Workshop Notes

for Jewelers and Watchmakers

Ralph Waldo Emerson, in an Essay on Eloquence said in speaking of a man whom he described as a Godsend to his town, "He is put together like a Waltham Watch."

WORKSHOP NOTES

FOR JEWELERS AND WATCHMAKERS.

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 WATCHMÁKERS' SHOP. . . . .

BY

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

THIRD EDITION.

PART I.

1899

NEW YORK:

JEWELERS' CIRCULAR PUBLISHING CO.,

11 JOHN ST., COR. BROADWAY.

PREFACE.

SUBSCRIBERS to THE JEWELERS' CIRCULAR are well aware that since the appearance of its first number, 30 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 publisn 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 numcrous 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 lèver 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 turned 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 $1\frac{1}{2}°$, 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 eyeglass 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,

or, 1 inch $\times$ 16 grs. $=$ 16.
$\frac{1}{2}$ " $\times$ 64 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 fineness, 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, screw-drivers, 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 main-spring 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 main-spring 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 lärge 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 MAINSPRING.

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 skilful 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 $2 \times 2 : : 6 = \frac{2}{3}$ 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 (5×6) = 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 ½ × ½ = ¼ 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 endshake 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 distançe 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:

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

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:

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

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:

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

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 solder d 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 1/8 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 pràticable, 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 composition 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 simple 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 bees-wax; 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 = 373¼ 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 = 3⅙ grains Troy (nearly).
151½ 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 437½ 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 = 3½ grams fine gold.
1 mark gold weight = 8 ounces avoirdupois.
1 loth (German) = 16⅔ 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 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 equatoı, 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 polcs, 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 wi[illegible] 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.

PART II.

Note to Third Edition.

WHEN the first edition of "Workshop Notes for Jewelers and Watchmakers" was offered to the craftsmen for whom it was published, we were convinced that its elements of utility would be evident to the average observer, but we hardly hoped that it would meet with the hearty reception it did, that an entire edition would be, comparatively speaking, so rapidly exhausted, and that the demand for it would necessitate not only a second edition but now a third edition. For it must be remembered that the field for its distribution is limited, and that in every craft there is a number of workers who possess little or no ambition to increase their store of knowledge. But while this number of non-readers is considerable the demand for such a book as "Workshop Notes" is evidence that more workers are desirous of perfecting themselves in their crafts and of performing their work satisfactorily than generalizing pessimists are inclined to assert.

The virtue of "Workshop Notes" resides in the fact that it brings together in convenient and handy form for reference numerous stray and isolated recipes and processes distinctly applicable to the various branches of horology, gold and silversmithing, and their allied crafts. In printing a third edition, we have accepted the opportunity to add to the volume new matter to the extent of about 50 per cent., occupying the pages 195 to 290, this new matter being properly classified and indexed.

1899. THE PUBLISHERS.

NOTES ON HOROLOGY.

RELATION OF ESCAPEMENT TO BALANCE SPRING.

THE relation of the lever escapement to the balance spring is quite an important matter. Most workmen imagine that adjusting is a great mystery, and that the man who masters this portion of the watchmaker's art must necessarily stand at the head of the profession. The word "profession" is used advisedly, and it is to be hoped that the different horological schools will sooner or later bestow degrees as do schools of law and medicine.

It is well known that a balance spring adjusted to isochronal vibrations in a duplex or chronometer watch would not possess this property if placed in a detached lever. To make this proposition better understood, suppose we were to make two movements, one of which was provided with a detached lever escapement of the most perfect construction, the other a detent or so-called chronometer escapement, the trains of each watch as far as the scape wheel being precisely alike; for these movements we made but one balance staff and balance spring. In other words, the balance staff and balance spring were interchangeable after we changed the rollers on the staff to adapt it to the escapement of the particular movement to be experimented with. The balance and its spring were perfectly adjusted to isochronism with the lever escapement.

Now, if we changed the balance with its spring to the chronometer movement we would find the general rate of the watch about the same; that is, if the weights of the rollers were alike; but the spring, which was perfectly isochronal with the lever escapement, was badly out with the chronometer. What does this tell us? Simply, that the escapement is a great factor in isochronal adjustments. This influence does not exist in an abstract sense, because one is a lever escapement and the other a chronometer escapement, and that if the balance had been changed to another lever escapement that was adapted to receive it, it would have been perfectly isochronal, as it was with the first movement. One fault in watch manufacture should be remedied, viz.: the watch constructor and watch adjuster should be one person, because the adjuster is constantly trying to remedy the defects of the constructor. If the maker did the adjusting also, he would be able to correct the fault and remedy it instead of trying to make one error correct another, which is much like the doctrine of doing evil that good may come of it. Much of the adjusting, especially of the more delicate methods relating to position, consists of remedying downright mechanical defects.

Adjusting is divided into three departments, viz.: heat and cold, isochronism, and position, and it is the adjuster's province to treat his balance and balance spring in such a way that they are rendered proof against any alterations occurring in the latter, jointly or severally.

TRUING AN EXPANSION BALANCE.

THE truth of an expansion balance plays a very important part in the timekeeping of a watch, and with practise the truing of one is a very easy and simple thing; but in this as in all operations connected with the watch, great care and judgment are essential to success. The delicacy of the arms and segments requires that they be so handled that the metal is strained the least amount possible when restoring them to their original shape; with this point in view as well as that of convenience and ease of handling, there is no form of tool better adapted to this job than the figure-8 caliper made so heavy that there is no perceptible spring even with a pressure in excess of what is required to do the actual work of truing.

The joints must be well made so as to work somewhat stiffly, yet smoothly, so that when in putting the balance into the caliper, it can be done with no danger of injury to the pivots. The staff must be wholly supported by the cones of the pivots and not on the ends of them, as they would be bent or broken. A cross hole should be drilled so that the point of the pivot may be seen when the staff is in the caliper, this being necessary as well to keep the holes free from any foreign particles. The index or guide is a very important part and should be so made as to get a delicate adjustment in any direction, the best form being an arc of a circle about one-eighth of an inch long and conforming to the circle of the balance rim. Such a guide will facilitate the ease and accuracy of the work, as will be proven by a trial. The tool for bending the rim in the round is made of a piece of brass wire about three and one-half inches long flattened for about half an inch from the end by filing on both sides, leaving it about one-sixteenth of an inch thick; then cutting several slots crosswise to fit the different thicknesses of the balance rims.

When it appears that a balance is not true, first examine the staff to see if it is bent; being satisfied that it is true, examine to see if the balance is fastened firmly on the staff, as otherwise it will be impossible to do a good job. Now examine the balance, by twirling it around, and if it is badly out, it must be first approximately trued in the flat and round before the final finishing. The arms of the balance must be tested to see that they are of exactly the same length, and if they are, the truing may be proceeded with, but if they are not they must be made so by stretching. This may be done best in the staking tool by putting in a flat-faced stump and using the punch with which most staking tools are provided. This punch resembles a chisel, but instead of being sharp, the edge is slightly rounded. One arm shorter than the other indicates unskilful work in the making, and while such a defect might be corrected by taking out the staff and boring the hole out true in the lathe, by using the boring tool in the slide rest, yet it would be doubtful, as there is liable to be other faults that could not be seen. Consequently should this occur in any except the cheapest grades, the surest way would be to put in a balance that is known to be well made. When the arms are equal, true them in the flat, that is so that each is in the same plane. When truing a balance it is necessary to get the body in such a position that it will be perfectly steady, and this can be best done by using a seat as low as possible so that the elbow and forearm will rest on the bench. If the shoulders are almost on a level with the top of the bench the position is right.

Truing in the round is done by bending the rim where needed with the piece of slotted wire, but in the flat it is best to use only the fingers. The guide must at all times be set as close as possible, without touching at any point, to get the greatest accuracy. If the light is strong it will be an advantage to shade the top of the balance with the left hand while holding the tool so that the light will be reflected from a white bench paper below. The temperature of the room should be about 70 degrees, this being about the mean; above or below this, the balance rim will not be true in the round owing to the expansion and contraction, but this change will have no effect upon the poising if the balance be a good one. If necessary a screw should be removed to make a bend at the proper place. With some experience there need be no fear of bending the staff even with a balance having heavy arms. When the truing is done, test the poise.

DECEPTIVE BALANCES.

An evil that watch repairers may justly complain of, as it also is a growing one, is the number of what are called compensation balances that are now to be met with in the commonest of watches. Formerly, these sham compensation balances were not cut through, but occasionally a nick was cut on the upper side of the rim, for the sake of appearance, so these balances were no worse than the ordinary solid metal ones; but now the practise, having its origin in the same motive that induces manufacturers to apply Bréguet springs to this class of watch, is to cut the balance through; and, as these balances are of the commonest make and the softest materials, it is difficult to handle them without bending. If the balance be bent, it will be out of poise, and of course the time of the watch in different positions will be all out. But even if the equipoise of balance was perfect, a balance out of circle would be an eye-sore to even the wearer, and so the repairer must spend as much time over getting the balance true as it takes him to clean the watch. But supposing, as must often be the case, that the balance has been bent and tried by some not very skilful operator, the repairer's task of making it look nearly true has become infinitely greater, if not impossible, as the first operator has no doubt used either pliers or tweezers freely, and here the illustration of the bent pin becomes applicable and important.

Watch repairers, and even watch manufacturers, have sometimes strange notions as to the division of labor, and the difficulty of doing certain things that appear difficult and mysterious, only because they have not taken the trouble to ascertain where the difficulty lies, nor why one man should be able to do a certain thing better than another man who is equally capable. And one of the things assigned to a certain trade is the cutting and truing of compensation balances. A repairer should be able to do this as well as any balance maker, as he has certainly far more opportunities of seeing balances in all forms of distortion, and more practise in correcting them than a balance maker can have. It is true that the cutting of balances is not very much in the line of the watch repairer, but getting them true is his every-day work, and he should be able to do this efficiently and quickly. Although it is both the precept and practise of some people to take the screws out of the balances before commencing operations, I should never think of doing so, even to a new balance; it is a mere waste of time, as in those jobs that oftenest require the balance to be trued, the balance rim is soft and the screws so badly fitted that screwing them into the holes again would frequently make the balance as untrue as it was at first.

The first requisite then is a pair of calipers with good centers that move moderately tight and without guard or adjusting bar screwed on to them. As the cross bar or touch piece is better held by the finger and thumb of the left hand this bar should be of thin sheet brass and the point for touching the inside of the rim of the balance filed up small and square; this point can be brought to bear on the inside corner of the balance, free of the taps of the screws. If the rim is bent outward there is no other way so good as bending it in with the fingers; if the circle of the rim is complete, this bending will be sufficient, but if it is only complete in a small segment close to the arm, and is bent either outward or inward after that, the rim of the balance should be held tightly in the finger and thumb of the left hand, at the part where it deviates from the circle, and the outer end of the lamina bent either out or in by holding a peg against the inside of the balance in the right hand, pressing the thumb against the outside, always taking care not to bend too much. This process might be called the rule of thumb; but it is the simplest and best way of truing a compensation balance, and under no circumstances should pliers or tweezers be used, except in a case where these tools have been used freely before, and where the bends are so sharp and numerous that the process described would be ineffectual, when bending with a pair of tweezers, made of hard wood or ivory, may be resorted to.

IMPROVED METHOD OF STRAIGHTENING A BENT BALANCE PIVOT.

Any workman who has tried to straighten a bent pivot knows how uncertain and unsatisfactory are the results obtained by the ordinary method, generally resulting in a broken pivot, or at best in not being able to get it as true as is desirable. It is not to be understood that such a course is to be recommended in the higher grades where accurate work is required, but as there are a great many cases in which the customers would refuse to pay a price sufficient to allow the workman to put in a new staff, it is well for him to know how such a job may be done with the least expense, doing the best he can in each instance.

It will not be necessary, except in rare cases, to draw the temper of the pivot, as the strain is only what is required to bend it back to its original position—no bending back and forth. The only tool required in addition to an American lathe, which every workman should have, is a small tool which can be easily made, resembling one of the small pivot gauges with the long tapering slot; in fact it is the same tool except that the sharp corners of one side are rounded so as not to mar the pivot if conical, or, if a shoulder, the side having the sharp corner may be used. The making of such a tool is so simple that any workman can do it in a short time; but it must be borne in mind that the sides of the slot must be smooth and polished and exactly at right angles to the outside faces of the tool. Having such a tool on the bench, put the staff in the lathe so that it will run true and clamp it firmly so that it will not move with the pressure necessary to bend the pivot to its original position. Now place the tail-stock in position with a flat-faced brass taper in it. Carefully place the tool on the pivot with the corner next that fits the pivot best, at the same time holding the tail-stock spindle against it lightly to keep it from rocking with the pivot, as the lathe is turned slowly. As the lathe is turned, the tool must be forced gently down so that the slot fits the pivot and so trues it. The pivot should be well oiled to prevent sticking. Repolishing the pivot is now all that remains to be done, after which the repairer will have performed a job that it will be difficult for anyone to detect.

ISOCHRONISM IN FLAT AND BRÉGUET SPRINGS.

BY M. SANDOZ.

By isochronism, from the Greek, meaning equal time, is designated the property possessed by the pendulum and balance spring of accomplishing their arcs of vibrations of different amplitudes in the same space of time. In a pendulum, the only condition required is that its length be such as to make the center of gravity move according to its cycloid curve; but in the balance spring the means change with the form of the spring. In the spherical or conical springs, the extreme curves, constructed after the mathematical rules discovered by Professor Philippe, of the Polytechnical School of Paris, will produce an isochronism very nearly perfect. In the flat springs these curves cannot exist; therefore other means must be resorted to. I shall now give the result of several years of experiment and study embodied in the following theorems.

1. In the flat spring, every coil has, theoretically, a point where the vibrations are isochronical. 2. That point of isochronism is determined by the relative positions of the two points connecting the balance spring with the collet and stud, called *points d'attache.*

These two propositions form the base of isochronism in the flat spring; therefore the idea generally accredited among watchmakers that the isochronical property of a flat spring is incorrect, since the tenth as well as the twentieth coil of the spring is able to produce isochronism, the only limit being such size of springs as would perfect the freedom of its action.

Freedom of action being necessary for the isochronical properties of the spring to develop themselves, the spring must be bent to the center. If the first coil is too near or the curve too flat, so that even a minute part of the spring touches the collet, it will hinder isochronism. Next, the spring must be pinned perfectly tight in the collet and stud, and move freely between the regulator pins. These conditions being complied with, the watch is run three, six or twelve hours with just strength enough to keep it going; the result is compared with a regulator and set down. Next, the watch is fully wound up, and after a space of time equal to the first trial, the result is set down again.

The watch will generally run slower in the short vibrations than in the long, and consequently lose time in the pocket in the last twelve hours of its running. Having set down as a principle that every coil has an isochronical point, we have now to determine that point, remembering that as a general rule every increase of length of the spring over that point will cause the watch to gain in the shortest vibrations, and every decrease back of that point will cause it to gain in the long vibrations. This rule is correct only for certain limits, as I shall explain. Supposing that a balance spring of fifteen coils is perfectly isochronal, with the two fastening points just opposite each other, the fourteenth and sixteenth coil, as well as the fifteenth, will produce the isochronism very nearly at the same point. Suppose that we increase gradually the length of that balance spring of fifteen coils, pinned up so that the two points of fastening are placed opposite each other, so that its length will now be fifteen and a half coils; the two points of fastening are now in a position where they are said to be pinned to the half coil. The result will be that the balance spring will cause the watch to gain in the short vibrations in the very same proportions in which it has been gaining by the increase of the length of the first half. This change will continue until we reach the same point on the sixteenth coil that we started from on the fifteenth, and the two pins are opposite to each other, at which point we shall again have isochronism. The same method is applicable to the fourteenth coil with the same result.

Now it is immaterial whether we take half the coil to the center or to the outside of the spring, because both of these operations will produce the same result, viz., the change of the relative places of the points of fastening of the spring. Therefore the workman has his choice and is guided by the size of the spring and the weight of the balance; for taking half a coil to the center of the spring will not much affect the rate of the watch, but taken outside the difference will be great. On the other hand, a very short cut to the center will greatly affect the isochronism, and at the outside a full half-coil will generally produce from fifteen to twenty-five seconds difference in twenty-four hours. Of these the watchmaker would produce the greatest possible changes of isochronism in a watch; the change of position of the two points of fastening of the spring of one coil around will give him the two highest degrees of gaining and losing in the short vibrations.

It follows from the foregoing remarks that if a watch loses in the last running (short vibrations) the first thing to do is to increase the length of the balance spring from the outside; if the result is good, but not yet sufficient, give still more length; if the result is worse, it shows that you are too far on the coil. Take back the whole length that you had given in the first operation and draw more length so as to affect the spring the other way; or if your spring is already small, or your balance pretty heavy, cut to the center so as to come around to the required positions.

Some springs cannot produce isochronism because of a defect in their make, or on account of a want of homogeneity in the metal. The only remedy for this is a new spring. In the Bréguet spring, the isochronism is produced in the same manner as in the flat springs; but great care is to be taken in making the curve, for if it is not made in conformity with the principles of Philippe, the isochronism will be disturbed.

Few watchmakers understand the art of adjustment in positions, and those few make it a regular business. It requires of the operator considerable manual skill and reflective powers. The great principle is to equalize the frictions, so that the pivots will offer to the action of the spring the same resistance in the four positions generally required, viz., dial up, XII., cock up, and III. up.

After having inspected and corrected the train, so that the motive power is transmitted uniformly to the balance, the pivot and jewels of the lever should be polished and shortened so as to have very little friction; next, the base should be poised as perfectly as possible, the notch in the fork where the ruby pin acts should be polished, and the balance jewels made short enough to have the holes square, rounded inside and perfectly polished, the balance pivots well burnished, their ends half rounded, and the balance poised very carefully. The English method of throwing the balance out of poise, to obtain the same rate in different positions, is not generally accepted, and is considered a bad practise by the most eminent watchmakers. The balance spring is put in position without the balance, and bent so that the collet of the cock jewel will have the same centers.

The watch being now in good running order, is put on trial for twelve or twenty-four hours, and the rate in each position carefully noted. If there is any difference in the running with the cock up or dial up, this slight defect can probably be remedied by making the ends of the pivots even and equally polished. If the watch loses with XII. up, which is generally the case and the friction on the balance jewels is reduced as much as possible, the remedy is to increase the friction when the watch is either dial up or cock up. This is done by throwing the balance spring a little out of the center of the cock jewel, thereby adding to the friction on the pivot end a lateral pressure against the balance jewels. If the watch is well regulated with XII. up and loses with III. up, throw the spring a little toward the figure III.; this operation lifts up the balance when the watch is in losing position, and diminishes the friction of the pivots in the particular case. Making the ends of pivots perfectly flat has a tendency to cause the watch to gain with dial up or cock up. The sound of the watch must be clear in all positions, or else friction is indicated, such as is due to rough jewels or pivots and the rubbing of the safety pin against the roller.

CONCERNING THE BRÉGUET SPRING.

As to the application of Bréguet springs to common watches, or even to watches that may not be described as common, they are certainly worse than flat springs, even if they were not shams, which most of them are, as it is much easier to get an ordinary watch to time in position with a flat spring than with a spring that has an overcoil. In the first place, these springs are always a great deal too large, the overcoil is turned up anywhere, without reference to where it is to be pinned in. They are generally soft, and, if the overcoil is bent, as it so often is, the difficulty of straightening it is so great that it is no wonder watch repairers generally dislike them.

The Swiss make their overcoils by bending the spring up at a sharp angle and then bending it down again at the height above the spring which they require; therefore, it is impossible to do anything with this kind of a spring but break it off. As most, I may say all of such watches, have balances with screws, a couple of screws added to the balance will compensate for the loss of the half turn of the spring, and turning up a new overcoil is not so formidable a job as it appears to some. If a piece of brass wire is driven into a small wooden handle, and the end of the wire has a hole drilled in it, and is filed up to something of the form of the spring stud of a full-plate watch; if the end of the spring is brought through the hole in this little spring-holder, say two-thirds of a turn, and made fast there with a pin that has a flat side, the end of the spring can then be lifted gradually the required height over the body of the spring, and the overcoil can be bent in with the tweezers while the spring is held in the left hand by the spring-holder, without any fear of bending or disturbing the coils, even if the spring is a very soft one.

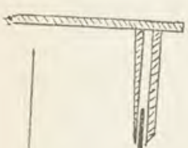
A workman often finds difficulty in bending this overcoil in consequence of the shape of his tweezers, the points of which are usually tapered, and consequently, as the end is bent inward, it keeps bending downward. This must be watched, and the overcoil should be the right height from the spring, and the curve the proper diameter before the spring is unpinned from the holder. Although this looks formidable, a little practise will make it simple and easy enough, and the workman will find that it takes far less time than it will take him to cobble and try to restore the shape of a spring that has already been a trial to some one.

HAIRSPRINGS AND REGULATOR PINS.

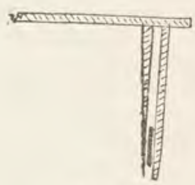
A great deal has been written and said about the Bréguet hairsprings, and almost invariably in their favor, particularly by the advertisements, and to-day nine out of ten retail jewelers will speak of a watch that has a Bréguet spring in it as something superior, when, as a matter of fact, other things being equal, it has no advantages. The most popular errors seem to be, that as the " throw out " of a Bréguet is so nearly equal all round, and as that of a flat spring is mostly on one side, there must be less friction on the pivots with a Bréguet spring than there would be with a flat spring; therefore the watch must be a better timekeeper; also that a Bréguet spring is less liable to get caught in the regulator pins. There is a great deal of truth in the latter argument, but the advantage does not arise entirely from the shape of the spring. In regard to the timekeeping qualities of a Bréguet spring, they are very much overrated.

While it is admitted by adjusters that they prefer Bréguet springs to flat ones, this is because these springs are easier to handle, and in bringing a watch to time in positions, a Bréguet can be "juggled" more and will show less than a flat spring; but no adjuster will claim that he can get better results from a Bréguet spring. That he cannot has been proved to the satisfaction of every adjuster in the business. The explanation of the "throw out" of a flat spring not affecting the timekeeping qualities is, that while it is an admitted error, it is a constant error, and happens nine thousand times every hour, and is a simple matter of regulation. If it happened only once or twice a day, or only in certain positions, then there would be some excuse for lauding the Bréguet in comparison. Perhaps the strongest argument advanced in favor of the Bréguet springs is that they are less liable to get caught in the regulator pins. There are several reasons for this. One is that the Bréguet springs are put in the better class of watches, and more attention is paid to the fitting of the regulator pins; again, the regulator pins are almost always nearer the hairspring stud. The principal reason why a flat spring gets caught is that the pins are not filed properly, and this fault is aided very materially by the fact that the pins are so far from the stud that the spring has considerable action between the two. This should be prevented, as far as possible, by changing the mean time screws in the balance, so that the regulator can be moved over to "slow." An improved rate would then be noticed.

A glance at the diagrams will give an idea as to properly and improperly fitted regulator pins. Usually, they are left too long. In No. 1 it will be seen that the



No. 1.



No. 2.

pins do not extend below the spring; in fact, they are hardly as low, and are closed so that there is not space between them for two coils. Should the watch receive a blow hard enough to throw the second coil over the pins, the position of the outside coil and the shape of the point of the outside pin would prevent its catching, and, should it catch on the inside pin, it would be immediately pushed out by the outer coil, which is, of course, stiffer than the second coil on account of its being fastened to the stud. But in the case shown by diagram No. 2, things would be different, and I am sorry to say No. 2 is better than six out of ten watches that leave the jeweler's hands in supposedly correct condition. It is very easy to see how the second coil, or almost any coil, could get caught in pins like these, and stay so, too.

A little more attention to details like these will prevent criticism, at least of the last man who repaired the watch.

TO COIL THE BALANCE SPRING ROUND THE COLLET.

The following process may be useful to those who experience difficulty in coiling a balance spring after it is pinned to the collet: Take a small eyed blue sewing needle, file off the extremity up to the eye and smooth the corners. You have then a kind of fork by which you can form the center coils without fear of damaging the spring.

TO REPLACE AN OLD BALANCE SPRING.

To substitute a new balance spring for an old one the repairer should place another watch going to time on the work board; having selected a spring, bend the inner turn and place it so that it bends or catches the cylinder; lift it up with the tweezers and cause the balance to vibrate, letting the bottom pivot touch a smooth surface, such as the top of the glass oil cup. By catching hold of one or more turns and altering the position of the tweezers, the arms of the balance must be made to vibrate in unison with those of the watch going to time, which may be known by listening to one and observing if the ticks correspond with the motions of the loose balance, or by looking at both balances to see if they appear to trace together. The size of the spring is reckoned from where it is held by the tweezers as a temporary stud; by this means a suitable spring can always be secured without the trouble of putting on the collet and spoiling a number, and wasting time by mere guesswork, and watching second hands for a time; the spring being suitable, its size should be half the balance diameter, which is considered as most correct by good authorities.

THE EAR TESTS FOR ADJUSTMENTS.

The ear tests for adjustments is one of the most thorough and complete. It must not be understood that any and all corrections can be determined by the ear; but it is a fact known to most adjusters that many irregularities which the eye will fail to detect can be detected by the ear. We are all aware that the sense of sound is conveyed to us by vibrations carried through the air to the tympanum of the ear. Now, asks the reader, what has this to do with the adjustment of a watch? Much, if the vibrations of the parts which emit the noise detected by the ear are not in harmony ; they must be in discord, or in other words, disagree, and become antagonistic. To analyze the effect, let us make a few experiments in acoustics.

As a primary experiment let us strain two wires upon a board ; we first set up one wire, until its vibrations emit to the air waves corresponding to the middle C of a pianoforte; in this condition the wire will give 525 vibrations to the second, if the piano is up to the concert pitch. We next set up the tension of the companion wire to yield the same tone, that is to give the same number of vibrations to the second. When the two wires are on the same board, we can allow a sensible difference of tension to exist, and still the two wires will vibrate in unison, one yielding a little to the other, in order that the vibrations of both shall be synchronous. If we separate the two wires, or put each wire on a separate board, and place one on one side of the room and the other on the opposite side, and one wire is caused to vibrate, the sound waves in the air will immediately cause the other to set up synchronous and harmonious vibrations in response. But when the wires are separated, as just described, the tension on each wire must be more nearly alike than when the wires are attached to the same board ; but, even when so separated, a small amount of license is admissible in the tension of the two strings.

Perhaps some reader will ask, how are the deviations of such small intervals of time determined ? The reply is : by comparison with light waves ; but the methods by which the tests are made are too complicated to allow of explanation in the present article. To profit by such instruction in adjusting, one should accept the assertion that, if we desire to arrive at fine and close results in watch work, we must render those parts which constitute the sound-emitting portions of the escapement harmonious—that is, *they must vibrate in unison, and produce a clear, harmonious, musical tone.* If we strike one hand down on the key-board of a piano with our fingers extended so that each finger will strike a white key, we make a *musical noise*, but there will be no harmony in it. So in the tick of a watch, if the sound-emitting parts are synchronous they will be melodious, not discordant. This should be looked to and studied by workmen. Let any workman make a practise of noticing the sound of the tick of a watch, and he will, in a very brief period of time, be able to judge of the average performance of a fine watch by the purity of tone. Not one watch in ten will have the same tone with dial up and dial down ; but this is not of very great importance so long as the tone in each position is clear and melodious.

The course to pursue to remedy an imperfect tone in the tick of a watch is not easy to point out; oftentimes it can be effected by simply repinning the balance spring at the outer end of the coils. Again, both ends will need to be repinned ; occasionally it will require an entirely new spring. The tick is given at the time of the escape of the tooth, and probably most of the sound comes from the fork striking the jewel-pin when the impulse commences to act. At this time the balance spring is free from contact, except at each end, where it is attached to the collet at one end and the stud at the other. In this position, the balance spring is free to receive such initial forces as to establish the vibration in it which embodies in it the tone we hear when listening to the tick, and a cause which will in any way affect the tension of the spring will affect the character of the vibrations, and consequently, the tone. All these tones could give us intelligence of a change in the rate of our watch, if we could only interpret them.

The writer is led to speak at this length, from a conviction that the next great advance in adjusting will be governed by attention to what can be heard as well as seen in this matter. We cannot instruct you to adjust and arrange your balance spring so that it will emit a sound of any one musical note, or a combination, an octave, or fifth, but we should strive to avoid as much as possible a tone of dissonance and discord, because such sounds tell beyond dispute that the parts are each acting at variance one with the other. Frequently by taking up the balance spring a mere fraction, and placing a pair of light washers under a pair of screw-heads at the opposite sides of the balance, it will entirely change a discordant tick to a clear musical one. A slight change in the lock of the banking screws may also do much in this way. A tension force in the balance spring will also affect the tone—I mean by this that a spring which is not true in the flat and the round, particularly in the flat. To explain : Suppose we are putting on a new balance spring, we true it in the calipers until it runs true in the flat before we pin it into the stud ; in pinning into the stud we distort the spring so that the center has a tendency to rise or fall ; such a spring will give a pronounced difference in tone in the positions dial up and dial down. A balance spring, after it is turned in the flat, should be removed from the balance to be pinned into the stud, and the fastening points arranged so as to bring the point where the spring is pinned into the collet opposite the curb pins, when the regulator stands in opposite the center of the index plate. The spring is next pinned into the stud, so that it lies flat with the cock when held vertical ; that is, the flat of the balance spring, when held perpendicular, is parallel with the under side of the cock. The cock should then be laid down, and the point where the spring enters the stud bent so as to bring the center of the collet to correspond with the center of the jewel hole. This will probably require the outer coil of the spring to be bent away from the next inner one, as the spaces between coils of a closely dialed spring are not sufficient for the stud or the curb pins to act freely. What is required is that the outer coil of the spring should be so manipulated that the normal coils of the spring shall be concentric to the hole in the jewel which receives the pivot of the staff.

These precautions taken, usually the tones of the ticks, if one may be allowed the expression, will be nearly or quite alike (if the frictions are the same), with the dial up or dial down. The same precautions should be taken if the balance spring is one with an over-coil, usually called a Bréguet spring; it should lie flat, and the center of the collet correspond to the center of the jewel. A very little practise, after one has had his attention called to it, will enable him to make small changes which will effect the desired result—that is, in obtaining a clear musical tone in the tick.

Of course, all scraping and rubbing noises should have been remedied before any attempts of the kind just noted are made. A tremulous motion of the balance spring should be carefully avoided, watching that such a condition does not establish itself in certain positions, as we often see a watch in which the spring coils and uncoils freely in all but perhaps one or two positions, while in the sea rapid vibratory motion is established which gives out to the ear a sizzing sound that would lead an inexperienced workman to imagine there was an undetected friction in that position. Such vibrations are more apt to be detected in close than in open coiled springs. Springs developing such vibrations will usually be found a little out of sound, or to have an unequal space between the coils, from being tampered with ; if restoring the spaces to their natural order and toning in the sound does not correct the trouble, a new spring is about the only remedy.

