use by the trade for many purposes, but it is the antimony with which they are coated that gives the solder its good quality. It flows easy, will stand chilling in the pickle, and retain its toughness; is white enough to use on silver, and is suitable for all kinds of repairing.

COLD SILVERING.

IT sometimes happens that the country goldsmith or watchmaker has a silver-plated article in repair, and not having a battery either in his possession or in working order, he is nonplused how to restore the silver-plating. For doing this, there is nothing so good as the methods described by A. Roseleur, and which are as follows:

COLD SILVERING BY RUBBING WITH THE THUMB, A CORK, OR A BRUSH.

The results are better than those by the whitening process, but not very durable; the method is useful to repair slight defects upon more durable silverings, and to produce mixtures of gold and silver, or gold upon slightly gilt objects, thus avoiding the use of resist varnishes. Make a paste by thoroughly grinding in a porcelain mortar, or with a muller, and, as far as practicable, not in the light:

Water	ounces,	3½ to 5
White fused nitrate of silver, or preferably the chloride	"	7
Binoxalate of potash	"	10½
Bitartrate of potash	"	10½
Common salt	"	15

or,

Chlorate of silver	ounces,	3½
Bitartrate of potash	"	7
Common salt	"	10½

Pulverize finely in a porcelain mortar, and triturate it under a muller upon a plate of ground glass until there is no granular feeling. Keep the paste in a porcelain pot or in a black glass vessel, to preserve it from the light, which decomposes it rapidly. When about to use it, add a little water so as to form a thin paste, which is applied with a brush or pencil upon the cleansed articles of copper, or upon those gilt by dipping, or even upon those gilt by the battery, provided that the coating is thin enough to allow the copper to decompose the silver paste through the coat of gold; allow the paste to dry naturally or with the aid of a gentle heat. The chemical reaction is more or less complete according to the thickness of the gold deposit, and the dry paste is of a pink shade, or entirely green. The salts are removed by a thorough rinsing in cold water and the silver appears with a fine frosted appearance, the brightness of which may be increased by a few seconds' immersion in a very dilute solution of sulphuric acid or of cyanide of potassium. This silvering bears the action of the wire brush and of the burnishing tool very well; and it may also be oxidized. Should a first silvering not be found sufficiently durable after scratch-brushing, apply a second or third coat. This silvering is not so adhering or so white on pure copper as upon a gilt surface. For the reflectors of lanterns, the paste is rubbed upon the reflector with a fine linen pad; then, with another pad, a thin paste of Spanish white, or similar substance, is spread over the reflector and allowed to dry. Rubbing with a fine and clean linen rag will restore the luster and whiteness of the plated silver.

FOR PLATED SILVER REFLECTORS.

A bath made of water, 1¾ pints; nitrate of chloride of silver, 2 ounces; cyanide of potassium, 10½ ounces; add sufficient Spanish white, or levizated chalk, in fine powder, to produce a thin paste, which is kept in a well-closed pot. This paste is spread with a brush, or a pad of old linen, all over the surface of the reflector, and allowed almost to dry, when it is briskly rubbed over with another clean dry rag of old linen.

SILVERING BY DIPPING IN A WARM BATH.

For small articles, a bath is made by dissolving in an enameled cast-iron kettle, in two gallons of water, 17½ ounces of ordinary cyanide of potassium. Also dissolve 5¼ ounces of fused nitrate of silver in 1¾ pints of water, contained in a glass or porcelain vessel. The second solution is gradually poured into the first. Stir with a glass rod. The white or grayish-white precipitate produced soon dissolves, and the remaining liquor is filtered, if a perfectly clear bath is desired. When brought to the boiling point it will immediately silver the cleansed copper articles plunged into it. The objects must be quickly withdrawn. The silvering should immediately follow the cleansing, although the rinsings after each operation should be thorough and complete. This bright and light silvering is adapted for set jewelry, which cannot be scratch-brushed without flattening the clasps, and to which a bright luster is absolutely necessary as a substitute for the foil of burnished silver placed under the precious stones of real jewelry. The employment of the solution of nitrate of binoxide of mercury is useless, and even injurious for this bath. It is useless to keep up the strength of the solution by new additions of cyanide and silver salt, as it will invariably give results far inferior to those of the former solution. The baths should therefore be washed out, as long as the silvering is satisfactory, and when exhausted, put away with the waste. With this process a battery and a soluble anode may be used to obtain a more durable deposit; but the operation is no longer a simple dipping, and properly belongs to electro-silvering by heat.

A solution which, when boiling, produces a very fine silver coat with a mat, or partly mat, luster upon cleansed copper, is made by dissolving, with the aid of heat, in a well-scoured copper kettle: Distilled water, 9 pints; ferro-cyanide of potassium, 21 ounces; carbonate of potash, 14 ounces. When the liquid boils, add the well-washed chloride obtained from 1 ounce of pure silver. This should boil for about half an hour, and be filtered before using; part of the silver deposits upon the copper kettle, and should be removed when a new bath is prepared. On account of this inconvenience, the process has been nearly abandoned, although the products are remarkably fine. All the dipping silver baths, which contain a comparatively great excess of cyanide of potassium to proportion of the silver salt, will silver well copper articles perfectly cleansed, even in the cold; whereas this characteristic diminishes in proportion to the increase of the amount of silver in the bath, or with the decrease of the amount of cyanide. For small articles, partly copper and partly iron, such as those used for saddlery and carriage wares, a particular process of silver is used. The bath is composed of.

Water................	pints,	9
Caustic potash........	ounces,	6
Bicarbonate of potash..	"	3½
Cyanide of potassium ..	"	2
Fused nitrate of silver..	"	⅔

The cyanide, caustic potash, and bicarbonate are dissolved in seven pints of water in an enameled cast-iron kettle; then the remaining quart of water, in which the nitrate of silver has been separately dissolved, is added to the former solution. For the silvering operation, a certain quantity of articles are cleansed, thoroughly rinsed, and put in a small enameled kettle. Enough of the silver bath is poured in to cover the articles entirely, and the whole is brought to a boil for a few seconds, and stirred with a wooden spatula. When the silvering appears satisfactory, the liquor employed is put with the saved waste; the same liquid is never used for two batches of articles. This process gives a somewhat durable silvering with a dead luster of a grayish-white, which is increased in whiteness and brightness by soap and burnishing.

TO DISSOLVE SILVER FROM SILVERED ARTICLES.

Cold Bath.—For dissolving silver in the cold, the objects are hung in a large vessel filled with the following mixture: Sulphuric acid 66° B., 10 parts; nitric acid at 40° B., 10 parts. The articles remain in this for a greater or less length of time, according to the thickness of the coat of silver to be desolved. The liquid, when it does not contain water, dissolves the silver without sensibly corroding copper and its alloys; therefore avoid introducing wet articles into it, and keep the liquid perfectly covered when not in use. As far as praticable, place the articles in the liquid so as not to touch each other, and in a vertical position, so that the silver salt will fall to the bottom. In proportion as the action of the liquid diminishes pour in small and gradual additions of nitric acid. Dissolving silver in the cold is regular and certain, but slow, especially when the proportion of silver is great.

Hot Bath.—Nearly fill an enameled cast-iron pan with concentrated sulphuric acid, and heat to a temperature of from 300° to 400° Fahr.; at the moment of using it, pinches of dry, powdered saltpeter are thrown into it; then hold the article with copper tongs in the liquid. The silver rapidly dissolves and the copper or its alloy are not sensibly corroded. According to the rapidity of the solution more or fewer pinches of saltpeter are added. All the silver has been dissolved when, after rinsing in water and dipping the articles into the cleaning acid, they present no black or brown spots—that is, when they appear like new metals.

These two methods are not suitable for removing the silver from wrought- and cast-iron, zinc or lead; in these cases it is preferable to invert the electric current in a cyanide bath, or to use mechanical processes. Old dissolving liquids become green after use; to recover the silver they are diluted with four or five times their volume of water; then add hydrochloric acid or common salt. The precipitation is complete when the settled liquor does not become turbid by a new addition of common salt or by hydrochloric acid. The resulting chloride of silver is separated from the liquid either by decanting or filtering, and is afterwards reduced to the metallic state by one of the usual methods.

TO IMITATE INLAYING OF SILVER.

A VERY neat imitation of silver inlaying for small boxes, handles, and articles *de luxe*, may be made in the following manner: Carefully draw your pattern upon the work, and then engrave or cut away your lines with sharp gouges, chisels, etc., so as to appear clean and even, taking care to cut them deep enough, and rather into it, like a dovetail, so as to secure the composition afterward to be put into the grooves. The silver compositión may be made as follows: Take a small quantity of the purest and best grain tin and melt it in a ladle; add to it, while in fusion, the purest quicksilver, stirring it to make it incorporate; when you have added enough, it will remain as a stiff paste; if too soft, add more tin, or if too stiff, add more quicksilver. Grind this composition in a mortar or upon a marble slab, with a little size, and fill up the cuttings or grooves in your work, as you would with putty. Allow it to remain some hours to dry, after which you may polish it with your hand, and it will appear like work inlaid with silver.

OXIDIZING SILVER.

EVERY worker in the precious metal knows the liability of silver to become tarnished in an atmosphere containing sulphurous emanations, sewer gas, or sulphureted hydrogen; in the language of the day this tarnishing is called "oxidizing," although erroneously so, because the silver enters into a chemical combination with the sulphurous gas and forms a sulphide of silver. The object assumes a dark lead-color, and in order to restore the brightness of the silver, pickling must be resorted to. This proclivity is taken advantage of for causing an artificial oxidation upon the silver surface by covering this latter with certain re-agents that will produce such an effect. Such a re-agent must naturally contain an easily decomposing sulphur combination, which the silversmith has in the so-called liver of sulphur (German *Schwefelleber*, sulphide of potassium), which is so easily decomposed that it parts with hydrosulphide even at a simp.e exposure to air. The workman can readily prepare it himself by mixing two parts of sharply dried potash with one part of pulverized sulphur, and then fusing the mass in an iron vessel. This potassic sulphide can also be purchased in any drug-store; it is a crumbling, liver-brown mass, and has to be kept in firmly closed receptacles on account of its liability to decompose. When a silver article is to be coated entirely with sulphide of silver, the former must first be thoroughly cleaned from all filth and grease with soda lye; it is then rinsed in water and at once immersed in a bath of the sulphide of potassium solution. Action begins at once, and the coating adheres according to the state of dilution of the bath. The course of the process must not be hastened too precipitately, however, as under such circumstances the coating of the sulphide will adhere loosely and drop off when slightly touched. (The writer ascertained by experiments that a much more firmly adhering coating may be obtained by exposing the article for some time to an atmosphere of humid sulphureted hydrogen gas.) It may be well to remember that the more dilute the bath is the more tenaciously adheres the "oxidation"; the formation of this is hastened by warming the fluid.

When coated sufficiently with sulphide of silver, the article is taken out of the bath, quickly rinsed in water, and then dried; if the work has been conducted correctly the piece must be of a uniform gray color. Ornamentations may then be executed showing the brightness of the silver; this is effected in two ways—mechanically and chemically. By the former, the layer of the sulphide of silver is completely removed with a graver, so that the color of the metal underneath is made to appear. By the second, that part of the design which is to appear bright is executed with a goose quill dipped in moderately strong nitric acid, which changes the sulphide of silver into a sulphate, that can be washed off by dipping the article for some time in boiling water, after the drawing of the design is finished. The sulphate of silver dissolves with difficulty in water.

It is not easy to produce entirely faultless designs in this manner, and especially do the contours occasionally lack sufficient sharpness. Sharper designs are obtained by coating the places of the silver which are to remain bright with asphaltum varnish, and, after drying, dipping the article into the potassium-sulphide bath. When the action is satisfactory the article is rinsed and the asphaltum lacquer removed by dipping in benzoin.

By tracing the design directly upon the article, experiments have also been successful; a highly concentrated solution of sulphide of potassium in water was prepared, and so thickened with sufficient thick mucilage solution that it could have been used for writing and drawing. The designs upon the bright silver were executed with a quill and brush; the article set aside for 24 hours, then heated so that the dried mucilage mixture either dropped off of itself or separated by gentle tapping. If the fluid is thickened sufficiently with the mucilage solution the outlines of the tracings will be of very great sharpness, and the dark gray sketches on the bright silver will make a very agreeable effect.

There are two distinct shades in use, one of which is produced by chloride, which has a brownish tone. For this it is only necessary to work the article with a solution of sal-ammoniac. The other, described in the proceeding, is of a much more beautiful tint.

The nice blue-gray to black tone, the characteristic of sulphide of silver, is obtained by this sulphur bath; but if the silver is alloyed with much copper the color will be different, inclining more to dead black, and not so handsome. When, therefore, an oxidation simply produced by sulphide of silver is to be obtained, the article must be heated to a red heat for some time, so as to oxidize the copper on the surface to a proportionally great depth; this oxide is then to be removed by pickling twice or three times. If the color of the oxidized silver is to be very dark, passing into a velvety black, dip the article, before entering the liver-of-sulphur bath, in a solution of proto-nitrate of mercury. The article assumes thereby a fairly white color, metallic mercury separating upon its surface which unites into an amalgam with the silver. The solution of the proto-nitrate of mercury is produced by dissolving mercury in the cold in nitric acid, so that a little mercury remains in excess; this solution is to be kept in a closed bottle, upon the bottom of which is a little mercury. When the article is next immersed into the sulphide of potassium bath, a thicker layer of a mixture of sulphide of mercury and sulphide of silver, of a velvety black tone, is produced.

The silver oxidation may also be shaded by chemical re-agents; for instance, the oxidized article is dipped into a fluid consisting of 10 parts of sulphate of copper, 5 parts of sal-ammoniac, and 100 parts vinegar, which imparts a warm, brown color to the bright places of the silver. Elegantly colored designs may be produced in this manner by a skillful manipulation of the process. For instance, ornamentations are first traced upon the bright silver surface with asphaltum lacquer; the article is next oxidized in the liver-of-sulphur baths, after which the asphaltum layer is removed; next it is dipped into the solution of proto-nitrate of mercury, and again oxidized, when black designs upon a blue-gray ground are obtained. Now brighten certain places of the silver surface, dip the article in the above-stated copper solution, and you will have the bright spots oxidized brown. Care is always necessary that the oxidations already produced are not ruined by the succeeding ones, and it is always necessary to coat such finished places with asphaltum lacquer.

OTHER METHODS.

I.

SILVER work may be oxidized by any of the following processes:

Sal-ammoniac	2 parts.
Sulphate of copper	2 parts
Saltpeter	1 part.

Reduce the above ingredients to a fine powder, and dissolve it in a little acetic acid. If the article is to be entirely oxidized, it may be dipped for a short time in the boiling mixture; if only in parts, it may be applied with a camel's-hair pencil, the article and the mixture both being warmed before using.

II.

Platinum	1 part.
Hydrochloric acid	2 parts.
Nitric acid	1 part.

Dissolve the platinum in the mixture of acids, evaporate to crystallization, and when cold, dissolve again in a little sulphuric ether. Apply the mixture with a camel's-hair pencil to the parts required to be blackened.

III.

Saltpeter	2 parts.
Common salt	1 part.
Spirits of salts	1 part.

Reduce the salts to powder, and place it in a black-lead crucible along with the acid, boil up, and then dip the articles into the mixture for a short time, or otherwise apply it to the parts required to be oxidized.

These mixtures will give the various tints of oxidation to silver work if properly treated; but if other tints be desired, the following chemical substances may be employed according to taste: For slate-colored surface, dip the articles into a boiling solution of sulphuret of potassium. Strong hydrosulphate of ammonia produces a dark tint of oxidation, and if diluted with much water a light tint is produced. Nitric acid produces a light surface. The fumes of sulphur produce a beautiful blue-colored surface. This operation should be conducted in a closed box, and all parts not to be blackened should be coated with a suitable resist varnish. After any of these processes the articles may either be scratched or otherwise burnished.

IV.

We find the following process for oxidizing silver in the *Journal des Applications Electriques:*

The salts of silver are colorless when the acids, the elements of which enter into their composition, are not colored, but they generally blacken on exposure to light. It is easy, therefore, to blacken silver and obtain its oxide; it is sufficient to place it in contact with a sulphide, vapor of sulphur, or the sulphides or polysulphides of potash or soda, dissolved in water and called *eau de barège*. The chlorides play the same part, and the chloride of lime in solution or simply *eau de javelle* may be used. It is used hot in order to accelerate its action.

The bath must be prepared new for each operation for two reasons: 1. It is of little value. 2. The sulphides precipitate rapidly and give best effects only at the time of their direct precipitations. The quantity of the re-agent in solution forming the bath depends upon the thickness of the deposit of silver. When this is trifling, the oxidation penetrates the entire deposit and the silver exfoliates in smaller scales, leaving the copper bare. It is necessary, therefore, in this case to operate with dilute baths inclosing only about 3 grams (45 grains) of oxidizant at most per liter. The operation is very simple: Heat the necessary quantity of water, add the sulphide or chloride, and agitate to effect the solution of the mixture, and then at once plunge in the silver-plated articles, leaving them immersed only for a few seconds, which exposure is sufficient to cover it with a pellicle of deep black-blue silver. After withdrawing they are plunged in clean cold water, rinsed and dried, and either left mat or else polished, according to the nature of the articles.

Should the result not be satisfactory, the articles are brightened by immersing in a lukewarm solution of cyanide of potassium. The oxide, the true name of which would be the sulphuret or chloruret, can be raised only on an object either entirely of silver or silver-plated.

FROSTING SILVER.

HAVING been requested to give some general information with regard to the processes of frosting and finishing silver and metal work, we give the following few particulars with the expressed proviso that, although every process and detail may be here laid down for the perfect and most complete accomplishment of the art, the uninitiated or even the less experienced operator can do the same work and achieve such good results as the skillful workman.