ADJUSTING THE ESCAPEMENT OF AN 18s AMERICAN WATCH.

FIRST we will suppose the scape teeth are all right, and the pallet stones whole, balance in and dial off; then we will examine the lock. Use a double glass and look through the " peep holes " in the pillar plate ; now slowly turn the balance first to one side, then to the other. Notice particularly the lock on both pallet stones. You can form a more correct opinion if you stop the balance the exact instant the scape tooth drops, and then turn the other way. The lock should be just as light as it can safely be—that is, to have all the teeth stay on the locking face and not slip down on the impulse face of the pallet stone. A deep lock retards the motion. Do not depend on the examination of two or three teeth, but try every one ; there may be a short one or the wheel may be out of round. In the latter case do not try to improve it; get a new one if the customer will stand the cost, if not let it alone unless you have special facilities for doing that kind of work.

After correcting the lock see that the guard pin is not bent sideways, then close the banking pins until the guard pin just rubs on the roller—not hard, but so that there is no shake. Now turn the balance as before and see if the teeth of the scape wheel will " let off " the pallet stones. If a tooth sticks on one stone, open that banking pin, and see if the tooth on the other pallet stone sticks on it ; if it does then move the fork toward the roller a little, then close the banking pins as before and try the " let off ; " if the teeth stick on one side and do not on the other, move the pallet on the fork until the teeth will " let off " both stones.

Now try the pin action. Move the balance so that the jewel pin is toward one side of the fork ; then slowly move the balance back until the jewel pin touches the slot in the fork; then move the balance back enough to bring the flattened face of the jewel pin opposite the corner of the slot in the fork it has just passed. Now, while holding the balance at this point, use the tweezers and try the shake of the fork on the face of the pin. The pin should just clear on entering and the shake should be almost imperceptible. Then try the entrance with the fork on the other banking pin. One side or "horn" may be longer than the other; if there is much difference, it should be corrected with a very fine, round file about the diameter of the circle in the end of the fork. Remove the burr and try again. It may be that before this the jewel pin has refused to enter the slot. In that case it was too far forward and should have been moved back a little.

If these directions have been closely followed, the watch will be in this condition: No slide of scape teeth on pallet stones after dropping; no shake of fork on banking pins or of guard pin on the roller; no shake of fork slot corner on the face of the jewel pin. The watch is now "banked up to the drop." Now open the banking pins just enough to allow the guard pin to clear the roller all round, and your escapement is adjusted as perfectly as it is possible to do it.

INFLUENCE OF MAGNETISM ON A CHRONOMETER'S RATE.

An issue of the *Annalen der Hydrographie*, etc., contains an interesting article on this subject.

The problem whether any, and if so, which, influence is exerted upon a chronometer by magnetism, has not, by any means, been decided. The observations made hitherto only showed a noticeable influence, cases of which were mentioned at proper occasions. Airy found among hundreds of chronometers examined by him only one that showed a pronounced deviation, although of various others observed in the Kiel Observatory, a few exhibited an influence of magnetism upon their rate, still the change produced amounted to not more than a second. Nothing was said specially about the metal of the several parts of the chronometers examined. More weight is attached to the observations established by the French lieutenant of marines, Le Goarant de Tromelin, which he discussed in an article published in the *Revue Maritime et Coloniale*, and in which he arrives at the conclusion that the influence of magnetism upon the rate of a chronometer depends simply upon the metals of which the two parts of the balance are composed, and to a lesser degree, upon the metal of the balance spring. It may be interesting to the reader to debate upon a few of the observations and discussions, and to mention their most salient points.

Isochronism, amplitude, and duration of vibrations, and consequently, also the rate of the chronometer, all depend essentially upon the balance spring and balance, and it may, therefore, also be assumed *a priori*, that when an influence of magnetism upon the rate is suspected, it must first be looked for in the last mentioned parts. Observations confirm this in such a manner that a stronger influence of magnetism could be found only in those chronometers, the last mentioned parts of which consisted of metals with a tendency to be influenced. Specially interesting in this regard are the observations of Arnold and Dent, who used chronometers, the balances and springs of which were of steel, as well as other materials, and the following observations were made:

A chronometer with balance spring of steel only, simply showed trifling alterations of a few seconds, while chronometers, the balance spring and balance, or the balance only of which was of steel, showed very great deviations up to thirty-seven minutes. The magnetic influence upon a chronometer, the balance of which together with its spring contained no iron, was nil.

Mr. Fischer, who also experimented in the same manner, placed a strongly magnetic rod at a distance of two inches from his timekeeper; he noticed with all chronometers an acceleration of 8 to 9 seconds. It is to be regretted that nothing regarding the structure of the balance and its spring is mentioned in the dissertation of Mr. Tromelin.

Messrs. Delamarche and Ploix instituted analogous experiments by approximately placing the chronometers on land under analogous conditions to which they are exposed on board ship—that is, they placed a magnetic rod at such a distance from the chronometers in which it is able to deviate an ordinary magnetic needle from 15° to 40°. After having finished this experiment these engineers came to the conclusion that the magnetic condition of the ship exerts no noticeable influence upon the rate of the chronometers, and that the rate deviations generally experienced in the transport from land to aboard ship, and *vice versa*, must be ascribed to other causes. The latter remark is perhaps made because sea captains were for a time inclined to ascribe these deviations to magnetic influence due to the transport of the chronometers from land to on board; this erroneous opinion, however was proved to be fallacious long ago. The experimenters, Delamarche and Ploix, forgot to state, however, of what materials the balance and spring were composed, and for this reason the results found are of a limited value only, in view of the above remarks concerning the composition of these parts.

Mr. Tromelin accidentally experienced another occurrence with his own watch which stopped while he experimented with strong electro-magnets. This phenomenon caused him to institute further investigations concerning the influence of magnetism upon watches and chronometers. The balance arm of his watch was of steel, as is generally the case in a good watch with compensated balance, and, as he expressed it, changed the watch into a compass, which indicated not the time, but the magnetic meridian.

In order to explain the action of magnetism upon the balance spring, let us imagine a circular steel hoop that vibrates near a magnet lying in its plane. The magnet will exert no influence upon the vibrations as long as it is in the plane of the hoop; but if this is not the case, then the hoop will endeavor to vibrate in the direction of the magnet. This explains the phenomenon why the experiments instituted by Arnold and Dent produced barely noticeable alterations in chronometers, only the balance spring of which consisted of steel, because this spring may be regarded as composed of a number of such hoops. A deformation of the spring is produced only, and it is known that such a one has almost no influence upon the rate of a chronometer. But it is otherwise with a balance containing steel parts; if it is placed to one side of a magnet it will seek to accommodate itself with its steel arms until it has assumed an equipoise. During its vibrations it is constantly subjected to a magnetic attraction, and the regular motion produced by the balance spring changes into a pendulum motion, due to the attractive force of the magnet. When the arm is permanently charged with magnetism, the terrestrial magnetic elements also influence it, and even after it is no longer exposed to further magnetic influences, the motion of the balance spring must then combine with the terrestrial magnetism. The magnetism acts upon the arched parts of the balance in about the same manner as upon the balance spring.

If from the preceding it appears established, on the one hand, that by the operation of magnetic forces upon the balance and balance spring, if of steel, the isochronism of their vibrations can be impaired, they may on the other hand, occur also of such strength as to cause a noticeable alteration of the rate. When in a thunderstorm, after strong flashes of lightning, a sudden simultaneous jump is observed in six chronometers, there can no longer exist a doubt but that the cause is due to magnetic influences. The only lesson to be drawn from this is, that the use of iron or steel is to be avoided as much as possible in the construction of chronometers, but more especially in the balance and its spring. Before everything else, the captain should know the composition of his chronometer, not only for correctly judging incidental changes observed in the timepiece, but also for employing precautions, by a judicious placement, to guard against all disturbing influences if his chronometer contains steel parts.

To be correctly informed about the faulty condition of the location where the chronometer is to be placed, Lieutenant Tromelin proposes to employ a small quickly-moving hanging magnetic needle. To show how easily alterations in the magnetic character are produced by trifling causes he mentions a very interesting case which happened on board the *Tonnère*. The steering compass, enclosed in a compass house entirely of sheet iron, showed noticeable and very irregular differences of from 5° to 15° in the deviation of the compass, both day and night. It was at first believed that this phenomenon was due to the heating of the compass house and ship by day and the subsequent cooling at night; but the insufficiency of this assumption was quickly seen, because this thermic difference could not produce these large magnetic deviations. The compass house was overhauled thoroughly with the small magnetic needle, and it was found that there were in it a few movable parts of a strongly pronounced magnetic polarity, to wit, the doors and windows, which were opened in day time on account of the heat, and closed at night. They were replaced by others of brass, after which the occurrence ceased.

In order to protect the chronometers having steel balance arms against the magnetic influences induced by the alterations of the course of the ship, Tromelin proposes to enclose them in their iron receptacles. Other propositions made for the placement of a chronometer on board and remote from all iron parts, especially the vertical, are doubtless known and do not require elucidation.

MAGNETIZED WATCHES.

To ascertain if any part of a watch is magnetized, take a small piece of iron wire (jewelers' binding wire), attach it to a silk thread, and fasten the silk thread to a small brass rod or a peg-wood, and approach the part or parts suspended. 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 contains case springs, and 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.

To divest steel of magnetism, a strong horse-shoe magnet, or several of them, is attached to a lathe, pointing outward. When this is set in motion, the parts to be operated upon are brought close to the magnet, and are likewise rotated by means of a twisted cord or any other appliance and gradually withdrawn from the effects of the magnet. More than one application may sometimes be necessary to remove all traces of magnetism, but with some practise success is assured every time. The springs of a watch case had better be annealed, re-hardened, and tempered, or, what is still better, be replaced by new ones.

FRICTION.

With that kind of dead-beat escapement, says Robert Immisch, where the friction remains active throughout, as in duplex and horizontal watches, the gyration is, of course, much less, and here it is imperative that attention should be paid to a proper proportion of weight and diameter of the balance. In the case of a cylinder watch, no amount of change in the balance spring will make long and short vibrations equal, if these proportions are incorrect. The friction on the sides of the cylinder is a given factor, and must be turned to a proper account; the gyrations being small in themselves, the arc of escape bears a large proportion to the whole extent of the vibration. During this arc of escape there is no side pressure against the cylinder, and a stronger impulse will consequently propel the balance forward with a greater velocity This increase during the arc of escape in a properly constructed watch will be compensated for by the increased friction on the cylinder.

If a balance is too small and too heavy it is clear that its greater momentum will overcome this friction easier, and so neutralize the equalizing effect it would otherwise have had. It follows, if a cylinder watch gains with increased motive force, the balance is too small and too heavy. By making it lighter and putting in a weaker spring, a change is certainly effected in the right direction; but as any change in the motive force will be at too great a proportion to the absolute power of percussion in a slight balance and spring, any diminution will cause the vibration to fall off considerably; any outward influence, such as thickening of the oil, and imparted motion, will also influence the going of the watch to an undue extent.

There is, in a large and light balance, not that alertness which we find in small and heavy ones, and the wear on the edges of the cylinder is certainly greater, but it has the important advantage of greater steadiness. In a watch having an escape wheel of 15 teeth, making 18,000 vibrations per hour, the extreme edge of the balance should just reach up to the tooth of the wheel, and the weight be so proportioned that, being clear and fully wound up, it should make a little less than two-thirds of a turn. With slower vibrations, the size must be increased proportionally.

In a duplex watch the friction is much less; but, as it continues throughout, a change of the momentum of the balance would also considerably affect the long and short vibrations. This escapement affords a facility of altering the proportions of the impulse velocity to the friction in the remainder of the vibration. If the angle formed by the pallets and the notch in the roller is lessened, the drop is increased, and the impulse power so lessened causes not only the vibrations themselves to fall off, but also the smaller ones to be slower than the large.

The following rule will be a guide in conducting experiments. All alterations which increase the arc of vibration without changing the amount of friction, will make the long vibrations slower than the short. If the impulse power remain the same and the friction is increased, the long vibrations will be quicker than the short, inasmuch as to a smaller arc of vibration the same increase of friction bears a greater proportion than to a larger.

If in a duplex watch the balance holes are too large and the balance is brought into such a position as to bring it into a closer proximity with the escape wheel, the long vibrations are sure to be quicker than the small, for two reasons, firstly, on account of increased friction on the rollers; and secondly, in consequence of the greater drop in the escapement. The difference caused by the change in friction on the roller will be considerably influenced by the momentum of the balance. We also find that if the balance holes are large, a considerable difference arises in the rate of going in the four vertical positions.

The pressure of the wheel against the roller is never directed to the center of the latter, but acts obliquely, and if, according to what position the balance is in, it becomes more or less so, it will cause a variation of friction in the pivots in different positions, though it is less an amount than that on the roller, it is extremely inconvenient, as its variable effect can never be compensated for. It is therefore of great importance in a duplex watch that the holes should fit exactly. When the escapement is set out of beat, the point where the vibrations are quickest does not correspond with the center of the arc of escape, and therefore such change will have an influence on isochronism; but of course this ought not to be done, as it would make the escapement imperfect.

In a duplex watch the friction on the roller is sufficient to exercise a proper control over the momentum of the balance, and consequently the latter becomes liberated and gets more free in its action when the motive power relaxes. The balance is, on the other hand, sufficiently independent of the friction to allow the properties of the balance spring to be brought into play. Those circumstances combine to make the general performance of duplex watches very satisfactory. In lever watches and chronometers the motion of the balance is, except during the arc of escape, unfettered by any escapement friction, and the properties of spring on balance have their full sway.

ENGLISH LEVER AND ITS REPAIRS.

A FREQUENT use of the depthing tool is necessary in making alterations and repairs to an English lever escapement, as many errors are quickly detected with the escapement in the tool, that are troublesome to discover in the plates. When practicable, alterations of the pallet stones are best confided to a hand who is thoroughly acquainted with the subject of resetting stones and polishing them, although most repairers understand how to make mills for cutting corners of pallets by charging a brass of soft metal ferrule with diamond dust or bort. The method of charging is very simple: some diamond dust being mixed with oil is placed on the flat stake of the vice, and the ferrule is placed upon it and hammered; the diamond dust is imbedded in the brass, and when mounted on an arbor may be used as a circular file or grinder, against which the pallet may be held and cut.

The cutting of pallets may often be avoided by shifting the positions of the jewels, which, being fixed with shellac or cement, will, if warmed, allow the pallets to be moved. Many repairers use spirits of wine for cleaning; this dissolves shellac and most cements, and escapements should not be left in it any time, or the jewels will be loosened.

Alterations of wheels and pallet depths generally involve alterations of the angling or position of the pallet on the lever, to secure equality in the run and action on each pallet as moved by the roller. Unpinning may not be necessary, but the lever being held edgewise in a suitable recess, a brass punch applied with a light hammer to the pallets will make great alterations of the angles with little trouble or disturbance of existing conditions. Where the holes are jeweled, a favorite plan of altering depths of escapement is the making of an eccentric staff to the pallets. The staff and bottom pivot are made in the usual way, that is, turned and polished perfectly true; but before making the top pivot, the center on which it has been turned is filed away, and a new point for it to be run on is made, so that when in the turns, the pallet arbor runs out of truth or eccentric, the top pivot being now turned and polished in the usual manner. With the staff in the pallets we can make alterations of the escapement deeper or shallower, or one deep and the other shallow, as its position in the pallets may be altered to vary both roller and lever depths, and wheel and pallet depths, as may be desired.

The correct depth of a wheel and pallet is ascertained by placing them in a depthing tool and observing three of the wheel teeth pass freely inside the pallets, and holding the lever tightly with the fingers, see that the tooth falls on the inside locking plane as shallow as possible, without missing or falling on the second impulse plane, and that three teeth have a little shake between the corners of the pallet it has just left and the one it has fallen on. Rather more shake will be required on the outside of the pallets, as these have to move between four teeth, and without fair shake between the four teeth and the outside corner of the pallets, the pallet, though it may escape, is liable to dig into the back of the teeth of the ordinary ratchet escape wheel. The club tooth wheel, having substance which allows of the back being hollowed, the inside and outside shake may be equal; and in this respect it is preferable as well for strength and the greater equality of the impulse and locking frictions, as the whole of the actions are more concentric.

If wheel and pallets are the right size, by making the pallet deeper increases the freedom on the inside of the pallet, but decreases it on the outside, and the level escapement, unlike most others, is most effective in being made as shallow and light on its actions as consistent with safety.

The replacing of any part of the lever escapement, if lost, should not involve much difficulty to the repairer, the mounting of the wheel being much the same as every other wheel, except in new work, when it is usual to rub the brass rivet down with a pointed center to secure the wheel to the collet; but riveting will be most reliable for the repairer, if unpractised, and if unskilled in polishing with grain tin polisher and rouge, a sufficient polish may be given by rubbing the wheel on the burnishing glass, which is made by rubbing two pieces of glass together with fine emery and water, and keeping them, and whatever is polished on them, perfectly polished. These glasses serve the same purpose with brass that the deal burnishing board, charged with emery, does with steel and steel burnishers, and a clean flat gray is, even in new work, always preferred to unflat high polishing, which, to be done well, requires much application and practise. This latter method is going out of fashion in good work of all nationalities. A clean piece of wash leather must be used to hold the wheel down on the glass, and a light circular rub is given.

Repairers never seem to understand the importance of clean linen in polishing. Rouge, which in other hands polishes beautifully, is with them no better than oilstone dust. Burnishing with a clean brush is no use in polishing. Nothing but soft bread, kneaded in the palm of the hand to a dirty paste, and the work to be cleaned imbedded in it, will remove dirt properly for polishing purposes; or if a pivot or arbor, polishing in the turns for burnishing, a clean card scraped on the edge with a knife and applied to the polished surface, will clean and dry sufficient for burnishing, or for observing what progress has been made in burnishing.

TO SET AN ENGLISH WATCH IN BEAT.

The method of setting an old English watch, that is, a lever watch, in beat, does not differ materially from setting any lever watch in beat except as to the means employed in some instances. Whereas most lever watches are set in beat by shifting the hairspring collet on the balance, some of the old English watches sprung *under* the balance are put in beat by unpinning the spring at the stationary brass balance spring-stud. This unpinning and thereby lengthening or shortening the balance spring if within moderate limits may be indulged in if, as is usually the case, the regulator has a long range from "fast" to "slow" or *vice versa*; and it depends on the position of the regulator whether or not it will be necessary fo move the hairspring collet to avoid having the regulator too close to "*slow*" or to "*fast*."

To set a lever watch in beat as a general thing is not and ought not to be done by simply having the lever in the center between the banking pins, but depends entirely on the conditions of the impulse faces of the pallets and on the unlocking resistance of the same. The balance, or rather the jewel pin, ought to occupy such a position in the slot of the fork, that the escape wheel by its action on the pallets impels the balance on both sides with equal facility. The point which we aim to make clear is brought to notice more distinctly by calling attention to the fact, that the engaging pallet in its contact with the escape wheel gradually lifts and drives the balance with more difficulty, while the disengaging pallet performs the same functions gradually with more ease; the former acting progressively on a shorter lever and the latter acting progressively on a longer level.

The effects of these conditions are modified by the unlocking resistances which, as a rule, act in the opposite direction. As these conditions are variable factors and different in almost any two individual escapements, the spring ought to be set on the balance in such a manner that it is driven to both sides with equal facility.

In this connection the fact might be mentioned, that the club-tooth escape-wheel has an advantage over the English or ratchet-tooth escape wheel, provided the former drives the pallets with the points of the teeth first, and finishes driving them by the incline of its club teeth towards the end, which obviates the lengthening or shortening of the arms of the pallet towards the end of the impulse of either.

THE BARREL ARBOR.

The most effective form of barrel arbor and ratchet is the old form, now disused, but for what reason it is difficult to tell; but it seems that the law of constant change governs watchmaking also, even if there is no improvement. The only ratchet and disk not liable to failure is that seen in old Swiss watches, with the ratchet held by three screws screwed into the steel barrel arbor, which gives the best possible hold for them, and this part of the arbor also forms the pivot and bearing for the arbor's support to the bar. Its large circumference prevents wear, and the effects of wear do not cause so much motion of the barrel extremities, while the pressure during winding is not on the hole and its thin sink, but on the large circumference embraced by the ratchet; its superiority is shown by the fact that watches with this form of ratchet with fifty years' wear are often seen in sounder condition in this part than modern watches and barrel arbors with only a few years' wear; and any damage to modern ratchets involves a new entire arbor, the ancient form involving only the replacing of the ratchet, if damaged in teeth, by a new one, which the repairer, if skilled with the file, could make himself from a piece of round steel tightly fitted on the winding square by opening with a broach; the screw-holes are then marked and drilled through the holes in the arbor; then opened wider to let the winding key through the ratchet; then two fine circles are turned for size top and bottom of the teeth, and a three-square file used to cut the teeth, great accuracy in which is not requisite for effectiveness, as the click will follow any sort of teeth in this arrangement and be effective.

POINTS FOR REPAIRERS.

The chief fault in low class levers is that they generate too much friction, and that but a small portion of the motive power is left for expenditure in vibrating the balance, which must have considerable impetus to unlock the pallets. Hence we find strong main-springs a necessity in this class of watches, entailing much wear and damage to the immediate connections. Accuracy in any part of this work cannot be taken for granted, and before taking the movement out of the case, a suspicious vigilance is desirable, to see that winding (if a key winder) and hand square are free of case and glass, and that the balance, end stones and screws are free of the case. Most of the watches have brass edges on which the joint and dial are screwed (English low class lever watches are taken as subjects of these remarks), having three feet to serve it to the plate. If the watch has been going any time, the joint and three feet are usually loosened, not having sufficient substance in the brass edge to endure the strain incidental to winding and opening the watch. Soldering the feet carefully is sometimes done, but a better plan is to put a hollow punch in the vise, which will hold each foot loosely, and with a sharp pointed three-square punch strike one fair blow with a hammer in the center of the rivet end of each foot. The joints may be tightened with an ordinary round punch. Some care is required or the dial may be altered in position on the watch; and caution in repairing the dial is desirable, as the pins often project and come in contact with parts of the train of wheels.

REPAIRING A BATTERED WATCH.

A CORRESPONDENT of THE CIRCULAR complains that he repaired a battered watch. It ran very loose. Since repairing it, the best performance in the five positions is unsatisfactory; he is answered as follows:

It would have been cheaper and quicker to have sent the movement to the factory, but correspondent would have missed good practise. If customer is patient the watch can be made to perform again to satisfaction. The slow rate, dial down, would indicate some trouble in the potance jewels; perhaps there is too much space between the hole jewel and end stone, allowing the pivot shoulder to touch slightly, or practically the same thing happening by reason of the hole jewel being out of flat, *i. e.*, not true in the setting, or the setting not true in the potance; perhaps the potance itself was bent in the accident. See also that the fork clears the roller in all positions, and that the jewel pin is of the right size and not tapered, and stands perfectly straight with the staff. The rate in the fourth position—pendant right—may be caused by one or more of several things. First, I should try the poise of the balance. This is a branch of watchmaking which few repairers appreciate the necessity of doing well. In this case poise it as fine as possible; if it is found in poise, look to the pin action and listen for "strikes."

If there is considerable difference in the sound in different positions, you will generally locate the trouble in the pin action. The bankings may be opened too wide, or the jewel pin be too far back (toward the staff), or the slot in the fork be rough or cut. The opening in the collet should not be wide; if it is, then the poising of the balance may be offset in a measure by it, and counterpoising be resorted to, though it is not considered the most workmanlike method by some adjusters, and has the disadvantage of its liability of being undone by some other repairer. Counter-poising in this case should be done by holding the movement pendant right, and after finding which meantime screw came to the bottom when balance is at rest, turn in this screw one-half or three-fourths of a turn, and turn out the opposite screw. If it happens that two screws are equally near the bottom, turn each one-half as much; the top screws should also, of course, be so turned. This is an operation that is often carried to excess, even by adjusters who know, or ought to know, better. However, act on the above suggestions.

STEADY PINS.

IT is of the utmost importance that the steady pins of the balance cock should fit closely. In saying this it is not to be understood that loosely fitting pins in any other part of the watch should be tolerated, but particular attention should be given to those in the balance cock. Sometimes one pin will fit closely and the other will be loose. This is just as bad as if both were loose; it may, in fact, be worse, as it certainly is more deceptive and would be passed by most watchmakers. The cock screw is not where it is as a steady pin; it is only to hold the cock down to the plate. The steady pins are what their name indicates, and both should fit closely, as the slightest variations of the cock will throw the balance out of upright; and if the watch has been adjusted—then good-by adjustment. The effect is increased friction on the pivots, and change of depthing of the jewel pin in the fork.

It is not always advisable to put in a new steady pin; in fact it seldom is, except where the old one has been so badly used that it is past repairing, as in many cases the pins extend through the cock, and, of course, a new pin would show on the top side of the cock. Neither is it a workmanlike job to close the pin holes in the plate with a round-faced punch, as is often done. The metal thrown in by the punch is simply a thin burr, and the pin will be loose after it has been tried a few times. Some watchmakers (?) make a close fit by flattening the pin with pliers; this is a butcher's job at best, and should not be done on any watch worth more than 50 cents.

There are several ways of making a close fit, but probably the neatest is to "upset" the pin. Use a concave-faced punch, preferably one in which the hollow is about the shape of the end of the pin; lay a piece of tissue paper on the steel bench block to protect the damaskeening or gilding, and then with the punch make the pin larger in diameter by slightly shortening the pin. This process leaves no visible mark on the pin and the "upset" pin is nearly if not quite as good as a new one.

REPAIRING A DIAL POST.

WHEN a repairer finds the post of an enamel dial broken off in the notch where the screw takes into it, it is most advisable not to attempt splicing it, but to put in a new post. First remove the old stump down as low as convenient, with sharp cutting pliers, being careful not to exert the slightest strain or twist on the post, but to let go of the dial while cutting. The posts are riveted in the dial plate and twisting will loosen them and scale off the enamel on the face of the dial.

Next file it down to the enamel with a sharp file and very light pressure, supporting the dial underneath on the tip of the finger. Then take a small emery grinder, made in either wheel or ball form running in the lathe, and grind out a little hollow through the enamel, having the post at a center, and say 1-8 or 3-16 inch in diameter cutting away both the enamel and stump, and exposing a clean copper surface upon which to solder a new post.

The post is to be made with an enlargement or foot, something like a dial screw. This foot may be a copper disk riveted upon the end of a wire of proper size for the post, but preferably by taking a wire large enough for the foot, and turning down the body of the post to size. The foot is to be fitted into the hollow and soldered there. Its thickness should be such as to rest upon the watch plate when the dial is down properly in its place. If found a little too thick when soldered on, the excess can be dressed off with a "hollow drill" or cutter fitting around the post.

All being finished ready for soldering, tin over the surfaces which are to be joined on both the dial and the foot. To tin the hollow, heat the dial very evenly and gradually till a little lump of soft solder will melt. Keep the copper from tarnishing by rubbing it with a bit of wood, like a match, wet with soldering fluid. When the solder melts, rub it around till the whole surface is thinly covered with an adhering coat of solder. Do the same with the foot of the post, which is easily done by rubbing it over a flat piece of tin plate held in the lamp flame till a lump of solder on it melts and spreads, then rubbing the dial post upon it and shaking off any surplus of solder. Such a plate of common tin, or several of different sizes, will be found more handy than a soldering iron or a naked flame for most of the jewelry repairing jobs which require soft soldering. Use plenty of the soldering fluid; put on with a soft stick.

In soldering the post to the dial, different ways are followed. Some wrap the dial in several thicknesses of soft paper on the side more distant from the broken post, so that they can hold it without burning their fingers. They then wave the dial over the lamp flame, gradually bringing it closer, and finally passing it through the flame from side to side, to avoid heating it too suddenly. The dial-post wire is held in a pin vise in the other hand, and is also heated. When the dial is hot enough to melt solder, a small piece is placed in the hollow with soldering fluid, the foot of the post put in position, gently pressed down with a twist or two to insure close contact and held so, upright and correct, until cold. Some workmen brace the fingers of the two hands together, to facilitate the keeping of their relative positions, and remove the dial from the flame for the cooling. Others rest the hands against some support, when the parts are properly together, then blow out the flame while the hands remain where they are, till the solder sets.

Others make a light spring or wire clip, which fits over both dial and post, and clasps and presses them together. This holds the post in place during the heating and cooling. Still others lay the dial face down on a flat metal plate which is slowly heated up, and the dial post applied, either by hand or by spring clips, as described. These clips are something like a safety pin, one-half resting against the face of the dial, while the other presses upon the end of the new post. Or it may have an eye or ring on the end, to fit around the post and press upon the foot by its spring.

HANDS CATCHING TOGETHER.

SOME repairers make a great mistake in trying to cure this trouble without doing much to the watch. They probably spend double the time that would be necessary to do a thorough job. The only right course is to first upright the center and the fourth wheels, so that the hands will all stand level. It will do no good to bend the pivot or second hand, nor the center staff. The pinions of the wheels must stand vertically to the plate, and stay so, and the fourth wheel pivot and center staff must be straight. Next the dial must be secured to the plate—not loosely, shaking up and down, but tight. The hour wheel should have just shake enough to be free, when the center wheel is pushed up; the thickness of the third wheel pivot is ample motion for any watch, and half of that is enough for a good one. If it has more play than that, fit a foil washer over it to keep it in place. But, before leaving it, push the center wheel to its highest point to see if that pinches the hour wheel against the dial—for it must of course be free at all times. The same amount of end shake is enough for the center and fourth wheels, and they should be corrected if they have more. All this may be called putting the watch in order, for it should be fixed that way, whether the hands make trouble or not.

Now we come to the hands. Usually, it should be easy enough to avoid any catching together. But sometimes there is hardly room enough for them to move in. First put on the seconds hand as low as it can be without touching the dial at the socket, and watch during one revolution to see if the point touches the dial anywhere—gently pressing on the socket to keep the hand down to its lowest point. Bend the hand down, at both sides of the socket, to run close to the dial but not touch it. If it tips, then it must clear the dial where it tips lowest. Do not leave it till you have got it so. In very troublesome cases the seconds and hour hands can be shortened, which will reduce the height that they can stick up. The rule is for the seconds hand to reach just over but not beyond the dots; the hour hand reaches nearly to the middle of the figures, while the minute hand reaches beyond the figures to the dots. In bad cases the seconds hand can be shortened $\frac{1}{16}$ inch, or even more, with an hour hand which barely reaches to the figures.