The frosting of silver goods is not done with an acid or combination of acids, but is simply due to scratching with the scratch-brush. These scratch-brushes take different forms, according to the kind of work to be submitted to them for frosting, and are made of various strengths; that is, the wires of them are specially prepared of several thicknesses, and when a very fine satin finish is required, a brush of very fine wire is taken, and so on. A brush with wires thicker and thicker in proportion is taken as a more extended roughness is desired. These wire scratch-brushes are fixed upon a horizontal spindle in the lathe; the lathe is made to revolve by means of the foot of the operator and a treadle attached to the crank of the lathe, but where a gas or other small power engine can be employed it is far preferable, as the speed is much greater and far more regular. Frosting requires great speed to do the work nicely. The wires of the scratch-brush must lie even on the surface, all of the same length, and always kept straight at the points, otherwise the frosting will not be regular. Sometimes the little hand scratch-brushes are employed for coarser work; four of them are taken and firmly secured in four corresponding grooves in a circular chuck, which screws into the lathe. The ends of the four little brushes are repeatedly cut off as occasion requires, in order to present a straight surface for a continual contact with the work.

Metal work is first prepared for gilding by dipping, and when gilt, submitted in the same manner as silver to the processes just described.

Metal work can be frosted by acids with advantage, whereas no good results can be arrived at with silver, or by its treatment in any analogous manner, as the color, in the first place—and this is highly important—would be very inferior, and the frost produced would in no manner compare with that produced by the scratch-brush.

A few good recipes consist as follows for dipping metal goods. Each one effects a bright frosted surface upon work submitted to their various actions, and this, of course, is always providing the alloy is right of which such work is composed:

No. 1.

Nitric acid	4 ounces.
Sulphuric acid	1 ounce.
Common salt	½ ounce.
	5½ ounces.

In preparing this solution add the sulphuric acid to the nitric, and lastly put in common salt in a state of fine, dry powder. Keep your work free from water, and dip it in the mixture for a few seconds only. The work must be scrupulously clean and free from grease of every kind.

No. 2.

Nitric acid	4 ounces.
Muriatic acid	4 ounces.
Hydrochloric acid	½ drachm.

Prepare the mixture, and treat it exactly in the same manner as the previous one; be careful and not leave the work in the solution too long.

No. 3.

Nitric acid	1 ounce
Muriatic acid	1 ounce.
Common salt	1 ounce.

Well mix these ingredients together by stirring, and then dip the work for a very short time only, when the object of your desire will be readily attained.

TO ETCH SILVER AND GOLD.

THE process of etching silver is done for the purpose of embellishing an otherwise dead flat surface of a certain article. When an etching is to be introduced, the place of the article is slightly warmed to a temperature to melt a coating of beeswax upon it. The design is then carefully scratched with a sharp-pointed instrument, the etching needle, through the coating of the beeswax, working and managing the lines precisely as we would if we were making a pen-and-ink drawing, forcibly drawing the outline of the design—say a rabbit—and if the operator is confident of his ability to preserve the roundness of the form, let the furry appearance be given in the etching; if not, let him content himself with the outline and a few vigorous touches, as far as his ability enables him.

The etching, or "biting in," as it is also termed, is best done with nitric acid, diluted with three or four times the amount of water. The piece to be etched should be protected all over either with beeswax or shellac varnish (shellac dissolved in alcohol). The article or plate to be etched is best sunk in the dilute nitric acid, where it should be brushed (as it lies immersed in the acid) with a camel's-hair pencil, to remove gas bubbles. A little practice will enable one to judge of the time required, as acids vary so much in strength that no rule can be given. The etching can be carried to different degrees of depth and width, by the time to which it is subjected to the action of the acid; as, for instance, the same line can be bitten in with acid so as to be so fine and delicate as to be almost imperceptible, but if the acid action is continued it will bite deeper and deeper, until a full, heavy, strong line is obtained. Gold can also be etched by using nitro-muriatic acid (2 parts muriatic, 1 part nitric), diluted in about the same proportions. In the rabbit the effects may be varied by matting some portions and leaving others bright. After the etching is complete, and before the bright cutting is done, the article should be cleaned from the wax by washing with spirits of turpentine, and then with soap and water, after which it should be dried in boxwood sawdust. After the etching wax is entirely cleaned off, the etching lines should be rubbed with a fine wire scratch-brush, to remove any oxide of silver remaining in them. Such etch effects can be made in figures of men or animals, but more particularly landscape scenes. When in the hands of a skillful designer, a witching little rural scene can be lined in in a comparatively short time.

POLISHING SILVER.

POLISHING is an important process with all precious metal workers. It is applied for the production of surface to their wares, and in proportion to the smoothness required upon the work, so should be the fineness of the material employed in effecting it. The polishing powders are emery, powdered pumice, crocus, rotten-stone, putty of tin, and rouge. In the best work, scratches are removed with a smooth and rather soft dark gray stone (Water-of-Ayr stone); it is then polished in the lathe with a stiff brush, and the application of a little fine polishing mixture. We have placed the materials for polishing in their respective order of smoothness or fineness, beginning with emery, which is the coarsest. A very good mixture for ordinary work consists of equal portions of emery, pumice, and crocus, with oil added to consistence of a thick paste. Good work does not want much polishing, for the beauty of it depends more on its being executed by a well-trained workman; whereas rough and badly executed work requires much polishing, and for this the coarser powders are preferable, or a mixture of them; but for the finer, better finished work the finer powders should be employed.

The Water-of-Ayr stone employed for polishing is usually obtained in the form of small square sticks, and is used with a small quantity of water to the surface of the work, in a similar manner to filing. The stone is softer than the material upon which it operates (and, in fact, so are all the materials for polishing), and therefore wears away, producing a mud-like substance upon the article, which should be repeatedly moved, in order to ascertain the progress made. This may be done with a clean rag, or tissue paper. When the work is polished at the lathe it will gradually become enveloped in grease, etc., which should be removed occasionally, to show when the process has been carried far enough. The polishing of silver work is the branch of the trade commonly performed by girls. It is hard work for them, as the metal possesses a very soft nature; it therefore pulls hard against the brush which holds the polishing mixture. The lathe employed is the ordinary polishing lathe with a horizontal spindle, and is worked with a common foot-treadle; steam-power is used by some firms for moving lathes, but it is by no means the usual custom at present.

After the completion of the polishing process, the work is well washed out in a prepared solution, to remove the mixture which adheres to it; a solution of soda is found to answer the purpose best, both from its cheapness and effectiveness. It should be used hot, with the addition of a little soap, and with a stiff brush the dirt is soon removed. The quantity of soda used to a given proportion of water differs in the trade, and there is no set rule to go by; it depends, more or less, upon the adhesiveness of the polishing mixture. We have found about two ounces of it to a quart of water amply sufficient for the purpose.

RESTORING THE LUSTER OF SILVER.

THE best way to restore the original dead or lustrous whiteness of silver goods, lost or impaired by exposure to sulphurous atmospheres, or by having been too often and perhaps carelessly cleaned, is effected by annealing in a charcoal fire, or before the flame of a gas or oil lamp, by means of the blow-pipe, which affects the destroying of all organic matter adhering to the surface of the article, at the same time oxidizing on the surface the base metals with which the silver is alloyed. The article is allowed to cool, and then immersed in a boiling solution, consisting of from one to five parts of sulphuric acid, and twenty parts of water—the quantity of the water depending upon the quality of the silver the article is made of; the coarser the silver, the more acidulated. The boiling in this solution has the effect of dissolving the extracted deposit of oxide and leaving a coating of pure and fine silver on the surface. The time for allowing the articles to remain in the solution also depends on the quality of the silver; while good sterling silver will be whitened in almost an instant, common silver will take a minute, or even longer; care is, however, to be taken not to allow the articles to be too long in the solution, as in that case the surface will turn into an unseemly grayish color, and the manipulation will have to be commenced afresh; if the silver is very common, the article will require to be repeatedly treated in this manner before the desired whiteness is obtained, and in some cases will even have to be silvered by the galvanic method. As soon as the desired whiteness of the article whilst in the acid is observed, it is removed and quickly thrown into lukewarm water; it is advisable to have an additional vessel with warm water at hand to place the articles in after having been removed from the first. The articles are then immersed in boxwood sawdust, kept in an iron vessel near the stove, or any warm place, when, after thoroughly drying in the sawdust, the article will be found to look like new. Any places on the article desired to look bright are burnished with a steel burnisher.

The annealing, prior to placing the article into the acid solution, requires some care and attention, or else the workmanship of the piece will be irretrievably lost. It is first of all necessary to closely examine the article, whether it has been soft-soldered previously, as under such circumstances it is unfit to be annealed, as the heat necessary for this would burn the solder into the articles and produce blemish past remedy. It is, secondly, necessary to remove all stones, steel, or any material not silver, or liable to be injured in the fire, and it is also advisable to remove pins or tongues from brooches, or spiral springs attached to some very showy ornaments, to produce a shaking or trembling greatly admired in artistic jewelry, in order to preserve the hardness of the pins and the elasticity of the springs. After being satisfied that these precautions have been observed, and the article is without risk fit to be annealed, another precaution, and especially by mechanics not accustomed to such work, should be observed, namely, to prevent an over or under heating. If the article is overheated, it is liable to melt, and if underheated, the organic matter adhering is not effectually destroyed, and the surface not sufficiently oxidized. In order to obtain the required degree of heat, and running no risk of either under or over heating, the article is held with a pair of pincers very close over the flame of the lamp so as to be covered with soot all over, and then exposed before the blast of a flame by means of a blow-pipe, until the soot burns or disappears, when quite sufficient and yet not more heat than is required is obtained. The practice of this last precaution will greatly assist the manipulation and prevent accidents.

Silver ornaments which have merely become oxidized by exposure in a sulphurous atmosphere, and not by repeated cleaning, are simply restored by brushing with a clean tooth-brush and a little carbonate of soda.

TARNISHING OF SILVER.

OF the many agents proposed to prevent the tarnishing of silver and plated goods, none appear to have given as satisfactory results as a varnish of collodion—a solution of gun-cotton in a mixture of alcohol and ether. All other varnishes appear to impart a yellowish tinge to the silver or plated wares, but collodion varnish is quite colorless. The articles should be carefully brushed with the varnish, using an elastic brush, making sure that the entire surface is covered. The film of collodion will protect the underlying metal surface for a long time.

TO CLEANSE SILVER TARNISHED BY SOLDERING.

SOME expose it to a uniform heat, allow to cool, and then boil in strong alum water. Others immerse for a considerable length of time in a liquid made of one-half ounce of cyanide of potash to one pint of rain-water, and then brush off with prepared chalk.

TO CLEAN SILVER.

TAKE either a small sponge, a piece of flannel, a piece of chamois, or a clean and dry silver brush. Rub all the articles which have bad spots with salt, which removes the spots more quickly than anything else. The simplest method is to place a little prepared chalk in a saucer with water, of which make a thick paste, and add a few drops of ammonia. In place of ammonia, the chalk can be prepared with alcohol or simply with water. This paste is to be brushed or rubbed carefully over the article.

RAPID SILVER PLATING.

DR. BURGER recommends the following for rapid silver plating: Prepare a powder of 3 parts of chloride of silver, 20 parts carefully pulverized cream of tartar, and 15 parts pulverized cooking salt; mix it into a thin paste with water, and rub it upon the well-cleaned metallic surface with blotting paper. After you are certain that all parts of the article have been touched alike, rub it with very fine chalk powder or dust upon wadding or other soft cloth, wash with clean water, and dry with a cloth.

SILVERING RECIPE.

AMONG the several recipes given for obtaining a silvering solution, Marquand recommends the following of Mr. C. Ebermacher, which has been tested repeatedly, and was found very useful, as it gives, after a short time, lustrous silver layers on metals, and especially on brass. Care must be taken that the pieces which are dipped in the metal bath be treated before in the ordinary manner in a potash solution and dilute hydrochloric acid. The silver bath is made with a solution of four ounces lunar caustic (equal to a solution of two and one-half ounces silver in seven and one-half ounces nitric acid); the silver of this solution is precipitated as oxide of silver by the addition of a solution of two and one-half ounces caustic potash in six and one-quarter ounces distilled water; and the precipitate, after being washed, is added to a solution of 12 and one-half ounces of cyanide of potassium in one quart of water. This solution is then filtered and water added to bring it to four and one-quarter quarts. In this solution, which is heated on the water bath, the pieces to be silvered are left for a few minutes. After being agitated, they are taken out, and put to dry in fine sawdust, and then polished.

COLD SILVER PLATING.

FRESHLY deposited chloride of silver, well washed with hot water, is mixed in equal proportions of table salt and cream of tartar, until it becomes a paste, if necessary, with additions of water. The article to be silvered is first cleansed with a good stiff brush and a solution of soda and soap, and thoroughly rinsed to remove any dirt, and again rinsed with hot water. It is to be recommended to submit it to a dry cleaning with pulverized and washed chalk, pumice-stone powder, or quartz powder. When well rinsed with cold water, make a ball of loose cotton wrapped in soft muslin, and with this coat the wet article with a thin layer of salt; then rub some of the silvering paste onto it until the whole article under treatment is well silver-coated. When sufficient, quickly rub with a little ball some cream of tartar upon the silvering, and wash. The silver deposit will be found handsome, clean, and as white as snow.

SILVERING WITHOUT A BATTERY.

SILVERING by contact is not as durable as by battery, although the color is the same. The solution is prepared as follows: Take one part chloride of silver, six parts prussiate of potash, four parts purified potash, two parts salt, four parts caustic ammonia, four and one-half parts rain-water. First prepare the chloride of silver, next dissolve the prussiate of potash in water, and add then the potash, salt, and ammonia, and boil the whole for one-half hour in a porcelain vessel; filter, and the fluid is ready for silvering. The utmost cleanliness is also a primary condition by this method. Heat the fluid up by boiling, then introduce the article, together with a piece of clean zinc. Take it out after a few minutes and brush it with cream of tartar, and put it back again in the solution, in which leave it for three or four minutes. Then brush again, and continue this until it is sufficiently silvered. This silvering will bear polishing with the steel, and takes a nice black luster. Articles silvered by this method cannot be distinguished from silver articles. It is very good to protect galvanic casts against dimming. But when silvering, no more must be taken of the fluid than will be used.

FROSTING POLISHED ILVER.

CYANIDE of potassium one ounce, dissolved in one-half pint of water. Do not hold the silver in your hands, but use boxwood plyers, and apply the mixture to the surface with a brush.

PICKLE FOR FROSTING.

SILVERWARE may be frosted and whitened by preparing a pickle of sulphuric acid one drachm, water four ounces; heat it and in it immerse the silver articles until frosted as desired; then wash off clean and dry with a soft linen cloth, or in fine clean sawdust. For whitening only, a smaller quantity of acid may be used.

SILVER-ALUMINUM ALLOYS.

ALUMINUM and silver make handsome white alloys, which, compared to those from pure aluminum, are much harder, in consequence of which they take a much higher polish, and, at the same time, they are preferable to the silver-copper alloys, for the reason that they are unchangeable in air and retain their white color. It has been proposed, therefore, no longer to alloy the world's money with copper, but with aluminum, which makes it far more durable, and even after a long-continued use it retains its white color. Experiments on a vast scale were for this reason instituted in European countries, but for some reason or other, it appears that the silver-copper alloys were retained. According to the quantities of aluminum added, the alloys possess varying characteristics. An alloy consisting of 100 parts aluminum and five parts silver differs but little from the pure aluminum, yet it is far harder and assumes a higher polish. An alloy consisting of equal parts of aluminum and silver rivals bronze in hardness.

WASHING SILVERWARE.

NEVER use a particle of soap on your silverware, as it dulls the luster, giving the article more the appearance of pewter than of silver. When it wants cleaning, rub it with a piece of soft leather and prepared chalk, the latter made into a kind of paste with pure water, for the reason that water not pure might contain gritty particles.

EXTRACTING SILVER FROM WASTAGE.

MIX your refuse with an equal quantity of wood charcoal, place in a crucible and heat to a bright red, and in a short time a silver button will be found at the bottom. Carbonate of soda is another good flux.

SILVER ALLOYS.

PURE silver is a metal of only an inferior degree of hardness, in consequence of which silverware manufactured from the pure metal would be subject to rapid wear, and for this reason it is generally alloyed, except for articles for the chemical laboratory. Silver is more frequently alloyed with copper; beside this, it is also alloyed with gold and aluminum. Alloys containing silver and nickel, or silver, nickel, and zinc, are much employed in the manufacture of table ware and articles *de luxe*, which, while being of a handsome white color, are much cheaper than those from silver and copper, which was formerly much used in the manufacture of silverware.

RESILVERING BRASS CLOCK DIALS.

THE following solutions are generally employed for electro-plating: Silver solution, No. 1: cyanide of potassium, ¼ lb.; cyanide of silver, 1¼ oz.; water, 1 gallon. The cyanide of potassium, in the form of white cakes or lumps, is dissolved in the water and allowed to settle; it is then filtered. The cyanide of silver, a white powder, is then gradually added to the alkaline cyanide solution in the above proportions; it will dissolve on stirring, and the result is the electro-plating solution desired. It contains 1 oz. of silver to the gallon. Solution No. 2: This is the solution of silver which is most easily prepared; it is also the cheapest, and there is neither time nor labor spent in preparing the silver salt for solution in the cyanide solution. The materials employed are: Cyanide of potassium, ¼ lb.; water, 1 gallon. This solution is placed in a large vessel, and a similar solution is placed in a flat, porous vessel, which is supported in the larger vessel, so that the liquid is the same height in each vessel. In the porous vessel is put a small and clean piece of iron, and in the outer vessel a large and thick sheet of pure silver, the iron being so fixed that the conductor in contact with it does not enter the solution, and the silver being supported entirely in the liquid by means of thick silver wire. When these details are properly arranged, the silver plate and the iron plate are so connected with the source of electric power that the electric current proceeds from the silver to the iron. The size of the silver plate may be half a square foot, and the electric power employed may be equivalent to six Smee's cells, each with an area of 18 square inches. In a few hours the silver plate will have lost 1 oz. of the metal. The disposition of the metal on the cathode is prevented by the use of the porous vessel. The liquid in the porous vessel may contain some silver; this may be ascertained by the addition thereto of muriatic acid. Although there is free caustic potash in the solution, which by contact with the air becomes carbonate of potash, and although the resulting solution is not quite so conductive of electricity as No. 1, it is a very good solution in practice, and is said to be less likely to deposit non-adherent metal, or, in technical terms, metal "that will strip," than many others.

SILVERSMITHS' ALLOY.

COPPER, 1 oz.; nickel, 3 dwts. 12 grs.; bismuth, 6 grs.; zinc, 2 dwts. 12 grs.; soft iron, 12 grs.; tin, 12 grs. This compound is said to form a fusible and malleable metal that can be easily worked by the silversmith; it is also said to resist oxidation through atmospheric influences.

IMITATION SILVER.

FINE silver, 6 dwts.; nickel, 6 dwts.; copper, 8 dwts.

REMOVING GOLD FROM SILVER ARTICLES.

SILVER articles which have been gilt may be brought back to their original color by simply covering them with a thick solution of borax, and then well annealing them. After this process, if the articles are boiled for a short time in one of the whitening mixtures and scratched, they will present a beautiful white and uniform surface.

OXIDIZING SILVER.

A BEAUTIFUL deep, black color, possessing great luster, may be given to finished silver work by boiling it in the following preparation for some time: Bromine, 5 grs.; bromide of potassium, 5 dwts.; water, 10 oz. The boiling should be effected in a stoneware pipkin, and generally from two to five minutes will suffice for the purpose. The work is finished after the proper color has been attained by well rubbing with a soft piece of wash-leather and a little best jewelers' rouge. It is better to make the work as bright as possible before submitting it to this mixture; for this reason it is preferable to thoroughly buff all plain surfaces on a piece of felt by the application of the lathe, as by that means a characteristic brightness is imparted.

DIPPING MIXTURE.

BRASS or metal goods may be cleaned and their oxides removed by dipping into the under-mentioned liquid for a few seconds only: Oil of vitriol, 5 parts; water, 5 parts; nitric acid, 2½ parts; spirits of salts, two drachms. Well mix the several ingredients together, and immerse the work in the solution cold. The mixture improves after a quantity of work has been dipped into it.

SILVER POWDER FOR COPPER.

CHLORIDE of silver, 2 parts; cream of tartar, 2 parts; alum, 1 part. Mix with water to the consistence of a paste, and apply with a soft leather or sponge; when sufficiently whitened, well polish.

ANOTHER RECIPE.

Chloride of silver, 1 oz.; sal-ammoniac, 2 oz.; sandiver, 2 oz.; white vitriol, 2 oz.; bichloride of mercury, 5 dwts. Make into a paste with water, and rub the articles over with it; then expose them to a good heat upon a clear fire, in order to run the silver and evaporate the mercury, after which process dip in very weak sulphuric acid to clean.

SILVER-STRIPPING MIXTURE.

SULPHURIC acid, 6 parts; nitric acid, 1 part. Take a large black-lead crucible or pipkin and heat the mixture in it; when this is done put in the work required to be stripped, occasionally withdrawing it to ascertain the progress made. The large proportion of sulphuric acid allows of the dissolution of the silver, and does not sensibly corrode or interfere with copper or any of its alloys, if kept quite free from water; therefore be careful not to introduce wet articles into the mixture. After finally withdrawing the work, it should be well rinsed, annealed, and then boiled out.

STRIPPING SILVER.

PUT some strong oil of vitriol in a similar vessel to those above described, apply heat, and during the process add a few crystals of saltpeter. When the solution has become hot enough, the work should be immersed in it, and be moved about or agitated until the silver is dissolved from the surface. The articles should not be allowed to remain too long in the solution, and if it does not remove the silver quickly, more saltpeter should be added from time to time until the desired end be attained.

SOFT SOLDER.

PURE tin, 2 parts; lead, 1 part. Melt, and well incorporate together; when this is done, pour into strips for use.

SOLDERING FLUID.

MURIATIC acid (spirits of salts), 3 parts; metallic zinc, 1 part, or as much as the acid will take up. When dissolved and all effervescence ceases, allow it to settle, then decant the clear solution from the sediment at the bottom of the vessel in which it has been made, and it is ready for use. If a small quantity of water be added to the mixture at this stage, say ⅙, it will answer quite as well for some purposes. For soldering iron and steel, a very small portion of sal-ammoniac is of great advantage to the mixture for promoting toughness.

DISSOLVENTS.

DISSOLVING fine silver: Nitric acid, 2 parts; water, 1 part.

Dissolving silver alloys: Nitric acid, 1 part; water, 2 parts.

Dissolving copper: Nitric acid, 1 part; water, 4 parts.

Dissolving soft solder: Perchloride of iron, 1 part; water 4 parts.

Dissolving silver solder: Nitric acid 1 part; water 4 parts.

Dissolving sealing-wax: Place for a time in a solution of spirits of wine.

RESIST VARNISH.

DISSOLVE resin or copal in essence of turpentine, or boiled linseed oil; to give it different shades of color, add red lead, chrome yellow, or Prussian blue.

PLATE POWDER.

WHITENING, 2 parts; white oxide of tin, 1 part; calcined hartshorn, 1 part. Reduce to a powder and well mix together; apply as usual.

ELECTRO-PLATING SOFT SOLDER.

TAKE nitric acid, 1 ounce; water, 2 ounces; copper, about 1 ounce in small, flat pieces; when the copper has dissolved and effervescence has ceased, the solution is ready for use. To apply it, take up a few drops by means of a camel's-hair pencil and apply it to the desired part, then touch it with a bright piece of steel, and there will be instantaneously a film of copper deposited. If the copper has not spread all over the desired part the process should be repeated, when deposition in the plating bath will take place with perfect success.

ANOTHER RECIPE.

Take sulphate of copper (that which accumulates in the whitening mixture), 1 ounce; water, 6 ounces. Reduce the sulphate of copper to a fine powder and dissolve it in the water. Treat according to the directions given in the previous one. A good mixture for effecting the same result may be made by dissolving verdigris in vinegar.

TESTING SILVER WARE.

TAKE nitric acid, 6 ounces; water, 2 ounces; bichromate of potash, 1 ounce. Reduce the salt of potash to a powder and mix it well with the acid and water. The solution is used cold, and should be placed in a stoppered glass bottle, the stopper having a long dropper extending into the mixture, which acts as the agent for conveying the liquid from the bottle to the article to be tested. The surface of the article should be perfectly clean; and to make certain what kind of metallic substance you are testing, it is advisable to rub a file over some obscure part of the surface and to apply the liquid to that part. The test liquid should be used, by means of the glass stopper, to the filed part, and immediately removed by a sponge dampened with cold water. If the article consists of pure silver there will appear a clean blood-red mark, which is less deep and lively in proportion to the quality of the metal. Upon platinum the test liquid has no action whatever; on German silver at first a brown mark appears, but this is removed by the sponge and cold water; on Britannia metal a black mark is produced; and on all the various metals an entirely different result takes place to that on silver; therefore the test is a simple one, and may be advantageously employed for the detection of any fraud in relation to the precious metal.

ANOTHER TEST.

Water, 2 oz.; sulphuric acid, 2 drs.; chromate of potash, 4 dwts. This mixture is applied in the same way as before and produces a purple color of various depths, according to the quality of the silver. No other metallic element exhibits the same color with this preparation.

ANOTHER TEST.

The testing of silver is far more difficult than that of gold; an experienced eye and a steady hand are necessary for doing it. By laying bare a spot with a scraper an expert will easily distinguish whether the silver has been alloyed with white nickel metals, such as cadmium, aluminum, bismuth, zinc, etc., which are generally employed for the purpose; or whether it was alloyed with copper, in which case the fineness is easily ascertained by the use of a test-needle upon the touch-stone. The easiest test for distinguishing silver from silver-like metals that can be employed, even by a layman, is by scraping or filing a place of the article rather heavily, so as to remove the coating, for fear that it might be silver-plated, and then to moisten the spot with nitric acid; if, after wiping it off again, a dirty white ground has formed, it is silver; if no essential alteration of color has ensued, it is a base metal.

TO REFINE SILVER.

AFTER having rolled the silver, cut it into pellets, and curl them to prevent them from lying flat; then drop them into a vessel containing 2 ounces of good nitric acid, diluted with one-half ounce clean rain-water. When the silver has entirely disappeared, add to the 2½ ounces of solution nearly one quart of clean rain-water. Then sink a clean sheet of copper into it; the silver will collect rapidly upon the copper, and you can scrape it off and melt it into a button.

TO WHITEN SILVER ARTICLES.

TO whiten silver articles, boil them in a solution of 1 part of cream of tartar, 2 parts of salt, and 50 parts of water, until they assume a fine, unpolished white.

DEAD-WHITE ON SILVER ARTICLES.

HEAT the article to a cherry-red or a dull red heat, and allow it to cool; then place it in a pickle of 5 parts sulphuric acid to 100 parts water, and allow it to remain for an hour or two. If the surface is not right rinse in cold water, and repeat the heating and pickling operation as before. This removes the copper from the surface of the article, leaving pure silver on the surface. When sufficiently whitened, remove from the pickle, well rinse in pure hot water, and place in warm boxwood sawdust.

WHITE-PICKLING SILVER.

THE purpose of pickling silver is the same as that of the coloring of gold; the alloy lying immediately exposed upon the surface is dissolved by the acid in the pickle, whereby the metal upon the surface is made purer and appears of the color of the pure and unalloyed metal. After the article has been ground well it is heated to red heat and, when cold, boiled in water which has been charged with a sufficient quantity of sulphuric acid, so that it has the acid taste of sharp vinegar, in which fluid it is boiled for one or two minutes. The crust formed upon the surface of articles which are to be burnished is rubbed off with fine sand or with the scratch-brush and beer; articles which are to be matted with the mat-brushing machine, are brushed off with chalk and alcohol. This process of heating, pickling, and brushing is to be repeated three times. There is another kind of pickling, by boiling the heated article in water which contains in solution one part cream of tartar and two parts table salt. Silver articles which are to preserve the hardness imparted to them by rolling or hammering, which consequently cannot be heated, are pickled by being uniformly coated with nitric acid or by being silver-plated.

TO SEPARATE SILVER FROM COPPER.

MIX sulphuric acid, 1 part; nitric acid, 1 part; water, 1 part. Boil the metal in the mixture until it dissolves; then throw in a little salt, to cause the silver to deposit.

IMITATION SILVER.

SILVER, 1 ounce; nickel, 1 ounce 11 dwts.; copper, 2 ounces 9 dwts. Or, silver, 3 ounces; nickel, 1 ounce 11 dwts.; copper, 2 ounces 9 dwts.; spelter, 10 dwts.

RAPID SILVERING.

THE watchmaker is occasionally called on to resilver old clock faces or other parts belonging to clocks. When the article is not exposed to handling, the following recipe for silvering will be found to be very efficacious: Get ¼ ounce of nitrate of silver, to be had at every drug store, dissolve in a teaspoonful of water, and then add ¼ pound of cream of tartar and ¾ pound of common table salt; thoroughly mix these ingredients together with a wooden stick, adding sufficient water to make a thick paste. Put this by in a glass-stoppered bottle for use as required, and it will keep any length of time. This is the silvering powder, and before applying it to the brass this must be made quite clean and bright. Get a piece of chamois leather, and fold it up small enough to be handy; with this rub on the silver paste thoroughly all over, till by the appearance of the brass work you judge the silvering to be properly effected. Now wash the article quite clean, finally polishing off with a little whiting; this will finish, as far as the silvering process is concerned; but to make the coating last under atmospheric influences, it must be protected by a coat of varnish. Any colorless varnish will answer for this, which can be procured anywhere. Of course the more silver powder is rubbed on the thicker the coating, and it will stand good for years.

TO REDUCE CHLORIDE OF SILVER.

ONE of the best methods for reducing chloride of silver to the metallic state is in use in the mint at Paris; it consists in mixing 5 parts of dry chloride of silver with 1 part of freshly calcined lime, and to melt it. The chloride of lime thus formed melts easily, without rising in, and running over, or adhering to, the crucible, which takes place by almost every other method, and produces a loss of silver.

CLEANING SILVERWARE.

ACCORDING to Professor Davenport, hypo-sulphurous soda is the simplest and best cleansing agent for silverware. It operates quickly, is cheap, and has not yet been proposed for the purpose. A rag or brush moistened with the saturated solution of the salt cleans, without the use of cleaning powder, strongly oxidized silver surfaces within a few seconds.

ANOTHER RECIPE.

Carbonate of ammonia, 1 oz.; water, 4 oz.; Paris white, 16 oz.; well mix the ingredients together, and apply to the surface of the plate by means of a piece of soft leather or sponge.

LIQUID FOR CLEANING SILVER.

THE following solution will be found to produce a high brilliancy in silver work: Cream of tarar, 30 parts; sea salt, 30 parts; sulphate of alumina and potash, each 39 parts; water, 1,500 parts. Boil the article in this mixture.

TO CLEAN SILVER FILIGREE WORK.

MANY goldsmiths encounter great difficulties in cleaning silver filigree work. Put the article to be cleaned in a solution of cyanide of potassium. It will come out perfectly white and frosted, as when new. Rinse with water, and dry by shaking in a bag of boxwood sawdust. Another method is to boil for a few seconds in a strong potash lye, take out and rinse in hot water, and allow to dry in hot boxwood sawdust. If the filigree has worn bright, its appearance can be improved by a very slight dip in the cyanide of silver bath of the electro-plater; this dulls and whitens it, and gives it a very chaste appearance.

ANOTHER RECIPE.

Anneal your work over a Bunsen flame or with a blow-pipe, then let go cold (and this is the secret of success), and then put in a pickle of sulphuric acid and water, not more than five drops to one ounce of water, and let your work remain in it for one hour. If not to satisfaction, repeat the process. This is undoubtedly the best process that can be used.

RECOVERING SILVER.

A CORRESPONDENT inquires of the "Workshop Notes" editor how he can recover the silver from silver-plated iron. We furnish him with two recipes: Pour some concentrated nitric acid on the electro-plated iron. It will dissolve the silver, leaving the iron intact. When the operation is finished, pour the liquid off and dilute with water; add a solution of common salt. Silver chloride will settle as a bulky precipitate, which must be filtered and well washed. Remove the silver chloride from the filter, put it in a porcelain dish, add a few cuttings of sheet zinc and a little water, and allow to stand for a week or two. The silver will then be reduced, forming a heavy gray powder. Remove what remains of the zinc, wash well and melt in a crucible, adding some sodium carbonate as a flux. Or, procure an earthenware pan (of course the size is determined by the quantity of material to be treated) and into it lay the pieces of iron until about three-quarters full. Cover them with concentrated nitric acid and gently warm. As soon as all effervescence is finished, the pieces are fished out and replaced by others. This is continued until the effervescence becomes slight; the pieces of iron being washed and the washings added to the main quantity of acid. Muriatic acid is now added until no further white precipitate is thrown down, at which point the whole is heated and allowed to stand for some time; the clear liquid is decanted off, and the precipitate thrown into a thick calico bag and well washed with hot water and dried. Mix the dried mass with carbonate of soda and fuse in an earthen crucible, when the silver will be found in a button at the bottom.

INK STAINS FROM SILVER.

THE tops and other portions of silver inkstands frequently become deeply discolored with ink, which is difficult to remove with ordinary means. It may, however, be completely eradicated by stirring a little chloride of lime into a paste with water and rubbing it upon the stain.

MAT BRUSHING.

VERY excellent results are obtained by running the fine wire matting brush at about 2,500 revolutions per minute, applying rain-water or sour beer diluted with water at the place where the brush strikes the work; occasionally hold a piece of sandpaper to the brush. Should the points of the brush be too straight, let them strike over a piece of wire, but do not hook them too much, as this would prevent matting. Always preserve the brush in a good condition; should the wires become entangled or twisted into knots, separate or cut them out. After the work is matted take a soft hair-brush and brush it in soap water, then rinse it in warm water charged with a small quantity of spirits of ammonia and caustic potash; immerse it in pure alcohol for a short time and finally dry it in sawdust.

TO CLEAN PEARLS.

SOAK them in hot water, in which bran has been boiled, with a little salts of tartar and alum, rubbing gently between the hands when the water will admit of it. When the water is cold, renew the operation until the discoloration is removed; rinse in luke-warm water, and lay the pearls in white paper in a dark place to cool and dry.

CHARCOAL.

THE charcoal used in soldering, nor, in fact, any other charcoal used by the goldsmiths, should not possess the evil habit of viciously snapping and cracking. Coal burned from oak, or any other coarse-grained wood, will snap and crack, while a close, fine-grained, soft-wood coal will not. The underlay coal may have its snap taken out by being heated very hot in an oven or by blowing the flame with a blow-pipe upon it.

JEWELERS' SOLDER.

TO make platinum firmly adhere to gold by soldering, it is necessary that a small quantity of fine or 18-karat gold shall be sweated upon the surface of the platinum at nearly white heat, so that the gold soaks into the face of the platinum; ordinary solder will then adhere firmly to the face obtained in this manner. Hard solder acts by partly fusing and combining with the surfaces to be joined, and platinum alone will not fuse or combine with any solder at a temperature anything like the ordinary fusing point of ordinary gold solder.

ACID-PROOF CEMENT.

A CEMENT that resists acid is made by melting one part India rubber with two parts linseed oil; add sufficient white bolus for consistency. Neither muriatic nor nitric acid attacks it; it softens a little in heat, and its surface does not dry easily; which is corrected by adding one-fifth part litharge.

GERMAN SILVER.

THE following alloy has recently been invented on the continent, and comes highly recommended. It is similar to German silver, contains no nickel, but manganese instead. It consists of seventy-two and one-half per cent. of copper, sixteen and one-half of manganese, eight and three-fourths of zinc, and two and one-half of iron. This alloy is malleable, does not change when immersed in water for forty days, takes the silver plating well, but is a little yellowish.

TO RESTORE GERMAN SILVER.

IN order to restore the silver luster to articles from German silver which they have lost by repeated cleaning, use the following silvering process: Ten parts dry chloride of silver, sixty-five parts cream of tartar, and thirty parts table salt are pulverized and intimately mixed. This powder is then with water stirred to a thin paste, and the article is rubbed with it, left to dry, rinsed off well with water, and finally rubbed off with washed chalk.

TO SOLDER GERMAN SILVER.