The hour hand is usually put on pointing about to the XI., then turn the hand forward till it points exactly to the dot of the XII., and put on the minute hand exactly over the dot. But a better way, when you expect interfering hands, is to put the hour hand on over the VI., press it to its lowest point and raise the seconds hand to its highest, watching while it passes under the hour hand at the 60, to see that it clears safely. Then keep the hour hand over the point of the seconds hand as the latter revolves through an entire turn, to be sure that it clears the hour hand at every part of its circle. Lift the seconds hand to its highest position while trying this, say with a fine knife-point at its socket, not *prying* it up, but gently lifting. Adjust the hour hand as low as can be without interfering with the seconds hand. When you have become sure that they will not catch, by trying them turn after turn, these two hands are right. Next turn till the hour hand points to the dot of the XII., and put on the minute hand. The hour hand must not be disturbed, but the minute hand must be bent and made to clear it, when the center staff is pressed down and the hour wheel lifted up, each to its extreme position. Then put the movement in the case, with the crystal on, and see if the point of the minute hand touches the glass. If so, bend it down till it clears, but do not alter the part over the hour hand. If it touches the dial, clip off a trifle of it. Then turn till it stands over the VI., to see if it interferes with the seconds hand at the 30, also if it touches anywhere. Do not take anything for granted, but *look* and see, at five or six places around the circle. If it will touch the glass, after you have done all you can to avoid it, and especially if the part over the hour hand touches, fit a higher crystal. When you have done all this thoroughly, you may feel secure against any catching of the hands, if it is a half-way decent watch.

TAKING DOWN A WATCH.

Any one working largely in repairs to foreign watches, will have been struck at times by the inconsistent and ignorant manner in which they have been repaired, especially in the country. This arises in many instances, I believe, more from ignorance as to the proper method to pursue than lack of will on the part of the workman; it is also, in many instances, due to a want of the necessary tools with which to do the work properly. The object of this article is to show, if possible, how to avoid these inconsistencies by substituting a proper and comprehensive method of repair; and although I do not for a moment wish to insinuate that this is the only method that will produce good results, at least I am assured that any one exchanging their method for mine will not lose by the exchange.

By far the greater quantity of foreign watches that one gets to repair in the country are of common quality, and in these cases it is very difficult to do all that is necessary to put the watch in thorough order, receive adequate remuneration, and give satisfaction to the customer. As, however, there is no conjuring in the matter, the man whose work gives the best results will, in the long run, get the most patronage, and this will be the one who spares neither time nor trouble to make his work as perfect as possible. I will suppose that you have a Swiss cylinder watch to examine and repair; then proceed in the following order:

Preliminary examination before removing the movement from the case.—Wind the watch a little, if down, and try it by the ear in the following positions, viz.: with the 6 up, the 12 up, dial and clock up. By this method you can usually detect the following faults: Not in beat, wheel rubbing in cylinder passage, cylinder pivots acting on shoulders instead of their ends, incorrect fourth depth with scape pinion, balance spring rubbing, etc. Next ascertain that the center pinion, or if a key-winder, set square is free of glass, also of the bottom of case; see that teeth of barrel are *well* free of band of case when shut; it is often free (in thin gold cases), when open, but shutting the case pinches the band in and fouls the barrel; to try it put a piece of paper between teeth and barrel and shut the case; if foul, it will mark or cut the paper.

See that the dirt cups on winding and set squares are free of dome; frequently the dome presses on the center lid and binds the center pinion, causing, if not instant stoppage, the oil to disappear and the pivots to cut. See that balance is free of case; if it is much out of flat it will probably be foul of the case or center wheel. See the fly spring, when the cover is shut, is not foul of the balance.

Put a key on set square and turn the hands to see that they are free of themselves, the dial and glass; if they do not turn truly it will proceed from either the center hole being out of upright, a bent set square, or a badly fitted pinion. Here let me impress on those who take the trouble to read this, to wit: the necessity of making a note on your bench paper of all the corrections as you come to them; it is very little trouble and saves the annoyance of finding when your watch is, perhaps, cleaned and together, that some important item has been forgotten.

For taking the movement from the case use paper—nothing is so slovenly as working without—and lock the train, by putting a bristle through either fourth or scape wheel; remove cock and balance, being particularly careful not to strain the balance spring; put the balance and cock in tray, and remove the hands by means of two pieces of steel; take one under each side of hour hand boss, depress the ends, and both hands are off at once without danger of marking or slipping; the second hand can be removed in the same manner without danger of bending the pivot. Remove dial and motion work, using brass pliers to take hold of the canon pinion to avoid marking it.

At this stage, if I have reason to suspect that the escapement is faulty, I generally remove the balance spring from the balance, putting cylinder and cock in their places, and try the escapement. First, see that the web of scape wheel is free of cylinder passage, also that the top of tooth is free of upper plug; then with a little power on, and either a piece of paper or a cork wedge under the balance to check its motion, try if all the teeth have sufficient drop, both out and inside. If only one or two teeth is tight, the vibration of the balance is checked each time they are in motion; if the balance is watched when going (with the balance spring on), it will be seen at once how the vibrations fall off when these teeth are in action. If the drop is sufficient inside, but none out, it would show a wheel too small; if the reverse, a wheel too large—*if the depth is correct.*

The method of correcting the wheel, where only some of the teeth are without the necessary freedom, is to mark with red stuff a tooth which has the proper amount of shake, remove the wheel and open a hole in a piece of thin sheet brass until this tooth will just enter: this serves as a gauge to shorten the other teeth by, being careful to operate on the *points* of the teeth, either with the ruby file or steel and oilstone dust, finishing with bell metal and red stuff lengthways and followed by a burnisher. The tooth should be rounded both ways so that a mere point is in contact with the cylinder.

The question of depth is a vexed one, some workmen setting it deep and some shallow, each having some supposed advantage to urge for the practise. Saunier, in his work says, "To insure that the drop is no more than sufficient to secure proper action of the mechanism, it is of the first importance that the middle of a straight incline corresponds to the center of the cylinder." Or suppose a line drawn from top to point of tooth and bisected, that point should pass the center of cylinder jewel holes.

Further, he shows why this rule should not be departed from: "The older watchmakers adjusted the escapement so that the middle of a straight incline came rather beyond the center of the cylinder, in order that the point of rest might be tangential. Among modern makers it is universally recognized that more is lost by making the outside drop excessive than is gained by a slight diminution of the friction during rest."

Some watchmakers of the present day who, from insufficient knowledge are not in a position to judge correctly as to the cause of the circumstances which they observe, have asserted that they obtained "a greater regularity by making the middle of the plane fall a little short of the center of the cylinder." Before making any alteration to the escapement, it is necessary to be certain that the scape wheel is perfectly upright, as a simple alteration to this may correct one or all of these faults.

After examining the escapement, it will be necessary to look over all jewel holes, noting cracked ones, and, in brass, those that are too wide, trying end shakes, etc.; also to see that the passage in the scape cock for the wheel teeth is not too close, so as to draw off the oil, as when this is the case it is impossible to get the piece to go for any length of time.

You will now take the movement completely down—foreign workmen use a brass block with a series of holes drilled in, to place the screws in; it is a good plan, as if left in their respective bars or cocks they are apt to get lost. Having the piece down, you will examine all pivots to see that none is cut or bent. The barrel and its arbor and stopwork should receive attention; it should turn with freedom and perfectly true, any want of truth in these particulars being fatal to good going.

I have now, I think, touched on most of those points that should receive attention in examining a watch previous to repair; not all, because to do that would require much space to enumerate, but sufficient, and the repairer may proceed to correct them.

Beats Per Hour.—The first thing to do is to find how many beats per hour the watch was intended to make. This is done by "counting the train," *i. e.*, finding how many revolutions the scape wheel will make to each revolution of the center wheel, and then multiplying that number by 30, or double the number of teeth in the scape wheel, as each tooth makes two beats—one on each pallet stone. Probably the quickest and most satisfactory way is to count the number of teeth in the center wheel and the leaves of the pinions and teeth of the third and fourth wheels and the scape pinion. For example: If the center wheel has 80 teeth, the third 60 teeth and 10 leaves, the fourth 64 and 8, scape 15 and 8, it will be seen that the third wheel will make eight revolutions to every one made by the center (10 into 80); the fourth will make seven and one-half revolutions to each one of the third wheel's. Multiply the eight revolutions by the seven and one-half, and we have 60, the difference in speed of the center and fourth. The scape wheel with eight leaves will go eight times faster than the fourth wheel; so we multiply the 60 by 8 and get 480, namely, the revolutions of the scape wheel. Now, every revolution of the 15-toothed scape wheel gives us 30 beats; so we multiply the 480 by 30, and find that the watch was intended to beat 14,400 per hour. For convenience in vibrating, divide the 14,400 by the 60 minutes in an hour, which makes 240, and this by the seconds in a minute, and we find that the watch beats quarter seconds—four beats per second.

Now select a spring of the right diameter to touch the regulator pins and stud; pin it in the collet and put in the balance. Then vibrate the usual way by taking the outer coil in the tweezers and lifting so that the lower pivot just touches some hard, smooth surface; now give the tweezers a "pin vise motion," to get the balance going. Then holding the tweezers as steadily as possible, count the number of vibrations in 10 seconds. In this watch there should be 40; if more than 40, the spring is too strong; if less than that number, it is not strong enough. If it cannot be brought to time by either lengthening or shortening the spring in the tweezers, try another spring. With a little practise one can count the vibrations of a balance and the tick of the regulator at the same time, but the second hand of a watch running on time will do for all practical purposes and rather more convenient.

TO REPLACE A BROKEN CYLINDER PLUG.

TO replace an old, worn, or broken cylinder plug do as follows: First take out the old plug; for this use a punch, the hook of which is as short as possible, and has no sharp but round corners. Beside the shape of such a punch, also the care expended in hardening and annealing contributes greatly to its usefulness. For hammering out the broken plug, prepare also a piece of soft steel sheet, about three millimeters [0.11 of one inch] thick, in which the holes, No. 54 to 70, English gauge, are drilled and numbered. These holes are almost imperceptibly countersunk: and from underneath enlarged, funnel-shaped, to about one-half the thickness of the plate.

Next try through which hole the cylinder will pass closely, and then place it upon the next following smaller hole, so that only the cylinder shell will stand upright, and the plug to be driven out cannot lodge in it. If, in doing this, the gauged plate is laid upon a large anvil or other block of iron of considerable weight, it will be possible to drive out very obstinately fixed plugs, which cannot be moved in the ordinary manner, with a slight tap of the hammer. The job is made still more easy if the plug was previously rubbed with a little oil, both outside and within. The plug having been driven out in this manner, immerse the cylinder in benzine for a few minutes, to clean it from the adhering grease and filth. Then commence with the making of a new steel plug. It is generally turned; this is a very delicate and tedious job, however, as many a watchmaker will have found out to his cost. It is far better if a piece of round steel, No. 54, English gauge, or correspondingly thinner, from 0.79 to 1.18 inches long, is hardened, annealed grayish blue, and fastened in a small hand vise, fitted in by filing it thinner upon the filing peg, taking pains to make it imperceptibly tapering. It is evident that this work requires a file of the finest cut. If the steel was taken one or two numbers thicker, the job will not be inferior to a turned pivot. Special care must be had in the hardening of the steel, not to heat it beyond red, as it becomes brittle and cracked thereby, and generally breaks, when the pivot is turned on or polished.

When the plug fits with tight friction into the shell, shorten it so much that when driven in it fits firmly, and is neither too short nor projects inside. A little practise and experience are necessary to hit this point. It will seldom fail, however, if the shape of the plug has been made very slightly tapering. The lower the cylinder is, the greater the attention to be paid to this matter. Now measure, to ascertain what height the cylinder must have from one pivot end to the other, and according to this determine the approximate length of the plug. Then cut it off at the proper length, fasten it in a true-running chuck of the screwhead polishing tool, grind flat and polish first its lower end, and then file a center for the upper end, after having previously flattened it, constantly revolving the chucks upon the screwhead polishing tool. Then hammer the plug in the known manner fast into the cylinder. A heavy support will here again offer excellent service. In order not to damage the center in hammering, use a brass hammer.

Then begin with the turning of the pivot. The cylinder shell, to keep it from breaking, is to be strengthened with shellac. This is done by quickly moving it to and fro through a small alcohol frame, paying attention that beside the piece of shellac laid upon, also the cylinder will become sufficiently warm, whereby a more intimate connection is effected, and it becomes more capable of resistance. With a little care, no annealing of the cylinder need be anticipated, a fairly high degree of heat being necessary for this. Small cement chucks are generally used for turning a short cylinder. They are mounted by heating; for large cylinders, small screw chucks can also be used. They must be lined with brass so as not to injure the polish. Turn the plug about two-thirds thinner, then let the cylinder revolve in a hole of the round truing-tool, and take off the center point by gently holding a fine file against it. The height of the cylinder must be considered hereby, which still must be one-half line more than the actual measure.

It is important when doing this job, that the shoulder of the cylinder shell runs with easy friction in the lathe, in order that the arbor projects through the hole of the round truing-tool, so that the fastened end can be turned pointed again with a sharply ground graver. It is clear that the cylinder must hereby run true. After the round truing-tool has been taken off, and the undercutting, as well as the arbor, shoulder, and pivot, has between two ordinary centers been turned as smooth and thin as possible, correct the length and thickness of the latter according to the jewel hole, by polishing and rounding upon the polishing tool.

All cylinder pivots should be of conical shape, as 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.

It depends generally upon the number of the emery, to give to the burnishing steel a gently cutting sharpness, and this is of great importance. Workmen who attach no importance to the frequent sharpening of their polishing files must dearly pay for this by long continued work and frequent breakages, because a dull polishing file generates a glass-hard film upon the pivot, and requires an inordinate pressure. It must not be neglected that the polishing file, during its use, must be repeatedly moistened with oil, and that the bearings of the polishing tool must often be cleaned from the collecting steel dirt. For taking off the cylinder, heat the cylinder a little, and place it in alcohol, which is to be warmed for the purpose of cleaning, so as to accelerate the dissolving of the shellac. The remaining thin resinous film upon it is removed by careful rubbing with a pegwood saturated with alcohol.

If above directions are attended to the repairer will, with a little skill, only in rare instances, fail to turn out a faultless pivot.

THE REPAIRS OF THE BARREL.

THE click spring must not be too strong; beside the screw, its foot must also have a footpin, so that it can neither rise up, nor come out of depthing, nor yet pass downward and drag upon the barrel; the point must enter securely down to the bottom of the ratchet teeth, and be of a good and sufficient shape to prevent the return of the clickwork. The screws of the dustcap must be rounded off below. "The screws of the clickspring are the only ones of the whole watch which I do not temper," says Herman Grosch, in his Manual for Watchmakers, "because very disagreeable consequences would ensue if one of these screws were to break off in the barrel bridge; all the other screws, especially those for the stopwork and other parts, must be tempered, the heads and slits cleaned, and the points polished."

It is necessary occasionally to make the barrel holes smaller and to bush them. The barrel must run flat and true and the holes fit well; if the latter are too large even by a trifle, and the metal only barely thick enough, they may in exceptional cases be made smaller with a center punch and then be smoothed within with a round broach or a polished turning arbor.

If the barrel holes are too large and untrue, they are bushed with drilled bouchons, suitably turned in turning arbor. In bushing, especially in riveting, great care is necessary, because by too strong a hammering the part may easily draw out of shape—become untrue. Sometimes it is necessary to bush the holes full and then center again, which can be done in the lathe.

THE UPRIGHTING OF THE BARREL.—If the holes are not too large, and the barrel does not run true, try first what can be done by moving the cover in the groove to different places; if in this manner a place is found where the barrel runs true, make a mark on the cover and side, or you may also drill in a pin passing partly through the cover into the bezel of the barrel.

If nothing can be done by shifting the cover, find a place which runs closest, mark it, and give a few light taps with the hammer upon the edge of the cover, by laying it upon a small anvil and an underlay of silk paper; hit it at the place of the cover at which the tooth rim runs farthest from the card held against it. Do not hammer too much at once; it is occasionally necessary to take off a little with a file from the opposite side of the cover; when doing this, of course, the repairer must keep in view the contour of the edge. It is self-evident that a barrel with the cover opposite to the tooth rim is meant here; one with the cover on the same side with the teeth, requires the opposite treatment.

A barrel, which otherwise runs true and even, stands obliquely sometimes, when it is screwed fast to the bridge; this may be due to too great shake of the ratchet or too large a hole in the bridge, or else to a bad recess in the bridge; this may be remedied occasionally by screwing the bridge upon the plate, centering from below, and making the recess parallel to the plate, but at the same time making the recess for the cap deeper. If it is a one-bar spring-arbor with mounted ratchet, either one hole or both holes of the outer arbor pivot would have to be bushed.

THE STOPWORK.—The end of the screw of the star must not project; it is to be rounded off well and polished. If the screws are so short that, as frequently happens, they can no longer be shortened in the lantern of the screw-polishing machine, this may be done by using a strip of very thin brass, about twenty-five millimeters long, and from three to four millimeters broad, furnished with suitable small holes for this purpose, in which the screws may be inserted, and which are then laid upon cork or the filing wood.

The screwhead of the star must not scrape on the dial; the stopwork must work with entire security, especially at the end of the winding, when the full tooth turns up. It is very advisable to round off both parts, star and snail-stop, a trifle on the lower side with a slip of oilstone or a piece of wood covered with emery paper in a turning arbor. The snail-stop must, under no condition, touch its recess.

In order to satisfy one's self of the security of the stopwork, fasten the arbor by its winding square in the clamps which you press with the last three fingers against the thumb hole of the left hand, while thumb and forefinger catch around the tooth rim of the barrel and rotate it from left to right. During this performance try with a pegwood, held in the right hand, to move the star in a direction opposed to the rotations, so that its points offer themselves to the snail-stop under the most unfavorable circumstances. If under these circumstances the stopwork works all right, it will also perform securely in the future.

To Fit Bouchons.—It was said above that it was sometimes necessary to bush a hole. For this purpose a bouchon is selected as small as the pivot will admit, for the smaller the bouchon is, the neater will be the job. Open the hole of the plate or cock, so that the bouchon which should be previously 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 with a hole smaller than the pivot one to receive a fine brass wire serving as a center to prevent the tool changing its position while being used; or the wire may be put through the bouchon hole, and then the hole of the tool may be left open. This method is a far more expeditious way than using the mandrel.

TO CORRECT THE END SHAKE OF A BARREL ARBOR.

The beveling of the barrel teeth will sometimes not free the center wheel; 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 is in 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 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 on the arbor, there is then sufficient freedom for the center wheel. Some would cure this by simply striking the center of the 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 true, so that 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 than to 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 must be only just large enough to fit on the shoulder; the thickness will vary according to the acquired 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 notice the detrimental effects in some cases of even the least amount of end shake, where the fusee and chain are used. I have no doubt that most watchmakers 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, and 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 in many cases done with a punch; this simply means that the next man who sees the job will be liable to ask if there was a blacksmith at work. Yes, there are times when it is a shame to see it. Why hammer and bruise the plate, when the job can be done without any such methods? There is nothing that looks so bad to a practical man as a plate smashed about with a punch. It may be excusable to use a punch for closing a hole in an old thirty-hour clock, but even in this case it is doubtful in these days of bouchons. It is not only the appearance of the botchery, but just see what kind of a surface the hole has for the pivot to work in. Take, for instance, the fusee: it will always be neat toward the barrel; hence, if the hole is closed, it has to be done on the side nearest to 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.

BROKEN PIVOTS.

Pivots are broken from many causes. It's "the nature of the critter." When a new pinion is not practicable, says a European authority, a pivot can be put in and with the exercise of care be made a good job. Supposing the bottom pivot of the third pinion is broken; the best way to put in another pivot is first to cement the wheel into a chuck of the lathe. The chuck should be true and flat on the face. A cement strong enough to hold may be made of equal parts of resin and shellac, and can be easily removed from the work afterward.

The flame of a jet of gas or spirit lamp applied to the back of the chuck will keep the cement soft long enough, for the work being brought concentric by holding a blunt peg against the projecting pinion arbor, the center can then be made, not with a graver, but with a sharp auger pointed tool. The drilling is the principal difficulty. If the pinion is hard, the drill should have a rounded point and be quite hard at the point; it should be left as strong as possible, as some pressure is required to make it bite. The hole need not be deep. When the drilling is done the hole should be broached and the pivot turned and smoothed so that it fits the hole accurately. Fitting it to go to the bottom of the hole and afterward taking a piece from its length is the surest way of making a good fit. The hole and pinion should be cleaned and the oil removed in benzine. A few taps with the hammer will make the pivot as fast as if the pinion were solid. If the pinion head is not quite true, the center must be filed to get the pinion true, and then the pinion can be made in the usual way.

The top pivot cannot easily be made in this way. The hole for the pivot is better drilled in the turns, and it is much easier to drill the hole in the top of the arbor than the one in the pinion or lower part of it, as, if the arbor is hard, it can be softened without injuring the pinion or wheel. A brass runner is fitted to the turns, and a hole is drilled in the end of the runner, near the outside, a little smaller than the pinion arbor to run in; the runner should then be filed away at the back of this hole, leaving the sixteenth of an inch of the runner its full diameter at the end. If a piece of round steel is made to fit the hole in the runner with a triangular (not a drill) point, hardened of course, and is inserted in the hole in the runner to meet the end of the arbor, and the pinion made to rotate by a ferrule and bow, then the center will at once be found and the hole may be drilled in the same manner as that in which the center has been marked; but both the centering tool and drill will require bending to enable the operator to use them in this position.

It is not often that a fourth wheel can be made a good job of, if the pivot carries a second hand, as the undercutting of the pinion at the back leaves the arbor too weak. The only way to make good job is to make a larger and longer hole in the pinion, cutting away the projecting piece of the pinion arbor and making new both the pivot and shoulder.

HOW TO DRILL A STAFF.

A Correspondent desired to know how to drill a staff for a new pivot. He had hitherto used the old verge lathe, but recently he bought an American lathe. He has not yet been able to drill the hole of a sufficient depth without taking all the temper out of the staff; he uses the American finished pivot drill and has tried every shape of point, etc. An expert returns the following answer:

After removing the table roller and balance spring, take a circular copper wire, about the same size as a large silver case bow, except that the ends come together instead of being open as in the watch-bow; spring the ends far enough apart to insert the broken end of the staff between, then heat the copper wire ring in the alcohol flame, holding the ring in a pair of pliers, the ring will communicate the heat to the staff, and the temper will be drawn from the part to be drilled without discoloring the balance or the opposite end of the staff. The temper had better be drawn lower than blue; at any rate, draw it to a very light blue, or even soften—that part of the staff has no function to perform, and, therefore, the temper is of little consequence.

The average staff as it comes from the factory is not harder than a dark blue shade will indicate. I do not mean to say that when fitting a new staff the temper of any part of it is of little consequence, because, if the temper is properly drawn, it will be even throughout, and if drawn lower than a dark blue it would be too soft, as the pivots could not be turned down comparatively small without bending, and, even if they were, a high polish could not be obtained, and the result would be that after running in the watch for a short time they would show signs of wear and thereby increase the friction. But in pivoting a staff, as was said before, it will do no harm to thoroughly soften that part of the staff where the pivot is to be inserted, always bearing in mind that the heat must not be allowed to reach the balance, or the opposite end of the staff, which is not broken.

After drawing the temper place the staff in the lathe and smooth off the broken end with stone slip sufficiently to get your center by; strike your center by means of the graver, holding it in your hand. At first you will be almost sure to leave a little conical "tit" at the center instead of striking the center correctly, so therefore it will be better to practise a few times on a piece of brass wire in place of the staff, and after a few times you will be able to do it at once and well.

The reason why you cannot drill the staff deep enough is because the drill is not properly shaped or is allowed to get dull, and instead of cutting, it burnishes the metal and hardens it, thereby making it difficult for a sharp drill to attack it successfully.

Now, if the staff is softened as directed, and the drill made to suit the purposes, there will be no difficulty in drilling even deeper than necessary, but you must of course draw the drill occasionally across the slip to renew the edge which may dull before a sufficient depth is reached, but after you get into the "hang" of it you can drill a staff in half a minute. The wire for the pivot should be a piece of a needle with temper drawn to a dark blue. Almost any graver that you can buy will cut any staff if sharpened properly, which means a flat face, a sharp edge and point.

WATCHMAKERS' DRILLS.

THE drills used by watchmakers are generally made by filing the cylindrical steel wire slightly tapering and then spreading the point with a single blow from a tolerably heavy hammer. Using a light hammer and effecting the spreading by a series of gentle taps will effectually spoil the steel. There is not the slightest occasion to anneal the steel for hammering, providing it is moderately soft. For all drills up to one-eighth of one inch in diameter, the steel should not be forged, as the bulk of the metal is too small to heat to any predetermined temperature with any degree of certainty.

Pivot drills can be made from good sewing needles, which are of a convenient form to be readily converted into a drill. Firstly, the needle must be made sufficiently soft for working by heating until it assumes a deep blue color The extreme end may be made quite soft and filed slightly tapering to a trifle less than the size of the hole to be drilled. The point is now spread out by a sharp blow of a hammer—not by a series of gentle taps which would cause the metal to crack—and filed up to shape, the point being made more blunt than would be used for drilling ordinary metal. For drilling tempered steel the cutting angles must also be much less than usual. The thickness of the drill across the flattened part should be about one-third of the diametrical measurement. Finish up the end on a strip of Arkansas stone, a file being too coarse for such small work.

It is the great difficulty of getting such a very small piece of steel to an exact predetermined degree of temperature—hot enough to harden, but not so hard that it is burned—which makes the manufacture of these small tools uncertain, and this is abundantly proved by the fact that of half a dozen of drills made from the same wire, thereby assuring uniformity of quality in the material it often happens that some are exceedingly good, and others of no use whatever, the difference being caused by the manipulation during hardening. This does not apply to drills or other steel things which are of sufficient size to show, by the color of their surface, how hot they are, but it is the tiny pieces which, by the contact with the flame, are immediately rendered white hot that are difficult to manage. By heating the drill and plunging it into the body of a tallow candle the hardening will be effected, but the steel will not be rendered so hard that it crumbles away under the pressure in use. Thus, in one operation the drill will be hardened and tempered. In place of tallow, white wax, sealing wax, and such like materials are adapted to the purpose.

There is another method which finds much favor with some workmen. It is to envelop the thin point of the drill in a metal casing, and so get a bulk of metal which can be heated to a nicety, the drill inside being, of course, raised to the same temperature as the surrounding metal; the whole is then plunged into oil or water. Still, there is the difficulty of tempering to overcome, though the danger of burning is avoided; burnt steel is of no use for tools.

The best plan is to exercise the greatest possible care not to overheat the drill, and harden and temper in one operation by plunging into tallow. The following method dispenses with the hardening process:

Select a round pivot broach; as sold, they will be found to be tempered to the correct degree of hardness. By means of the split gauge, measure the part of the broach which is the exact diameter required for the intended hole, and break off the steel at that point; the small piece is used; it must be broken off, if too long; and cemented with shellac into a drill stock; an ordinary drill stock will do, or a piece of brass pivot wire serves the purpose. Soft solder may be used instead of shellac, and if carefully heated, the temper will not be drawn. The piece of tapering steel is now formed into a drill by grinding down the sides with a piece of Arkansas stone, and the end shaped up to a cutting angle. The thick end of the broach forms the cutting end, and the ordinary taper of a broach will be quite sufficient to give clearance to the drill, which may be sharpened by grinding until the whole is used.

THE DEPTHING TOOL.

A Depthing tool is an indispensable auxiliary to the repairer, and it should be the best that can be made. There are many of these tools made and sold that are worse than useless, as if the distance between the centers do not coincide at each successive point, at which they may be moved outward, it will be impossible to pitch a depth correctly with them; in other words, the centers as runners should be parallel to each other, whatever the size of the wheel and pinion may be that is being adjusted in them. When purchasing a new depthing tool, great care is necessary. The centers should be turned end for end and transposed, ascertaining after each change if there is any deviation in a circle described by the points; also if the points when they meet coincide exactly. If possible, a comparison should be made with an approved tool by trying in both a large and also a small wheel and pinion. The adjusting screw had better be removed so as to see that the joints work smoothly and that the spring has perfect control over it. If the joint is stiff and appears to be dirty, the joint pin may be taken out and the joint thoroughly cleaned.

But however correct the tool may be, it requires practise and skill to use it properly, as, when the wheel and pinion are removed from the tool, and the depth has to be transferred to the plate, if the depthing tool is not held at right angle to the plate, but is inclined either to the right or left, the depth will be either deeper or shallower than it was seen while in the tool. Care should also be taken not to screw the nuts up too tight, as it is quite possible to spring the runner a little from the way in which it is gripped; in fact, a watchmaker should not be a strong man, otherwise he will make many difficulties for himself by exercising his muscular strength.

DIAMOND LAPS.

In putting a pivot in a staff or pinion one of the handiest tools the workman can have is a diamond lap with which to flatten and sharpen the drills. Every workman knows that many times he has made what he thought was a nice drill and on examination found the sides rounded and the end "cross-eyed," and had the work to do over again. With a diamond lap it is very easy to do these drills right, in fact so easy that the workman is liable to make up a number of drills before they are needed, a proceeding few watchmakers are guilty of when they are obliged to flatten and point the drills on an oilstone. Most watchmakers have an idea that these laps are too expensive. Such is not the case, when you consider the time and material saved by the use of them. If the watchmaker has diamond powder he has no excuse for not making one, unless he doesn't know how. If he does not have the powder he can easily make the lap and any of the smaller watch factories would charge it with the grade of diamond needed at small expense. Probably this is the cheapest way to go to work, as it is an everyday job in a watch factory, where there are all the facilities for doing rapid and economical work of this kind.

Soft steel is probably the best metal to use. Copper was the favorite for many years, and there seemed to be a prejudice against anything else for a long time, but this prejudice has worn away, and soft steel is now generally used in factories for everything except polishing. It holds its shape better than copper. Cast iron is used to some extent, and does very nicely for the larger surfaces, but it is hardly adapted to such small surfaces as pivot drills. A lap one and one-half to two and one-half inches in diameter and $\frac{3}{16}$ or $\frac{4}{16}$ in thickness is a very convenient size. It should be mounted on a hardened steel arbor that fits a large chuck or taper and trued. Do not have the full face of the lap charged. You cannot use the middle of it, and it is not only difficult to charge it there, but it is a waste of material. After facing the lap, take another chip out of the center—about $\frac{1}{32}$—leaving about two-thirds of the face to be charged. No. 4 diamond should be used for very small drills, if it is to be used for that work exclusively; No. 2 for rapid cutting of larger surfaces. If the watchmaker feels that he cannot afford more than one lap, perhaps No. 3 diamond would be the best for all-around work.

USE AND ABUSE OF THE MAGNIFYING GLASS.

Although it is the opinion of eminent ophthalmists that the judicious use of the magnifying glass is by no means injurious to the eye, it is well to point out that this opinion is but conditional, and does not apply to its *abuse*. On this subject a correspondent of the *Deutsche Uhrmacher Zeitung* says that a watchmaker very often does not think to make use of his ordinary sight. It is, then, the duty of the master to make the pupil appreciate from the beginning of his apprenticeship the advantage he will find in the employment of the naked eye, and how much time and pain he will by that means avoid; especially in measurings and rough work. Want of habit in the estimation of sizes, or rather in their exact comparison; inexperience, variety, or convenience; perhaps also the idea of giving more rapidly to the eye the necessary dexterity—all are apt to induce beginners to use the eyeglass which they see employed by the more advanced apprentices. They do as the clown who, not knowing his alphabet, thinks that by putting on spectacles he will be able to read immediately. The responsible master should absolutely forbid the eyeglass to the beginner, and not permit its use until actually necessary. The habit which at first was only due to vanity or inexperience, becomes in time fixed.

But what a grotesque and at the same time deplorable effect! Only certain pieces are produced, the thick pieces hardly roughed out, when made by the aid of the glass. It is no excuse to say that the work has been badly done because the workman has bad eyes. If he has not good sight let him put on suitable spectacles. There are many watchmakers who rarely use the eyeglass and when they do it is only for fine work.

What can be done by one can be done by others. Nothing is requisite but a firm will.

Those who are not able to dispense with the eyeglass, commit also from habit the unpardonable fault of using glasses too strong, which leave an interval of only two or three centimeters between the work and the glass. This is pernicious to the eyes, because in using short focus glasses the eyes become pained, and if they are continued an enfeeblement of the sight is produced. And in consequence of the excitation of the optical nerves headaches result, which in some circumstances may become chronic. The eyeglass for ordinary use should be weak and allow of an interval of from six to eight centimeters between it and the work. It is quickly got used to and will not produce tiredness of the eyes.

Besides the weak glass, it is necessary to have a strong pebble eyeglass, but the latter is required very seldom.

With use it sometimes happens that when the eyeglass is held a long time near the eye the glass becomes blurred. This is very disagreeable, and proceeds from the vapors which emanate from the eye and become condensed on the eyeglass. It is easy to prevent this by making two holes opposite one another, so that the interval between the eye and the glass may have communication with the exterior air. These holes are made just above the glass, so that the current of air circulating touches it lightly and prevents the condensation. The lenses of eyeglasses are wiped ordinarily with an old piece of linen or with the leather. Both are bad, because in proceeding thus the glass is covered with imperceptible rays. It is preferable to make use of silk, or still better, of unglazed porous paper that is not frayed, or filtering paper. Breathe lightly on the glass before wiping it.

PICTURES ON WATCH DIALS.

For the production of photographic pictures on watch dials the *Photographische Chronik* recommends the following method of procedure: Beat the white of an egg, with addition of a little ammonia, to a white foam, add 300 cubic centimeters of water, and beat again. After the egg has settled, filter and let the liquid run once over the dial, which has previously been thoroughly cleaned with ammonia. After the surplus has run off coat once more and allow to dry. The sensitive collodion is now produced as follows: Dissolve 0.6 gram chloride of zinc in 20 cubic centimeters of alcohol, add 0.5 gram collodion cotton and 26 cubic centimeters of ether, and shake the whole forcibly. Then dissolve 1.5 grams of nitrate of silver in hot water, add 6 cubic centimeters of alcohol, and keep the whole in solution by heating. The silver solution is now added in small quantities at a time to the collodion, which must have well settled. This, of course, is done in the dark room. After 24 hours the emulsion is filtered by passing it through cotton moistened with alcohol. This durable collodion emulsion is now flowed in the usual way thinly upon the prepared watch dial, which, after the collodion has coagulated, is moved up and down in distilled water until the fatty stripes have disappeared. The water is then changed once, and the dial is, after a short immersion, left to dry upon blotting paper. It is now ready for exposure. Expose under the original in magnesium light and develop with a nitrate oxalate developer or in the following hydroquinone developer:

Hydroquinone	4 grams
Bromide of potassium	25 grams
Sulphite of soda	48 grams
Soda	10 grams
Water (cubic centimeters)	450

After fixing and drying coat with a transparent positive varnish.

In place of the developing process, the printing-out process with chloride of silver collodion can be applied, with the advantage that the picture can be toned. The collodion for this purpose is made as follows: Dissolve 8 grams of collodion cotton in 100 cubic centimeters of ether and 100 cubic centimeters of alcohol; add 0.3 gram chloride of strontia and then 0.2 gram chloride of lithium, which has previously been dissolved in alcohol slightly heated. The solution is left standing for 24 hours, and then is filtered through cotton.

THE CORD AND TENSION PULLEY.

The cord which transmits motion from the fly-wheel to the pulley of the distributor is always at the same tension. But the cord that passes from the pulley to the lathe must be tight or slack, according to the dimensions and weight, etc., of the work in hand. Moreover, if the ferrule be not fixed concentric with the object that is being turned, or if the pulley be not true on its axis, the cord will be liable to hold and to slip alternately. This inconvenience can be avoided, and the tension of the cord maintained constant and sufficient by using the tension pulley.

Another inconvenience is often occasioned by the unskilful joining of the catgut band. In delicate turning with the hand or footwheel it is important that no jerk should be communicated to the work when the joint in the band passes over the ferrule or the pulley of the mandril. Such a jerk can only be avoided, moreover, by a carefully-made joint. Several methods are adopted; for bands of large and medium size it is best to use the steel hook and eye screwed on to the ends of the band, these ends being first tapered with a knife and their ends burnt with a hot wire to cause an expansion that will prevent their drawing away from the screw. But such attachments cannot be used with bands under one-sixteenth of one inch in diameter, and one of the following must therefore be resorted to.

1. The most expeditious is a simple knot, and the weaver's knot is by far the best, as it permits of the ends being cut off close, and stands out to nearly the same distance all around the cord. The watchmaker in making this knot need only observe that the lower portion, representing the length of lathe band, must be somewhat shorter than is ultimately required, and the knot is to be tightened by drawing the two free ends, while the first point at which the cord crosses is held between the thumb and first finger. The ends must be cut off nearly to the knot, and slightly singed, to cause their expansion, and the knot rolled between the finger and thumb with a little beeswax.

2. The ends may often be spliced together, and although this occupies more time, it has the advantage of producing a gradual increase and decrease of thickness, so that all jerk is reduced to a minimum. The following method is given by Holtzapffel. Having stretched the band, measure off a length greater than is required for the lathe and make transverse holes through the catgut at two points rather nearer together than the measure of the lathe (to allow for further stretching). Pass each end through the hole in the other and draw tight; pierce two more holes at right angles to the first and just above them, again passing the ends through from opposite sides of the band. Unravel the full ends, cut away about one-fourth of their substance by a sloping cut from the inner side next the splice. Re-twist and again pass the ends through holes transverse to the last and pull tight. If these instructions are followed, no trouble will be given by the band.

THE PENDULUM FOR DETERMINING THE SHAPE OF THE GLOBE.

ALL engaged in horological pursuits, know that the velocity of the pendulum oscillations depends upon the length of the pendulum as well as upon gravity, which varies at different points of the globe. It is strongest at the poles and feeblest at the equator, for two reasons: first, it is influenced by the centrifugal force of the revolution of the globe, which opposes it, and next by the greater or smaller distance from the center of the globe, or perhaps better said, center of gravity.

When, now, pendulums of equal length are caused to oscillate at different localities upon the surface of the earth, the larger or smaller velocities tell us, first, the distance of the corresponding locality from the rotary axis, and, second, the distance from the center of gravity. The established formulæ for calculation are generally for the purpose of ascertaining the length which the pendulum must have at different localities of the earth to produce a unit velocity —*one* oscillation per second.

A noteworthy number of scientists, of all countries—Sabine, Foster, Schmidt, Airy, Bowditch, Baily, Borenius, Pouillet, Fischer, and others—have to ascertain the length of the seconds pendulum instituted probability calculations, each of which is based on a certain number of pendulum measurements (from 13 to 79) which have taken place at different points of the earth. The results of the calculations vary between 990.987 millimeters and 991.277 mm. length for a seconds pendulum at the equator and 996.123 mm. and 996.419 mm. at the poles; consequently they vary nearly 0.3 mm. But since the entire increase of the pendulum length for the 90° of latitude, from the equator to the pole, amounts to only 5.14 mm., the seemingly trifling difference of 0.3 mm. corresponds to a latitude difference of about 5°.

The following table is a summary of these deviations:

Localities.	Latitude.	Length of seconds pendulum. Millimeters.
St. Thomas	0° 24′ 41″	990.84
Mararhan	2° 31′ 43″	990.84
Ascension	7° 55′ 48″	991.15
Sierra Leone	8° 29′ 28″ N.	991.02
Trinidad	10° 38′ 56″ N.	
Bahia	12° 59′ 21″ S.	991.15
Jamaica	17° 56′ 7″ N.	991.42
New York	40° 42′ 43″ N.	993.15
London	51° 31′ 8″ N.	994.07
Drontheim	63° 25′ 54″ N.	995.21
Hammerfest	70° 40′ 5″ N.	995.49
Greenland	74° 32′ 19″ N.	995.69
Spitzbergen	79° 49′ 58″ N.	995.99

To reiterate, the preceding table shows that the second pendulum is shorter near the equator than in the higher degrees of latitude, from which scientists deducted that the earth is no true ball, but a spheroid, that is flatter near the poles and arched toward the equator. The shorter the diameter of the earth is at a given locality the stronger will an object upon its surface be attracted by gravitation; for which reason, also, a pendulum will there oscillate somewhat faster than in higher regions, and must consequently be made longer to obtain the same unit of time.

NOTES ON THE BALANCE SPRING.

ALTERATION CAUSED BY BALANCE SPRING. —Assuming that the balance is in perfect poise, then the moment the spring is placed on it and the outer end pinned to the steel, the spring at once forms a part of the mass of the balance when both are rotating, and its effect upon the balance when in action is most peculiar. The first coil near the collet passes through nearly as many degrees of arc as does the balance. The second coil describes a little less extent of arc; the third still less, the fourth still less, and so on, until at last we arrive at the outer extremity—the end of the last coil—which is stationary and rigidly fixed. Now all of these different coils, while vibrating, have established in themselves a certain momentum, each differing from the other in their effects upon the balance, according to the mass of each, the velocity of each, the position each occupies as regards distance from their centers of motion, and the degrees of arcs described by each. Any portion, then, of this system of coils which may be out of exact poise, is a disturbing factor. If, however, after careful trials, the proper distance is located at a certain point, and the balance quarter screws be changed so as to counterbalance it, an improved condition would result so long as the balance maintained arcs of about 360°; but when the watch (going barrel) is full wound and the balance describing arcs of not far from 540°, the error would be more marked than it was before the change in the poise of balance was made.

DUPLEX BALANCE SPRING.—The whole secret of obtaining isochronous vibrations of the balance of the duplex escapement lies in the spring; the fewer obstructions placed upon the free vibrations of the escapement, in the way of friction, etc., the better will be the performance of the watch; and this is also the secret of the good going not only of the well-made duplex, but also of the chronometer and lever watches.

FIT IN NEW BALANCE SPRING.—Put the collet on a round rat-tail file when you go to put in the spring; the file will hold it steady. File a pin so that it will fit the hole in the collet loosely and cut it nearly off; now put the end of the spring in its place, put in the pin, and give the wire a slight bend and you will break it off where you cut it. Bring the spring to its position, stake it on balance, pin with the other end in the stud, where you held it with the tweezers when you tried it, and you have the spring fitted and trued.

PINNING IN A TRIAL BALANCE SPRING.—When picking out a balance spring for trial, the usual plan of pinning in is to put the collet on a broach held between the thumb and finger of the left hand, while the pin is fitted and the spring pinned in, taking the precaution to push a piece of paper on the broach before the collet or the spring may touch the fingers, as in the case of a damp hand the spring would be likely to be injured by rusting.

ANOTHER MODE OF PINNING IN SPRING. —Another mode of pinning in is to place the collet on the board paper, and put the spring over the collet. With a short piece of boxwood sloped away at the end press the collet on the board; the pin can then be fitted with comfort and without danger of shifting the collet. The pin should be flattened where it presses against the spring, and when fitted and made can be pressed in with a small joint pusher. The spring should start away from the collet hole with an easy curve, and must not hug the collet, or isochronism will be out of the question.

TO ADJUST BALANCE SPRING.—I hardly know how to give directions for the adjustment of the balance spring, when it is disarranged, and the procedure is more readily shown by practical demonstration than by description. To commence: a balance spring, when there is no power applied to the balance from the jewel pin, should be, when pinned, just as free from any twist or cramping as it would be if lying flat and free on a smooth piece of glass, before it has been pinned at either end, and when it is pinned in the watch (at stud and collet) it should be thus free. To bring it thus, requires demonstration that cannot be made on paper, unless diagrams are made. What I have said, however, gives an idea of how a balance spring should be pinned. Common sense is demanded here as elsewhere.

Balance Spring.—When taking down a watch for cleaning, unpin and straighten the balance spring by placing it on a white paper and pinching the bent places with pliers, making it flat, and all the coils true, and see that they do not rub together; if they do, no good time need be expected from the watch. If the spring is not a good one, replace it; have it large enough to pass through the regulator without bending.

Fastening the Balance Spring.—The style of fastening is not by any means unimportant. If it were possible to make the fastening upon the collet vertical to the center it would be the best, according to my opinion. This, however, cannot be well done, and we are forced to follow the old custom, but try to make the bend of this inner curve not round, but as sharp an angle as possible. This is to be done with pliers, and at once lay the first coil at the proper distance from the collet. The end of the balance spring must be fastened with pins of hardened steel, and the sides turned toward the spring are to be furnished with flat face; they possess the advantage that they can be taken out or inserted conveniently.

Balance Spring.—When adjusting a watch, see that the balance spring is flat and true, and that it has a fly between the regulator pins of about one-half the thickness of the spring. Then if you will shorten the pins until they do not project below the edge of the balance spring, and file the end of the outside pin at an angle of 45 degrees, there can never be an extra coil of spring caught up. This too frequent trouble can be entirely prevented by the adjusting just now described.

Advantage of Overcoil Spring.—The great advantage of an overcoil 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 Bréguet spring in common with the helical and all other forms in which the outer coil returns towards 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.

Manipulating a Spring.—There is no doubt that the less a spring is "manipulated," the better. Mr. Glasgow contends that the whole question of isochronism resolves itself in the adoption of a spring of the correct length, and recommends for a lever watch 14 turns, if a flat, and 20 turns, if a Bréguet spring is used. He argues that if a spring is too short, the short vibrations will be fast and the long vibrations slow, and that all bending and manipulating of the spring, with a view to obtain isochronism, are really only attempts to alter the effective length of the spring.

Flat Springs.—The length of a balance spring, especially the flat without overcoil, is important. By varying the strength of the wire, two flat springs may be produced, each of half the diameter of the balance, but of very unequal lengths, either of which would yield the same number of vibrations as long as the extent of the vibration 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 a full turn would clearly be insufficient for a lever vibrating a turn and a half.

Overcoil of Balance Spring.—When the overcoil of a balance spring has been much bent or "manipulated" in timing, its acceleration is almost 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 lost elasticity. But however carefully a spring is bent, the acceleration is not entirely gotten rid of, even 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 have been subjected to continuous action, just as bells are found to alter a little in tone after use.

Acceleration.—It is pretty generally agreed among chronometer makers that the cause of acceleration is seated in the balance spring, although 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 the balances do undoubtedly increase slightly in size in the long vibrations from centrifugal action, this theory is disposed of by the circumstance 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 position 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 practise of some makers, but then chronometers accelerate on their 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.

To Harden and Anneal Springs.—To give push and fly springs a good temper, the following method may be employed: The ready spring is first heated and well rubbed with soap in a hot state. Next heat it to a cherry red (not a white) heat, and temper it in petroleum which does not ignite from the heated steel. The black crust formed in the steel is readily brushed off, and needs not be ground off, as is the case with other methods of tempering. The spring is then annealed to a light blue upon the annealing plate, say a broad clock spring, and at once rubbed in with tallow, after which it is left to slowly cool upon the annealing plate. A spring treated in this fashion will render good service and be durable.

Isochronism in Flat Springs.—Flat springs which are to be adjusted to isochronism should have from 14 to 15 coils. A still higher number of coils would be desirable for the purpose of obtaining isochronism, but springs with such a large number are objectionable for position adjustments. The usual method for adjusting a flat spring to isochronism is by pinning the spring into the hairspring stud, so that the pivot where it is pinned into the collet comes opposite to the regulator pins when the regulator stands in the middle of its arc; and then bringing the watch to time by changing the balance screws; of course, a spring should be selected which is very nearly correct. Consequently the taking out or putting in of a pair of screws would bring the watch nearly right. By cutting out a little from a screw underneath the head, we can increase the rate a minute or two a day; or by punching out some small washers of the size of a balance screw-head from thin sheet silver, or even the same kind of tinsel used for dial washers, and placing them under the screw-head, we can cause the watch to run as much slower.

Choosing a Spring.—When choosing and timing a new spring some practise is required to accurately count the vibrations in a second, and many, after picking up the balance by means of the bit of wax on the pivot, give it half a turn, so that it will vibrate for over a minute, and then count every alternate vibration till a spring is obtained that gives about 150 double vibrations if it is for an 18,000 and about 135 if for a 16,200 train. When a spring of the right strength has been found, it may be pinned in.

Making the Overcoil.—Two pairs of pliers with curved noses lined with brass are generally used for forming the overcoil of marine chronometer springs. The coil of the spring where the overcoil is to start is grasped by one pair curved exactly to correspond with the spring, and the other pair is used to bend the overcoil. The operation looks easy enough, but it really requires great skill to get at once an overcoil of the desired shape. The overcoils of watch springs are turned with steel tweezers having carefully polished curves. In forming the Phillips curves some watchmakers use hot pliers of the required shape to set the curve to the required form.

Pinning in Short Springs.—A short spring as a rule requires to be pinned in short of complete turns, and a long one beyond the complete turns. In duplex and other watches with frictional escapements, small arcs of vibration and short springs, it will be found that the spring requires to be pinned in nearly half a turn short of complete turns. The marine chronometer springs are found to isochronize better and act more true when pinned in about a quarter of a turn short of complete turns.

Cockling Springs.—Watch springs of thick and narrow wire are apt to cockle with large vibrations, while springs of wide and thin wire keep their shape and are more rigid. It is of even greater importance that the springs of marine chronometers, subjected to the tremor of steamships, should be of wide and thin wire.

To Flatten Balance Spring.—To

flatten 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.

PINNING IN THE SPRING.—The end of the overcoil of a Bréguet spring should run into the hole of the stud before being pinned in, and if the stud is screwed into the cock without the balance it will easily be seen if the jewel hole is in the center of the hole in the spring collet, as it should be. This spring should also be pinned in at equal turns.

FEATURES OF THE BALANCE SPRING.—Sir G. B. Airy, of England, has demonstrated that the loss in heat from the weakening of the balance spring is uniformly in proportion to the increase of temperature.

CHOOSING A BALANCE SPRING.—A very common and at the same time very uncertain method of ascertaining the strength of a spring is by lifting the balance itself. The almost uselessness of this method is seen when we know that the diameter of the balance has very much to do with the timing of a watch, and the diameter, when the weight of the balance is considered principally, counts for nothing. A spring should be chosen that is smaller than the circle of the steel hole and index pins. That is, the spring should look small when the balance is at rest, as a spring of this size has more freedom at the coils and assists in quickening the short arcs of the balance.

SLOW ACTION OF SPRING.—A spring too large in relation to the position of the index pins and stud is pretty sure to be slow in its short arcs.

CORRECTING THE SPRING.—I have seen directions by experienced men for timing in positions by the curb pins. This should never be attempted. The curb pins (always an evil) should be wide enough apart to let the spring just move between them and no more, and should never be far from the stud. As "manipulating" the curb pins, as it is termed, is done only with the object of lengthening or shortening the acting length of the spring, this should be accomplished in the proper way at once by adding to or taking away weight from the balance.

ISOCHRONISM OF BALANCE SPRING.—A balance spring of whatever form, to be isochronous, must satisfy with 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. Mr. Phillips, in his memoir, demonstrates these conditions, and proves theoretically that the terminal curves deduced with the view of satisfying the one condition and verify at the same time the other.

BRÉGUET SPRING.—A Bréguet spring should never be applied to a watch with an index. It is perhaps the best form of spring for a pocket watch, having all the properties in action of the cylindrical spring, and the great advantage of flatness in form, but any attempt at producing a good timekeeper with this spring and index pins will end in failure. And any attempt at getting time in positions by pressing the outer coil of the flat spring against the outer or inner pin is mere botchwork, and, even if successful, would require to be repeated every time the balance had to be taken out.

FLAT SPRING.—For flat springs with index I would strongly recommend the plan of pinning a spring into the collet in order to get the stud hole and index pins to correspond.

ATTACHMENT OF SPRINGS.—The position of the points of attachment of the inner and outer turns of a balance spring in relation to each other has an effect on the long and short vibrations quite apart from its length. For instance, a very different performance may be obtained with two springs of precisely the same length and character in other respects, but pinned in so that one has exactly complete turns and the other a little under or a little over complete turns.

BALANCE SPRING.—The dimension of the spring, its form at the attachments, the position of the attachments with relation to each other, are all factors affecting its controlling power.

HOW TO TEST A BALANCE SPRING.—Pick out a balance spring which in size and thickness appears to be suitable; pin it in the collet, which place on the balance. Then enter the balance in the calipers and straighten the spring to an exact flatness and height. Now take a well regulated watch with seconds hand, seize the outer end of the balance spring with the tweezers and let the balance vibrate upon the watch crystal, thereby counting the double vibrations made by the balance in one minute. Mark the place where you commenced counting, and when the seconds hand has arrived again at this place you must be about to count the 150th double vibration. If the balance makes fewer vibrations catch the spring more to the inside with the tweezers and commence counting again; repeat this until you have found the correct place where the vibrations coincide. At this place the spring must be pinned in the stud. If the curb pins are as open as they should be and the watch in good order a difference of at most one minute to two minutes in twenty-four hours may be found, which can then be easily corrected with the index. The counting requires some practise, and the repairer who is sufficiently skilled can regulate a watch quicker in this way than by the ear. If the balance with the new spring makes in the first trial more than 150 double vibrations in one minute the spring is too strong, and a weaker is to be put in.

MOMENTUM.— Momentum overcomes some of the elastic force of the balance 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 it travels a given distance in a given time. Weight is that contained in its rim. A balance may be 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 for one of one-half its 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.

THE ACTION OF BRÉGUET SPRING.—The Bréguet spring, although differing very little in form from the simple volute, is essentially different in action and principle; the overcoil, being fixed above the spring, and nearer the center, gives it perfect freedom to expand in a circle all around. This spring must be longer than the flat spring, as the force of the outer curve inward gives it more power of resistance, and also an easy and perfect means of obtaining isochronism. I find about 20, according to the size of the watch, the best length for this spring, and curb pins should never be used with it, if perfect timekeeping be aimed at.

ISOCHRONISM.—It may be taken as a very good rule that a balance spring should be half the diameter of the balance and have 14 turns if it is a flat spring for a lever watch, or 20 turns if a Bréguet. These lengths, it will be understood, only apply where the work is good; with coarse work a shorter spring is required in order to get the short arcs fast enough. Springs for cylinder watches should have from eight to twelve turns.

SHORT ARCS.—It is remarkable that while in watches the difficulty is generally to get the short arcs sufficiently fast, precisely the reverse is the case with the marine chronometer, in which the trouble is usually to get the short arcs slow enough. The escapement is not responsible for the difference, because pocket chronometers follow the same rule as watches with lever escapements. The size of the pivots in proportion to the size of the balance is partially the cause, for in very small watches where, of course, the pivots are relatively large, the slowness of the hanging position is proverbial, and a shorter spring by a turn or two has often to be substituted. Very quick trains should be avoided on this account.

ISOCHRONISM.—Some are under the impression that an isochronal spring will correct vertical position errors, but this is a mistake; still, it has much to do with the horizontal positions as compared with the vertical. There are many factors which play important parts in the rate of any watch to run in all the positions. Sometimes two of these will compromise favorably with each other, while others will tend to aggravate and augment the errors. Of these factors, we mention a few, such as want of isochronism, unequal friction in the different positions; side shake of balance pivots; slight errors in poise of balance; various escapement errors, etc., together with the errors in the *poise of the balance spring*.

SPRINGING.—In all springing great care is necessary in pinning the spring on the collet. Always broach the collet before pinning in, and see that, in the case of a flat spring, the hole is parallel with the collet and properly chamfered at both ends, that the spring has a flat side, and that the spring is not permanently pinned in till it is nearly true, for when once on the collet, much difficulty is experienced in bending the center inward. Put the collet on an arbor, and in the calipers you will see if the spiral is quite true ; if not, bend it gradually until it is so. By putting the arbor in the turns the spring can be gotten flat.

NOTES ON THE ESCAPEMENT AND DIAL.

THE ACTION OF THE ESCAPEMENT.—The force of the balance mass in revolving winds up the reciprocating spring, and as soon as this spring has secreted all the force of the balance the motion is reciprocated by the uncoiling of the spring. Arrived at the place of the escapement arc (where the lever is lying at the proper angle against one of the banking pins), the roller pin jewel enters the lever notch, and the reciprocated force of the balance, by the aid of the roller pin, now moves around the lever and pallets sufficiently to draw the locking out from under the escape wheel tooth, and all the mechanism being then set free the escape wheel moves forward again over the impulse plane of the opposite pallet, giving another impulse to the pieces and again another tooth of the wheel drops on to the opposite locking, the wheel resting there and stopping all the machinery, while the roller and balance vibrate freely as before.

ESCAPEMENT IN BEAT.—When the balance spring is at rest the balance should have to be moved an equal amount each way before a tooth escapes. By gently pressing against the fourth wheel with a peg this may be tried. There is a dot on the balance and three dots on the plate to assist in estimating the amount of lift. When the balance spring is at rest the dot on the balance should be opposite to the center dot on the plates. The escapement will then be in beat, that is, provided the dots are properly placed, which should be tested. Turn the balance from its point of rest till a tooth just drops, and note the position of the dot on the balance with reference to one of the outer dots on the plate. Turn the balance in the opposite direction till a tooth drops again, and if the dot on the balance is then in the same position with reference to the other outer dot, the escapement will be in beat. The two outer dots should mark the extent of the lifting, and the dot on the balance would then be coincident with them, as the teeth dropped when tried in this way, but the dots may be a little too wide or too close, and it will, therefore, be sufficient if the dot on balance bears the same relative position to them as just explained ; but if it is found that the lift is unequal from the point of rest the balance spring collet must be shifted in the direction of the least lift till the lift is equal. A new mark should then be made on the balance opposite to the central dot on the plate.

RECOIL ESCAPEMENT.—The recoil escapement is used mostly for clocks with short pendulums, for which it is well adapted where no very great accuracy is required ; it is easily made and performs regularly. But although variations in the impulse produce less alteration in the arc of vibration than similar variations would in the arc of the Graham escapement, which for some time led clockmakers to think that it was the more reliable escapement of the two, they affect the time of the vibrations very considerably (the clock going faster for an increase of the motive force and slower for a decrease), as should be patent to any one without further demonstration, after a little consideration of the form of the pallets and the direction of the forces. Yet after the many years during which the two escapements have been tried, and the experience which has proved undeniably the superiority of the dead-beat, people may still be heard to assert that the recoil is the better escapement of the two.

REMONTOIRE.—Those who read German and French will in their horological literature often come across the word "remontoire." Originally it meant a spring or other device which is wound by a clock and discharged at regular intervals. The function of a remontoire is generally either to impart impulse to the pendulum or to cause the hands of the clock to jump through certain spaces. Though this word comes from the French it is not now used in that language, except in the sense of a stem-winder.

CHRONOGRAPH.—Although the chronograph, on account of its ability to measure fractions of a second, has almost displaced the independent center seconds watch, it is by no means a perfect construction. The serrated wheels are not calculated to withstand continuous wear, and it is evident that, however fine the serrations, they would cause the chronograph hand to jump backward or forward when brought into contact unless a projection and groove happen to exactly coincide. This is often aggravated by minute portions of a broken glass or other grit getting into the serrations.

ISOCHRONISM.—The eye of the balance spring is occasionally operated on to obtain isochronism, and is left more open for that purpose. It is found that alterations of the eye are most effective when the ends are attached about one-eighth short of half a turn or one-eighth short of a whole turn. Great experience, which is only acquired after many failures, is required to effect the desired purpose, as in setting the spring true again after the alteration, the effect is easily destroyed.

RECOIL ESCAPEMENT V. ANCHOR.—There are watchmakers who believe that the recoil is a better escapement than the dead beat —mainly because the former requires a greater vibration of the driving power to affect the extent of the vibration of the pendulum than the latter does. But the matter is beyond argument; the recoil can be cheaply made and is a useful escapement, but beyond question it is inferior to the dead-beat in its time-keeping qualities.

UNITING ESCAPEMENT PARTS.—The mode of connecting the balance and roller with the lever and pallets is by planting the pieces sufficiently close together, so that the jewel pin of the roller is linked into the lever notch, by which contrivance the lever and roller can turn each other alternately. It is well to remark, however, that the vibration of a watch balance is a reciprocating circular motion, the motion being reciprocated by a spiral spring, usually called the balance spring, one end of which is fastened to the collet placed on the balance axis, and the other end to a stud.

TESTING ESCAPEMENT.—When you have mounted the watch after cleaning, wind a little and test the escapement. Hold a fine broach so that the end of the lever will strike it; this will throw the guard point or pin against the roller; if this will catch and hold the roller after the broach is removed, the roller is probably rough and must be repolished; if the lever will throw over so far that the roller jewel will not enter the fork without striking, then the lever is too short and must be corrected by bending the guard pin, or filing back the guard point, drilling and putting in a pin American style. In adjusting the guard pin, bend it in such a shape that the end shake of the part cannot change the action. If the roller and guard action is all right, but the roller jewel strikes the corner of the fork when the lever is thrown against the roller, then the jewel must be changed for one more flattened, or be set a little nearer to the staff.