DISSOLVE granulated zinc in muriatic acid in an earthen vessel. Cleanse the parts to be soldered and apply the acid. Next put a piece of pewter solder on the joint and apply the blow-pipe to it. Melt German silver 1 part, and zinc in thin sheets 4 parts; then powder it for solder.

NON-CORROSIVE SOLDERING FLUID.

MANY years ago I used to add bicarbonate of soda to the soldering fluid to neutralize the acid (or nearly so), and found that ordinarily it worked just as well, and did not rust steel but very little, if any. The best way to remove the fluid from the work is to boil it out two or three times in alcohol (fresh every time); this removes the acid much more surely than any other plan I have ever known. Soldering fluid should never be used in watch work or allowed about the bench.

A NEW ALLOY.

A NEW alloy, which is known as Nuremberg gold in Germany, is at present frequently employed for the manufacture of cheap gold ware, and is most excellently suited for the purpose; since, as far as its color is concerned, it is absolutely identical with that of pure gold, nor is it in any manner influenced by a continued exposure to air.

The alloy will retain its color even after violent use, and the fracture will exhibit the pure gold color. Its composition is as follows: Copper, 18; gold, 2½; aluminum, 7½.

MYSTERY GOLD.

At the present time a considerable amount of jewelry made of this alloy is believed to be manufactured chiefly with the object of defrauding pawnbrokers to whom it is offered in pledge; and as it will stand the usual jewelers' test of strong nitric acid, the fraud is often successful. The article examined was a bracelet that had been sold as gold to a gentleman in Liverpool.

The alloy, after the gilding had been scraped off, had about the color of 9-karat gold. Qualitative analysis proved it to consist of platinum, copper, and a little silver; and quantitatively it yielded the following results:

Silver	2.48
Platinum	32.02
Copper (by difference)	65.50
	100.00

Strong boiling nitric acid had apparently no action on it, even when left in the acid for some time.

ARTIFICIAL GOLD.

Metallic alloy, at present very extensively used in France as a substitute for gold, is composed of: Pure copper, 100 parts; zinc, or preferably tin, 17 parts; magnesia, 6 parts; sal-ammoniac, from 3 to 6 parts; quicklime, ⅛ part; tartar of commerce, 9 parts, are mixed as follows: The copper is first melted, and the magnesia, sal-ammoniac, lime, and tartar are then added separately and by degrees, in the form of powder; the whole is now briskly stirred for about one-half hour, so as to mix thoroughly, and then the zinc is added in small grains by throwing it on the surface and stirring until it is entirely fused; the crucible is then covered and fusion maintained for about thirty-five minutes. The surface is then skimmed and the alloy ready for coating. It has a fine grain, is malleable, and takes a splendid polish. It does not corrode readily, and is an excellent substitute for gold for many purposes. When tarnished its brilliancy can be restored by a little acidulated water. If tin be employed instead of zinc, the alloy will be more brilliant.

ABYSSINIAN GOLD.

This compound was so called because it was brought out in England during its war with Abyssinia. It consists of copper, 90.74; zinc, 8.33. This alloy, if of good materials, and not heated too highly, has a fine yellow color, resembling gold, and does not tarnish easily.

ALUMINUM GOLD.

One part of aluminum to 99 of gold gives a metal the color of green gold, very hard but not ductile. An alloy of 5 parts of aluminum to 95 parts of gold gives an alloy that is nearly as brittle as glass. An alloy of 10 parts of aluminum to 90 parts of gold is white, crystalline and brittle. An imitation of gold, used as a substitute for the precious metal in cheap jewelry, is made by fusing together 5 to 7½ parts of aluminum, 90 to 100 parts of copper, and 2½ of gold. The color of this alloy resembles gold so closely as to almost defy detection.

CROCUS FOR POLISHING STEEL.

The commercial crocus does not at all times possess the properties necessary for polishing the different metals, and it is advisable, therefore, for the consumer to prepare it for himself, and the manipulations to effect this are easy. Take pure and the clearest obtainable sulphate of iron (iron vitriol, green vitriol, copperas), heat it in an iron pan up to fusion, and permit to remain over the fire, while constantly stirring it with an iron spatula, until it is thoroughly dry and drops into a pale yellow powder. This is then triturated in a mortar and sifted, placed in a new crucible and left in the fire of a smelting furnace, or calcined until no more vapors are evolved. After cooling, the powder appears as a handsome red material, which represents the crocus for the use of gold and silversmiths, etc. The crocus is found in several color gradations, from pale red to brown, red, blue, and violet. The cause of the diversity of its colors is due to the different degrees of heat made use of in its manufacture, the darkness of the color increases with the degree of heat, and the hardness of the crocus also increases thereby; for which reason a pale red (rouge) is used for gold and silver, while violet is employed in polishing steel, and known under the name of "steel red." Each one of the different kinds of crocus, in order to obtain a favorable result, must be ground as fine as possible, and then washed in water. Three clean glasses are used for the purpose, one of which is filled with water, and the quantity of the crocus is well stirred in with a wooden stick, and left to stand for about one half minute; the fluid is then carefully decanted from the sediment gathered in the glass in the second; after it has stood in this for about two minutes the fluid is again poured into the third glass and left in it for several hours, to permit the complete settling of the powder. The sediment of the first glass is useless; that of the second is a crocus of an inferior quality, while that of the third is crocus of the best grade. It simply requires to dry slowly to be fit for use. It is also advisable to moisten the dried powder with alcohol, and in some iron vessel to ignite it, whereby the last traces of fat contained in it are destroyed.

ANOTHER RECIPE.

Readers living at a distance from material houses will sometimes run short of material, and it is safe for them to have the formulæ for manufacturing stuff needed in this manner. For instance, crocus is prepared as follows: Table salt and sulphate of iron (iron vitriol) are well mixed in a mortar. The mixture is then put into a shallow crucible and exposed to a red heat; vapor escapes, and the mass fuses. When no more vapor is evolved, remove the crucible and let it cool. The color of the oxide of iron produced, if the fire was properly regulated, is a fine violet; if the fire was too high, it becomes black. The mass when cold must be pulverized and washed to separate the sulphate of soda. The crocus powder is then to be subjected to a process of careful elutrication, and the finer particles reserved for the more delicate work.

SOLDER FOR ALUMINUM.

THE following alloys are recommended for the purpose: 1. Melt twenty parts of aluminum in a suitable crucible, and when in fusion add eighty parts zinc. When the mixture is melted, cover the surface with some tallow, and maintain in quiet fusion for some time, stirring occasionally with an iron rod; then pour into molds. 2. Take fifteen parts of aluminum and eighty-five parts of zinc; or twelve parts of the former and eighty-eight parts of the latter; or eight parts of the former and ninety-two parts of the latter: prepare all of them as specified for No. 1. The flux recommended consists of three parts of balsam copaiba, one of Venetian turpentine, and a few drops of lemon juice. The soldering iron is dipped into this mixture.

ETCHING ON GLASS AND METAL.

GLASS is etched by means of hydrofluoric acid gas or liquid hydrofluoric acid, that is, a solution of the gas in water. The former in contact with glass produces a rough surface, as on ground glass, while the latter ordinarily leaves the surface clear. The gas is prepared by mixing together finely powdered fluor-spar, calcium fluoride, three parts, and strong sulphuric acid, two parts, in a leaden dish, and applying a very gentle heat. The plates to be etched may be placed over the dish. The operation should be conducted under a hood or in the open air, to avoid inhaling the pernicious fumes. The plates are prepared by cooling them while warm with wax or paraffine, through which to the surface of the glass the design is cut with suitable graving. In preparing the liquid acid, the mixture of spar and oil of vitriol is placed in a leaden or platinum retort which is heated and the gas given off is conducted into a leaden bottle partly filled with water, which absorbs it. In contact with the flesh the acid produces stubborn sores. Metals are usually etched with dilute nitric acid, or niter and sulphuric acid, or sulphate of copper and salt, or hydrochloric acid and chlorate of potash.

JEWELERS' ARMENIAN CEMENT.

THIS cement has extraordinarily great binding powers, and is used by the Oriental, principally the Armenian, jewelers for gluing jewels to metals. It is prepared as follows: Soak two ounces of isinglass in water, put it into a bottle together with one ounce of very pale gum arabic (in tears), cover the ingredients with proof spirits, then add six large tears of gum mastic, dissolved in the least possible quantity of rectified spirits. Cork loosely and boil it until a thorough solution is effected; then strain it for use. When carefully made, this cement resists moisture and dries colorless. Keep in a closely stoppered vial.

ALUM.

ALUM is sometimes used for removing the stains left by soldering in lieu of acids, and is also used in removing broken screws from brass plates by immersing the plates in a strong solution of alum and water, the best results being obtained from a boiling solution, which rapidly converts the steel into rust, while it does not attack the brass plate.

CEMENT FOR GLASS AND METAL.

BRASS letters may be securely fastened on glass panes with a cement composed of the following ingredients: Litharge, two parts; white lead, one part; boiled linseed oil, three parts; gum copal, one part. To be mixed just before using, and it will form a quickly-drying and secure cement.

VARNISH FOR BRASS.

YELLOW brass may be made to keep its color without appearing to be varnished, by means of a thin varnish of white shellac or a coating of collodion.

BRITANNIA.

THIS alloy as prepared by Koller consists of 85.72 parts of tin, 10.34 of antimony, 0.78 of copper, and 2.91 of zinc.

BELL METAL.

AN alloy of copper and tin, in proportions varying from 66 to 80 per cent. of copper and the balance tin.

SUPPORT OF ARTICLES IN HARD SOLDERING.

A SUPPORT for articles in hard soldering can be recommended—asbestos board—a thick layer of asbestos fibers. This substance is well known to be incombustible, and when felted together loosely makes a very good support for heating articles on. It resembles thick blotting paper in appearance, holds pins well, and does not burn away any to speak of, at least during any ordinary mending operation. It has been considerably used by jewelers, assayers, and others, but had one fault—it would curl up. It was made of two or more layers, and when heated the layers would separate and the outer one curl out of shape. This fault has been remedied by making a solid block in a single layer, with wooden frame or sides to keep it in shape and hold it by, thus making a very excellent support. This improvement is brought out by the Chalmers-Spence Company, 419 Eighth street, New York, where it can be obtained in various forms. One form sold by them is a solid block having a cavity scooped out, large enough to hold a lot of pieces of gold or other metal to be melted. At one side of this cavity is a slot extending out a short distance. The scraps are put into the cavity and a flat piece of asbestos board laid over the slot, then the scraps are melted as usual. A piece of coal can be laid over them to increase and confine the heat if necessary. When all is fluid, it is only necessary to tip the block up endways and let the metal run into the slot between the two asbestos blocks, where it will soon cool into an ingot. This saves the risk and trouble of pouring the melted metal into another dish or mold to make an ingot. Before the melting, the asbestos pores are closed by rubbing whiting over the surface.

SILVERING SOLUTION.

THE following is a good silvering solution for electrotype plates: Nitrate of silver, 2 drs.; distilled water, 37 drs. Dissolve and add sal-ammoniac, 1 dr.; hydrophosphite of soda, 4 drs.; precipitated chalk, 4 drs.; agitate the preparation occasionally for twelve hours, when it will be ready for use. Apply with a fine sponge.

COLORING GOLD AS IN ETRUSCAN JEWELRY.

THERE are various methods for coloring gold as in Etruscan jewelry; in fact, every jeweler has a method of his own. The following, however, has been successfully used for some years, and has given general satisfaction: 2½ ounces crocus, 2 ounces yellow ocher, 1½ ounces verdigris, 1½ ounces copperas, ½ ounce white vitriol, ¼ ounce borax. All these ingredients are to be reduced in a mortar to an impalpable powder and intimately mixed with 5 ounces yellow beeswax; or, 20 dwts. saltpeter, 20 dwts. common salt, 2½ dwts. copperas, 2½ dwts. white vitriol, 2½ dwts. alum. The ingredients are to be put into an old crucible, and set over the fire, and the articles to be colored boiled in it until on trial they are found to have acquired the desired color.

The beautiful satin finish is given to the class of goods called Roman gold by carefully brushing the dead gold surface with a scratch-brush made from spun glass.

RING STICK.

A CONSIDERABLE misapprehension exists in the matter of measuring a ring on a gauge; we would say that the edge of the ring should come as far as the mark, while some contend that the mark on the stick should come inside the ring. This is not right, because any ring properly made is of the same size at the center as it is at the edges, and the ring stick is made tapering, so that when the edge of the ring is pushed up as far as it will go, the center of the ring will necessarily stand off from the stick. In a narrow ring this would make little difference, but in a wide ring it amounts to something.

CEMENT FOR PETROLEUM LAMP.

BOIL 3 parts of resin with 1 part of caustic soda and 5 of water. The composition is then mixed with half its weight of plaster of paris, and sets firmly in from ½ to ¾ of an hour. It is of great adhesive power, and not permeable to petroleum, a low conductor of heat, and but superficially attacked by hot water.

SOFT SOLDERING ARTICLES.

MOISTEN the parts to be united with soldering fluid, then, having joined them together, lay a small piece of solder upon the joint, and hold over the lamp, or direct the blaze upon it with your blow-pipe, until fusion is apparent. Withdraw them from the blaze immediately, as too much heat will render the solder brittle and unsatisfactory. When the parts to be joined can be made to spring or press against each other, it is best to place a thin piece of solder between them before exposing to the lamp. When two smooth surfaces are to be soldered one upon the other, you may make an excellent job by moistening them with the fluid, and then having placed a sheet of tinfoil between them, holding them pressed together over your lamp till the foil melts. If the surfaces fit nicely, a joint may be made in this manner so close as almost to be imperceptible. The bright-looking lead, which comes as a lining of tea-boxes, is better than tinfoil.

HOW TO MELT ALUMINUM.

TO melt alumina use a black-lead crucible. Drive the alumina foil into an iron cone much the same shape as the bottom of the crucible, place the alumina in the crucible and cover with crude soda and charcoal pulverized together. Heat slowly.

NON-CORROSIVE SOLDERING FLUID.

THE different fluids bearing this pompous name all labor only under a common disadvantage, viz., that they corrode the article for which they are used. We cannot, however, vouch for the fact whether the following will do the same or not: Small grains of zinc are thrown into muriatic acid until this is saturated, to be recognized by the cessation of the ebullition; the zinc also being added after this point remains undissolved; add about one third the volume of spirits of ammonia, and dilute with a like quantity of rain-water. The solution of the zinc is materially accelerated by slightly warming the acid. This fluid causes no rust on iron or steel.

GOLD-LIKE VARNISH.

AN excellent gold varnish which gives bronze the color of gold is prepared in the following manner: Three ounces bright gum-lac are dissolved in 2 pounds best alcohol, and tinctured either with annatta or gamboge; the first gives it a handsome dark gold, the latter a lemon-yellow color. The bronze to be treated is slowly heated over a fire of charcoal, left to cool a little, and them dipped in a mixture of 3 parts water and 1 part nitric acid, and left in it until entirely black, which requires time of about one or one and a half hours. Then take it out, brush it with a stiff brush, and dip into strong nitric acid; seize it with copper tongs, as those of iron and steel are very injurious. When the black coating of the first immersion has entirely disappeared, take out the bronze, rinse it off clean in lukewarm water, and dry in sawdust. The operator must be cautioned that the smallest part of iron in the bronze will ruin the whole piece, by showing itself in the shape of a large black spot, which cannot be removed or covered. When the piece has been thus treated, it is laid upon a red-hot iron plate, until so hot that it would burn the hand. Apply the varnish in one or several coats.

WRITING INSCRIPTIONS ON METALS.

TAKE one-quarter pound nitric and one ounce muriatic acid. Mix, shake well together, and it is ready for use. Cover the place you wish to mark with melted beeswax; when cold, write your inscription plainly in the wax clear to the metal, using a sharp instrument; then apply the mixed acid with a feather, carefully filling each letter. Let it remain from 1 to 10 minutes, according to appearances desired, then throw on water, which stops the process, and remove the wax.

GOLD TINGE.

A BRIGHT gold tinge may be given to silver by steeping it for a suitable length of time in a weak solution of sulphuric acid and water, strongly impregnated with iron rust.

REFINING SWEEPINGS.

THE sweepings of the workshop contain quite a quantity of gold and silver. To 8 ounces of the dirt, which has been washed and burnt, add salt, 4 ounces; pearl ash, 4 ounces; red tartar, 1 ounce; saltpeter, ½ ounce; mix thoroughly in a mortar, melt in a crucible, and dissolve out the precious metals in a button.

POLISHING POWDER.

AN excellent polishing powder for gold and silver consists of burnt and finely pulverized rock alum, 5 parts, and levigated chalk, 1 part. Mix and apply with a dry brush.

FICTITIOUS SILVER

NO. 1. Silver, 1 ounce; nickel, 1 ounce 11 dwts.; copper, 2 ounces 9 dwts.; or, No. 2. Silver, 3 ounces; nickel, 1 ounce 11 dwts.; copper, 2 ounces 9 dwts.; spelter, 10 dwts.

PECULIAR QUALITIES OF ALUMINUM BRONZES.

A SCIENTIFIC journal says: Five per cent. aluminum bronze is golden in color, polishes well, and casts beautifully; is very malleable cold or hot, and has great strength, especially after hammering. The 7½ per cent. bronze is to be recommended as superior to the 5 per cent.; it has a peculiar greenish-gold color, which makes it very suitable for decoration. All these good qualities are possessed by the 10 per cent. bronze. It is bright golden, keeps its polish in the air, may be easily engraved, shows an elasticity much greater than steel, and can be soldered with hard solder. It gives good castings in all sizes, and runs in sand molds very uniformly. Thin castings come out very short, but if a casting suddenly thickens, small off-shoots must be made at the thick place into which the metal can run, and then soak back into the castings by shrinkage at the thick part. Its strength, when cast, is between that of iron and steel, but when hammered is equal to the best steel. It may be forged at about the same heat as cast steel, and then hammered until it is almost cold without breaking or ripping. Tempering makes it soft and malleable. It does not foul a file, and may easily be drawn into wire. Any part of a machine which is usually made of steel can be replaced by this bronze. The 10 per cent. bronze has a tenacity of about 100,000 pounds, compressive strength 130,000 pounds, and its ductility and toughness are such that it does not even crack when distorted by this load. It is so ductile and malleable that it can be drawn down under the hammer to the fineness of a cambric needle. It works well, casts well, holds a fine surface under the tool, and when exposed to the weather it is in every respect the best bronze known. Aluminum brass, consisting of 67 parts copper, 30 parts zinc, and 3 parts of aluminum, possesses a breaking strain of 48 kilogrammes per square millimetre, and an extensibility of 21 per cent. A beautiful alloy is produced by adding a small proportion of pure silver to pure aluminum.