PIN PALLET ESCAPEMENT.—This excellent escapement, invented by Mr. Brocot, is rarely seen except in small French clocks, but appears to be worthy of more extended use. The fronts of the teeth of the escape wheel are sometimes made radial, sometimes cut back so as to bear on the point only, like the "Graham"; and sometimes set forward so as to give recoil to the wheel during the motion of the pendulum beyond the escaping arc. The pallets, generally of ruby, are of semicircular form. The diameter of each is a trifle less than the distance between two teeth of the large wheel. The angle of impulse in this escapement bears direct reference to the number of teeth embraced by the pallets. Ten is the usual number. The distance between the escape wheel and pallet staff centers should not be less than the radius of the wheel multiplied by 1.7. This gives about 4 degrees of impulse measured from the pallet staff center.

VALUE OF CYLINDER ESCAPEMENT.—The cylinder escapement is essentially a frictional, as distinguished from a detached, escapement. It performs fairly well and is just suited for the lower grades of watches. The vibrations of the balance are not so much affected by inequality in the force transmitted and by other faults, if the escapement is a frictional one, and the work comparatively coarse, as when a highly detached escapement and very fine pivots are used.

ACTION OF CYLINDER ESCAPEMENT.—In order to describe the action of the cylinder escapement, let the watchmaker imagine that the pivot of a tooth of the escape wheel is pressing against the outside of the shell of the cylinder. As the cylinder on which the balance is mounted, moves around in its proper direction the wedge-shaped tooth of the escape wheel pushes into the cylinder thereby giving it impulse. The tooth cannot escape at the other side of the cylinder for the shell of the cylinder at this point is rather more than half a circle, but its point rests against the inner side of the shell till the balance completes its vibration and returns, when the tooth which was inside the cylinder escapes, and the point of the succeeding tooth is caught on the outside of the shell.

DROP IN THE CYLINDER ESCAPEMENT.—Though excellent for ordinary pocket watches, the cylinder escapement cannot be said to be equal to the lever and some others, where great accuracy is required. The drop of the escapement is the cause of much trouble to watchmakers, but the following method will enable them to ascertain how far the drops are equal and correct. The movement being slightly wound, turn the balance with a fine wire or slip of paper 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; 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 rubs on the point of one tooth and the heel of the next, then there is no outward drop. The internal drop is increased by reducing the length of the teeth; the external drop is increased by increasing the space between the teeth. When the drop is very slight, the watch is quite liable to stop through 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 course, the same effect may be the result if some teeth lift more than others. A noisy drop is caused by badly polished surfaces, and in such a case the wheel of the cylinder should be carefully noticed.

CYLINDER ESCAPEMENT.—One property which the cylinder escapement possesses, and which renders it peculiarly well adapted for going-barrel watches is that it is not so much affected by any change in the motive power of the watch as any other escapement, the friction rest of the tooth on the cylinder exercising a compensating power over the extent of the vibrations, so that any addition to the motive force is attended with additional friction on the cylinder, while the balance is performing the supplementary arcs of vibration, and so retarding it and compensating for the additional force of the impulses. This isochronizing power was what recommended it especially to the Swiss, who saw the possibility of suppressing the fusee, of which they never had been in favor, and which, in fact, they never understood thoroughly.

DEAD-BEAT OR "GRAHAM" ESCAPEMENT.—This escapement is considered to be the best for regulators and other clocks with seconds pendulum. The only defect inherent in its construction is that the thickening of the oil on the pallets will affect the rate of the clock after it has been going some time. Notwithstanding this, it has held its own against all other escapements on account of its simplicity and certainty of action. The pallets of the Graham escapement were formerly made to escape over fifteen teeth of the wheel, and until recently ten, but now many escapements are made with pallets escaping over but eight teeth. This reduces the length of the impulse plane, and the length of the run on the dead face for a given arc of vibration, and consequently the relative effect of the thickening of the oil. The angle of impulse is kept small for the same reason. There is not much gained by making the pallets embrace a less number of teeth than eight, for the shake in the pivot holes and inaccuracies of work cannot be reduced in the same ratio, and are therefore greater in proportion. This involves larger angles and more drop. It is purely a practical question, and has been decided by the adoption of eight teeth as a good mean.

DETACHED LEVER WATCH.—The characteristic of the detached lever is its fork, which is solidly united with the pallets. At the other end of the fork it is furnished with a prolongation for establishing a central poise, nevertheless, it may be observed in many watches, that in spite of this provision attached to the fork, this body is far from being perfectly and evenly balanced upon its axis. As may be supposed, this absence of equipoise prevents the adjustment in the horizontal and vertical positions, and before the adjuster expends any work, it is necessary to place pallets and fork into the poising tool, and to establish the equipoise in a suitable way.

EXAMINING CYLINDER ESCAPEMENT.—See that cylinder and wheel are perfectly upright. Remove the balance spring and put the cylinder and cock in their places. Then with a little power on and a wedge of cork under the balance to check its motion, try if all the escape wheel teeth have sufficient drop, both inside and out. If the drop is sufficient inside, with none outside, the wheel is too small; if the reverse, the wheel is too large—that is, provided the cylinder is planted the correct depth. If some of the teeth only are without necessary freedom, make a hole in thin sheet brass of such a size that one of the teeth that has proper shape will just enter. Use this as a gauge to shorten the full teeth by. For this purpose use either steel and oilstone dust or a sapphire file, polish well with metal and rouge, and finish with a burnisher. Be careful to operate on the noses of the teeth only, and round them both ways, so that a mere point is in contact with the cylinder. If the inside drop is right and there is no outside drop with any of the teeth, although this would indicate a wheel too small it may be prudent to change the cylinder for one of the same inside diameter, but thinner, rather than remove the wheel, for it often happens that a larger wheel would not clear the fourth pinion.

RESTORING THE COLOR OF A NICKEL MOVEMENT.—The following method for restoring the color of a nickel movement is recommended by a correspondent. Take fifty parts rectified spirits of wine, one part sulphuric acid, and one part nitric acid. Dip the pieces for about ten or fifteen seconds into this bath, then rinse them in cold water, and throw into rectified spirits of wine. Dry them with a piece of fine linen or in sawdust. Nickel and the majority of other metals which are liable to tarnish, may also be restored to their original color by dipping into the following bath: Dissolve in half a glass of water, six or seven grains of cyanide of potassium; plunge the pieces into the solution, and withdraw them immediately. As the cyanide mixes well with the water, it is sufficient to rinse them at once in the latter to destroy any traces of the acid. After this, dip the pieces in spirits of wine, and dry in boxwood dust to keep them from rusting. The balance spring even may be subjected to this operation without any danger. If the pieces to be restored are greasy, they must be cleaned in benzine before being dipped in the cyanide because it will not touch grease. Cyanide of potassium being a voilent poison, great care must be exercised and the operation should be performed in a well-ventilated place. The same bath, preserved in a bottle, may be used for a long time.

BANKING AMERICAN WATCH.—If an American watch has movable bankings, proceed to adjust them so that the guard pin will stand as close to the roller as perfect freedom in all positions will allow. The finer the watch the closer it can be banked with safety; with a cheap affair, plenty of play should be left.

OVERBANKING.—Overbanking depends on the position of the guard pin or point, with reference to the roller table. If the guard pin stands too far from the roller table, it will overbank. Some watchmakers will advise to put in a large roller jewel; but this will not remedy the matter, and it is therefore quite useless. We would suggest that the repairer bend the pin, a fairly sharp bend, close to the lever, and then a little distance from this bend, bend it straight up so that it will stand perpendicularly where it works against the roller table. The guard pin should always stand perpendicularly where it touches the roller table; if it does not, the banking will be different when the watch lies on its back and when on its face, unless the end shape of the lever and balance are exactly the same: even then there is danger of trouble, as the lever may not drop as soon as the balance. Again the pin is liable to stick or catch against the table when it stands slanting.

DUPLEX WATCH.—In affirmation of the opinion some time ago expressed by THE CIRCULAR about the duplex watch, Mr. Glasgow says: "When we consider the delicacy of this escapement, its unsuitability for a full plate watch, and the way many of these watches were made, we may easily understand why the duplex escapement got a bad name in that quarter of the world, and also how it was the Americans took to machinery, and made watches themselves. It must have taken a good deal of ingenuity to devise so thoroughly bad a watch as a full plate duplex, and what was bad in the original construction was soon made worse by the American repairers and the fitters of these movements to the cases. The consequence has been that an escapement which is capable of and has given excellent results, has gradually gone out of favor, and almost out of use."

DUPLEX SCAPE-WHEEL.—The train used

in duplex watches is invariably the 18,000, as in the chronometer, and the balance usually vibrates nearly a turn. Overbacking cannot take place with this escapement as it does with the cylinder and the lever, the effect of the balance vibrating too far will cause the escapement to "run," that is, two or more teeth will escape at one vibration, causing the watch to gain a few seconds, as is the case with the chronometer. Various methods were tried to prevent this running or tripping of the wheel. The old-fashioned plan was to fix a stud or pin on the balance staff just above the pallet, having a slot cut in it into which a pin fixed in the staff, projected, allowing it to move a quarter of a turn. This stud had a sort of pallet projecting from it, and, if the balance moved more than half a turn either way, this pallet came in contact with a banking stud or pin fixed in the plate.

GRAHAM ESCAPEMENT.—The Graham escapement requires a heavy pendulum, especially if the train is comparatively rough. The clock weight must be sufficient to overcome increased resistance arising from inaccuracy of work; consequently when the train runs freely so much extra pressure is thrown upon the dead faces of the pallets that a light pendulum has not sufficient energy to unlock and the clock stops.

PROPORTION OF SCAPE-WHEEL TO PINION.—It is a good rule, when a repairer takes an escapement into his hands, to first look at the scapewheel and pinion to see that he has not a fully large wheel to the pinion. Next let him hold up the pallets to the light to see that they have not very great angles on them. Then let him compare the radii of the lever and wheel and see that the lever is not much longer than the wheel, and finally see that the roller goes three or four times in the lever, reckoning the roller from balance staff to ruby pin. If he has these things the escapement will do well as regards its pieces, all the rest depending upon properly fitted pivots, proper depth and freedom, well uprighted staffs, poising, hooking and equalizing.

RATIO OF SPRING TO BALANCE.—The momentum of a moving body varies with its velocity, and in the coils of a balance spring the variation is according to the square of their distances from their centers of motions, and as the center of gyration in the mass of each coil is always nearer the center of motion than are the balance screws, it is self-evident that these two factors bear unfavorable relations to each other, and consequently the one cannot be made to compromise with the other for the faults of either.

THE SAFETY ACTION.—See to the safety action; when the tooth drops on to the locking, the safety pin should just be clear of the roller. If it is not clear, the edge of the roller should be polished down till it is right. If there is more than clearance, the safety pin must be brought closer to the roller. See upon pressing the safety pin against the roller that the tooth does not leave the locking, and that the impulse pin is free to enter the notch without butting on the horn of the lever; also that the safety action is sound, so that the pin is in no danger of passing the roller. If the action is not sound, the diameter of the roller should be reduced and the safety pin brought toward it sufficiently to get a broad action, if it can be done; but if the escapement has been so badly proportioned as not to allow of a second action being obtained in this way the pin must be shifted forward and the bankings opened to allow more run.

GUARD PIN DEPTH.—When a guard pin depth is too shallow, the pin must be bent minutely inward to the roller, and the bankings opened a trifle. When a guard pin depth is too deep, the edge of the roller may be topped down with a bell metal polisher and sharp rouge. If a screw is placed up through the nearer of the turns, part of the polisher will work on the screw and part on the roller's edge, so as to keep the latter square.

NO WASHERS.—Washers either laid under or mounted upon the minute wheel pin are occasionally found. This remedy, made use of for raising the depthing of the minute wheel to the plane of the cannon pinion, is not permissible, because such a small steel disc is lost only too readily.

USE OF WASHERS.—If the watch accelerates its rate, bring it to time by means of washers under the heads of the screws, if the balance is not provided with mean-time screws. These washers are cut out of brass or gold plate rolled down to as thin as $\frac{1}{1000}$ of an inch. It is best to have three pieces of stock, $\frac{1}{1000}$, $\frac{2}{1000}$, $\frac{3}{1000}$, in thickness. A half-dozen washer cutters will embrace all the sizes of American balance screws. These washer cutters are punches the size of the head of a screw with undercut end, a "tit" protecting the size of the threaded portion of the screw. Place pairs of these washers under opposite screws, usually the screws at the extremities of the balance arms. A little experience will soon guide you about the thickness of stock required to correct given errors; also, you can always present the watch with the regulator in the center, something which many customers look at. Punch out the washers on a lead block.

THE COLLET.—The balance spring collet often gives trouble, owing to bad fitting and want of freedom of the cock and screw-heads of the 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 slit 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 that being out of beat is a greater source of stoppage than anything else, and suppose the trouble and danger attending frequent removal of the spring and balance the reason why it is overlooked, and devised this plan to save trouble and insure accuracy of beat.

TO CLEAN A GOLD DIAL.—First dissolve one-half ounce of cyanide of potash in hot water; to this add two ounces of strongest ammonia, and one-half ounce spirits of wine. Dip the dial for a few seconds and immediately immerse in warm water, brushing it lightly; this will soon show a clean dial; then rinse and dry off in hot boxwood dust. Some use diluted nitric acid for cleaning dials, or hyposulphate of soda will do it if dissolved and mixed with ammonia; but with either of these the painted numbers go with the dirt, so only dials with gold numbers can be done with this process. We could give several recipes for dial cleaning, but the above is as simple and effective as anything we know of.

SAFETY PIN.—The object of the safety pin is to prevent the wheel 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 any blow from the impulse pin on the outside of the lever is received direct. They are sometimes placed at the tail of the lever, but in that position the banking pins receive the blow through the pallet-staff pivots, which are liable to be broken in consequence.

LENGTH OF LEVER.—You may easily ascertain whether or not the lever is of proper length by measuring from the guard point to the pallet staff, and then comparing with the roller table; the diameter of the table should always be just one-half the length measured on the lever. The rule will work both ways, and may be useful in cases where a new table roller has to be supplied.

TO REDUCE DIAMETER OF 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 to act while advancing, and is at the same time displaced 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.

REPLACING A DIAL FOOT.—To replace a dial foot, prepare a piece of copper wire with an enlarged surface where it is attached to the dial. Tin this surface, scrape away the enamel for its reception by means of a graver moistened with turpentine, tin the copper, place the wire in position and gently heat with a blow-pipe.

BROACHING HOLE IN ENAMEL DIAL.—Use a flat-ended drill or a conical broach of copper into which diamond powder has been hammered. A graver kept moistened with turpentine is sometimes used. The edges of holes in dials may be trimmed with corundum sticks to be obtained in material stores.

DIAL FEET.—In common watches, pins falling out of the dial feet are a fruitful source of trouble. Sometimes a dial foot is burst at the hole. In this case a better plan than removing the foot is to encircle it with a bit of tubing, soldered to the copper of the dial. The hole in the pillar plate can be opened to suit the tubing and a new pin fitted, with the assurance that the position of the foot has not been altered.

BLEACHING WATCH DIAL, ETC.—Dissolve 1-2 oz. cyanide of potassium in a quart of hot water and add 2 oz. strong liquor ammonia and 1-2 oz. 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 with clear water; rinse and dry in hot box-wood dust. Another good plan is to greatly heat the dial and dip in diluted nitric acid, but this method must not be adopted for dials with painted figures, for these would be destroyed.

NOTES ON ADJUSTMENT AND COMPENSATED BALANCE.

ADJUSTMENT. — When adjusting a detached lever, examine the motion of the balance with an attentive eye. A balance which does not run truly circular, the rim of which does not everywhere show the same breadth and thickness, or one in which steel and brass are unequally divided, is entirely unfit for close adjustment. The writer saw, some months ago, an excellent balance manufactured in Germany, which he considered very proper and useful. The timing screws were placed in longitudinally cut holes in the balance rim. A delicate incision in the direction of length is made through the screw holes in such a manner that they have a slight elasticity, which enables the screws to move very gently, without becoming loose.

POINT IN ADJUSTING.—The distance of the curbpins one from the other should, under no consideration, be greater than twice the thickness of the spring coil. The center of the spring must coincide exactly with that of the jewel hole. The inner coil of the balance spring around the collet must be at a sufficient distance from the latter, so that there is no danger that it will either touch this or the place of fastening in the folding of the spring. This contact, which can be recognized by a jerk similar to the crack of a whip, would cause acceleration of the large vibrations.

COMPENSATION.—The principle of compensation adopted has nearly always been the construction of the pendulum with two or more metals of different expansibility, so arranged that the position of the center of oscillation shall remain approximately unaltered. The most successful inventions have been, for regulators and house clocks, the mercurial and gridiron pendulums, and for large turret clocks, the zinc and iron compensation which, while being as effective as the mercurial, is a good deal cheaper.

TO CALCULATE VIBRATIONS.—In order to calculate the vibration of a pendulum or balance, multiply together the number of teeth of the wheels, starting with the one that carries the minute hand (which, therefore, makes one revolution in an hour, but exclude the scape wheel. Next multiply together the number of pinion leaves, commencing with the one that engages with the center wheel. If, then, the first product be divided by the second, the number obtained gives the number of revolutions of the escape wheel in an hour. Multiply this figure by twice the number of teeth of the escape wheel, and the product is the number of single vibrations performed by the balance or pendulum in one hour.

BALANCE VIBRATION.—The phrase commonly in use "balance makes a turn," or "a turn-and-a-half," requires, perhaps, explanation, as it is obviously impossible for a watch with any ordinary escapement to go if the balance swings round over a complete turn; the meaning is that it makes a turn, etc., at each complete vibration—that is, in its backward and forward arcs of motion added together.

QUARTER SCREWS.—When withdrawing or inserting the quarter screws, it is not necessary to take the movement out of the case: simply hold the balance rim at the place where the screw to be operated on is placed, with a pair of tweezers, and make the alteration in such a manner as to exert no latent pressure on the balance rim or staff pivots. Very delicate and sharply filed screw-drivers are necessary for this job.

BALANCE VIBRATION.—The complete or full vibration of the balance is a motion produced by several additions of the impulsive force, the excursion of the balance emanating from the first impulse frequently being about 120° by measure on the balance circle, while the vibration at the end of the additional impulse is, perhaps, 200°; this, doubled for both sides of vibration, makes 400° altogether, so that the impulses, as we see them at the full vibration, are given when the balance is already in motion, and no mechanical power ever operates with its full energy when the impelled body is already in motion, and in this case the force of pressure of the escape wheel and lever gradually decreases, as the balance crank or roller recedes faster from these impulse agents. It is only at the first impulse that the energy of the main power is fully effective in impelling the balance; all the after impulses gradually decrease in intensity up to the full vibration.

TRUING THE BALANCE. — Truing the balance is best done with copper-lined tweezers. One pair needs a slot in each jaw, transversely, so as to catch the arm near the rim to elevate the segments to match. To make the arms the same height, place the wheel on a stick with a large hole in it, and when the staff is at one side and the end of the arm at the other, rub the arm with a piece of pegwood so as to elevate the arm, and watch the height of the two. Perfectly true and poised balances are very necessary to correct timing, but recollect a perfect round is more essential than a perfect flat.

EXAMINE THE BALANCE.—I have been in the habit for several years of putting my balance wheel separate from all connections and trying its freedom in all positions, and if you will try this method you will be surprised how many you will find that bind or are not perfectly free in all positions, when you give them the slightest impulse by a trial of the hand holding the plate. Then, too, carefully examine each jewel; you will be surprised how many are either loose in the setting or plate.

END SHAKE OF BALANCE.—When you are through with cleaning a watch, and have put in the balance, see that it has but a slight end shake, and is in beat.

THE BALANCE.—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; 2. The distance of its center of gyration from the center of motion; or, to speak roughly, the diameter of the balance; 3. The strength of the balance spring, or, more strictly, its power to resist change of form.

REMOVING BLUE FROM BALANCE ARMS.—When it becomes necessary, in pivoting an unduly hard staff, to partly draw its temper, there is danger of bluing the balance arms. Nothing makes a more unsightly job than having the balance arms blued or almost blackened, half way to the rim as may sometimes be seen. If they should become slightly colored by heat, the blue may be removed by dilute hydrochloric acid, cleaning thoroughly with alcohol after to prevent their rusting.

CONDITIONS OF THE BALANCE.—The time in which a balance will vibrate cannot be predicted from its dimensions alone. A pendulum of a given length always vibrates in the same time, as long as it is kept at the same distance from the center of the earth, because gravity, the force that impels it, is always the same, but the want of constancy in the force of the balance spring, which, in watches and chronometers, takes the place of gravity and governs the vibrations of the balance, is one of the chief difficulties of the times. There is another point of difference between the pendulum and the balance. The time of vibration of the former is unaffected by its mass, because every increment of the mass carries with it a proportional addition to the influence of gravity, but by adding to the mass of a balance the strength of the balance spring is not increased at all, and therefore the vibrations of the balance become slower.

THE COMPENSATED BALANCE.—It is well known that the linear extension of all balance springs is the same by increasing heat, but the diminishing of the elasticity is disproportionate, and corresponds to the degree of hardness of the spring. This fact may explain the variation of watches that have been regulated in temperate climates, when exposed to the extremes of the heat or cold. A well-hardened balance spring retains its elasticity best, and in some temperatures insures the best rate. Not so, however, in extreme ones, since it is subjected to a greater change. The general compensated balance is unable to remedy this defect. It is apt to increase it, because its compensating arms do not, by increasing heat, move toward the center, but toward the sides. Ingenuity has for a long time been at work to overcome this evil, and has devised many contrivances, of which the auxiliary compensation by springs, dating to 1835, and more recently added compensating arms, need only to be mentioned. Both contrivances, however, do not work to satisfaction, and have not been adopted in practise.

ADJUSTING BALANCE.—The compensating balance fails to meet the temperature error exactly; the rims expand a little too much with a 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. A marine chronometer is usually adjusted at 45 degrees and 90 degrees, unless special adjustment is ordered to suit particularly hot or cold climates; pocket watches at about 50 degrees and 85 degrees. In this range there would be what is called a middle temperature error of about two seconds in 24 hours. To avoid this 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.

BALANCE VIBRATIONS.—It should be remembered that if the vibrations of a balance are to be isochronous the impulse must be delivered in the middle of its vibration, and that therefore no spring will be satisfactory if the escapement is defective in this particular.

NOTES ON BALANCE TRUING.

IN truing a balance do not use pliers nor any tool that leaves a mark on the rim. Every kink can be taken out with the fingers; sometimes it is necessary to use the thumb-nail or finger-nail as a fulcrum, but they leave no mark, while pliers or tweezers always do. Thousands of balances have been ruined in appearance by the reckless use of such tools. The ability to put two and two together, and a little patience with the first two or three balances, are all that is necessary to convince the average watchmaker that "bending tools" are out of place in such work. Calipers adapted for this kind of work can be obtained from any material dealer to-day, and while they cost more than the articles of Swiss manufacture, there is no comparison between them in actual value. It is not necessary to have them jeweled; hardened steel ends with a lateral hole to give the pivot clearance, allowing the conical shoulders only to bear the strain, without touching the pivots, is all you need. Then you can "touch up" a balance without taking it out of the calipers or breaking a pivot.

COMPENSATED WATCHES. — No good watch is now made without a compensation balance, but there are also many bad ones made with them, and it has become the custom to put what are called compensation balances in the very worst of the foreign watches sold everywhere; these balances are infinitely worse than brass or steel ones, especially if they are cut open, as the material of which they are composed is so soft that the least touch puts them out of shape, and consequently out of poise, so essential to the going of even the worst of watches. Cheap watches with compensation balances should be discouraged by both the sellers and wearers of them, and instead of a compensation balance in such a watch being a recommendation it should be considered as indicating a sham, which it generally is.

ADJUSTING A WATCH.—As soon as a watch is brought to within 10 seconds a day of correct time, the work of adjusting to isochronism can be commenced. If the balance is one which has been previously adjusted to heat and cold, it is highly probable that we will have to change no more than one pair of screws to restore this adjustment.

PUTTING IN COLLET.—The collet should be put on an arbor with a bow and the spring carefully set true and flat in the turns. In setting the spring it must only be touched close to the eye. Steady timekeeping will be out of the question if the eye of the spring is bent to and fro in reckless attempts to get it true. The eye should be brought around gradually to get it in circle, taking care not to overdo it. When this is right and the spring is also true on the face many good timers heat the spring and collet to a blue to set the eye.

NOTES ON PALLETS.

POISING PALLETS, ETC.—A correspondent desires to know how to poise pallets and balance. In the first place, pallets are not poised without the lever, and then only approximately, as they cannot be so weighted with the ordinary construction that they will not gravitate in some positions. The balance cannot be poised in any quick and easy method, but this can only be done by a rather long and tedious manipulation, too lengthy to be described in a short Workshop Note.

CARE OF PALLETS.—Pallets should be washed in benzine and dried in sawdust, or with the edge of a fresh piece of blotting paper; under no circumstances should pallets or roller go into the alcohol, except to remove old shellac preparatory to resetting. Ninth-tenths of the pallets and jewel pins that are found loose, come so by having been in the alcohol.

FREEING JEWEL PALLETS.—The way some repairers free garnet stone pallets is with a sapphire file, which is only a fair-sized piece of sapphire flattened down in the ordinary way and cemented into a brass handle. The sapphire should not be flattened too rough, or it will chip the pallet stone. Ruby or any other jewel pallets may be freed by making a small mill, to be placed in the turns, of tortoise shell or vegetable ivory; some diamond powder is to be rubbed on the mill. A quarter of a karat of diamond powder should be well mixed with about a dessert spoonful of sweet oil, and allowed to settle for about two hours; it should be poured off into another vessel, and allowed to stand a long time—until it settles and leaves the oil clear again. The first sediment will be too sharp to rub on the mill; it is the second sediment that is to be used. A good, useful article can also be obtained at a material dealer's.

UNEQUAL PALLETS.—When the pallets are unequal, but too shallow on one pallet only, the pallet should be fixed in some sort of clamps, and the clamps made warm, the stone raised up sufficiently, and the pallets afterward forced—if they require it. When a pallet depth is too deep, the wheel must be topped. The topping of the wheel does not cause them to be foul outside, although the wheel is then smaller, the wheel being drawn farther away altogether by the topping. When a lever is not equalized on the pallets, it mostly happens that the two pins are slight enough to permit the pallets to be so minutely twisted further round on the lever; but if the pins are thick, they must be taken out and the holes drawn which ever way they require.

THE "SETTING."—When a watch "sets" on the impulse face of a pallet, the "set" can be removed by polishing the faces to a smaller angle, but the repairer must see that the pallet depth is deep enough to allow of being made shallower and yet be safe, because, by reducing the impulse angles, the wheel will drop shallower, and, although the watch will go while it is clean if the pin and notch is not altered, yet if the pallet depth is not quite secure, the wheel may sometimes pitch on the locking edge, and probably stop the watch. If the depth is made too shallow by reducing the angles of the pallets, a slightly larger wheel must be put on.

PALLET LOCKINGS.—In respect to the pallet lockings the equality of sharpness of draft inward is readily judged. 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 the draft 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 distance 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 shorter, therefore the long arm of the lever bears a greater ratio to that shorter 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 resistance to the force of the balance would be unequal, as the two radii of the unlockings were unequal. Unequal radii must have unequal resisting lockings to subtract equal portions of velocity from the same reciprocated force of the balance.

NOTES ON PINIONS.

CLEANING PINION LEAVES.—Take a piece of pegwood and clean the leaves of pinions. If you find any of them rusty, clean with pegwood and oilstone powder and oil.

OILING ROLLER JEWEL.—Some watchmakers recommend oiling the roller jewel. Never do this, as the roller jewel in its flying motion (being sticky from oil) will gather dirt and foreign substances, and soon clog in the fork, and beside this, it is perfectly superfluous, as it does not lessen the friction or improve the fork and jewel action.

CANNON PINION.—When putting on the cannon pinion, see that it is tight enough, and give it very little oil: the friction lasts better than if it is dry. To tighten a cannon, file in the side with a small round file, and punch in until right; to tighten the Swiss center arbor, roll it between two files and oil it slightly when you put it in.

Cannon Pinion.—A loose cannon pinion can be made to fit snugly by running the center-point of the center pinion back and forth between two files.

Pinion Leaves.—If the repairer comes across rusty pinion leaves, he must clean them with pegwood and oilstone powder and oil.

Replacing Pivot of Hollow Pinion.—It often happens that the pivot of a hollow center pinion is so deeply cut that it cannot be repolished in consequence of the careless manner in which too many factories finish their center holes. If the pinion itself is found to be still in a good condition, it can be made serviceable as follows: Cement the pinion, with its wheel attached, firmly to the chuck of a lathe after having removed the two worn pivots, and when it is accurately centered, increase the hole by means of a drill that is a trifle larger than the original pivots; in the hole thus enlarged and carefully smoothed, insert a close fitting steel tube that has been hardened and tempered to a blue color, which must be smoothed and run true. The portion of this tube that projects on either side is then adjusted to the proper length, and it only remains to polish the pivots.

Loose Cannon Pinion.—Remove the center wheel and put the end of the staff in a solution made as follows: 1 part cyanide of silver, 10 parts cyanide of platinum, 100 parts of soft water. Leave it in the solution till the proper size is obtained—the size it was when new, or till it fits the cannon pin. Immerse the worn part only.

Tightening a Cannon Pinion.—The best way to tighten a cannon pinion is to take the pinion and place it between two files of medium fine cut, placing one file on the edge of the brush and the other in the hand. Place the center pinion between the files and run the file in the hand in a parallel direction. This raises a little burr on the pinion and does not bind it, and is sufficient to hold the cannon. Cutting around with the cutting pliers is apt to bend if not break the pinion, besides spoiling both pinion and cannon in a little while if the watch is set often.

Beveled Pinions.—In watch work beveled pinions are seldom or never formed correctly, the teeth being formed by one cutter, which cuts the spaces out the same width throughout, instead of tapering them, as they should be, and consequently the teeth (even if they were cut at the right angle, which they seldom are) are only touching at the extreme points; but as they are only used for the winding work, and are in action for only a short time, not much attention need be paid to this, the main object being to get a good depth and a smooth action, and this will be best secured by attention to the shape of the teeth and to their angles with regard to one another.

Lantern Pinion.—The lantern pinion, as used in the German clock, is a very good form of pinion for a follower, all the action taking place, even in low numbered ones, after the line of centers; but it is not suitable for a driver, because then the action would be reversed, and would all come before the line of centers. It is much used in French turret clocks, but it is not used much elsewhere, though there is no reason why it should not be, it being especially suited for the cheaper clocks, and it might be made as cheaply as the ordinary drawn pinions. Of course, it could not be used for watches or very small clocks, as the collets or bushes into which the pins forming the leaves are riveted would take up too much room.

Parachute.—Bréguet devised the parachute, thinking that if the watch is let fall or subjected to sudden jerks in any other way, the balance staff pivots may be saved from breaking by the yielding of the end stones.

NOTES ON PIVOTS.

Pivoting.—Everybody knows what it consists of, but there are few who can take a fine staff, pivot it, and hand it over to some colleague for inspection, and not have something said about one thing or the other not being just right. In the first place, the broken staff must be accurately centered in a finely centered chuck, and then the end should be smoothed off, but no more than enough to present just enough surface to catch a center with a fine graver point, and do not cut the center any larger than the diameter of the drill to be used. Should the shoulder at the rut of the pivot be very small in diameter and inconvenient to drill with a small drill, it may be turned off even with the hair-spring shoulder and a hole drilled of sufficient size to hold a plug from which a new shoulder and pivot can be turned. I generally use for plugs needles which have been tempered to the proper degree. In filing them into shape do not temper them too much, for they are almost sure to split the staff when driven home, or will be very apt to work out of the hole while being turned. Get the taper to be almost imperceptible; it is better to have them parallel than too tapering. Never draw the temper from the staff. If the graver can be made to cut the center very readily, there is no reason why a drill could not be made to cut, for if the graver can be made hard enough, there is no reason why the drill cannot be made just as hard or harder.

POLISHING PIVOT.—After the pivot has been turned and satisfactorily fiinshed, take the square-edged polishers and proceed to polish the shoulder at the root of the pivot, and at the same time face the top of the hair-spring shoulder, if it has been left square. First use your steel polisher and oil-stone dust to remove any graver marks, and follow with the bell metal polisher and crocus-antimony, and finish with diamantine; then burnish.

HIGH FINISH ON PIVOTS.—If you are not satisfied with the finish on a pivot produced by the pivot polisher, you may put on a higher finish with another lap (bell metal) and diamantine, or jewelers' rouge and oil. To finish by hand, you had better turn the cuts out with the graver, as it takes too long to dress down with soft iron file and oil-stone. To get nice corners, always dress polisher with the file, after each application of polishing material, and use a polisher curved on its face next to the shoulder.

PIVOTS BLACKENING.—The quality of the oil has much to do with the blackening of the pivots, and those which have the greatest friction will become discolored first. In ordinary watches jeweled in the third and fourth wheel holes, the lower third wheel pivot will be blackest, it having the greatest friction, from being so close to the action of the center wheel in the pinion; and if the center holes be jeweled, the bottom pivot will generally be found more discolored than the top one from the same cause.

SHAPE OF PIVOTS.—It is somewhat of a disputed question what is the best shape for pivots that turn on cap jewels. In my opinion the cylindrical decidedly is, but the bearings should be conical. Not only does this shape give more solidity, as pivots with rectangular bearing are always more liable to break than the former, but the conical pivots can always be made shorter and consequently finer. They also present less surface for capillary attraction, and there is less likelihood of the oil running from the pivot hole.

LENGTH OF BALANCE PIVOTS.—For 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 eight 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 depthings are bad, in consequence either of the teeth being badly formed or the holes too large, etc. To test the latter point, cause the wheels 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 practise, 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.

BALANCE STAFF PIVOTS.—The pivots to the balance staff should always be carefully examined. See that they are not too wide in their jewels; if so, replace by closely fitting jewels. Watch the cap jewels to see that they are not pitted; if so, replace or polish them with fine diamond dust on black tin or tortoise shell.

BALANCE STAFF PIVOTS.—There is no part of a watch repairer's work that requires so much constant attention as the pivots of the balance staff, either from the watch having had a blow or a fall; or very often, from the balance having been put into the frame carelessly, the end of the pivot will have become flattened or will have a burr thrown up on one side of it which, although it may not be sufficient to stop the watch, will certainly prevent anything like good timekeeping.

BROKEN BALANCE PIVOT.—If a job comes in with only one pivot gone on the balance, always make a new staff; never put in a new pivot, which, if done, nine times out of ten will spoil the staff, and then it will not run true.

END OF PIVOT.—As for the end of a pivot there is considerable controversy as to how it should be shaped and finished. Some workmen claim that a pivot left only slightly rounded will give better results than when entirely rounded, and in some watches either one or both pivots are found perfectly flat, which is usually done to correct certain position errors. I generally finish my pivots slightly round.

NEW CENTER PIVOT.—It occurs quite often, says a writer in a Continental exchange, that one of the center pivots is badly worn, and can no longer be made to serve by polishing; nevertheless, many repairers try to do it, with the one never failing result, viz.: it breaks under the polishing file. In such cases the pinion must be renewed if the repairer cannot put in a new pivot.

Some time ago, I learned a new knack from a very skilful fellow-journeyman, by which one may put a pivot into a center pinion just as easily and nicely as can be done into a balance staff, etc. If correctly made the pivot sets as firmly as if it were of one piece with the pinion; this is not injured at all, and the place where inserted cannot be recognized after finishing the repair, and which of the two pivots has been inserted cannot be distinguished.

No one can say that this is a piece of botch work, and I make use of this method and advise others to do the same thing, not only on account of the saving of time, but also in all cases where I meet with a defective center pivot in a fine grade watch. It is true, the good repairer will, by using sufficient time, make just as good a new pinion as the old was; still the wheel will be strained more or less by taking it off; but this danger is entirely avoided by in serting a new pivot as follows:

Mount the pinion first on a turning arbor and turn off smoothly to the injured pivot, without, however, injuring the burnishing of the pivot shoulder. Then choose a drill corresponding exactly to the thickness of the new pivot, and take the wheel directly upon the lathe, by letting the other pivot run backward in a center, while in front you have set the T-rest squarely to the wheel and have laid the drill upon it. You may hereby let the carrier pin operate directly upon the wheel crossing, and in this manner you will drill into the pinion a hole which must be 1½ times as deep as the pivot is long.

After having performed the drilling, begin with the pivot by making a steel tube, the inner width of which truly corresponds to the thickness of the center staff. Before it is finished harden and anneal it blue, then reduce it by grinding so that it fits precisely and truly into the hole, after which burnish it handsomely. Corresponding to the bottom of the hole, taper the entering end of the tube, afterward insert it and drive it home with a few taps of the hammer if necessary, chamfer the hole in the center pinion, shorten the new pivot to its correct length, and the job is ready, without occupying more than one-fourth, or at most one-third the time necessary for inserting a new pinion. Not a trace can be seen of the pivot shoulder, provided the job has been done in a workmanlike manner. In this way it is possible to oftentimes preserve a handsome and well-made center pinion, which could never be replaced by one bought in some material store.

TO REPAIR THE FUSEE TOP PIVOT.—First file up and repolish the square, taking off the corners sufficiently to prevent them standing above the pivot when it is repolished. Put the square into an eccentric arbor, and get the fusee quite true. Now put a screw ferrule on to the fusee back arbor, and put the whole piece in the turns with the eccentric in front, using the bows on the ferrule at back. If the pivot is much cut it should be turned slightly with the point of the graver. Polish first with steel and coarse stuff, and finish with the glossing burnisher.

LAP FOR POLISHING PIVOTS, ETC.—Those who have much experience in polishing may, with advantage, use a lap for straight pivots and shoulders. The lap and pinion are rotated in opposite directions by means of two bows held in the right hand, the lap being centered in the back limb of a depthing tool and the pinion in the front one. An arm is fixed to the depthing tool to hold it in the vise, and a piece of brass wire clasps the rudders of the front limb, so that the operator can move the pinion to and fro with his left hand. A soft steel lap at first, and a fine lap afterward, are generally used. They should be turned true on the edge and the face slightly undercut.

To Redress a Bent Pivot.—For this purpose some workmen merely use a pair of pliers or tweezers; others place the pivot in a slot of the Jacot tool, and press on it with a burnisher that has little or no cut, at the same time causing the shaft to rotate. Another good method is to drill a number of straight holes in a plate exactly at right angles to its surface. Now introduce the pivot into a hole that fits it with little play, and redress it by causing the staff to rotate, and the same time holding the plate in the hand. Caution is necessary, since there is some risk of bending the pivot too far.

Foot Pivot in a Cylinder.—A steel stake with a large number of closely graduated holes is essential for this purpose; stakes of this kind, especially made for the purpose, are kept for sale in many watchmakers' material stores. Having tried the cylinder into the holes until one is found that fits tightly, then the hole immediately smaller is the proper one to use while pushing out the plug, which is done with an appropriately shaped plug made from a piece of mainspring hook wire. A new plug is then turned up and fitted carefully, so that a tap of a hammer will drive it home to its place. Before placing it in the cylinder, the end should be polished off square with the lap in a screw-head tool. The plug is then driven into its place.

Rounding a Pivot.—In rounding a pivot a highly polished burnisher is used. Always begin from the edge to the center of the pivot, for if it is polished from the center to the edge a burr will be formed which will sometimes give trouble.

Bent Pivots.—If a pivot is bent, place in pliers and blow the flame from your lamp on to the pliers until the temper is drawn from the pivot; then press them together, and the pivot will be straightened in two or three trials.

Bending Pivot.—If a cylinder pivot is bent it may very readily be straightened by placing a bouchon of a proper size over it.

Polishing Conical Point.—A soft steel polisher made to suit the pivot is used with either oilstone dust or rouge. 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 on a piece of lead with emery, which makes an equally good pivot.

Balance Staff Pivot.—There is a little difference of opinion as to the proper shape for the ends of balance staff pivots. Many manufacturers say the watches time better if the ends are left nearly flat; this, however, is disputed by others, who prefer the pivot ends to be left rounded.

Conical Point.—The cone should be an easy curve dying away 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 runner of the turns. Every time the work is examined the bed of the runner must be cleaned 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.

Broken Pivot.—If a job comes in with one pivot gone on the balance, put the balance in a split chuck, and proceed to stone off the end of the staff. Then take a graver with a fine point and center it nicely for drilling. If possible, always make your own drills. A correspondent makes them of Sharpe's best needles, which he considers better than wire. He draws the temper, files down to size, and hammers the end flat, shapes and sharpens it, and then tempers it. Resin is used for tempering, but we all have our own way of doing that. The drill being ready, the lathe is run at a slow speed, and the operation commences. When you have drilled twice the length of the pivot, stop and clean out the hole thoroughly with a piece of pegwood. Then select a nice piece of Stubbs' steel wire, and getting the right temper, file down to size, making sure at the same time that you do not get it tapering. When you have it down to size, take a hammer and tap the end gently until you get it down to the bottom, then turn down the pivot to size to fit the jewel; next finish it, and the job is complete. In finishing, first use a small oilstone slip to get a gray finish, and then use lime and crocus mixed on a square piece of boxwood, which leaves a fine finish on it.

NOTES ON THE MAINSPRING.

PUTTING IN A NEW MAINSPRING.—It would be quite useless to lay down any rule for the length or strength of a mainspring to be put into a watch coming for repairs, as in nearly every case the matter is arbitrary and must be determined, not by any principle, but by the work the mainspring has to do. In full-plate watches, of foreign manufacture, the balances are generally too large, and if the escapements are also large and not very good, a spring as strong as the capacity of the barrel will admit of will be acquired. The number of turns of the spring in the barrel is no sure indication of the number of turns the barrel will make by the spring unwinding, as the spare space in the barrel, which is partly governed by the size of the barrel arbor and partly by the thickness of the spring, determines the number; but the mainspring should only occupy half the space of the barrel bottom with the arbor in the place.

The best method of attaching a mainspring to a going barrel has given rise to much controversy, any addition to which would be out of place here; nor would it be very useful to repairers, the manner being generally settled for them, as a new spring must be hooked in as its predecessor has been; and, as it is now the universal practise to put a simple steel hook in the barrel and a hole in the end of the spring, it is only necessary to see that the hook projects very little beyond the eye of the spring, and that it is at a sufficient angle to prevent the spring from slipping off. The hole in the spring should be oblong, and made with the lever punch, which is much used for this purpose. The hole should be square at the end, and beveled off from the inside to give it a good hold on the hook; and the end of the spring beyond the hole should not be left longer than what is necessary for strength; but should be made square at the end and rounded off from the outside. One often finds mainsprings choked up by having a quantity of oil put on them which has not been removed when other parts of the watch were cleaned. The spring in a fusee watch should not have oil put to it; all that is necessary is to see that the spring is put into the barrel in such a state that it will not rust; and the best way to insure this is to apply a small quantity of oil to a narrow strip of wash leather and draw the spring through it before winding it into the barrel.

If a strong mainspring breaks in a going barrel, it sometimes breaks a leaf or two out of the center pinion, as neither Swiss nor English watches are furnished with Fogg's patent pinion; but I oftener have found a broken third-wheel pivot to be the result; and if the spaces of the center pinion were cut round at the bottom, as they should be, the patent pinion would be of very little use in so far as the center pinion is concerned.

Great care should always be taken when winding a spring into a barrel; the winder should be quite true and never smaller than the barrel arbor.

NOT TAKE OUT MAINSPRING.—If it can possibly be avoided, a mainspring should never be taken out of the barrel, because the spring is thrown into an unnatural shape in so doing, and is afterward much more inclined to break. Many a good spring has been spoiled in this way. Some watchmakers think benzine will cause a mainspring to break if washed with it. This can be avoided by washing in alcohol and letting it dry before being oiled. I have used benzine for many years and never could see that it caused a spring to break.

TRACTION 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 circumstance 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, a uniform action in the same conditions is not the result. Nothing indeed is more interesting than experiments on their action, to prove the irregularity produced by them, as far as this action is concerned, even with springs of the same height and thickness of blade; this irregularity is a great defect.

THE MAINSPRING.—Pay particular attention to the mainspring. There are lots of theories why a spring will break just after cleaning, but I only know that since

I have adopted the method of never taking out the spring, except when, after taking off the cap of the barrel, I find it is all gummed up with bad oil, and then of course I clean it. I have found that a spring does not break any oftener than is common, even if the watch is not cleaned; but I invariably remove the barrel arbor and clean out the holes and the barrel itself.

CLEANING MAINSPRING.—The mainspring should be cleaned by wiping it with soft tissue paper, being careful not to pull it out straight. It must never be put in the benzine, for this would remove that peculiarly oily surface which is obtained by working in the barrel. Put the spring in with a winder.

FASTENING MAINSPRING.—Among other methods of attaching the outer end of the mainspring to the burrel, one of the most simple and effectual, by Mr. Philippe, is to coil inside of the barrel a piece of thicker mainspring of a little more than one complete turn in length, so that the ends just overlap. The mainspring of the watch is riveted to this loose piece, the adhesion of which against the barrel is sufficient to drive the watch. Three or four half-round grooves are cut inside the rim of the barrel, and a corresponding projection riveted to the outside of the loose piece, and the clicking of this projection as it enters the grooves indicates when the spring is fully wound.

FRICTION OF COILS.—In order to diminish the friction of the coils in a going barrel, mainsprings have been made heretofore with the outer coil curved backward, so that the spring, when unconstrained, takes a form something like the letter s. This spring is made with a view to the better separation of the coils upon the spring's unwinding as the outer coils will fall more readily away from the inner ones toward the edge of the barrel when the spring is bent in this way than when it is straight or of the usual form. It is said to be freer in the barrel, but more liable to break.

HOW TO SELECT A MAINSPRING.—Of all parts of a watch, the mainspring is perhaps oftenest repaired. Before proceeding with our remarks we would advise the repairer to always buy the best material, as it pays both the repairer and the customer. When you replace a spring examine whether the breaking of the old spring has not bent any teeth on the barrel or center wheel. See if the hook on the barrel arbor is not too long, so as to break the spring you are about to put it in. If everything is right in your judgment, select a spring of the proper thickness and width; wind it and put it in, taking care that the brace end does not stick through so as to catch the center wheel or balance as it comes round. If these points have been observed you cannot help but have a good job.

MAINSPRING FASTENING.—It is worthy of notice that all the best Swiss watches have a rigid attachment of the mainspring to the barrel, as, although the hook is in the barrel, and the usual oblong hole in the spring, the attachment is made rigid by the pivotal brace or post, which contributes greatly to the free action of the spring, and prevents to some extent the friction and adhesion from the coils rubbing against one another.

MAINSPRING TO BE PUT IN.—When a mainspring is to be put in, care should be taken not to move the regulator when removing the balance. Put in the new spring of the same length and strength as the old one. Oil it and wind it three or four times to test it before replacing the barrel. The cannon pinion can best be tightened by rolling the part between two files.

EXPERIMENTS WITH MAINSPRINGS.—From a great many experiments with mainsprings made by French watchmakers, in a variety of ways the result seems to be that a spring of moderate length, set up about a turn, with something to spare, will have an easier action in the going barrel and be freer from adhesion and clustering than a spring of greater length, although the longer spring may give a more uniform pull if set up several turns.

MAINSPRING UNCOILING.—A mainspring in the act of uncoiling in its barrel always gives a number of turns equal to the difference between a number of coils in the up and down positions. A celebrated watchmaker says: "Thus if 17 be the number of coils when the spring is run down, and 25 the number when against the arbor, the number of turns in the uncoiling will be 8, or the difference between 17 and 25."

BARREL ARBOR.—In the absence of a suitable top or screw plate when turning in a Geneva barrel arbor, if the collet is good it may be used as a plate. Soften the collet and file two slight passages across the three with a fine three-sided file, screw a piece of brass wire through the collet so as to clear the threads of burr, then reharden the collet and cut the screw or the arbor with it. A pair of pliers with faces curved to suit the collet are used to hold it. In an emergency the old arbor may be prepared for use as a tap if the old collet is not available.

Displaced Barrel.—Remove the arbor from the barrel. Turn a washer of brass or steel the same size as the arbor. Put it —the washer—on the inside of the barrel on the arbor below where the mainspring winds.

Self—Winding.—It is well to know that several styles of self-winding are in existence. Among others, one by M. Lebet, for winding the watch by action of closing the hunting cover; but as it can be applied only to a hunting watch, the arrangement is of limited use only. Another invention of Herr von Loehr utilizes the motion of the wearer's body for winding. There is a weighted lever pivoted at one end, and kept in its normal position against the upper of two banking pins by a long curved spring so weak that the ordinary motion of the wearer's body causes the lever to continually oscillate between the banking pins. Pivoted to the same center as the weighted lever is a ratchet wheel with very fine teeth, and fixed to the lever is a pawl which engages with the ratchet wheel. This pawl is made elastic so as to yield to undo strain caused by the endeavor of the lever to vibrate after the watch is wound. For setting hands there is a disc which has a milled surface slightly cupped to suit the point of a finger.

NOTES ON THE STAFF, ARBOR, WHEEL, TEETH AND DEPTHING.

Turning in Staff.—Should you be unable to get the rough staff to run exactly true, just get it to run as true as you can, as it will not make any difference whether it is exactly true or not at this stage of the work. Now, with a medium-sized and well-sharpened graver proceed to turn the shoulder to fit in the hole of the balance. There is no necessity for taking the measurement with an instrument, for we have the hole, and it must be tried frequently to avoid turning it too small; for if it is too small it will be impossible to fasten the wheel on centrally. It should fit very snugly and at the same time not so tightly as to require any force to put in place. The corner must be cut out clean and sharp, which can only be done with a very finely pointed graver. Another point to be observed at this stage is to see that the seat for the balance is perfectly flat; for if it is undercut, even to a slight degree, it will have a tendency to throw up the other ends of the balance arms, and thus distort it and change seriously, if not entirely ruin, its rate.

Balance Staff Complete.—When you have one end of the balance staff complete, carefully turn off the shellac and turn down the center or hub of the staff to proper size, and cut back from the left-hand side to proper thickness, and then with the flat polishers proceed to polish the outside of the hub; then turn off the shellac, gradually turning the staff true as you go along, until it is cut back far enough for the length of the roller end; cut it off at this point and preserve as fine a point as possible, as it is to be used as a center.

Pivoting Balance Staff.—Never pivot the balance staff of a fine watch, especially an adjusted movement, as removing the temper from any portion of the balance staff destroys the adjustment to heat and cold. If your customer insists upon cheap work, explain to him the injury it will do his watch, and, if he still insists, it may then be permissible to put in a pivot.

To Temper a Staff.—For tempering a staff, the best way is to pack it into a metal receptacle, similar to a baling-out cup, filled with fine brass filings, in such a manner that the color may be observed as the changes occur. Hold the receptacle over an alcohol flame and subject it to about 530° F., which would bring the color of the staff to a dark purple. This, I think, is sufficiently hard for a balance staff, which should by no means be made softer. It will upon a fair trial be found that a staff of such a degree of hardness can be very readily turned with a good graver in good condition, is capable of taking a very fine polish, will produce a good coloring pivot, and will stand more hard usage, while in the watch, in the way of sudden shocks and falls, than a staff either of a greater or less degree of hardness.

To Make a Balance Staff.—A subscriber says that in the making of a good, fine balance staff, the steel from which the staff is to be made is the first consideration.

As to quality, it is beyond question that the very best only is suitable for such a purpose. When he turns his own blanks, he uses Stubbs' wire steel of the required diameter, than which nothing better can be procured. Material stores occasionally have some very good blank staffs, sold at from 40 to 50 cents per dozen. They are supposed to be tempered, but it is advisable for the watchmaker to attend to this part himself, so as to know exactly what kind of metal he is working.

CENTER WHEEL ARBOR.—The arbor of the center wheel is sometimes cut or worn. Put it in the lathe and turn it down smooth; but always stop before turning off the shoulder entirely, as enough must be left for the cannon pinion to rest on, or it will bind on the plate.

SIZE OF BARREL ARBOR.—A good deal of stress is laid by various writers on the necessity of a proper sized barrel arbor; but if the arbor used is too small, as it is often, especially in fusee watches, when too thick a spring is used, the mainspring will break at the eye, unless it is made very soft at that part, when the only effect will be that it will bend round the arbor, acting as a larger arbor and reducing the acting length of the spring. The size of arbor found to answer best, allowing of the necessary length of spring and preventing too small a circle at the eye, is one-third the inside diameter of the barrel; the arbor should be snailed, so that when the spring is wound on to it, it will take a spiral form, and not be disturbed, as it would be by winding on a circular arbor.

WHEELS AND PINIONS.—Wheels and pinions are divided into two kinds, which are called drivers and followers. In watches and clocks, the wheels are the drivers and the pinions the followers, except in the dial wheels, or motion work, the winding work of stem-winders, and some parts of complicated Swiss watches. The main object to be aimed at in the gearing of wheels is to avoid "engaging friction," that is friction which takes place through the teeth coming into action before what is called the "line of centers" (a straight line drawn from center to center of wheels gearing together), and the reduction to a minimum of the drop or shake of the teeth. This object is best attained by the use of epicycloidal teeth for the drivers and hypocycloidal for the followers, and these forms of teeth are the only ones the watchmaker has to consider.

SIZING WHEELS AND PINIONS.—The numbers of a wheel and pinion and their distance apart from center to center being given, their respective pitch diameters may be obtained by means of the sector, provided it is equally divided all through. Suppose a wheel of 60 and a pinion of 8 are to be planted 75 apart; open the sector so that at 68 (which is the sum of then wheel and pinion teeth) the width between the limbs is double the distance of centers —that is, 1.5 inch. Then the width between the limbs at 60 will represent the pitch diameter of the wheel, and at 8 the pitch diameter of the pinion. Or the full diameters may be obtained at one operation instead of the pitch diameters by adding three to the number of the wheel-teeth and 1.25 to the pinion, if it has circular, or two if epicycloidal addenda. Say it is a circularly rounded pinion, the sector would then be opened so that at 72.25 the width was 1.5 inch, and the width at 63 would represent the full diameter of the wheel and the width at 9.25 the full diameter of the pinion.

NEW WHEELS.—When a new wheel is applied to a watch under repair, it is necessary that the angle of the old wheel's tooth should be looked to, as well as the wheel's size and thickness of the tooth's point. If a pallet depth is shallow, and a new wheel is put on of a trifle larger size, care should be taken that the new wheel is not more sloping in the teeth than the old one, or else the pallets will be bound unduly hard; it is best to have the new wheel a little straighter in the teeth, if possible.

WHEEL GAUGING.—In gauging wheels and pinions round holes should be used as sizes where practicable, as the full diameter cannot be measured on a slide gauge if the teeth are not immediately opposite one another; and, it should be remembered in depthing wheels and pinions that it is the pitch circles of the wheels and pinions, and not the diameters, which are proportional to the number of teeth contained in them, so that allowance must be made for the parts beyond the pitch circles, which vary with the width of the teeth and the size of the generating circle used in tracing them.

STEEL WINDING WHEELS.—I invariably lubricate them slightly, not only to make them move easier, but also for the following reason: I have often noticed that after they have been in use for some time a red dust is formed, especially when the depth ing was not truly exact. This dust consists of oxidized parts of steel, and will find its way into the movement. It is most dangerous, especially at the pallets, as it dries the oil. This occurrence is followed not only by a deviation of rate but may also provoke the standing of the water, especially if the draw is somewhat deep.

CLUB-TOOTHED SCAPE WHEEL.—A club-toothed scape wheel allows of a closer action than a ratchet tooth. Grossmann, in his Essay, chapter 7, gives three degrees for drop with a ratchet tooth, but that is more than sufficient. If the wheel is a good one, with a fine tooth, two degrees are enough and leave one-half degree of shake, though pallets are more often made with three degrees of drop than they are with two degrees.

CYLINDER HALF-SHELL FOUL OF WHEEL.—In the repairing of Swiss watches, the cylinder half-shell will sometimes be found foul of the wheel. In this case, it may sometimes be found possible to raise the cylinder sufficiently by stoning down the brass setting of the lower cylinder end-piece, where there is much space between it and the jewel holes; at the same time it should not touch it, as in that case the oil would be prevented from entering the reservoir, and the pivot would speedily run dry. If this method is not available, the cylinder notch can be lowered by either a ruby file or steel polisher and oilstone dust, resting the balance on either a piece of pith or cork while doing so.

CYLINDER SCAPE-TEETH.—If the teeth of a cylinder escape wheel are too high or too low in passing the opening of the cylinder, the wheel should be placed on a cylinder of soft brass or zinc, small enough to go inside the teeth, with a hole through it and with a slightly concave face. A hollow punch is placed over the middle of the wheel while it is resting on the concave face of the brass or zinc cylinder, and one or two light taps with a hammer will bend the wheel sufficiently. In fact, care must be taken not to overdo it. It really happens that the wheel is free neither of the top nor bottom plug, but should this be the case sufficient clearance may be obtained by deepening the dust or with a sapphire file. A cylinder with too high an opening is bad, for the oil is drawn away from the teeth by the scape wheel.

SHAPE OF TOOTH.—Although epicycloidal teeth are practically the nearest thing to perfection it is possible to attain, they have the disadvantage of a slight rubbing friction on one another in receding from the line of centers; and what are called involute teeth—that is, teeth having the acting curves of the shape described by any point in a string unwound off the circumference of a circle—were sometimes used in order to prevent this, and where several pinions geared with the same wheel in the old French turret clocks and train remontoires; but notwithstanding any advantage they possess in the saving of friction on the pivots caused by their obliquity and the squeezing pressure they produce, and although they are theoretically the perfect teeth, the surfaces rolling on one another throughout the contact without any rubbing friction, they are now looked upon as entirely useless.

BROKEN TEETH.—The best way to replace a broken tooth is to discard the wheel and supply a new one. To replace a broken tooth in a barrel, drill in about one-eighth of an inch with a drill smaller than the thickness of the back of barrel; lap the hole and turn a piece of brass wire to fit the hole; cut the thread and screw in, then file down to match the center pinion.

BROKEN TOOTH.—If there is a tooth broken on the barrel, I drill a small hole and cut a thread into it. I then take a piece of brass wire, file it down, cut a thread on it, and screw it down tight. Then file off the right length and thickness of the other teeth. If there is a tooth broken on any of the other wheels, I always put in a new wheel.

PUTTING TEETH INTO WHEEL.—Suppose a tooth is broken out of the barrel—which is the case nine times out of ten when any is broken at all—take your saw, cut a slot as deep as the barrel will bear, shape a piece of brass to fit the slot tightly. Now take one ounce alcohol, one half-ounce chloride of zinc, mix the two ingredients and let stand twenty-four hours. Now take a small piece of tinfoil and solder the new tooth in, using the above solution instead of acid, and proceeding just the same way as you would solder anything else. This, after being dressed up, will show little or no lines of solder, will not rust the pinion, and will stand as much pressure as any tooth in the barrel. Any wheel may be mended in like manner.

VISIBLE DEPTHINGS.—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 jewel 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. Depthings that cannot be clearly seen or about which any doubt exists, must be subsequently verified by touch. If examining a new watch it may be found necessary to form inclined notches at the edges of the cocks or near the centerhole of the plate so as to see the action of the depthings. But it is important that the settings 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 DEPTHINGS.—These must be tested by touch in the manner well-known to every repairer, and the requisite corrections applied after having polished the pivots, etc., as may be necessary. We would observe that holes a trifle larger are less inconvenient than those which afford too little play, providing the depthings are in good condition.

EFFECT OF BAD DEPTHING.—Repairers are often puzzled by the statements of owners who bring their watches for cleaning that they are good timekeepers, but after having been cleaned and put together again they are everything but that. This is due to the depths having been set by forcing the cocks with the pliers the last thing, in the required direction, and when unscrewed they will resume their original position.

SECURING THE DEPTH.—When the pallet depth is *barely safe*, and the pallets exceedingly full to the wheel, the depth may be made secure by polishing up both locking a good bit. They must be done a good bit, else it will not be any use; this will save putting on a new wheel.

TRAINS.—The train of wheels in a watch or clock is the method of applying and the medium for regulating and distributing the power from the prime mover to the escapement, which regulates the speed. The power exerted by wheels on pinions is inversely proportional to the relative diameters of their pitch circles, and they may for purposes of calculation be considered as a series of levers, the centers being the fulcrum, and the acting parts of each tooth at the line of centers being their effective strength.

NOTES ON JEWELING.

STONES FOR JEWELING. — The stones used for jeweling watches are the ruby, sapphire, chrysolite and garnet; a thin rose diamond is generally put as an endstone to the balance cock of English watches, but only as an ornament, and that is the only diamond ever used in the jeweling of a watch. There is an uncharitable belief that watchmakers sometimes change the jewels in watches for stones of inferior value, but there is no foundation for the calumny, as the time spent in making the exchange would certainly exceed the value of the jewels.