UNITED STATES OUNCES (AVOIRDUPOIS) IN GRAMS.

Oz.	Grams.	Oz.	Grams.
¼	7	8	227
½	14	9	255
¾	21¼	10	283
1	28.35	11	312
2	57	12	340
3	85	13	369
4	113	14	397
5	142	15	425
6	170	16	454
7	198		

FLUORIC ACID FOR ETCHING GLASS.

THE operator can make his own fluoric (sometimes called hydro-fluoric) acid, by getting the fluor, or Derbyshire spar, pulverizing it, and putting as much of it in a quantity of sulphuric acid as this will dissolve. Inasmuch as the acid is very destructive to glass, it can only be kept in lead or gutta-percha bottles.

TO SOLDER A PEARL RING.

THE country watchmaker, who is supposed to be conversant with the art of soldering, must be very careful when he has to perform this on a pearl-set ring, as it is quite a risky job, and difficult to hard solder under any circumstances; in fact, should it be broken up, it can in no other manner be hard soldered, except by taking out the pearls. If, however, the break is at the bottom, or far from the set, it can be hard soldered as follows: First, clean the ring well, make it the size wanted, fit close and even to where to be soldered; make the size a little smaller than wanted, to allow for dressing and toning up; tear tissue paper into strips, twist it loosely, wrap around the sets every way, thoroughly covering them; take one coil of binding wire, twist it around the paper so as to hold it together; put the set part of the ring in clean, clear water, until the paper swells full; lay or pin on a piece of good charcoal; put a slip of coal between paper and the part you wish to solder; apply the borax; use good, easy-flowing solder; make a large blaze; blow directly on the point you wish to solder; keep as much of the blaze off the paper as possible; make the solder flow quick, and stop as soon as it flows; take the ring off the coal and put it in the water to cool off. Should the paper, during soldering, become dry and commence to burn, stop, and apply more water on it, tear the paper off and finish. By working it this way, the expert man will never fail to save the most delicate setting, unless the ring is extra heavy all round.

SOLDERING STONE-SET RINGS.

THERE are various ways for doing this, but the following will be found to be as good as any: Take tissue paper and tear it into strips about three inches wide; twist them into ropes, and then make them very wet, and wrap the stone with them, passing around the stone and through the ring until the center of the ring is a little more than half full of paper, always winding very close, and then fasten upon charcoal, allowing the stone to project over the edge of the charcoal, and solder very quickly. The paper will prevent oxidation upon the part of the ring it covers, as well as protect the stones.

TO PROTECT THE POLISH OF METALS.

MELT one part by weight of best wax paraffine, and when sufficiently cooled, add three parts of petroleum. Mix well together, and apply to the polished article by means of a soft brush. The protecting film need only be very thin, wherefore not too much should be applied.

CEMENT FOR FASTENING METAL UPON GLASS.

IN order to quickly and well fasten metallic objects upon glass, the use of the following cement is recommended: 100 grams of finely pulverized litharge and 50 grams dry white lead are intimately mixed together, and with boiled linseed oil and copal varnish worked into a half stiff paste. The proportion between boiled linseed oil and copal varnish hereby is as follows: 3 parts linseed oil and 1 part copal varnish. The quantity of the latter depends upon the quantity of the litharge and white lead used. In every case sufficient of the oil is added to the latter to make a suitable paste. The cementing is very simple: The lower face of a medallion, etc., is filled with the cement, pressed upon the glass, and the exuding excess is removed. The cement dries very rapidly and becomes very hard.

COLORING AND LACQUERING BRASS.

THE FOLLOWING general description of the methods employed in coloring and lacquering brass work are useful for all metal workers, goldsmiths, mathematical and optical instrument makers, etc. Brass, it may be remembered, is an alloy of copper and zinc, and, by dissolving or cutting out either of those metals from the surface, a certain amount of variety of color can be produced. For instance, if brass is left for some time in moist sand it assumes a very handsome brown color, which, if polished with a dry brush, remains constant, and requires no cleaning or polishing. A darker or lighter green color may be imparted if a thin layer of verdigris is created upon the surface by means of dilute acids, which are to be left on until dry. The antique appearance imparted to the brass in this manner is very handsome and more or less durable. But it is not always possible, for want of time, to do this with each article, and a more rapid method for effecting the end is therefore necessary, and the simplest way to do it is to cover the brass with a coat of varnish. All the necessary work to be done is performed before the bronzing. The brass is annealed, dipped in old or dilute nitric acid until the scales can be loosened from the surface, and is then treated with sand and water and dried. The next step is to produce the necessary bronze. Although this word actually signifies a bronze color, it is rather loosely applied in the trades at present and applied to all colors. Brown of all shades is produced by immersion in a solution of nitrate or chloride of iron, the strength of the bath determining the depth of the color. Violet shades are obtained by immersing in a solution of chloride of antimony; olive green, by means of a solution of iron and arsenic in muriatic acid, polishing afterward with a plumbago brush, and, when warm, coating with a lacquer composed of one part varnish lacquer, four parts turmeric, and one part gamboge. A steel gray color is precipitated upon brass by means of a weak boiling solution of arsenic chloride, and a blue by an attentive treatment with strong sulphide of soda. Black is much used for optical instruments, and is produced by painting with a platinum solution or with chloride of gold mixed with nitrate of tin.

The success in the art of bronzing chiefly depends upon circumstances; for instance, the temperature of the alloy or solution, the proportions and qualities of the material used for alloying, the proper moment at which the article is to be withdrawn, its drying, and a hundred other minutiæ of attention and manipulation, require a skill only taught by experience.

If the brass is to receive no artificial color, but simply to be protected against tarnishing and oxidizing, it is to be lacquered after having been thoroughly cleansed. In order to prepare the brass for this coating it must be dipped, after having been annealed, and, as aforesaid, rinsed and washed, dipped either for a moment in pure commercial nitric acid and then washed in clean water and dried in sawdust, or immersed in a pickle of equal parts of nitric acid and water, until covered with a white coating of the appearance of curdled milk, when the article is taken out, rinsed in clean water and dried in sawdust. In the first case the brass becomes lustrous, in the latter it becomes mat, which is generally improved by smoothing and polishing the prominent places. The article is then dipped for a moment in nitric acid as found in commerce, and containing a little crude cream of tartar in order to preserve the color up to the moment of lacquering, and finally dried in warm sawdust. When prepared in such a manner the article is taken in hand to be lacquered, for which purpose it is first to be heated upon a hot plate to be lacquered afterward. For this purpose is used a simple alcohol varnish, consisting of 1 ounce shellac dissolved in 1 pint alcohol. To this simple varnish are afterward to be added the coloring substances, such as sanders wood, dragon's blood and annatto, which increase the luster of the color. In order to moderate the shading of the color, turmeric, gamboge, saffron, cape aloes, and gum sandarac are added. The first colors make the lacquer reddish, the second yellowish, while the two, when mixed, give a nice orange.

A good pale lacquer consists of 3 parts aloes and 1 part turmeric, to one part of the simple varnish. A gold lacquer is obtained by adding 4 parts dragon's blood and 1 part turmeric to 1 part of the simple varnish, while a red lacquer is produced from 32 parts annatto and 8 parts dragon's blood, to 1 part of the varnish.

THE SIZES OF WATCH MOVEMENTS.

THERE are four different methods of expressing the sizes of movements. The French and Swiss measure across the dial, and give its diameter either in millimeters or in French lines. A millimeter is about four one-hundredths ($\frac{4}{100}$) of an inch; or, more accurately expressed in decimals, 0.03937 inch. A French line is about nine one-hundredths ($\frac{9}{100}$) of an inch, or, in decimals, 0.0888 inch.

English movements are sized by what is called the Lancashire Movement Gauge, which is a three-inch measure. The sizes begin with one inch, *i. e.*, a movement 1 inch in diameter is size 0. The sizes differ by one-thirtieth ($\frac{1}{30}$) of an inch. Size 16 English would, therefore, be $1\frac{16}{30}$ inch in diameter, and so on. But it must be remembered that English sizes refer to the diameter of the pillar plate of the movement, not that of the dial. As everybody knows, the dial of an English watch is considerably larger than the movement, to allow the dial plate to rest upon the watch case, while the movement goes inside of the case and is supported in its place by the dial plate—the movement itself not being allowed to touch the case. The dial is five sizes larger than the movement; so a 16 size English watch would have a dial $1\frac{21}{30}$ inch in diameter, or, in decimals, 1.700 inches. A French or Swiss watch having approximately the same size of dial would be called a 19 line watch or a 43 millimeter watch. The American movements are sized by the Lancashire gauge, only omitting the allowance of five sizes between the movement and the dial—measuring the dial itself to get the size of the watch. The table will be found on p. 176.

CONVERSION OF WEIGHTS AND MEASURES.

MANY people who have no difficulty in reading a French journal or book find it a nuisance to translate the metric into English measures and weights. For such the following rule may be useful. To convert grams to ounces, avoirdupois, multiply by 20 and divide by 567. To convert kilogrammes to pounds, multiply by 1000 and divide by 454. To convert liters to gallons, multiply by 22 and divide by 100. To convert liters to pints, multiply by 88 and divide by 50. To convert millimeters to inches, mutiply by 10 and divide by 254. To convert meters to yards, multiply by 70 and divide by 64.

HOW TO CONVERT THE THERMOMETER SCALES.

FORMERLY, when the different nations of Europe kept more secluded one from the other, by reason of the want of facilities of rapid locomotion, each adopted a coinage, weights, and measures, etc., best suited to its requirements; their little traffic jogged along all right, and every other nation accommodated itself to the peculiar institutions of its neighbors. Times have changed since then, however, and international traffic has assumed proportions which even the boldest minds of our forefathers did not foresee, and we are beginning to sadly want all our coinage, measures of time, of bulk, etc., reduced to an international standard, so that one nation living thousands of miles away from another will readily be able to understand its local institutions in this regard. None of the least perplexing are the various thermometer scales; the educated man, of course, understands how to compute one differing from that used in his country, but then we have not all had the opportunity of becoming educated men, and for the latter the following ready means of converting one scale into another may be of interest. By the way, the thermometer scales are a forcible illustration of the Biblical verse about the prophet enjoying the least honor in his own country. Réaumur, whose scale is principally used in Germany, was a Frenchman, but the French use the Celsius scale (100°), who was a Swede. Fahrenheit was a German, but his scale, although almost unknown in Germany, is exclusively used in England and America. Again, the latter scale, although apparently the most irrational and arbitrary of the three, is nevertheless about the best for our moderate zone. The reader of these NOTES is well aware that both Celsius (the centigrade scale) and Réaumur fix their freezing point at the congealing point of water—a very unsafe point, for irrelevant reasons, and call it 0°; Fahrenheit, however, has his zero at a temperature produced by the mixture of ice and salt, while the freezing point is located at 32°. The range from the boiling point at 212° and 0° F. embraces about all the degrees of heat and cold likely to occur in our zone, and thereby dispenses with the + or — necessary to be added to the other scales; plus (+) for degrees above the freezing point, and minus (—) for those below. For instance, when Celsius has — 17°, Fahrenheit has still + 1.4°.

Fahrenheit into Centigrade (or Celsius).—Subtract 32° from Fahrenheit's degrees, multiply the remainder by 5, then divide by 9. The product will be the temperature in Centigrade.

Fahrenheit into Réaumur.—Subtract 32° from Fahrenheit's degrees, multiply the remainder by 4, and divide by 9. The product will be the temperature in Réaumur's degrees.

Centigrade into Fahrenheit.—Multiply the Centigrade degrees by 9, divide by 5, and add 32 to the product. The sum will be the temperature according to Fahrenheit's scale.

Réaumur to Fahrenheit.—Multiply the degrees on Réaumur's scale by 9, divide by 4, and add 32 to the product. The sum will be the temperature by Fahrenheit's scale. Tables will be found on p. 178.

DIAMOND, GOLD, ETC., WEIGHTS.

TROY WEIGHT.

IN Switzerland the old French ounce, = 30.59 grams, is still much used. It is divided into 24 deniers, each at 24 grains.

In England the Troy ounce is divided into thousandths.

In the United States the English Troy ounce is divided into 20 dwts. (pennyweights), each at 24 grains. 1 pound Troy = 12 oz. = 24 grains = $373\frac{1}{4}$ grams.

4 grains = 1 karat.
24 grains = 1 pennyweight.
20 dwts. or 480 grains = 1 ounce.
12 oz., or 5760 grains = 1 pound (lb.)

DIAMOND WEIGHT.

16 parts = 1 grain.
4 grains = 1 karat.
1 karat = $3\frac{1}{6}$ grains Troy (nearly).
$151\frac{1}{2}$ karats = 1 oz. Troy.

According to this the karat = $3\frac{17}{101}$ grains Troy.

In giving the weight of a diamond we say it weighs so many karats, or a fraction of such karat, and do not express it either in grains or pennyweights.

AVOIRDUPOIS WEIGHT.

1 drachm (dr.) = $27\frac{11}{32}$ grains.
16 drachms = 1 ounce (oz.) or $437\frac{1}{2}$ grs.
16 ounces = 1 pound (lb.) or 7000 grains.
28 pounds = 1 quarter (qr.).
4 quarters = 1 hundred-weight (cwt.).
20 cwts. = 1 ton.

RANDOM WEIGHTS.

1 ducat = $3\frac{1}{2}$ grams fine gold.
1 mark gold weight = 8 ounces avoirdupois.
1 loth (German) = $16\frac{2}{3}$ grams.
1 pound, German (avoirdupois) = 500 grams.
1 pound, English and American (avoirdupois) = 453.59 grams.
1 ounce, English and American (avoirdupois) = 28.35 grams.

GRAM WEIGHT IN TROY WEIGHT.

Grams.		Oz.	Dwts.	Grains.
1000	=	32	3	0.34
900	=	28	18	17.10
800	=	25	14	9.86
700	=	22	10	2.63
600	=	19	5	19.40
500	=	16	1	12.17
400	=	12	17	4.03
300	=	9	12	21.70
200	=	6	8	14.16
100	=	3	4	7.08

SIZES OF WATCH MOVEMENTS.

English.	Swiss.	Size in Millimeters.
0 Size		30.48
1 "	14 lg. (31.58 m.)	31.33
2 "		32.18
3 "		33.02
4 "	15 "	33.87
5 "		34.72
6 "		35.56
7 "	16 " (36.09 ")	36.41
8 "		37.25
9 "		38.10
10 "	17 " (38.35 ")	38.95
11 "		39.79
12 "	18 "	40.64
13 "		41.49
14 "		42.33
15 "	19 " (42.86 ")	43.18
16 "		44.03
17 "		44.87
18 "	20 " (45.12 ")	45.72
19 "		46.57
20 "	21 "	47.41
21 "		48.26
22 "		49.11
23 "	22 " (49.63 ")	49.95
24 "		50.80
25 "	23 " (51.88 ")	51.65
26 "		52.49
27 "		53.34
28 "	24 "	54.19
29 "		55.03
30 "		55.88

SPECIFIC GRAVITY.

TAKING water at 1.0, the specific weight of aluminum is 2.56; zinc, cast, 6.80; zinc, rolled, 7.20; iron, cast, 6.90–7.50; iron, wrought, 7.60–7.84; German silver and brass, 8.55; copper, cast, 8.75; copper, wrought, 8.78–9.00; bell metal, 8.80; nickel, 8.82; silver, 10.57; palladium, 11.80; mercury, 15.60; gold, 19.26; platinum, 21.50.

CONVERSION OF MILLIMETER AND INCH MEASURES.

Millimeter.	Inch.	Millimeter.	Inch.
0.01	0.0003937	18	0.70866
0.02	0.0007874	19	0.74803
0.03	0.0011811		
0.04	0.0015748	20	0.78740
0.05	0.0019685	21	0.82677
0.06	0.0023622	22	0.86614
0.07	0.0026559	23	0.90551
0.08	0.0031496	24	0.94488
0.09	0.0035433	25	0.98425
		26	1.02362
0.1	0.003937	27	1.06299
0.2	0.007874	28	1.10236
0.3	0.011811	29	1.14173
0.4	0.015748		
0.5	0.019685	30	1.18110
0.6	0.023622	31	1.22047
0.7	0.026559	32	1.25984
0.8	0.031496	33	1.29921
0.9	0.035433	34	1.33858
		35	1.37795
1	0.03937	36	1.41732
2	0.07874	37	1.45669
3	0.11811	38	1.49606
4	0.15748	39	1.53543
5	0.19685		
6	0.23622	40	1.57480
7	0.26559	41	1.61417
8	0.31496	42	1.65354
9	0.35433	43	1.69291
		44	1.73228
10	0.39370	45	1.77165
11	0.43307	46	1.81102
12	0.47244	47	1.85039
13	0.51181	48	1.88976
14	0.55118	49	1.92913
15	0.59056		
16	0.62992	50	1.96850
17	0.66929		

CONVERSION OF MILLIMETER AND INCH MEASURES—Continued.

Inch.	Millimeter.	Inch.	Millimeter.
0.001	0.025399	0.2	5.0798
0.002	0.050798	0.3	7.6197
0.003	0.076197	0.4	10.1596
0.004	0.101596	0.5	12.6995
0.005	0.126995	0.6	15.2394
0.006	0.152394	0.7	17.7793
0.007	0.177793	0.8	20.3192
0.008	0.203192	0.9	22.8591
0.009	0.228591		
		1.0	25.8990
0.01	0.25399	1.1	27.9389
0.02	0.50798	1.2	30.4788
0.03	0.76197	1.3	33.0187
0.04	1.01596	1.4	35.5586
0.05	1.26995	1.5	38.0985
0.06	1.52394	1.6	40.6384
0.07	1.77793	1.7	43.1783
0.08	2.03192	1.8	45.7182
0.09	2.28591	1.9	48.2581
0.1	2.5399	2.0	50.7980

THE NEW METRIC SYSTEM OF SPECTACLE LENSES.