LOOSE JEWEL HOLES.—Loose jewel holes will often cause the watch to stand, especially lever watches. It is advisable, therefore, when repairing a watch to examine the state of the holes, best in the following way: After having laid into benzine all the parts with jewels until the old oil is all dissolved, take them out and dry; then take a short annealed round broach, insert it with a light push carefully into the pivot hole and turn it to the right and left. It will often be found that jewel holes having every appearance of being quite firm can easily be turned with the broach, care is necessary when doing this not to exert any down pressure with the broach, because it might injure the hole. This examination must be conducted with great care in cheap watches with inferior jewels, as these might burst thereby. Set cap jewels are best tested with a broken broach ground to a point, by trying to push the jewel with it in four different directions—obviously before the pivot hole is lubricated. These tests must always be made by using the magnifier; burst jewels, even though they look ever so innocent, should not be left in a watch.

JEWEL HOLES.—There are so many reasons in favor of good jewel holes that every good watch should have all the train holes jeweled. Garnet is largely used for jeweling common watches, especially in the collets to lever escapement; it is of the same hardness as chrysolite, but not so brittle. The pallets are soon cut, a few years' wear pitting the rubbing face of the stone on which the escape wheel tooth drops, in which case the only remedy is new pallets, as to polish out the pits would spoil the escapement. Chrysolite would answer better for pallet stones, only it is not so like ruby as garnet is. Garnet is also used for the impulse pins of lever escapements, but the least violent external motion to the watch will break off the pin, if the balance is a heavy one, and the cost of replacing it will be many times the difference between the original price of ruby and a garnet pin.

SHAPE OF JEWEL HOLE.—There has been considerable difference of opinion among watchmakers as to the best shape of a hole; some advocate a long straight hole with a pivot largest at the extreme end to lighten the friction; but no person who has had much experience with the going of watches would think of making a balance-staff pivot unnecessarily weak, and of a form most liable to injury. A jewel hole should not be straight, but rounded from both ends to the middle, so that the rubbing surface shall be small and equal, whatever the amount of end shake may be.

WIDENING A JEWEL HOLE.—Chuck a hole in the lathe with cement. Place a spirit lamp underneath to prevent the cement hardening. Hold a pointed bit against the hole while the lathe is running until the hole is true, then remove the lamp. The broach to widen the hole should be made of copper, of the size and shape required, and the point, after being oiled, should be rolled in diamond dust until it is entirely covered. The diamond dust should then be beaten in with a burnisher, using very light blows, so as not to bruise the broach. After the hole is widened as desired, it requires polishing with a broach made of ivory and used with oil and the finest diamond dust, loose, not driven into the broach.

WATCH JEWELS.—When fitting hole or cap jewels always try to get a good fit, never cement or fasten them with shellac. Should a roller jewel be lost or broken, select one that fits the lever fork closely, as much of the impulse is lost by a jewel being too small. Use a jewel pin setter to set the jewel, and always fasten with shellac, being careful to put on as little as possible. The jewel, if rightly set, should carry the lever clear into the locking; if this is not the case the safety pin will roll on the edge of the roller table. Backing pins should be so set that the roller jewel on its return will strike into the lever fork and not on the edge. Pallet jewels also should be fastened with shellac.

THICKNESS OF JEWEL HOLES.—When adjusting a watch, the thickness of the jewel holes is quite an important factor. Unduly thick jewel holes cause difference of rate between the horizontal and perpendicular positions; they must either be replaced by new or reduced to proper size, should they be too thick. This reduction is done with a copper chamfer, and diamond powder (not to be mistaken for diamantine), mixed with oil. This diamond powder can be bought at every watch material store; there are three numbers, Nos. 1, 2, and 3. No. 1 is used for grinding; No. 2 for first polishing, and No. 3 for fine polishing. The reduction of the hole is continued until the hole is as thin as the length of the pivot. The sharp edge of the hole produced by the correction of the jewel is chamfered with a pivoted copper chamfer, by twirling the tool.

SETTING PALLET JEWELS, RUBY PINS, ETC.—A good course to pursue when setting pallet jewels, ruby pins, etc., is to heat a piece of shellac over the lamp and draw it out to a long, slender thread; then break the end in small particles of suitable size for cementing the jewel; by this means the shellac may be placed just where it is needed, and it will not run over the pallets or table roller.

END STONE.—A good way to clean an end stone or cap jewel is to lay it down on the bench paper and rub the stone on it with the finger. When about to put in the cock and foot jewels, put in the hole jewel first; then put a little oil on the jewel before putting in the end stone. Be sure to get this in as far as it will go.

RUBY PIN.—A matter that is very essensential for good timing result is the ruby pin; see that it fits loosely in the fork. If you are compelled to replace it and do not have one just right, select a slightly wide one and scratch the fork with the soft iron file and oilstone dust. If the hole in the table will not take a proper one, enlarge with a piece of soft iron wire in the lathe. Draw-file the wire, cover with oilstone dust (with oil, of course), and be careful or you will have the hole too large in a jiffy.

RESETTING JEWELS.—There are many ways to jewel or to reset jewels. A cap jewel is the one we mostly have to deal with, many of which are not set at all. These we will leave unnoticed. Nearly all

American watches have their cap jewels in settings. When one of these is broken or rough, press it out with a piece of pegwood, and then with a cannon jewel-bezel opener turn the bezel back as far as it will go easily, and select a jewel that goes in tight; then with a small burnisher turn the old bezel back far enough to hold the jewel in place firmly. A great many watchmakers do not try to reset them at all. They knock the old ones out and countersink the cap, and lay a cap jewel in the same as a Swiss watch. This is not exactly a piece of good workmanship, but, nevertheless, it will answer all purposes and satisfy the customer. I always have found that a cap jewel with a nice and perfect face fitted close and even to the jewel hole, in or out of setting, gives my customers satisfaction.

CUTTING DOWN JEWELS.—To cut down balance jewels to fit smaller sinks, shellac the setting and jewel on the point of a stiff wire held in the lathe and turned down to a perfect point to enter the jewel hole. Cut with the point of a very sharp graver to the size required.

REPLACE BROKEN FOOT JEWEL.—Remove the broken jewel from the collet or setting; place the collet or setting in one of your lathe chucks, large enough to hold the same; start in motion, and with a fine pointed burnisher raise the bezel sufficient to receive a new jewel; select a jewel to fit both pivot and setting, replace in chuck, and with a little larger burnisher close down the bezel on pivot, and your job is complete.

JEWELING.—There are doubtless no watches made nowadays that have not at least the balance staff holes jeweled, and there is perhaps no watchmaker who will not admit that the holes of the escapement would in all cases be better for being jeweled. I am sure that there are thousands of European watches that would have gone longer and cost less to repair if they had been jeweled in a few more holes, the Swiss alone excepted, as they are jeweled in even the worst watches in as many holes as possible, but done so badly that brass holes would in many cases be preferable.

TO REPLACE ROLLER JEWEL.—The roller jewel requires careful attention in fitting it, as a great deal in the motion of the watch depends on it. Select a jewel that fits the fork, for if it is too small the watch will not take a good motion. Now place it in the hole of the roller, putting a small piece of shellac behind it; the tool I use for heat is one of my own contrivance, and in my estimation, is ahead of anything I have come across. Take a piece of brass about as thick as a five-cent piece, about one-eighth of one inch wide, and about half an inch long; take a small round rat-tail file, put the piece of brass in a pin vise and file a half circle in the end of it. Now from the center of this half circle file a slit a little further down, make the slit wide enough so it will take in a very wide roller jewel without touching it. Now shape up the outside hard, solder the other end to a heavy piece of wire for a handle. Heat this a little and lay it on the roller table with the roller jewel fitting in the slit and the wider part of the staff. You will be pleased to see how nicely the shellac will run around the jewel.

TO REPLACE A ROLLER JEWEL.—Select a jewel which fits the fork, holding with tweezers at the end, dip in shellac dissolved in alcohol and place it in the collet of the roller. Take a piece of brass wire one inch in length and one-eighth of an inch in width, hold the wheel in the right hand and wire in left with tweezers. Place one end of the wire in the flame of an alcohol lamp. Remove tweezers and let the wire rest on the burner of the lamp. When the shellac boils down, if it is crooked, heat the tweezers and grasp the jewel while the shellac softens, straighten, and when the shellac cools the work is done.

Another method of about the same import, furnished by a correspondent, is as follows: The ruby pin comes loose and many times breaks off, when it becomes necessary to insert a new one. When this is the case, I generally use the lever fork or slot as a sure means. Don't select one that is tight, but choose one that is loose enough in the slot to allow you to pass a double sheet of tissue paper on each side; then set the pin. This is a job I always had the least difficulty with, although there has been much comment, plans, modes and machines for this work. After you have a pin the correct size, insert it in the table roller, being careful to remove all the old pieces. Generally, the pin will go in with sufficient tightness to hold it in place. Then lay on a small lump of shellac—say half or one-third the size of a grain of wheat. After you have this done heat a small piece of steel—say a pivot file handle—and hold it under the table or against it, letting one end of the handle remain in the flame of your lamp, and in a second or so the shellac will melt and run to its place nicely and you can guide it to perfection while the cement or shellac is warm. Set the stone straight with the staff and straighten up and down, and you have your job done right and one that will last.

Another correspondent says: Should the roller jewel be broken take out the pieces and match a new one by the lever fork. Do not get it too small or too large, but select one that will clear the fork with a good piece of tissue paper by its side. Then place it in the pin holder, put on your table and fire in with a piece of shellac. Do not use cements, as they are all spoiled sooner or later by exposure to air. The shellac holds them forever, if a good job is done.

ROLLER JEWEL.—To put in a roller jewel, select one as large as the fork will take and be free; any unnecessary shake in the fork is not merely a loss of power, which may be supplied by a strong spring, but is detrimental to good timekeeping. Do not attempt to set the jewel with the roller on the staff; and to remove it the best appliance I have seen is a little table made for the purpose, and which can be had at the tool stores. If you have no special tool for setting pins, it can be done very well by holding the roller in the brass-lined pliers, and the latter in the flame of the lamp until heat enough is imparted to flow the shellac; see that the pin is upright to the face of the roller, and that the flat surface of the pin is at right angles to a line through it, and staff center, without reference to passing hollow, as that is often too much out of correct position. After cleaning off the superfluous surface, which should be done with a brass scraper similar to a chamfering tool, put the roller on the staff and the balance in the watch, and see if the jewel pin will pass freely in and out of the fork, and if it performs its function of supplementary safety-action; if not, it must be put forward or back, as the case demands.

WATCH "SETTING" ON LOCKING.—When a watch "sets" on a locking, and you are sure that the locking angles would still detach after being made to unlock easier, the outside locking may be made a trifle more sloping, and the inside locking more straight (not so much cut under); this will also cause the wheel to take a deeper hold of the lockings, which will be no harm if the pallet depth is not too deep already. If the watch is a small one, having a little steel balance and consequently a very weak balance spring, the spring, when it is so very near its rest, has not power to twist round the pieces to extricate the locking from under the tooth of the wheel. In such cases, the lockings would sometimes have to be so much altered to completely prevent a set, that the wheel should remain stationary where it dropped instead of drawing the pallet inward, and then the guard pin must trust to the momentum of the balance carrying round the lever sufficiently to free the pin of the edge of the roller. Such watches are constantly stopping, and never can be altered until the lockings are made to draw into the wheel. In all such cases it is best to let them set a little, rather than persist in completely getting off the set.

NOTES ON TIMING.

REGULATING IN THE TEMPERATURES.—It is a well-known physical law that heat expands bodies, while cold contracts them; the balance spring is naturally also subject to this law. An increase of the temperature lengthens, and at the same time weakens, the spring, causing a retardation of the watch. In cold it contracts, its elasticity is increased, and the rate of the watch is accelerated. In order to compensate these influences of the temperature, a specially constructed balance—the compensated balance—has been gotten up. It consists of two rims, or parts. The inner part of the rim is of steel, and the outer part, which is of brass, is twice the thickness of the inner, and is melted onto the steel. As brass expands more than steel, the effect of an increase of temperature is that the brass, in its struggle to expand, bends the rim inward, thus practically reducing the size of the balance. With a decrease of temperature the action is reversed. The action, which is very small at the fixed ends of the rim, increases towards the free ends, where it is greatest. The rim is cut, thus dividing it into halves, each of which is free at one end and fixed at the other to the central arm.

As already said, the brass expands more strongly in heat than the steel, in consequence of which the rim bends inward with an increase of temperature; the extreme part of the rim at the cut approaches toward the center of the balance, thereby making this smaller, as it were, and accelerates the motion, whereby the retardation produced by the balance spring growing weaker in heat is counteracted or compensated. In cold, brass contracts more strongly than steel, so that the rim expands, and the extreme ends bend outward, thereby enlarging the balance and causing a retardation of rate, which counteracts or compensates the acceleration, which would occur by the increasing elasticity in cold of the spring. The extreme ends of these rims are the most active parts of the compensated balance, and their effectiveness increases with the division of the weight upon them, and, inversely, their effect decreases in ratio with the amount of weight taken off, and upon this circumstance is based the process of regulating the compensation. If a watch with compensated balance retards in heat and accelerates in cold, the compensation is too feeble; more weight must, from the main body of the balance, be placed toward both ends of the rims; take out two screws standing opposite to each other, and place them into other holes opposite each other, but lying nearer to the effective extreme ends. By this greater weight of the outer parts more weight is carried toward the center of the balance by the bending by expansion, and this affects the retardation of the watch. If the watch accelerates in heat and retards in cold, then too much weight is carried to the center; the compensation is too strong. Two screws, standing opposite to each other, must be moved away from the ends. When the difference is but trifling, it suffices to file away a little from the cut, and to compensate the loss of weight by two other and heavier screws on the first parts of the balance.

The Timing of a Lever Watch.—The greater weight of the balance of a detached lever watch causes a greater friction of pivots in a vertical position, which friction must therefore be reduced to an amount equal to that in a horizontal position, by flattening the pivots and increasing the friction in a horizontal position.

The adjuster must first try the rate of the movement in a vertical position. An approximately close rate is produced by the index, which manipulation requires no description; the last exact timing in this position is effected by the four so-called timing screws. Should the watch retard, screw in two of these screws standing opposite one to the other, but when it advances, draw them out a little, but be careful to do it cautiously; turn one as many turns as the other, otherwise the equipoise of the balance is destroyed. When a correct rate has been obtained in lying, try the watch by suspending. If there is a difference, do as recommended for the vertical position, by means of the timing screws—in such a way, however, that nothing is changed in the timing of the rate in lying. Some equalize differences by changing the equipoise of the balances a mere trifle. This is done as follows: If the watch advances in hanging, the balance is overpoised above toward the pendant; but an overpoise below is required when it retards. If by taking the pendant as starting point, lines drawn between the timing screws would form a cross (+), then, in advancing, the upper screw is to be drawn out a trifle, and the lower one screwed in by that precise quantity; if the watch retards, proceed in an inverse manner—screw in the upper screw and draw out the lower and opposite. If the above mentioned lines form a sign of multiplication (×), treat the upper pair or the lower pair as described for the single screws.

When the watch is laid flat, the balance sinks by reason of its weight, so that the lower pivot rests upon the lower cap jewel; the cone (that part of the arbor passing over into the pivot) comes thereby closer to the oil sink of the jewel hole, and the friction is increased by the adhesion of the oil which enters between. The thicker the cone the greater this friction, and reverse; it is lessened and finally ceases entirely, according to the degree of tapering of this part of the arbor, and herein do we possess a means of equalizing small differences of rate between hanging and lying. If the watch retards in lying, its rate in lying must be retarded somewhat, which is done by increasing the friction by adhesion, moving the cone closer to the oil sink of the jewel hole; in other words, by shortening the two pivots to enable the cone to sink in deeper. The expert watchmaker will know the true quantity to be removed by careful manipulation and examination of the rate. If, however, the watch advances in hanging, its rate in lying must be accelerated by diminishing the friction by adhesion; this is done by grinding more or less, tapering with an iron grinding file the conical shoulders, according to the quantity of the difference of rate observed

Calculating a Lever Watch Train.—The fourth wheel turning 60 times for one turn of the center wheel, the numbers of teeth in center and third wheels, multiplied together, must be 60 times the product obtained by multiplying together the teeth of third and fourth pinions. For example, to take the seconds train most in use for lever watches having third and fourth pinions of 8, we should have $8 \times 8 = 64$, and $64 \times 60 = 3,840$. Any two numbers which, when multiplied together, make 3,840, would be suitable for the center and third wheels. But, unless some special numbers are desired, the calculation need not be carried further, because it is evident the two numbers we already have (64 and 60) will answer the condition. The escape wheel, having 15 teeth, turns once for every 30 vibrations of the balance, and with the train of 16,200 we have $16,200 \div 30 = 540$ turns per hour for the escape pinion. As the fourth wheel turns 60 times an hour, the number for fourth wheel and escape pinion must be in the same ratio as 540 and 60, that is ($540 \div 60 = 9$) as 9 to 1. An 18,000 train is calculated in similar manner; the escape pinion has six leaves; first wheel, 80 with pinion of 10; second wheel, 64, pinion 8; third wheel, 60, pinion 8; fourth wheel, 60, pinion 8; fifth wheel, 48, pinion 6.

NOTES ON OILING AND OIL.

Acid Oil.—The mode adopted for testing either the acidity or the purity of oil will afford no evidence as to how long it will maintain its fluidity, and very good results have at times been secured by the use of oils that were slightly acid, or from mixtures of oils of two or more qualities

Acidity in Oil.—The oil should be free from free water or acids, and should not change its chemical constitution through age or exposure to light. If a little of the oil is shaken up with distilled water and then the water, after settling, is carefully siphoned from under the oil, the water can be easily tested by a piece of blue litmus paper. If it turns red in the water, acid, of course, is present. The action of light on the oil can best be ascertained by exposing a bottle of the oil to the sun for several weeks. A dark or brownish deposit indicates a disintegration of the oil.

Mixed Oils.—Good results, said Cl. Saunier, are frequently obtained by mixing together two different kinds of oil. Thus, American watch oil, which is very fluid and apt to evaporate at the temperature of the pocket, is improved by the addition of a somewhat thicker oil. A mixture of real American oil with the Rodanet oil has been recommended as excellent. Although no results have been published on the question, it seems probable that some of the modern mineral lubricating oils might be added with advantage in small quantities to the ordinary oils.

Oil Sinks.—In cleaning, it is important to avoid removing the gilding in the oil sinks of watches or the superficial oxide in the sinks of clocks that have been going for a considerable time. For, if it be removed, there will be a fresh coating formed in time, and this, too, at the expense of the oil.

Oiling Watch.—The oil in a cylinder escapement will always deteriorate very rapidly; some watchmakers coat over the inside of the dome-joint and recommend the owner not to open it. By doing so the oil can be maintained in good condition at the escapement for a long time.

Lubricating.—An excess of oil will cause an infinity of errors to arise, and should be most carefully guarded against.

Deterioration of Oil.—The only evidence on which the watchmaker can rely is that which he obtains by experimenting on watches which he keeps to lend to his customers, while their own are undergoing repairs; and these trials should last at least for a year. And there is a great variety among the wearers of watches. Some live in constantly varying temperatures, often dusty; many ladies use perfumes; some persons perspire more than others; all these causes influence the oil and make it alter or evaporate more rapidly in one watch than in another.

Oil Adhering to Pivots.—A high or projecting finish, flat pivots, and the inside and outside turned at an acute angle, make the oil adhere better and prevent it from spreading. In a case where the holes are wrinkled there is more room for the oil, and it is, therefore, more rapidly decomposed. The smaller the pivot, the less it is affected by changes in the oil, and, consequently, the less will it vary in its working in various positions. Pivots, however, should never be made so fine that their solidity will be jeopardized.

Meaning of Capillarity.—Capillarity is the property which all liquid bodies have of adhering to the sides of vessels at a greater elevation than their own surface. When a capillary tube is inserted in a vessel containing any liquid, this will rise in the tube to a certain height, and the smaller the tube the higher it will ascend. Oil possesses this capillarity in a marked degree, and readily settles in the depressions beside the pivot holes. If the rectangular bearing enters the hole jewels horizontally the oil adheres more firmly than if the bearing were hollow turned.

Oiling.—Oil the escapement by touching the escape-wheel teeth with oil; do not oil the fork.

Oiling the Parts.—In setting up a watch, see that the jewels are all firmly set; put oil to barrel pivots (and ratchet, if a Swiss watch) but leave all pivots dry that are not covered until the balance is in place and you know that it is in beat and everything right; then take the balance out and put a very little oil in the caps of jewel holes; if it does not draw through to the endstone, take a pivot broach, and, after drawing the temper, reduce it under a slip of oilstone, until a little smaller than the pivots, and with this lead the oil to the endstone; or when the jewels are separated too much for the oil to follow this instrument, cut a peg very slender and use it; if this does not succeed, the endstone must come out and have oil applied directly to it; but it is seldom in American watches that it will not draw through from the cup by using the leader, if the proper quantity only is applied. As it disappears, put more on using the leader, but no more than will draw through. If you happen to get too much, filling the cup, sop it up with a freshly cut peg.

Results of Testing Oil.—Tests made on a whetstone and on a window pane, as well as observations made on drops of oil placed in jewel holes, or in oil cups in a metal plate kept for the purpose—some of the drops being exposed to the air, while others are in closed boxes—will afford valuable indications; and, according to the observations of W. Robert, it is safe to consider an oil bad if at the end of six or eight days after being placed on a plate of good brass it shows a marked green tinge, especially so, if a clearly defined fringe forms round the drop, or else if the brass itself is discolored.

To Test Watch Oils.—Two preliminary tests will afford some indication as to the quality of an oil. A thick layer is placed on a small portion of the surface of a glass plate, and side by side a similar layer of another oil is used for comparison, and they are exposed to the air for some time without being touched. The one that is found to be sticky under the finger when the other has dried up will, in all probability, be preferable. The second preliminary test is made on a whetstone; it is usually found that the oil which takes the longest time to thicken is of better quality. Of course, these tests will only suffice to afford a rough approximation and cannot be accepted as conclusive.

Testing Oils.—Many of the methods recommended for purifying oils are illusory to a great extent, for they cannot impart to the fluid those characteristics that are wanting from the beginning. Success depends largely on the skill of the manipulator, and if he is not endowed with the power of judging, mainly by the taste, whether oil satisfies certain prescribed conditions, he can never be certain of the results. Crops differ as regards degrees of maturity, etc., from year to year, and the animals from which oils are procured are rarely in the same condition as regards health, age, nourishment, etc.

The Lubricant.—The oil intended for use as a lubricant for watch work should be kept away from the light, as otherwise it would be discolored; it is on this account best that the bottles for such oil are preserved by being covered with black paper. Only the quantity wanted for immediate use should be placed in the oil cup.

Oiling Center Wheel.—Before putting in the center wheel, oil its lower pivot. Here is a place where the watchmaker must use careful judgment; if too little oil is used it will run dry, if too much, it will be drawn away upon the plate and cannon, with the same result. It is often advisable to counter-sink the center hole slightly, even making the hole thinner; the oil is retained better in its place.

Oiling Stem-Wind.—When putting the watch up, replace the stem-wind work and oil the crown and intermediate wheels with clock oil; this will be found best, on account of the great pressure which the wheels receive. Do not oil the setting wheels, for they run idle and it would only serve to make them stick.

NO OIL ON DIAL WHEELS.—Do not oil the dial wheels, as it could only serve to stick the minute wheel to the plate and increase the friction.

OILING DETACHED LEVER.—The repairer is frequently at a loss whether he should oil the roller pin jewel in the fork—in fact, all the pieces of a detached lever escapement. To this we would say that the fork of the lever should never be oiled. If it is properly shaped and polished and of the proper size for the ruby pin which plays into it, no oil is required, and if applied, it would do more harm than good. As for oiling the lever pallets and escape wheel teeth, it is considered a mark of poor workmanship to oil them in a fine watch, but in a cheap movement it is often better to oil them than to let them dry. Where it is a choice of evils, the workman may be allowed to do things which in other cases would be entirely inadvisable. But only very little oil should be used in any case, just enough to lubricate the surface, but hardly enough to be perceptible with the eyeglass. When the escape wheel teeth run very close up under the lever fork above the pallets, particular care must be taken to avoid any surplus of oil, as it would soon gather dirt and clog the passing teeth.

NOTES ON CLEANING, AGENTS, REPAIRING, ETC.

CHAMOIS LEATHER.—To clean a chamois leather, make a solution of weak soda and warm water, rub plenty of soft soap into the leather, and allow it to remain in soak for two hours; then rub it well until it is quite clear. Afterward rub it well in a weak solution composed of warm water, soda and yellow soap. It must not be rinsed in water only, for then it would be so hard when dry as to be unfit for use. It is the small quantity of soap left in the leather that allows the finer particles of the leather to separate and become soft like silk. After rinsing, wring it well in a rough towel and dry quickly, then pull it out and brush it well. In using a rouge leather to touch up highly polished surfaces, it is frequently observed to scratch the work; this is caused by particles of dust and even hard rouge, that are left in the leather and which may be removed by a clean rough brush.

DIAMANTINE.—There is nothing like diamantine for giving a good black polish. It is, however, very quick in its action, and requires some little experience to avoid overdoing it and making the work foxy. The work, polishers, etc., must be kept scrupulously clean. Diamantine consists of crystallized boron, the basis of borax. By melting 100 parts boric acid and 80 parts aluminum, crystals are obtained, the so-called bort, which even attacks diamond. Diamantine bought in commerce is very hard.

Diamantine used as a polishing agent requires even more care and cleanliness than rouge, and as the grains are sharper it must be beaten until it is very smooth, and used a little thicker than the rouges, as even the smallest quantity will polish; if too much is taken on the polisher, it cuts quickly, but does not polish. There is a prejudice against using diamantine for polishing pivots, as it is thought that some of the sharp grains become embedded in the metal and afterward cut the holes or pivots; if this is so, the diamond powder, used by watch jewelers to polish the jewel holes with, would have even a worse effect, but in practise we hear nothing of it.

ENGLISH POLISHING AGENTS.—An English polishing agent consists of 94.25 per cent. oxide of iron and 5.75 finely powdered charcoal. The mixture is ground in a moist state upon the slab, and the mass is again pulverized after drying.

ROUGE.—Rouge, or, as it is called in England, red stuff, is prepared of various degrees of fineness. The coarsest, known as "clinker," is used for giving a surface to steel after it is tempered. "Coarse" is used next for steel and for polishing brass. "Medium" is used to finish steel that has been blued, and "fine" for polishing bright steel. The latter must not be used for steel that has been blued, or the color will not be even.

POLISHING MATERIAL.—To mix polishing material properly requires a fair amount of care. Rouge should be thoroughly beaten up on glass or a polished steel stake to a stiff paste with very little of the best oil that can be obtained. It is very poor economy to use inferior oil. Far too much oil is often used and the mixture left thinner than it should be. Olive oils not suitable, and if used the polishing stuff becomes sticky in a day or two. Refined sperm oil, such as is used for watches, answers well. Diamantine should be mixed on glass with a glass beater in the same way, as dry as possible, so that when it is used the polisher is only just damped with it. If diamantine is brought into contact with metal in mixing it turns black.

CLEANING AGENTS.—In cleaning a watch I never use benzine or potash, or any patent article. Benzine leaves a greasy look which it is impossible to get off; besides this, it destroys the oil, while the potash makes spots on the plates, if in moist places. Pure alcohol and well crushed chalk do the best work and give the best results. The chalk is unequaled for cleaning the case. With a stiff brush it is also excellent for cleaning jewelry.

CHALK BOX.—A little box for holding a lump of chalk, upon which to rub the brushes used in cleaning, to free them from grease and dirt, is readily made by nailing up a small box from three to four inches square underneath the work bench, with a small piece of wood to prevent the chalk from falling out in front; or by fixing a piece of wood from the right hand support to a place underneath the workboard, where the chalk will wedge itself sufficiently firm for the purpose.

BURNT BONE.—Many watchmakers prefer burnt bone for cleaning brushes in preference to chalk, as being less gritty and dusty. Burnt bone may easily be prepared by placing ox bones in a crucible and exposing them in a brisk fire for several hours. The crucible should remain in the fire until it has died out; when the bones are cold, soft white pieces may be selected for rubbing the brush upon and so cleaning it.

BENZINE.—Benzine that becomes dirty in cleaning watch-work may again be rendered fit for use by filtering through animal charcoal. A certain good workman stops the end of an ordinary pint glass funnel with paper and places therein calcined bone dust until about three parts full. On the top of this he pours the benzine to be filtered.

CYANIDE FOR CLEANING.—Although cyanide of potassium in the proportion of two ounces to one quart of water, is frequently used for cleaning watches, its use is after all not to be recommended, as its careless employment may injure the gilding, if it does not entirely remove it. If every trace is not removed by hot water, alcohol, etc., the parts are sure to tarnish badly, and the steel will rust speedily. It is far better and safer to use benzine and alcohol, and finish up with dry bone dust. A mutton bone calcined in a slow fire will have a coating of fine dust on its surface which, when applied with a soft brush to the gilding, will impart a superior luster, and its use does not leave anything behind which could in the least either injure the steel or the gilded parts. Precipitated chalk mixed with alcohol and used moderately is also an excellent medium to remove grease or stains from gilded or polished brass. Strong caustics or acids of any kind are always to be avoided as much as possible in watch work, and their presence on the watchmaker's bench is very much to be deprecated. A clean brush is of paramount importance in all cases.

BRUSHES.—Watchmakers' brushes are in constant requisition, but are seldom kept in proper order. A soft brush for rough work is useless, a hard one for fine work is ruinous, and a dirty brush of any kind is a nuisance. Some brushes are cleaned with dry bread; some by laying a piece of tissue or other paper across the wide-open jaws of the bench vise, the corners formed by the jaws taking off on the paper a little of the dirt. These methods are imperfect. A good way to clean a brush is with soap and water—warm water being preferable. Wet two brushes, soap them, and then rub them together in plenty of water till perfectly clean. An objection to this method is the delay in drying. Much injury is done to the appearance of the movement by injudicious brushing, and the watch grows prematurely old in looks by such treatment.

PRECAUTION.—While treating of watch cleaning, it is worth mentioning that in the brushing of the plate a bristle of the brush may easily catch in some screwhole and seriously interfere with the action of some wheel. Before mounting the watch, inspect the plate carefully for some such occurrence. Happily, the disturbance is easily noticed and quickly corrected.

WATCH PLATES.—When cleaning the watch, never brush the plate with a stiff brush and chalk or polishing powder; it not only spoils the appearance of the work, but ruins the gilding. Work is never cleaned in factories otherwise than by washing.

WATCH CLEANING.—When cleaning a watch, the work should be conscientiously done. This is very important, as when the parts are carelessly cleaned with soap or impure benzine, they will, after a few months, assume a dull color, in consequence of a thin layer of the materials used in cleaning having been left on the surface. It has at times been noticed that steel work was preserved from rust through the perspiration of the wearer, after having been cleaned with certain fluids. Evidently this was due to a thin coating having been left on the surface of the metal. The conclusion to be drawn is obvious—clean carefully, push the pivots into rather hard pith, finish with a soft brush in proper condition, and clean out all pivot-holes with pegwood.