OLD SYSTEM. Numbers in inches.	NEW SYSTEM. Numbers in Dioptrics.	OLD SYSTEM. Numbers in inches.	NEW SYSTEM. Numbers in Dioptrics.
(160)	2.25	8	5.
80	0.5	7½	(5.25)
60	(0.67)	7	5.5
50	0.75	6½	6.
40	1.	6	6.5
36	(1.11)	5¾	7.
30	1.25	5½	7.5
24	1.5	5	8.
(22)	1.75	4½	9.
20	2.	4	10.
18	2.25	3¾	10.5
16	2.5	3½	11.
14	2.75	3¼	12.
13	3.	3	13.
12	3.25	2¾	14.
11	3.5	2½	16.
10	4.	2¼	18.
9	4.5	2	20.

CONVERSION OF THE DIFFERENT THERMOMETER SCALES.

THE SCALES BELOW ZERO.

C.	R.	F.	C.	R.	F.	C.	R.	F.
—30	—24.0	—22.0	—20	—16.0	— 4.0	—10	—8.0	14.0
—29	—23.2	—20.2	—19	—15.2	— 2.4	— 9	—7.2	15.8
—28	—22.4	—18.4	—18	—14.4	0.4	— 8	—6.4	17.6
—27	—21.6	—16.6	—17	—13.6	1.4	— 7	—5.6	19.4
—26	—20.8	—14.8	—16	—12.8	3.2	— 6	—4.8	21.2
—25	—20.0	—13.0	—15	—12.0	5.0	— 5	—4.0	23.0
—24	—19.2	—11.2	—14	—11.2	6.8	— 4	—3.2	24.8
—23	—18.4	— 9.4	—13	—10.4	8.6	— 3	—2.4	26.6
—22	—17.6	— 7.6	—12	— 9.6	10.4	— 2	—1.6	28.4
—21	—16.8	— 5.8	—11	— 8.8	12.2	— 1	—0.8	30.2

THE SCALES ABOVE ZERO.

C.	R.	F.	C.	R.	F.	C.	R.	F.
0	0.0	32.0	34	27.2	93.2	68	54.4	154.4
1	0.8	33.8	35	28.0	95.0	69	55.2	156.2
2	1.6	35.6	36	28.8	96.8	70	56.0	158.0
3	2.4	37.4	37	29.6	98.6	71	56.8	159.8
4	3.2	39.2	38	30.4	100.4	72	57.6	161.6
5	4.0	41.0	39	31.2	102.2	73	58.4	163.4
6	4.8	42.8	40	32.0	104.0	74	59.2	165.2
7	5.6	44.6	41	32.8	105.8	75	60.0	167.0
8	6.4	46.4	42	33.6	107.6	76	60.8	168.8
9	7.2	48.2	43	34.4	109.4	77	61.6	170.6
10	8.0	50.0	44	35.2	111.2	78	62.4	172.4
11	8.8	51.8	45	36.0	113.0	79	63.2	174.2
12	9.6	53.6	46	36.8	114.8	80	64.0	176.0
13	10.4	55.4	47	37.6	116.6	81	64.8	177.8
14	11.2	57.2	48	38.4	118.4	82	65.6	179.6
15	12.0	59.0	49	39.2	120.2	83	66.4	181.4
16	12.8	60.8	50	40.0	122.0	84	67.2	183.2
17	13.6	62.6	51	40.8	123.8	85	68.0	185.0
18	14.4	64.4	52	41.6	125.6	86	68.8	186.8
19	15.2	66.2	53	42.4	127.4	87	69.6	188.6
20	16.0	68.0	54	43.2	129.2	88	70.4	190.4
21	16.8	69.8	55	44.0	131.0	89	71.2	192.2
22	17.6	71.6	56	44.8	132.8	90	72.0	194.0
23	18.4	73.4	57	45.6	134.6	91	72.8	195.8
24	19.2	75.2	58	46.4	136.4	92	73.6	197.6
25	20.0	77.0	59	47.2	138.2	93	74.4	199.4
26	20.8	78.8	60	48.0	140.0	94	75.2	201.2
27	21.6	80.6	61	48.8	141.8	95	76.0	203.0
28	22.4	82.4	62	49.6	143.6	96	76.8	204.8
29	23.2	84.2	63	50.4	145.4	97	77.6	206.6
30	24.0	86.0	64	51.2	147.2	98	78.4	208.4
31	24.8	87.8	65	52.0	149.0	99	79.2	210.2
32	25.6	89.6	66	52.8	150.8	100	80.0	212.0
33	26.4	91.4	67	53.6	152.6			

CONVERSION OF GRAM WEIGHT INTO TROY WEIGHT.

Grams.	SWISS.			ENGLISH.	AMERICAN.		
	Oz.	Deniers.	Grains.	Oz. in $\frac{1}{1000}$.	Oz.	Dwts.	Grains.
1			18.83	0.032			15.43
2		1	13.67	0.064		1	6.86
3		2	8.50	0.096		1	22.30
4		3	3.33	0.129		2	13.73
5		3	22.17	0.161		3	5.16
6		4	17.00	0.193		3	20.59
7		5	18.83	0.225		4	12.03
8		6	6.67	0.257		5	3.46
9		7	1.50	0.290		5	18.89
10		7	20.33	0.322		6	10.32
20		15	16.70	0.644		12	20.60
30		23	13.00	0.965		19	7.00
40	1	7	9.30	1.288	1	5	17.30
48	1	13	16.00	1.545	1	10	20.70

MELTING POINTS OF THE PRINCIPAL METALS.

Names of elements.	Fahrenheit.	Centigrade.
Platinum *		
Cast-iron	2786	1530
Nickel	2700	1482
Gold	2016	1102
Copper	1984	1090
Silver	1873	1023
Aluminum	1300	705
Zinc	773	412
Lead	612	322
Bismuth	497	258
Tin	442	228
Antimony †		

* Infusible, except by the oxy-hydrogen blow-pipe.
† Fuses a little below red heat.

KARATS IN THOUSANDTHS.

FINENESS IN		FINENESS IN	
Karats.	Milliemes.	Karats.	Milliemes.
24	1.000	12	.500
23	.958	11	.458
22	.917	10	.417
21	.875	9	.375
20	.833	8	.333
19	.792	7	.292
18	.750	6	.250
17	.708	5	.208
16	.667	4	.167
15	.625	3	.125
14	.583	2	.083
13	.542	1	.042

LETTER ENGRAVING.

FOR practice, not only in setting up the tool, but also in using it, the learner will find a square graver the best. A square graver is also the best for cutting coarse lettering, such as is required upon door-plates, coffin-plates, satchel-plates, dog-collars, etc. For cutting upon articles of jewelry, watch cases, cane heads, and such like, where a smaller and lighter cut lettering is needed, a graver somewhat on the lozenge in shape should be used, the point of which, when the surplus steel is ground away, would be of about the same shape as a three-cornered file—the width of it across the face, from side to side, equalling the width of either face of its belly.

In setting the face of any graver for ordinary use, grind it back so as to be at an angle of about sixty degrees from the line of the edge of its belly. A less acute angle can be given to a graver and fair work be done with it. This is sometimes a necessity arising from the quality of the metal to be cut with it, or the temper of the tool used. In cutting such articles as solid-handled silver-plated table knives, stock mountings to revolvers, plates made of rolled nickel or brass, a graver that will continually keep losing its point when its face is set at sixty degrees will often retain it with average pertinacity when its face is set at an angle of forty-five degrees.

Good work cannot be done with a graver the face of which is set at a less acute angle than forty-five degrees. So much force has to be used in displacing the metal that the strokes cut with it, if so set, are apt to be "burry" instead of "clean," and their terminations in many instances, especially in cutting script lettering, are too blunt to be beautiful.

In practicing it is not necessary to use a polished graver, but in actual business it is very often requisite. Silver and plated ware, both flat and hollow, are now so largely finished with what is known as the "satin finish" that a polished graver is a tool always needed on the bench, for the strokes cut with the graver, the surfaces of the belly and the face of which are finished with no finer finish than an Arkansas oil-stone will give them, will not show effectively, the surface of the article having a dead style of finish given to it, demands that the work upon it, in order to be seen, must possess a finish which shall be exactly opposite in kind, and so produce the desired effect by contrast—the sharper the contrast the better.

The face, as well as both sides of the belly of the tool, should be polished when "bright-cut" work is to be done.

The materials ordinarily used for the purpose of graver polishing are the same as used by watchmakers for polishing steel; chief among which are diamantine, Vienna lime, crocus and saphirine. In using any or all of them, a small quantity should be put upon a piece of wood, hard and close in texture, and finished down as flat as can be. In using, moisten the material with a little alcohol and apply the piece of wood so charged to the graver and after the manner of a buff; or, reverse the process and apply the graver to the wood, in the same manner as though it were an oil-stone.

In country towns it is not an easy thing to get any of the materials named, and so it may come "handy" to know of some means always available, if not quite so effective, for doing the work. A very fair polish can be put upon the belly and face of a graver in the following manner: Take an Arkansas oil-stone, clean the flattest part of it; then rub the point of a lead-pencil over the cleaned portion of the stone until the pores are well filled with the lead. When this is done, apply the surfaces of the tool to be polished to the stone as though sharpening the graver upon it. The polish on the tool can be improved by mixing a little rouge with the lead upon the stone. The pencil should be one having a fine quality of lead in it—free from all traces of grit.

It may be well to say a word right here about the quality of the various makes of gravers in the market. The Vautier and Baumel gravers are the cheapest—and they ought to be, for they are the poorest. Few of them will "stand" for any length of time, if used in cutting other metals than the soft white metal, of which hollow silver-plated ware is made, and silver. Experience has shown to the writer that the most reliable gravers for general use are those made by Renard, John Sellers, and Stubbs. Stubbs' gravers are good for cutting German silver and brass, whether rolled or cast, and for all heavy work, such as door-plates, etc. The others named have no superiors for the ordinary run of letter engraving in demand by jewelers and silversmiths. Burt makes a good, fine-finished, and consequently high-priced graver. The next best gravers are also of the Burt make.

The amount of pressure needful for the

propulsion of a graver in cutting script lettering in silver is about from one to three ounces, according to the fineness or breadth of the stroke made with it.

In holding a graver, it should be placed diagonally across the palm of the hand, with the bulb of the handle resting a trifle below its center. From the palm of the hand, and from no other source, should the graver receive all the force necessary at any time in using it. The hand is steadied while cutting by the thumb resting upon the block, or the work in hand, as the case may be. The thumb forms a sort of side rest for the graver in its forward and backward motion, the thumb moving its position but little, excepting in cutting very extended straight lines. The fingers are gathered lightly around the blade of the tool, which in no case must be grasped and held down by them, as such action interferes, if not entirely prevents, the freedom of motion necessary to its successful use, making out of it either a scraper or a digger, and incision in metal cannot be made in free and graceful forms in any fashion, let alone with the perfection of "cleanness" and smoothness that must be given to the strokes in good letter engraving.

THE CARE OF THE EYES.

CAPTAIN MARRYAT has justly said: "A man may damn his own eyes, but has no right to exercise a similar prerogative over other people's visual organs;" and while a Chicago contemporary does not presume to "damn" at all, it proceeds in the following interesting article to endeavor to lead those who are suffering from remediable ocular defects—enduring the inconvenience, the headaches, and other afflictions which such defects occasion—to conduct, as it were, their visual organs through the courts of retributive justice, so that if they have given trouble, they may not only be sworn at, but also indicted, condemned to trial, and sentenced to proper correction.

Throughout life, from youth to old age, there is a process of change occurring in the refractive media of all eyes, so that every one who attains to a ripe old age will, at some time or other during his or her existence, be a fit subject for the oculist—or, in other words, will need to wear glasses. In young people this change is usually gradual and unperceived, but from middle life onward its effects are plainly apparent. Those who have normal vision while young will require glasses for reading when they have passed beyond the age of forty, and those who are near-sighted before the age is reached, need glasses in early life, if the degree of near-sightedness (myopia) be at all great, and yet they may be able to read perfectly well without glasses when fifty or even sixty years of age. Persons who are included in this category are apt to consider themselves as lucky exceptions to general laws, and are usually very proud of their sharp sight.

But not only does the eye undergo certain normal changes as age advances, but it may be abnormally formed; and hence optical defects are not only possible, but quite common in infants. The eye is a camera, and, while it may be free from disease and perfectly sound, still vision may be bad because the rays of light are not focussed upon the retina. Hence comes the necessity for wearing glasses, for, by placing suitable lenses before these eyes, normal, distinct vision may —within certain limits—be obtained. It is not generally known that it is the exception, and not the rule, to find eyes that are perfect in shape, or, technically speaking, that are "emmetropic." Still it does not follow that all eyes that are not perfect in shape should have glasses fitted to them, for some errors of refraction do not interfere seriously with vision, and never give rise to disease or decided discomfort to the patient; but, as a rule, persons whose eyes are "weak," or who suffer from complaints similar to those which we shall soon consider, should present themselves to some competent oculist for the detection and subsequent correction of any existing errors of refraction. Let me briefly say that by "competent oculist" is meant one who has not only a knowledge of the delicate mechanism of the eye, but of the other organs of the body as well; for abnormalities and diseases of the eye link themselves very closely to diseased conditions of other portions of the physical economy. Consequently, the competent oculist is a doctor of medicine, although he may devote himself entirely to the study and practice of ophthalmology. The jeweler is not always and the peddler is never a proper person to fit glasses; and, while it is true that certain opticians are conscientious enough to send the party to an oculist when they find that they cannot correctly fit a patient with glasses, still there are opticians who are less conscientious, and who, lest the acknowledgment of incapacity might lower their standard in the public mind, or cause the loss of a customer, advise glasses which are not correct in every respect. Moreover, the oculist has means at his command for the detection of errors of refraction which cannot be applied by the optician, and possesses a knowledge of the proper correction of these errors which years of study and experience can alone bestow.

There still exists quite a prejudice in the minds of many against the use of glasses; but why such prejudice should exist is very difficult of explanation on any other grounds than wilfulness and ignorance. All ophthalmologists teach the great necessity of correcting errors of refraction by wearing proper glasses, and we shall herein endeavor to show some of the undesirable, and even portentous, results of permitting optical defects to go uncorrected. As a rule, glasses add nothing to the appearance of the wearer, and they are often a source of inconvenience, and, unless there is a definite object to be attained by their use, patients are better without them; but where they are indicated and advised by one competent to decide, neither vanity nor prejudice should prevent their being employed.

The purposes for which glasses should be prescribed may be briefly summed up thus: First, to prevent disease of the eyes from "eye strain"; second, to aid in the curing of certain diseases and abnormal conditions, by releasing all strain and giving the eyes rest; third, to enable the patient to better pursue his avocation in life; and fourth, for his comfort and convenience. Our consideration of these items must necessarily be brief, and consequently imperfect. The first two are of paramount importance, and afford material for many chapters in the study of refraction. In general, it may be said that all errors of refraction which reduce the patient's vision to any extent below the normal, or which produce any marked change in either the near or the far points, require correction by the use of suitable glasses. These errors are: *hyperopia*, or far-sight; *myopia*, or near-sight; *presbyopia*, or old-sight; and *astigmatism*, or irregular sight.

Let us first consider the dangers from hyperopia. There is a constant strain, known as "an effort of accommodation," upon every far-sighted eye when viewing both near and remote objects. This effort of accommodation is a muscular exertion, and hence a tax upon the nervous system, and, if long continued, results in more or less exhaustion. When far-sighted eyes are used for reading or near work for any considerable period of time, the effort required produces congestion and redness of the eyes, a larger flow of blood is sent to them, and hence there is an increased secretion of mucus, or "watering of the eyes"; and, if the work be still continued, dizziness, headache, a feeling of sickness, or even actual vomiting, may be induced. But in far-sighted children another condition not infrequently arises as soon as they are made to apply themselves to books. A child begins to have a cast in the eye—that is, to squint, or look "cross-eyed." At first the squint may be periodic, and appear only when close work is undertaken; but unless means are employed to prevent it, it soon becomes permanent. In the great majority of cases, internal squint is due to hyperopia. An excessive effort of accommodation is always associated with increased convergence, and, as a far-sighted eye must always increase its accommodation in order to gain clear vision, it naturally squints inward. Nervous twitchings of the eyelids and other portions of the face are sometimes occasioned by hyperopia. Fortunately, the condition of hyperopia can be easily corrected by suitable convex spherical glasses, and thus the conditions of weariness and exhaustion of the eyes, catarrh of the eyes, twitching, headache, etc., can be prevented; or, where they have already occurred as consequences of long sight, they are usually at once and permanently removed as soon as the hyperopia is corrected by appropriate glasses. Squint is also thus prevented by glasses, and in a certain number of cases where it is already manifested in children, it may be remedied by correcting the existing error of refraction.

Myopia, or short sight, is often hereditary or congenital, but may be acquired from prolonged straining of the eye. This condition is not infrequently the precursor of serious, and sometimes irremediable, impairment of vision, and hence skilled advice and proper glasses are of highest importance to the patient in preventing the accidents to which every myopic eye is liable. In high degrees of myopia there is an excessive demand made upon the muscles that converge the eyes, in the efforts made to keep them both fixed upon small objects held close to the face, and sometimes, being unable to withstand this strain, they give out, and one eye is then turned outward by the opposing muscle, forming a divergent squint. Very serious intra-ocular changes, that are beyond the reach of therapeutic measures, are sometimes occasioned by high degrees of myopia. Short-sighted eyes, above all others, require the most rigid hygiene.

The vision should be rendered normal—except in very high degrees—by the use of concave spherical glasses, and everything which tends to congest the eyes—such as reading or writing in the recumbent or stooping posture, or by faulty light—is to be most carefully avoided.

Presbyopia, or the far sight of old age, is caused by a lack of power of accommodation, and although distant vision remains unimpaired, there is a constant recession of the near point. This is first noticed by the patient when he finds that he is obliged to hold his paper farther away from his eyes than before, and that the print is not so clear as formerly. Presbyopia is easily corrected by convex glasses for reading, and they should be employed as soon as the affection becomes manifest. It does not usually cause inconvenience until after the age of forty. Far-sightedness, when not corrected by appropriate glasses, causes the condition of presbyopia to manifest itself earlier in life than it does in eyes not thus affected, or in those in which the error has been properly corrected.

In astigmatism, or irregular sight, the refraction differs in different portions or meridians of the eye, and the retinal image is thus confused. This condition is usually congenital and may be hereditary; it is, however, sometimes acquired, often occurring after inflammations of the cornea, and may even be occasioned by the use of improper glasses. It is a very common optical defect, and is corrected—according to the variety—either by cylindrical lenses or by combining cylindrical with spherical lenses. Irregular astigmatism cannot be entirely corrected. As astigmatism is either a variety of hyperopia or of myopia, or a mixture of both, it can be productive of the train of symptoms already shown to be occasioned by these errors of refraction—such as headache, dizziness, nausea, and nervous irritability—and consequently, in all varieties of astigmatism, suitable glasses (preferably spectacles) should be worn continually, for both distant and near vision.

A different refractive condition in the two eyes of the same person is quite common. One eye may be correct, and the other long-sighted or short-sighted; or they may have different degrees of the same defect; or, again, one eye may be long-sighted and the other short-sighted. And since, in such cases, the condition of one eye can scarcely be improved by the same glass adapted to correct the error in the other, the vast impropriety of selecting glasses at random from the counter of a dealer is plainly obvious. Both eyes must be tested separately, and fitted acordingly. Where it is known that presbyopia—the condition due to age—alone exists, patients may select their own glasses, for any given distance, according to the needs of convenience of the patient. As age advances, the amount of presbyopia increases, and new and stronger glasses will be from time to time required.

Heterophoria, or weakness of some one or more of the ocular muscles, is very often a complication of some error of refraction. In this condition there is a continual strain upon the weaker muscle in order to do its work, and this alone will cause very many headaches, neuralgias, and general nervous symptoms. We have already considered this subject in cases where the irregular action of the muscles of the eyeball is sufficiently marked to produce squint, but ofttimes there is merely a loss of function, which can be determined only by careful examination. This condition, which is termed muscular insufficiency, is overcome by correcting the refractive error, and combining the glasses thus required with properly selected and applied prisms.

Let us now look at some common troubles not generally known to be due to ocular defects. Not a small number of reflex neuroses are caused by these defects. Headaches which come on after sewing, reading, watching a play, or otherwise using the visual organs in a special direction for a period of time, are usually the direct results of these defects. Neuralgia, dizziness, mental depression, melancholia, chorea (St. Vitus' dance), and even epilepsy, have been shown to be directly dependent, in certain cases, upon refractive errors for their causation. Out of nine cases of epilepsy in which there were optical defects, recently experimented upon, four cases were positively cured by correction of the defects; two of the cases were entirely relieved for periods of four and six months respectively; in another case the fits were greatly reduced in number during a given period of time, after the application of proper spectacles; while two cases were not influenced by glasses. Recurring styes are not infrequently due to some optical defect, and when thus occasioned they are to be cured, not by pulling out the lashes, but by having the defect corrected.

That by improving his defective vision one is enabled to pursue life's duties to better advantage and with increased convenience to himself, need not be insisted upon. Some people go through much or all of life content—through ignorance or prejudice—without seeing but half of their surroundings, and often enduring the ills which we have seen to result from remediable ocular defects. To some people glasses are a revelation—revealing powers and beauties of vision never before known to exist.

SPECTACLES AND EYE-GLASSES.

LENSES are ground in the following manner: pieces of glass are cemented on tools of the required curve and ground with emery of different grades until very fine is used, and they are polished on cloth cemented to the tools, rouge or putty powder being used to give them the last finish. The tools are made of any required curve; say a five inch glass is wanted. Open a pair of dividers five inches, draw a curve with them, take a section of the curve, make a wooden pattern like a saucer with a peg on the under part to hold the tool by, then make another tool just the same, but on one you put the peg on the convex side, and on the concave side of the other get two pairs of castings made; get them turned out by a machinist to the shape of the curve, then with emery grind them together. One pair has to be finished with rough emery for roughing down the glass; the other pair finish off with fine emery for finishing and polishing on. Now, if you want glasses of five inch focus: convex pitch on pieces of flat glass until the convex tool is full; fasten to a block your concave tool, and before the pitch is too cold lay the convex tool with the glasses on it upon the concave tool. To get the glasses down even let the pitch get cold, then put on some rough emery in the concave tool and commence grinding. The emery will touch the glass on the edges, and keep on grinding until the glasses are of the same curve as the tool; then wash out all the rough emery and use some finer; then wash that off and repeat the process with fine or flour emery, and after grinding a little while the emery will get finer; then with a wet sponge wipe off half the emery and add a little water, and commence again. Get the glasses so fine and smooth that when you wet them they look like polished glass. Now dissolve a little pitch in turpentine and paint the tool with it; lay on your cloth, and by rubbing with your hand you will get the cloth to lay down flat to the tool. Let it dry for a few minutes and add rough or putty powder; wet the cloth a little and commence polishing, which will be very quickly done if you have smoothed the glasses nicely. For concave glasses reverse the process by pitching the glasses on the convex tool and let the convex tool be the grinder. Then reverse the glasses and grind the other side, and when done you will have glasses of five inch focus.

If you took a ball of glass five inches in diameter, it would be five inches focus. Cylindrical glasses are made just the same way, but are ground on cylindrical shaped tools, and the focus or curves are measured in the same way by inches or meters. The latter is a good scale, but causes a great deal of confusion and trouble because tools are made in this country and England by the inch scale, and if the English inch was divided by tenths and not by eighths, it would be very simple and convenient. The way of making odd glasses, say five and one-half inches, or any odd number that may be required, can be done by grinding a glass on one side on the five-inch tool, and the other on a six-inch tool, which would give you a glass of five and one-half inches focus.

Periscopic glasses are concave on one side and convex on the other, and they are used to give more clearness of vision when looking obliquely through the glasses, and give a larger field of vision. In setting the glasses into the spectacle or eye-glass frame take a piece of thin brass or tin, make it the shape of the frame, but a trifle smaller, lay it on the glass, then with a glazier's diamond cut round the pattern, break off the edges with a pair of pliers, and grind it to the required size on a grindstone, care being taken to get the center of the lens in the center of the frame.

And this is very often the cause of a great deal of trouble to the seller and pain to the wearer. Be sure that your glasses are of exactly the same focus, and they vary considerably. Take a five-inch French glass and it will be different in power to a five-inch

English glass; and this is not the worst of it, but glasses of first quality will be different in power to second, second quality will be different from third, and so on. Therefore in matching glasses, except you keep a large stock of glasses of all qualities and numbers, it is better to put in a pair; if not, you can never match a glass, and the wearer will complain of not seeing as well with his spectacles since he had a new glass put in, and give him pain caused by seeing sometimes two objects, or seeing one like a shadow and the other one clear and sharp.

Periscopic glasses are sometimes called meniscus, and the focus is determined by the following rule:

Divide twice the product of the two radii by the difference of the radii.

Thus: say a glass is ground on one side on a six-inch convex curve, and on the other side it is ground on a fifteen-inch concave curve, the focus would be twenty inches.

Glasses are numbered as follows: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 22, 54, 30, 36, 42, 48, 60. Some English opticians call 60-inch focus No. 1; 48, No. 2, and so on. It is a very arbitrary rule for some to commence at 48 and call it No. 1, others again to commence at 42 and some at 36, and only use fourteen numbers, as follows:

Numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14.

Inches, 36, 30, 24, 20, 18, 16, 14, 12, 10, 9, 8, 7, 6, 5.

A new scale is being introduced into ophthalmology, and is giving to opticians no end of trouble. By the following rule it will be seen that one dioptric is equal to about a 36-inch focus:

Dioptrics—0.5, 0.75, 1., 1.25, 1.5, 1.75, 2., 2.25, 2.5, 3., 3.25, 3.5, 3.75, 4., 4.5, 5., 6., 7., 7.5.

Inches——72, 48, 36, 30, 24, 20, 18, 16, 15, 13, 12, 11, 10, 9, 8, 7, 6, 5½, 5.

It is a very good scale, and calculations can be very easily made with it. One meter is the unit, and it is called one dioptric.

TO WORK HARD STEEL.

If steel is rather hard under the hammer when heated to the proper cherry-red, it may be covered with salt and hammered to about the shape desired. More softness can then be obtained, if required to give a further finish to the shape, by sprinkling it with a mixture of salt, blue vitriol, sal-ammoniac, saltpeter and alum, made cherry-red again, sprinkled with this mixture, and hammered into shape. This process may be repeated until entirely finished. When ready, the steel is hardened in a solution of the same mixture. This method is recommended by prominent workers.

SOLDERING CAST STEEL.

The material employed is pulverized white marble. The two pieces to be soldered are simply heated, rolled in the marble dust, then quickly placed one to the other and hammered. This recipe is by Mr. A. Fiala, an eminent mechanician of Prague, and was communicated by Mons. G. Bertrand to the *Revue Chronométrique.*

BRONZE COATING ON IRON, ETC.

In order to cover articles of iron and brass with a durable, antique bronze coating, 100 grains of protosulphate of nickel and ammonia, 100 grains of hyposulphate of soda, and 50 grains sal-ammoniac are dissolved in 10 quarts boiling water, and the well-cleaned metallic articles are laid in at once. After a few minutes they have assumed a handsome lustrous bronze color. By a prolonged exposure in the bath, sustained at a heat of from 70° to 80°, cast or wrought-iron articles have become handsomely coated with sulphide of nickel, but they must be made lustrous again by cleaning, since they have become mat in color. The bath may be used again until its bluish-green color has disappeared as well as the hydroxide of iron.

ETCHING FLUID FOR STEEL.

We find the following praised highly for being an excellent etching fluid for steel: Mix one ounce of sulphate of copper, one-half ounce of alum, and one-half a teaspoonful of salt reduced to powder, with one gill of vinegar and twenty drops of nitric acid. This fluid may be used for either eating deeply into the metal or for imparting a beautiful frosted appearance to the surface, according to the time it is allowed to act. Cover the parts necessary to be protected from its influence with beeswax. tallow, or some other similar substance.

BRONZING IRON AND STEEL.

FIRST clean the piece to be treated in the usual manner, for which a bath of strong soda water is one of the quickest methods, and most thorough; then expose the piece to the action of vapors arising from a mixture of equal parts hydrochloric and nitric acids, temperature 550 to 600° F. When the piece has cooled, rub over with vaseline; heat until this begins to decompose, then allow to cool and repeat the dose of vaseline. Should the color appear darker than desired, mix acetic acid with the other acid in proportion to the change desired.

PAINT FOR SHEET IRON.

GOOD varnish, one-half gallon; add red lead sufficient to bring to the consistency of common paint; then apply with a brush. This paint is applicable to any kind of iron work which is exposed to the weather, thoroughly protecting the metal from rust.

PALE GOLD LACQUER.

BEST shellac (picked pieces), eight ounces; sandarac, two ounces; turmeric, eight ounces; annatto, two ounces; dragon's blood, one-fourth ounce; alcohol, one gallon. Mix, shake frequently, till all is dissolved, and the color extracted from the coloring matter, and then allowed to settle.

PREVENTING RUST ON MACHINERY, ETC.

THE following formula can be recommended for the prevention of rust on machinery. One ounce of camphor dissolved in one pound of melted lard; take off the scum and mix in as much fine black lead as will give it an iron color. Clean the machinery and smear it with this mixture. After about twenty-four hours, rub clean with soft linen rags. It will keep clean for months under ordinary circumstances. Iron and steel may be kept bright, even in the presence of dampness, by giving them a coat of chlorate of potash.

Nuts are frequently rusted so tightly upon the screws that the wrench will not loosen them; kerosene or naphtha, turpentine, even, will, in a short time, penetrate between the nut and stem. Next heat them in a fire, which will quickly sever them. In fact, kerosene is excellent for removing rust; leave the article for some time in it and the rust will come off easily.

Cast-iron is best preserved by rubbing it with black lead. For polished work, varnish with wax dissolved in benzine, or add a little olive oil to copal varnish, and thin with spirits of turpentine. To remove deep-seated rust, use benzine and polish off with fine emery; or use tripoli, 2 parts; pulverized sulphur, 1 part. Apply with soft leather. Emery and oil is also very good.

METAL LETTERS ON PLATE-GLASS.

IT is often necessary to attach glass or metal letters to plate-glass. Use the following binder: Copal varnish, 15 parts; drying oil, 5 parts; turpentine, 3 parts; oil of turpentine, 2 parts; liquefied glue, 5 parts. Melt in a water bath, and add 10 parts slaked lime.

TO PREPARE CHALK.

PULVERIZE the chalk thoroughly, and then mix with clean rain-water, in proportions of two pounds to the gallon. Stir well, and let it stand for about two minutes. In this time the gritty matter will have settled to the bottom. Slowly pour the water into another vessel, so as not to stir up the sediment. Let stand until entirely settled, and then pour off as before. The settlings in the second vessel will be prepared chalk, ready for use as soon as dry. Spanish whiting, treated in the same way, makes a very good cleaning or polishing powder. Some watchmakers add a little crocus, and, we think, it is an improvement; it gives the powder a nice color at least.

ALABASTER CEMENT.

MELT alum and dip the fractured faces into it; then put them together as quickly as possible. Remove the exuding mass with a knife.

EXCELLENT CEMENT.

A CEMENT for fastening glass upon wood is prepared by dissolving 1 part India rubber in 64 parts chloroform, to which 16 parts mastic have been added. Let the mixture stand until dissolved. It is then applied with a brush.

SMOOTHING OIL-STONES.

OIL-STONES are apt to wear hollow, and it is necessary to smooth them. For this purpose take coarse emery and water upon a slate or marble slab, and with a circular motion grind the oil-stone. Another very good way is to nail a piece of coarse emery paper upon a board, and treat it in the aforesaid manner. Paper is best, because the grains of emery remain stationary, while, when loose upon a slab, they roll around, and therefore are less effective.

TO CLEANSE BRUSHES.

THE best method of cleansing a watchmakers' and jewelers' brush is to wash it out in strong soda water. If the back is wood, favor that part as much as possible, for being glued, the water may loosen it.

CEMENT FOR MEERSCHAUM.

A CEMENT for meerschaum can be made of quicklime mixed to a thick cream with the white of an egg. This cement will also unite glass or china.

BENDING GLASS TUBES.

FILL the tube with finely sifted sand, close both ends, and heat it over the flame of a Bunsen burner. It can thus easily be bent without losing its roundness at the elbow.

TO DRILL ONYX.

IN order to drill onyx, the simplest method is to use a diamond drill (cost about $2) with oil, turning the drill with the bow which gives the necessary back and forward motion. Another, but slower, way is to use a hollow iron wire with diamond powder. The wire is placed in the chuck of a lathe perpendicularly. It ought to run 2,500 or 3,000 turns per minute. A good way of starting or countersinking the stone is by using iron wire turned into a little wheel or knob at the end, according to the size of the hole desired. This can only be used in a horizontal lathe.

TO MAKE A HOLE IN GLASS.

SPREAD on thinly some wax after warming the glass. Remove the wax where you wish the hole to be made; with a piece of iron wire put on the spot a drop or two of fluoric acid and it will eat through the glass. If not sufficient, make a second or third application of the acid. After this has eaten quite through, it may be enlarged or shaped with a copper wire with rottenstone and oil; or use dilute (1 : 5) sulphuric acid with the ordinary drill. When shaping or enlarging the hole, also apply this fluid to the file from time to time while using; when finished wash the latter well.

ALLOY FOR MODELS.

A GOOD alloy for making working models is four parts copper, one part tin, and one-quarter part zinc. This is easily wrought. The hardness increases by doubling the proportion of the zinc.

TRANSPARENT CEMENT.

ORDINARY cements generally leave yellowish traces which look disagreeable, especially with transparent objects. The following recipe, according to the *Mon. des prod. Chim.*, makes a perfectly colorless varnish: Sixty grams chloroform are poured over 7.5 grams India rubber, cut into small pieces, and contained in a bottle which can be closed air-tight. When the India rubber has been dissolved thoroughly, 15 grs. mastic are added and digested for about 8 days until dissolved. The cement prepared in this manner is used like any other.

POWDERED GLASS.

POWDERED glass is largely taking the place of sand in the manufacture of sandpaper. It is readily pulverized by heating it red hot and throwing it into cold water, the finishing being done in an iron mortar. By the use of sieves of different sizes of mesh the powder can be separated into various grades, from the finest dust to the very coarse, and these grades should be kept separate. A strong paper is tacked down and covered with a strong size or glue, and the coating covered with powdered glass of the desired fineness; when the glue is dry, the surplus glass is shaken or brushed off. Muslin is much better than paper and lasts much longer.

MAGNETIZED WATCHES.

TO ascertain if any part of a watch is magnetized, take a small piece of iron wire (jewellers' binding wire), attach it to a silk thread, and fasten the silk thread to a small brass rod, or a pegwood, and approach the part or parts suspected. If the iron is attracted or set in motion, magnetism is the cause, and the suspected piece is affected. Before making a test, remove the watch movement from the case; if this contain case springs, try these separately, as in most instances case springs are affected by magnetism, while parts of the movement are not. It is also advisable, in testing a watch movement, to take the movement apart and test the pieces separately. The parts most likely to be affected are the balance, the balance spring, and the fork. In some instances, very rare, however, every part of the movement is affected.

PROTECTIONS, REMEDIES, AND PREVENTATIVES.

There are methods and means for protecting watches from magnetism, remedying the evil after they have become affected, and for preventing them from being magnetized. The present article will deal with the second proposition, as a debate of all three would make it too lengthy for these WORKSHOP NOTES.

1. The employes around electric-light stations practice what might be called an "empirical" method with the "turnips" they wear in the shop. They hang the watch by the pendant at the end of a stiff cord, twist the cord tightly, then, holding the upper end of the cord in one hand, let the watch hang near the pole piece of a powerful dynamo. Holding it still with the other hand for a moment, to let the magnetism get "soaked in," they "then let her spin," and as the string gradually untwists, slowly walk away, removing the whirling watch further and further from the source of magnetism. The dose is repeated whenever the watch shows signs of ailments.

2. When the work of demagnetizing is to be performed on a watch of good quality, it is necessary to have three or four magnets of different sizes, also a good horse-shoe magnet for recharging, for these straight magnets soon lose strength. A piece of bar steel of the required size, hardened first, and then charged by the horse-shoe magnet, answers the purpose, or an old worn-out round or square file, or stump of an old graver, will do equally well, and save the trouble of hardening. The size of the magnet used must be determined by the size of the article operated on. Take a watch-balance, for instance—which is one of the most troublesome things to treat. Take a magnet about three inches long and one-quarter inch square. It will be found that polarity is situated principally in the neighborhood of the arms, and these are the points to be first attacked. Hang the balance by its rim on a piece of brass wire, and approach the magnet toward the rim in the direction of one of the bars. If it should be attracted toward the magnet, try the other pole, and it will be found to repel. Now take the balance in your hand and bring the *repelling* pole of the magnet in momentary contact with the balance at the point tried, then test it with a minute fragment of small iron binding wire, as directed in the introductory; if still magnetic, bring the magnet in contact again, and so on—trying after each contact—till the magnetism is entirely out at that point. Suspend the balance on the brass wire, as before, and proceed to try the rim at the point where the second arm comes, and the same with the third. Having expelled the magnetism at these three points, there will be but little remaining in the balance. However, try it carefully all round, when several places will probably be found retaining sufficient magnetism to pick up a small fragment of iron. These must all be treated in the manner before described; but when the magnetism is very feeble, a smaller magnet must be used, for if the magnet is too powerful, the article operated upon discharges what little remains, and, before contact can be broken, begins to be charged again by the reverse pole. After having operated successfully on the other portions of the balance, it frequently happens that it has become slightly charged again by one of the arms; try the pole, as before, and a few contacts, sometimes but one, of one of the smaller magnets will suffice.

A little patience is required, for it is often twenty minutes or more before the desired end is accomplished. After treating a balance, always try it whether it is in poise. The balance spring stud, which is usually found to be charged when the balance is so, is easily treated. Try the poles, and a few contacts will draw all the magnetism out of one end, when so little will be found remaining in the other that one touch of the other pole will usually be sufficient. Even the balance spring may be successfully treated, though so strongly charged as to be "feathered" with iron filings after being immersed in them.

A good way to try the polarity of many pieces is to suspend the article, by means of a particle of wax, to a piece of the finest silk. Steel filings, or fragments of chain wire, should on no account be used for testing; for if not magnetic to begin with, they speedily become so by contact with the article under treatment. Even with soft iron, it is well to occasionally charge the fragment you are testing.

THE PENDULUM AND ITS LAWS OF OSCILLATION.

HISTORY furnishes us with the information that Galileo in 1542, while in the cathedral at Pisa, observed the oscillations of a lamp which had been accidentally set in motion. He was struck with the apparent measured regularity of its vibrations, and tested this observation by comparing these oscillations with his own pulse. Galileo there invented the simple pendulum as a means of measuring short intervals of time. But for many years the pendulum was used without the clock movement, and astronomers counted the oscillations performed in a given time to measure the periods of celestial phenomena.

THE THEORETICALLY PERFECT PENDULUM.

In describing the pendulum I will first begin with a theoretically perfect pendulum, which would consist of a heavy molecule suspended at the extremity of a perfectly flexible cord, and oscillating in a vacuum. This ideal pendulum, of course, could not exist, but to demonstrate the simple pendulum, we will use a small metal ball suspended by a silk thread; if this freely-suspended ball is drawn from the vertical and allowed to oscillate, these oscillations will gradually diminish in extent on account of the earth's attraction, producing what are called long and short arcs. The function of the clock movement proper, besides registering the time and number of oscillations on the dial, is to furnish to the pendulum the small amount of impulse that is necessary to carry the same in its excursion from the vertical line upward, so it will return each time to the original point of starting and thus overcome the influence of gravity, and add enough force in its descent toward the vertical to maintain a uniform arc of oscillation to the required number of degrees. The oscillations of the pendulum were thought and affirmed by Galileo to be made in the same interval of time, whether the arcs were long or short.

That there is a difference, although very slight, between long and short arcs, where the distance passed over is not too great, is nevertheless true; and it was not till 1658 that Huyghens discovered and proved that long arcs required more time than short arcs to perform the oscillations of the same vibrating length of pendulum. I will add here, as the question is often asked, what constiutes the *length* of a pendulum. It is the distance from the point of suspension to the center of oscillation. This point is, in theory, very near the center of gravity of the pendulum, and it is described as being just below the gravity point. In order to describe the center of oscillation more clearly, I will make this simple illustration:

If a blow is struck with a club and the impingement takes place beyond the point of concussion, the blow is partially inflicted on the hand; and the same result is experienced if the impingement takes place between the hand and the point of concussion, only in a reversed manner. The full force of the blow is obtained only when the exact point of concussion meets the object. Now, it is true that the center of oscillation in the pendulum is identical with the point of concussion in the club, and the time-producing qualities of a pendulum depend entirely on the above mentioned oscillating point.

THE LAWS CONTROLLING THE PENDULUM.

I will first call your attention to the laws of motions controlling the simple pendulum, and will refer to the cycloidal pendulum later. First, the pendulum is a falling body, and is controlled by laws governing such a body, and when at rest points directly toward the center of the earth. Next, the square of the time of oscillation is directly as its length, and inversely as the earth's attraction.

For instance, a pendulum vibrating seconds at the level of the sea in the latitude of New York city, would be 39.10153 inches, and a pendulum vibrating two seconds in the same location would be the square (of the time) or two seconds, which squared would be four, multiplied by the length of the one second, 39.10153 pendulum, which is equal to 156.4 inches, something over 13 feet long. This rapid increase in length for a comparatively small change in the time of oscillation has resulted in fixing two seconds as the limit for any precision pendulum, as beyond this point the instrumental errors would be increased in the same ratio and would be difficult to overcome. The great Westminster pendulum vibrates in two seconds, and is probably the most accurately compensated long pendulum in the world. The correction for errors of lateral and cubical dilatation, barometrical error, long and short arcs of oscillation, are all reduced to a minimum.

As we have said so much about seconds, it might be in order to say there are two kinds, solar and sidereal, and they differ from each other in length.

The interval of time we call a second is reduced from the solar day, which is the time between two successive returns of the sun to the same meridian, and this interval divided into 86,400 parts. These solar days are not *equal*, but are made so by the daily equation of time added to or subtracted from the *apparent* solar day.

The sidereal day is the interval between two successive returns of a fixed star to the same meridian, and is 3 minutes, 56.5 seconds shorter than the solar day, and this day divided into hours, minutes, and seconds furnishes us with the sidereal seconds. The sideral day represents the time of the rotation of the earth on its axis, and is the most accurate observation of time that can be made, as it requires no equation, and has not changed as much as one-hundredth part of a second in over two thousand years. Astronomers use astronomical clocks reading 24 hours on the dial, with pendulums vibrating sidereal seconds, and by this time only do they find and locate celestial bodies.

ATTRACTION OF GRAVITATION.

Another law governing the pendulum is this: The action of gravity or the mutual attraction between bodies varies with their masses, and inversely as the square of their distances. Following from this, a pendulum will vibrate seconds only in a given place. Our standard of measurement is taken from a pendulum vibrating seconds in a vacuum at the level of the sea. It also follows that the further a pendulum is removed from the center of the earth the less it will be attracted in its descent toward the vertical. This explains why a pendulum loses on being transferred from the sea level to the mountain, or from one of the earth's poles toward the equator, as the earth is a spheroid slightly flattened at the poles.

A very interesting experiment can be made to show the influence of mutual attraction between masses. Take two well-regulated astronomical clocks with second pendulums, place them side and side, and cause each pendulum to oscillate simultaneously on the same side of the vertical; the pendulums will oscillate to the right together, and to the left for a time together, then they will change so as to oscillate in opposite directions, and will never depart from this motion. Another reason why a pendulum loses on being transferred to the equator lies in the fact that the rotation of the earth gives rise to centrifugal force at its surface. This, being zero at the poles, gradually increases to a maximum at the equator; and, as it acts in opposition to the force of gravity, it counteracts a gradually increasing proportion of this force which shows in the time of oscillation. The rotation of the earth on its axis also has another effect upon the oscillation of the pendulum, as you have just seen by the demonstration of the pendulum of Foucault by Prof. K. Ellicott. The error caused by the tendency of the pendulum to oscillate in one given plane is reduced to a minimum by the use of short arcs of oscillation, and is of very little importance in comparison with other errors.

CYCLOIDAL PENDULUM.

THE arcs of oscillation of any ordinary simple pendulum are a part of a circle with the point of suspension as a center.

Now, a pendulum producing isochronal oscillations, namely, producing *unequal arcs* in *equal* time is called *cycloidal*, because the center of oscillation must describe a cycloidal path during each excursion on either side of the vertical line.

This curve is one of the most interesting of any known, both in respect to its geometrical properties and connection with falling bodies, and is described in this manner:

If a circle roll along a straight line on its own plane, a point on its circumference will describe a *curve* which is called a cycloid. The peculiar value of this curve in relation to the pendulum will be better shown by inverting a cycloid curve.

The time of a body descending from a point of rest which we will call *A* to the lowest point of the curve at B will be the same from whatever point it starts. In other words, a pendulum will fall from A to the lowest point B of the curve in precisely the same time it would from a point C lying between A and B, which is, say, about half the distance. Following from this, a cycloidal pendulum produces *unequal* arcs in *equal* time or isochronism. The extreme mechanical difficulty of executing a pendulum that will describe a cycloidal path during each excursion has led horologists to originate many ingenious devices to accomplish this end. The pendulum described here is constructed so as to cause the center of oscillation to move in a cycloidal path, by coming in contact with cycloid cheeks near its point of suspension, but the effects of moisture, friction, dilatation and adhesion of contact against these cheeks would in time give rise to errors as great as those sought to be overcome. We therefore must make efforts in another direction.

The best method of to-day for producing isochronism is to cause the arc of oscillation to be as short as possible, and also have the suspension spring of a given length and given strength in proportion to the length and weight of the pendulum. Then we will only have to deal with the molecular arrangement of the spring, which is constantly changing; but this error is very small and exceedingly regular.

The length of the pendulum rod is just double the diameter of the generating circle. Now, from relations of parts of the cycloid, it is shown that the time of falling down the semi-cycloid is to the time of fall through the diameter of the generating circle as a quadrant is to a radius.

THE BAROMETRICAL ERROR.

A pendulum is affected by the density of the atmosphere, but to a degree that would only be of importance in a precision timepiece, where all the errors are reduced to a minimum. An increase of density of the air is *equivalent* to reducing the action of *gravity*, while the inertia of the moving body remains the same. The rule is, that the velocity of the pendulum varies directly as the force of gravity and inversely as the inertia, and it follows then that an increase of density diminishes the velocity and shortens the time of oscillation, causing the clock to gain time. The barometrical error can be reduced to within three to four tenths of a second in twenty-four hours for each inch rise or fall of the barometer. Short arcs of oscillation are also essential in reducing the barometrical error. An apparatus is sometimes attached to the pendulum to assist in reducing this error.

THE COMPENSATED PENDULUM.

Bodies increase in volume with an elevation of temperature and diminish when it falls. The pendulum then changes its dimensions with every variation of temperature, and the same is the case with all other parts of the machine.

The elongation of a body in any *one* direction by heat is known as its *linear dilatation*, and its increase in volume, that is, in all three directions, is the cubical dilatation; this depends on its linear dilatation in length, breadth, and thickness.

The result to be obtained in a pendulum by compensation is to so construct the same that the center of oscillation will always be in the same point. It is evident that heat lowers this point and cold raises it, and, as we said before, that the time-producing qualities of the pendulum depend on this oscillating point, and only by *compensation* is the desired effect obtained.

I will show you two of the best methods of producing compensation, and begin first by using two metals. The principle underlying this method is the unequal expansion of different metals in the same temperature. This furnishes us with the first step toward compensation.

Let us take a steel rod of the length arrived at by calculation, with a nut and screw on the lower end; resting on this nut is a brass collar with a groove cut in the top. Here is a rolled and drawn zinc tube of a calculated length and thickness in proportion to the main rod. This zinc tube is drawn on over the main rod, and rests on the brass collar at the lower end and at the upper end of the zinc tube; and resting on the same is an iron collar into which is firmly screwed an iron tube which is slipped on over the zinc tube, and at the lower end of this iron tube is attached the weight or bob. It will be seen that this main rod lengthens with heat, and as it lowers, the zinc tube which surrounds it lowers also; but the upper end of the zinc being free, and this metal possessing greater linear dilatation, moves upwards on the main rod, and with it draws up the iron tube that surrounds the zinc and carries with it the weight or bob. The upward dilatation of the zinc tube is just sufficient to overcome the downward dilatation of the main rod, thus keeping the center of oscillation in the same point. In order to construct a compensated pendulum of this kind it is necessary to have the proper proportions of one metal to the other; and besides this, corrections are made from actual tests in different degrees of temperature.

The principal objection to this kind of compensation is that metals expand and contract by infinitesimal waves or jumps, probably owing to the molecular friction of the metals, and this is most apparent in zinc, owing to its crystalline formation; and this metal is useless unless carefully drawn and prepared before using for the purpose in question.

THE MERCURIAL COMPENSATION.

This pendulum is constructed in the following manner: A steel rod of the calculated length and diameter is selected, and at its lower end is firmly attached a brass stirrup, into which is placed and secured from one to four glass jars containing mercury. If one jar is used, the volume must be sufficient to allow its *cubical dilatation* to raise the center of oscillation just as the *longitudinal dilatation* of the rod has *lowered this point;* and if four jars are used, their diameters shall be reduced to the point that the four will contain the volume of the one jar, and be filled each to the same level as it rose in the single jar. This represents more exposed surface to the changing temperatures and improves the *conductibility* of the *mercury*, causing the compensation to *respond* more *promptly* to *sudden* changes. The four-jar compensation is the most difficult to construct, but when well made and carefully adjusted is exceedingly satisfactory, and has the preference in seconds pendulums when greater accuracy is required.

THE SEISMIC ERROR.

This uncontrollable error is caused by earth waves, and may occur at any time. One peculiarity is, that many hours elapse before this error shows in the time of the instrument. This error may not be suspected until compared by transit observations.

The time it takes to develop this error is probably due to the molecular disturbances and re-arranging of particles that is taking place in the mercury used for compensation. The most accurately compensated pendulums have been known to vary several seconds in a day. I remember while in Geneva in 1872 that twice in one summer the standard pendulum of the Cantonal Observatory varied once seven and one-half seconds, and at another time five seconds in twenty-four hours; at that time it was not well understood what caused these sudden variations in a pendulum having a known daily equation. But later experiments have shown this error to be caused by seismic waves.

From the simple observation of the lamp swinging from the roof of the cathedral at Pisa, more than three hundred and forty years ago, has grown the thought included in the foregoing laws. The laws of inverse squares and mutual attraction as shown in the simple pendulum, the properties of the cycloid and cycloidal pendulum, the influence of the linear and cubical dilatation, the influence of atmospheric pressure on the pendulum and the centrifugal force from the revolution of the earth on its axis, and by reducing all these errors to a minimum we are furnished with an instrument that performs its work with as much accuracy as any piece of mechanism ever produced by man.

INDEX TO HOROLOGY.

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INDEX TO GOLD, SILVER, ETC.

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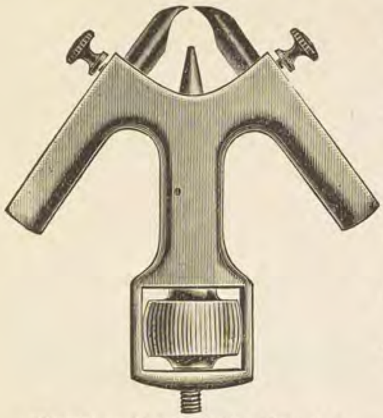

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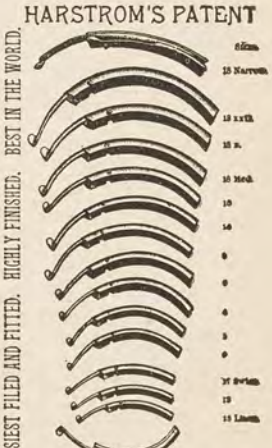

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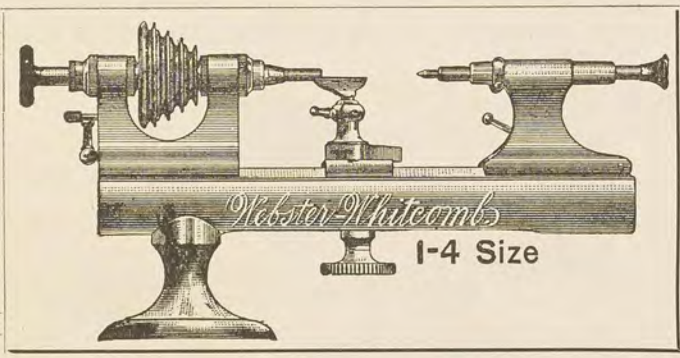

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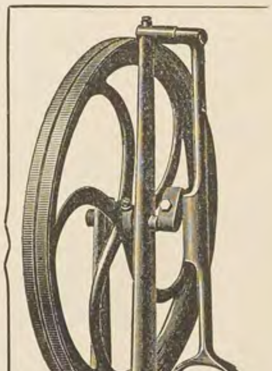

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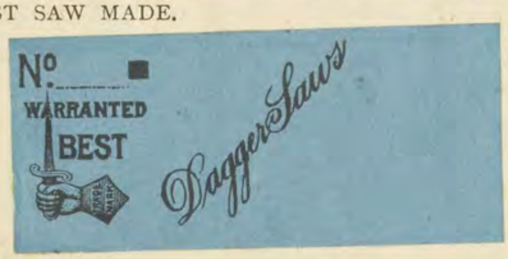

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