To Clean a Watch.—"For cleaning," says a correspondent, "I use benzine and alcohol. I have two wide-mouthed bottles, one for benzine, one for alcohol. I also use two camels' hair brushes, one for each bottle. Take up one piece at a time in a stiff pair of tweezers, dip one brush in the benzine, and brush off well with the benzine, and then take the other brush and brush off with alcohol. The benzine takes off the dirt and oil, and the alcohol takes off the benzine. Always take out the mainspring. Clean the mainspring by holding in your tweezers and brush off with benzine, putting plenty on, and let it run off at the end of the spring; brush over with alcohol. Clean the barrel the same way. Lay the pieces to one side as you clean them."

Examination.—When a watch is handed to you to be cleaned, and it has stopped, examine it to see what stopped it. Perhaps the minute hand cannot pinion, or center post may touch the glass; this can be found out by placing the thumb nail on the glass and running it along just over the hand, and by getting the light right so that you can see through between the nail and the hand, and be able to tell the exact distance between the under surface and the hand pinion, or center post; if the pinion or post touch the glass, put in a higher one, and if that cannot be done, lower the pinion or stop a little.

Safe Rules.—I cannot resist the temptation of giving my ideas about the cleaning and repairing of watches. First and foremost, do not undertake any job that you have any or considerable doubt that you can do it successfully; never leave a job worse than you found it, and never mar, cut or slash any part of a watch. In other words, do not undertake a job that you have any doubt as to whether you can do it correctly. One of my old masters told me never to undertake to improve on the maker's work, and this, while not true in every case, particularly in cheap watches, is a safe rule to go by. Never allow your file, screw-driver, plyers, tweezers, or any tool to deface any part of a watch. Be careful and not let the movement swing so as to in any way injure the balance in taking from case, and if a lever watch, take out the balance the first thing after uncasing the movement.

Watch Cleaning Fluid.—Prepare the following in a tin vessel: Two quarts of soft water, one and one-half ounces castile soap, one-half ounce aqua ammonia. Measure out two quarts soft water, which heat to a boil over a small lamp; cut the soap fine, and dissolve it in the water, after which pour in the ammonia. This fluid can be kept in a corked bottle or jar. When cleaning a watch, heat one-half pint of it to a boil, then have a small sieve, which can be bought in any tin store, and put in all parts except the roller-table, spring, lever, screws and dial. Dip in the preparation about half a minute, take out, and rinse in soft water; after this dip the parts in alcohol and put them in a small paper box with boxwood sawdust; shake them from side to side until dry.

The Use of Benzine.—We frequently see benzine recommended for cleaning watches, and, frankly speaking, do not hesitate to recommend it. But it should be remembered that only the purest should be used, as the ordinary contains a number of hydro-carbons that do not evaporate easily, but remain on the metal, soak into it and combine with the oil subsequently applied, making it thick and gummy. Pure benzine should evaporate completely. If the slightest smell can be detected on a piece of brass dipped into it, after exposure for some minutes to the air of the room, it is entirely unfit to be used for a timepiece. It is always well to warm the article cleaned with benzine to insure its complete evaporation, and afterward to thoroughly clean out the holes with soft pegwood.

Watch Cleaning Agents.—During an experience of more than one-third of a century, always striving to improve, and testing about all methods—solutions that do not require the use of a brush until the work is dry—the writer knows of no method so satisfactory as washing with good soap and water ; rinse thoroughly (at a running stream, if possible), and dry in sawdust, or, if gilding is very delicate, a piece of old, soft cotton cloth. If plates or bridges show tarnish that washing will not remove, dip them in a solution of cyanide of potassium (about an even tablespoonful to a pint of water), rinse again very thoroughly, and put in alcohol for a half minute and dry as before.

CYANIDE OF POTASSIUM.—For all parts of the movement that have been stained or will not come bright in cleaning, I use cyanide of potassium and water; in the proportion of one ounce to the quart of water is about enough, but about one-fourth part of each will suffice to make at one time. Place on the dark spots with a small brush, wash with alcohol, and be very careful to get off all the potassium from the steel if any is on it. The plates are placed on the mixture after all parts are removed, then brushed with alcohol.

USE NO CHALK.—When after having cleaned a watch, and while the parts are still in the sawdust, it will be necessary to go over all pieces, one by one, with a brush to remove particles of sawdust or lint, if a cotton rag has been used. If the washing has been thorough, very little pegging will be requisite at jewels, except there should be noticed a deposit of gum, which should have been removed before washing. Plates and bridges will need brushing to make them look well; brush in circles, breathing on the work frequently; it applies just enough of moisture to facilitate the work, and to show when brushed sufficiently. Under no circumstances should chalk—dry, or in solution—or any other abrading substance be used on movements that are in a respectable state of preservation.

AVOID ALCOHOL.—When cleaning a watch, remember that under no circumstances should the pallets or roller go into the alcohol, except to remove old shellac preparatory to resetting. You may think it impossible that a momentary immersion can do harm, if dried at once, but it does, and if it is proper to put pallets or roller into alcohol once, it is equally proper to do so at every subsequent handling of the watch, and they certainly cannot stand such treatment many times without destroying the life of the shellac. That pallet stones and jewel pins are found loose in new watches is no refutation of the charge that contact with alcohol is a prolific source of loosening jewels that are set with shellae; pernicious habits prevail in factories as well as out of them, and washing balances with springs and rollers attached is one of them, and surely the cause of many loose pins and rusty springs.

CLEANING WATCHES.—In cleaning I use the old method (after trying all ways suggested), that of chalk. I use the old lump chalk, because the carpenters' chalk balls are made with some kind of paste that adheres to the plate, and have this lump chalk at my right hand, in a perforated bottom box, so that any coarse pieces fall through to the floor, and by rubbing the brush across it and then giving it a slight rap, before applying it to the plate, any hard or heavy substance will fall out.

TAKING A WATCH DOWN.—When I get a watch for cleaning and repairs, I take the movement out of the case, and then remove the dust-band, dial and hands. I then take off the regulator, first noting the exact place it marked on the index, thus making sure that it will run nearly right when put up again. After removing the regulator, I unscrew the cock or balance bridge and remove the balance from it, noting at the same time the condition of the balance pivots, hairspring, and cock jewel. I then see if my watch is run down, and removing the pillar and case screw, take off the top plate and barrel bridge; I then take out the train, pallets, escape wheel, 4th, 3d, and center wheels, and remove the spring from the barrel.

TOOLS IN WATCH CLEANING.—Besides three widths of screw-drivers have the same number of tweezers (3), one of good, solid, heavy points, one-sixteenth inch wide at the points for taking down a watch, and handling the heavier parts; next, one a little finer, and one very fine to work in about the train, balance, spring, etc. Always keep the tweezers in perfect order at the points, so that whatever you handle you will not mar or drop the things. If you cannot find tweezers that will suit you, make your own, by selecting some nice steel. Then a good assortment of plyers, cutting, flat and round.

EXAMINING PIECES.—When the watch is all in pieces, before you proceed to clean it, examine with a strong glass to see if the rim of any wheel is rubbing or clashing with anything, particularly the center wheel in any full-plate American watch, for these wheels are often dragging on the plate or striking the rachet wheel because it is not true, and if examined before cleaning the places where it drags are a tell-tale of the mischief. Also make any diagnosis of the watch that is needed to discover any errors from wear or accident, and correct them before going further, such as looking to each jewel, pivot and other parts, and make all necessary repairs before cleaning.

Putting Up a Watch.—Lay the bottom plate on a movement rest, and proceed to set up your watch in the usual way. Put in the center wheel first, then the fourth wheel, then the third wheel, and lastly the escape wheel. Then put on the top plate. Lay a piece of tissue paper on the plate to keep your fingers from touching it. Take up the movement between the thumb and finger. Take up the lever in your tweezers and slip it in place. Then press lightly on the plate and with a pair of slim pointed tweezers bring the upper pivots to their holes; put in screws which hold on the plate and see if all the wheels have end-shake enough. Put in a hair-spring stud in the cock. Put cock and balance in place. Be sure you get the roller jewel in the fork and then put in the bridge screws. Shake the movement a little as you screw down the bridge, and as long as the balance swings you will know that the pivot is going in the hole all right. Wind the spring a turn or so, and see if the balance has a good motion; if it has, wind and put on the motion work. See if the cannon pinion fits tight enough; if not and it is a solid pinion take a small square file and with the corner file a notch across the pinion. Cut it almost or quite through, then take a sharp-pointed punch and drive in the bottom of the notch very little. Take an oilstone slip and remove the burr from the outside of the pinion. Put on the dial, examine the hour wheel to see if it works free under the dial. If it has too much play put on a dial washer. Put on the hands; see if they pass without catching. Put your movement in the case, set the hands, and the job is done.

To Put a Watch in Beat.—To put the lever watch in beat the most perfectly, wind the spring a quarter or half turn, and stop the balance with a tooth of the wheel on the impulse face of the pallet, allow it to pass off, and note the stopping point on the other pallet; if not equal, make them so, or if difficult to get just equal let it pass off the entrance pallet the freest. Same with the cylinder escapement; if not equal, let the tooth pass freest going into the cylinder, rather than out of it. A duplex will be very nearly in beat if it starts off when loosening the balance at the point of first and third drops. A chronometer should start off letting go the balance at the point where the jewel passes away from the gold spring, and where the tooth passes off the pallet.

Watch in Beat.—To put a watch in beat is a very important item, which is done by some by placing a sharp-pointed tweezer, first on one side of the arm of the balance and then in the other, and so pinning in the hairspring in the stud that it will let off as readily on one side as on the other.

To Bush a Hole.—To bush a hole, broach it out in the plate. Turn up a bush in the lathe to fit. My way of putting in a bush is to turn the bush tapering a little with a hole in the plate to match, drive the bush in from the inside of the plate; having countersunk the hole in the plate on the outside, take a large punch from your staking tool and rivet the bush on the outside just enough to force the metal out in the countersink. Put the plate in the lathe and turn off even with plate. I center and drill the bush before putting in, and then broach out to fit pivot; after putting in and finishing up, countersink the whole a little at both ends so as to hold oil.

Lubricating Watch.—It is a good plan to put a drop of oil on center pinion lower bearing, before inserting in place. The stem wind should be judiciously oiled with clock oil, although some watchmakers use a compound of beeswax and oil to lubricate stem wind, which gives a very smooth winding. To oil pallet action, sharpen a piece of pegwood down to a thin blade and dip it in the oil cup. As the escape wheel is revolving touch each tooth with the oiled wood. The capillarity of the wood will keep the oil from leaving in large drops, as it will from a metal oiler, and each tooth will receive a modicum of oil. In oiling all capped settings, after placing a drop of oil in the oil sink, take pegwood sharpened to a fine point and insert in hole; this will carry the oil down between the cap and the hole jewels where it belongs. Oil the inside of barrel and place some oil in the coils; clock oil should be used for barrel and center pinion.

Adjusted Watch.—The balance spring of a fine watch should never be disturbed when repairing the watch, unless in some very exceptionable circumstances. Its length and curvature have probably been carefully adjusted to secure isochronal vibrations of the balance, and taking it up or letting it out will at once damage the isochronism. Even taking up a balance spring and afterward putting it back where it was originally 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 REGULATE A FINE WATCH.—A correspondent addressed The Circular some time ago to know how to regulate a very fine watch made by a celebrated English watchmaker. He stated that although he "had tried to alter the balance spring by taking up and letting out, yet he could not obtain the desired effect." When a watch has no regulator, it is timed 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 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 repaired. This fault may be in the escapement or elsewhere. It is sometimes caused by the balance rim having been injured by careless handling.

EXTRACTING BROKEN SCREWS.—When the cramp cannot be used, because the screw hole is drilled only partly through the plate, do as follows: Slightly warm the plate and well cover it with beeswax. Be careful not to let the wax touch the broken screw, then make a solution of oil of vitriol, 1 pint of oil of vitriol and 4 of water. Let it stand until quite cold, then put the plate in, and in a few hours the acid will dissolve the screw. The wax may be removed by warming it in olive oil, and washing in hot soap and water.

HEADLESS SCREW FROM PLATE.—Take two pieces of steel wire, three-quarters of an inch in length, one size smaller than the screw; file one edge wedge shape. Put one piece in the head and the other in the tail stock of the lathe; push them near together with the plate between and the wire touching each end of the screw. Push hard, and turn the plate with your hand.

REMOVING BROKEN SCREW.—When all other means fail for getting out a broken screw and the watchmaker does not like to resort to the punch, he may use the following chemical method: Mix four parts of distilled water with one part of sulphuric acid, and put the plate in the solution over night, when the acid will generally eat away sufficient from the thread of the screw to cause a distinct separation between the steel and the brass, and the screw may then be removed by mechanical means.

LEFT-HANDED SCREW.—To make a left-handed screw plate, screw a piece of steel of the desired size in an ordinary right-handed screw plate. Then file it away to a feather edge and harden it. A good left handed screw plate may now be cut with the tap thus made if it is turned the reverse, or left-handed way.

CHAIN IN ENGLISH LEVER.—Sometimes, because of a defect in the fusee, the chain of an English lever will fall over flat on the barrel. It can be restored to its proper position with the point of a graver in the circumference of the barrel by forcing this forward, thereby taking off the power of the mainspring: and the defect in the fusee can often be corrected without taking the watch down.

TO RESHARPEN OLD FILES.—According to the *Eisen Ztg.*, cleanse the old files with soda and warm water, then immerse them in water, to which add sulphuric acid in drops until gas bubbles begin to form on the files. Leave for a few minutes in this bath, then take out and rinse with clear water. The files are said to be good again for work.

SOLDERING 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.

SMALL DRILLS.—In hardening small drills very good results are obtained by enclosing the blade in a pellet formed of prussiate of potash, lard and Castile soap, and cooling in beeswax. Or the surface may be protected by a layer of soft soap.

TRANSMISSION OF POWER.—One of the principal conditions of 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 other form for the teeth of the 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 the wheel teeth as a matter of taste.

Tightening Seconds Hand, etc. — Seconds hands may be tightened, by inserting the socket in a wire chuck and pinching by severe drawing in; also hairspring collets that are loose may be tightened in the same manner, holding the spring by inserting a pegwood in the center of the collet.

To Clean Top-Plate.—To clean the top-plate so as not to destroy the gilding or scratch the plate, wash this with jeweler's cleaning soap and a soft brush, which makes the plate look like new; rinse off in clean water or alcohol, and dry in sawdust. Then sharpen a piece of pegwood so it will have three corners; it can be sharpened with three cuts of the knife. Clean out all the holes carefully. Again sharpen the pegwood in the same way, only make it blunt so that it will fit in the oil sinks, and clean them out well; sharpen the pegwood as it gets dirty.

Center Pinion Touching Crystal.— A good way, besides the usual manner with the thumb nail, to tell if the pinion touches the glass, is by putting a little oil on the part supposed to touch, and then shut the bezel tight all around; then raise it and see if there is any spot of oil on the glass; if there is, the pinion touches.

Tightening a Glass.—To tightly fit a glass on 3, 4 or 5 oz. open-face cases, where the rim is cut under very deep, heat the rim of the case over an alcohol lamp, when you can easily put in a glass that will fit tightly after the rim cools off.

Countersinks.—In hole jewels with cap jewels over them, the countersink in the jewels must be toward the shoulder of the pivots; all without caps must be set the opposite way.

Inserting Barrel Tooth.—To set a tooth in the mainspring barrel, smooth the broken part with a small file, drill a hole where the tooth was, take a piece of brass wire, file flat and to the thickness of the other teeth; then file round at one end to fit the hole, solder with soft solder, and then round up. For center wheel, file a groove where the broken tooth was with a screw-head file, and fit another tooth in the same manner as specified for a barrel tooth.

Hour Hand.—Before putting on the dial, wind up the spring about half and see if you can turn the hands back without interrupting vibrations of the balance; if not, free until they will so turn without disturbing vibrations, and be sure to carry. Put on the dial, and if hour wheel has too much shake, use a tinsel washer, concave side to the dial. These are excellent things to prevent "dipping" of hour hand when the wheel socket is too large for cannon pinion. See that hands are free of dial, glass, and each other, and the job is done.

Spotting the Plates.—The spotting of the plates is a branch in itself; it is done in an engine resembling a wheel-cutting engine; after the plates are polished with rotten stone, the plate or piece that is to be spotted being fixed to the dividing plate, a small hollow ivory point charged with oilstone dust or emery and oil is attached to a jeweled arm. This point is brought into contact with the plate while it is rotating, the plate being shifted after each spot, and circular or geometrical patterns marked on it as arranged on the dividing plate. The steel works and the screws are blued, but it is not thought safe to harden the large screws, since, if a screwhead broke off and stopped the timepiece, the result might be serious.

Barrel Hook.—To put in a barrel hook, drill a hole into the barrel, and cut a screw into it; then cut a thread on a brass wire the same size as the hole, file under on one side to form a hook screw into the barrel, and cut off. Select a suitable spring, put it into the barrel; if an American, see that the catch on the end does not protrude too far, or the balance will be apt to catch on it.

To Smooth an Oilstone.—Oilstones 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 oilstone. Another very good way is to nail a piece of coarse emery paper upon a board, and treat the stone in the aforesaid manner. Paper is best, because the grains of emery remain stationary, while, when loose upon the slab, they roll around, and therefore are less effective.

TARNISHED GILT CLOCK BEZELS.—To remove tarnish from gilt clock bezels, dead white silver work, etc., dissolve one ounce of cyanide of potash in one quart of rain water; bottle it, and label it "poison." Place the work in an earthen vessel, pour sufficient of the cyanide solution on the work to cover it, and the tarnish will disappear in five minutes. Re-bottle the solution for future use.

TO MAKE A NEW COLLET.—Should the contingency arise when the repairer is forced to make a new collet, the old one being defective, and that a material dealer does not live near him, he can make one from a brass stopping (bouchon). The drilling of a balance spring collet is not easy; in fact, it is the most difficult thing there is to drill, and if the drilling is made easier by drilling in both directions, great destruction of pivot broaches results. In attempting to open a hole that has two directions, a special soft and fine pivot broach is needed to commence the opening. Workmen who sing and whistle over the finest pivoting, generally look serious when drilling the collet.

THE DOUBLE ROLLER.—The double roller, as its name indicates, has two rollers on the balance staff, the large one carrying the impulse pin, as in the table roller, while the small one is used for a safety roller only. In an ordinary escapement with a lifting angle of 30° at the roller, the intersection is only just safe when the escapement is a good one and all the parts well made and jeweled; but if the pallet staff have brass holes and less skilful workmanship generally, pallets of higher angles and a longer escaping are necessary. There are no proportions of the lever escapement upon which greater diversity of opinion exists than on the proper lifting angle of the pallets. Lifting angles of 15° may be found in old watches, while some modern watchmakers advocate as low an angle as 6°. Now, as the driving planes increase in length with the lifting angles, and also become more divergent from the course in which the wheel is traveling, the friction increases, and in an increasing ratio as the planes approach more nearly to lines of the wheel radii.

RIVETING OF BOUCHONS.—Some watchmakers have found considerable advantage in replacing the sudden and irregular impacts of a hammer by gradual pressure, without shock, obtained by a small press worked by hand on the principle of a punching machine. With a well made bouchon, the flat end of which is slightly rounded and the inside of the hole in the plate finished with a rattail rather than with a cross-file, it is found that the riveting is always perfect. Others employ an ordinary pair of sliding tongs, the noses of which are drilled to receive two punches, one flat and the other rounded, as in the mainspring punch. Three pairs of punches suffice for all sizes of bouchon, and the same tool can be used for closing up screw holes, etc.

TAPPED BOUCHON.—Every watchmaker knows how to proceed in adjusting an ordinary perforated bouchon or stopping. We would make a few remarks on the subject of bouchons generally. The tapped bouchon is very firm, but in order that it may be well centered, it is essential that its thread fits exactly the tube of the tool, and that the pointed rod is exactly central. A turned bouchon, especially when a broach can be passed into it after it is in position, is more easily made central.

SOLID BOUCHON.—When bushing holes that are rather large with solid bouchons, after the hole has been marked with the pointer, it must be drilled with a small drill, a larger one being subsequently passed through, so as to increase it. Otherwise there is great danger of the hole turning to one side. If a hole, say that of the center wheel, is bushed with a perforated bouchon, it will often be found to incline toward the barrel, so that the hole is displaced. Such an inconvenience may be avoided by using a bouchon with a hole smaller than is ultimately required, afterward enlarging it with the plate centered (by the bar pivot hole) in the mandril or lathe.

MOVABLE BOUCHONS.—These are for use in regulator clocks and others of large dimensions, and a few words must suffice for their description. It is always desirable, with a view to prevent wear, that when metal pivot holes are used the pivot should bear on a length equal to about three times its diameter; but for such a condition to be satisfied, it is essential that the axes of both holes and pivots be absolutely parallel.

NOTES ON MENDING CASES, AND VARIOUS ITEMS.

GOING ABROAD FOR HOME NEWS.—The *Moniteur de la Bijouterie*, etc. says that 1,200,000 watches are annually manufactured in the United States which require 12,000,000 precious stones, or from 7 to 21 for each watch. The larger part of these jewels are imported; there is only one company—the Waltham—which has them cut by more than 30 workmen.

MAGNETISM IN A WATCH—To ascertain whether any of the several steel parts of a watch are magnetized, suspend the article by sticking it with a piece of beeswax to a fine silk thread, when the polarity may be tried with a small magnet. On no account, however, should steel filings be used in testing, because if not magnetic to begin with, they will speedily become so when brought into contact with the article under treatment. With soft iron, even, it is well to occasionally change the fragment used for testing.

AGE OF A WATCH.—If an old watch has a balance spring, it is not older than 1660; if it has a minute hand, its age is not greater than 1770; should it have an enameled dial, it was made in the 17th century.

THE ASTRONOMICAL MEAN SOLAR DAY is reckoned from noon to noon, and the hours are counted continuously from 1 to 24 instead of being divided into two equal parts of 12 hours each, as is the ordinary custom; thus, half-past six o'clock in the morning, say, of the second day of January, would be expressed by astronomers as January 1, 18 hours, 30 minutes. In an astronomical regulator the hour circle is accordingly divided into 24, and the hour hand goes round once in 24 hours.

SOLAR DAY.—A solar or civil day is the time between the transits of the sun over the meridian on two successive days; but as the sun revolves relatively in the same direction in which the earth rotates (of course, strictly speaking, it is the earth which revolves round the sun; it is only apparently that the sun moves round us) the sun requires nearly 3 minutes, 56 seconds on the average longer than any particular star to bring him up to the same meridian on every successive day; there is therefore one more actual or sidereal day in the year than there are solar days.

SIDEREAL DAY.—The duration of a sidereal day is 23 hours, 56 minutes, 3 seconds.

CYCLE OF THE SUN.—A cycle of the sun is a period of 28 years, after which the days of the week again fall on the same day of the month as during the first year of the former cycle. The cycle of the sun has no relation to the sun's course, but was invented for the purpose of finding the dominical letter which points out the days of the month on which the Sundays fall during each year of the cycle. Cycles of the sun date nine years before the Christian era. If it be required to know the year of the cycle in 1882 nine years added will make 1891, which, divided by 28, gives the quotient 68, the number of cycles that have passed, and the remainder 15 will be the year of the cycle answering to 1882.

SULPHURIC ACID.—Sulphuric acid will dissolve iron, steel, copper, tin, silver, zinc, brass, nickel, mercury, German silver.

GILDING ON MARBLE.—To gild on marble mix white lead to proper consistency with fat oil, and then with turps; paint the portion to be gilded with the mixture, afterward sizing it with japanner's gold size, and when it is dry applying the gold leaf, the best material being employed.

MARBLE CLOCK CASES.—To polish marble clock cases make a thin paste of best beeswax and spirits of turpentine, clean the case well from dust, etc., then slightly cover it with the paste, and with a handful of clean cotton rub it well, using abundant friction; finish off with a clean old linen rag, which will produce a brilliant black polish. For light colored marble cases mix quick lime with strong soda water, and cover the marble with a thick coating. Clean off after twenty-four hours and polish well with fine putty powder.

MENDING MARBLE CLOCK CASES.—Plaster-of-Paris may be used, but it is better, especially if the mended part is visible, to soak the plaster-of-Paris in a saturated solution of alum, and then bake it. It is used with water, may be mixed with any desired coloring material, and will take a high polish. Lime and white of egg make the best cement for closely-fitting surfaces, but it requires using very quickly, as it soon sets. Marble case makers use a cement composed of Russian tallow, brick dust and resin melted together, which sets as hard as stone at ordinary temperature.

NOTES ON THE PENDULUM.

THE KNIFE SUSPENSION.—A watchmaker complains in a German horological exchange about the irregular rate of a second's regulator, and is answered as follows: If the clock has a knife suspension, as nearly all the clocks made in the first part of this century have, you will find that the pan causes this irregularity. If the watchmaker omits in the setting up of the clock to lubricate the knife-edge and pan, steel rust will form at the place of contact, and the knife wears the pan no matter if it is glass hard and polished black, and eventually forms a deep gutter. I have found this true at least twenty times in the course of my practise. When I then restored the conditions of knife-edge and pan, and lubricated both, or replaced them with a suspension spring, the arc of oscillation of the pendulum was at once enlarged, essentially, and in all cases the rate became more regular, and customers have often expressed their satisfaction. But if the clock has a suspension spring and has an irregular rate, there is something the matter with the fastening, so that at the time when the pendulum is about to return, the elastic force of the spring assisting the specific gravity of the pendulum bob is at fault.

PENDULUM BOBS.—Variously shaped bobs have been from time to time devised, the most common in all the old clocks, being the lenticular, or lens shaped, which has been recommended by Reid and others. If exactly made, this would not be a bad form for the bob, but it is a very difficult one to form accurately, one of the convex sides being invariably more protuberant than the other, or if these are properly divided there is another difficulty in getting the hole exactly in the middle of them. Any inequality of this kind will cause the pendulum to have a twist at every swing, and prevent the good going of the clock; for this reason pendulums are now nearly always made with cylindrical shaped bobs, which is also a convenient shape for compensation pendulums.

TORSION PENDULUM.—Rotating pendulums of this kind—that is in which the bob rotates by the twisting of the suspension rod or spring—will not bear comparison with vibrating pendulums for timekeeping. They are only used when a long duration of the pendulum is required. Small clocks to go for twelve months without winding are made with torsion pendulums about six inches long, making 15 excursions per minute. The time occupied in the excursion of such a pendulum depends on the power of the suspending rod to resist torsion and the weight and distance from its center of motion of the bob. In fact, the action of the bob and suspending rod is very analogous to that of a balance and balance spring.

STRIKING HALF HOURS.—The usual way of getting the clock to strike one at the half hour is by making the first tooth of the rack lower than the rest and placing the second pin in the minute wheel a little nearer the center than the hour pin, so that the rack hook is lifted free of the first tooth only at the half hour. But this adjustment is too delicate and the action is liable to fail altogether or to strike the full hour from the pin getting bent or from uneven wear of the parts. An arrangement devised by an English watchmaker appears to be much safer. One arm of a bell crank lever rests on a cam fixed in the minute wheel. The cam is shaped so that just before the half hour the other extremity of the bell crank lever catches a pin placed in the rack and permits it to move the distance of but one tooth. After the half hour has struck the cam carries the catch free of the pin.

LENGTH OF PENDULUM.—For regulators, the one-second pendulum is never exceeded and is generally adhered to, being a convenient length; but of course any decrease of the length of a pendulum is attended with a greatly increased effect of errors in the escapement, shake in the holes, etc.

BAROMETRIC ERROR.—The error caused by variations of the density of the atmosphere is called the "barometric error," and various methods have been tried for its correction, such as causing the pendulum to vibrate in a vacuum, fixing small barometers to the pendulum rod, etc.; but the first of these could hardly be adopted in turret clocks, and in these the adjustment is very troublesome. The best plan is to make the pendulum describe so large an arc that the circular error will correct the barometric. With a decrease in the pressure of air and consequent fall of the barometer the pendulum increases its arc of vibration with an increase in the pressure of the air and consequent rise of the barometer the pendulum diminishes its arc of vibration.

REGULATORS.—The pendulum lock of a a regulator should be securely bolted to the back of the case, which should not rest on the ground, but be fixed to a permanent wall of the room, and the back should be suitably substantial, not less than 1½ inches in thickness. Reid recommends that a bracket be in this manner fixed to the wall, and the movement screwed or bolted to it, the front of the case being capable of being pushed on or pulled off; and this is the method adopted in all the best regulators.

TIMING FRENCH PENDULES.—Escape wheels of French pendules make two revolutions a minute, so that the pendulum makes four times as many vibrations per minute as there are teeth in the escape wheel. A pendule may therefore be quickly brought to time by counting if the beats of the pendulum per minute equal four times the number of teeth in escape wheel.

MERCURIAL PENDULUM.—In the mercurial pendulum the jar of mercury does not answer so quickly to a change of temperature as the steel rod, and preference is therefore now generally given to the zinc and steel arrangements; still the elegant appearance of the mercurial renders it suitable for show regulators, for which it is often used. The following are the dimensions of a good pendulum of this class: Steel rod 0.3 inch diameter, 34 inches long from top of face part of suspension spring to bottom of stirrup, side rods of stirrup 0.3 inch wide and 0.125 inch thick, height of stirrup inside 8 inches, bottom of stirrup 0.5 inch thick with a recess turned out to receive jar; glass jar 7.6 inches deep and 2 inches diameter inside, outside 2.25 inches diameter and 7.8 inches high; height of mercury in the jar about 7.4 inches; the weight of mercury entering such a jar is about 11 pounds, 12 ounces.

FILLING PENDULUM.—Great care should be taken when constructing a mercurial pendulum to remove all the air bubbles from the mercury. To facilitate this the jar of mercury removed from the stirrup, and with a piece of bladder tied over the top, may be subjected to a temperature of about 150° for a week or two. The parts of the stirrup may with advantage be annealed after they are finished, so as to guard against the possibility of magnetism. It is important to get the mercury as pure as possible for a pendulum. A good way for removing impurities is to add sulphuric acid to the mercury, and shake the mixture well. The metal is then washed and afterward dried on blotting paper.

TO PURIFY MERCURY.—Mercury often becomes contaminated with alloys and other impurities which may be removed by simple filtration. This may be done in simple glass funnels, the stems of which are drawn out to a fine capillary tube. But this often becomes clogged after a short time, and then ceases to act; besides this, it acts very slowly. A chemist recommends a method which has long been practised in Bunsen's laboratory. A filter is made of writing paper and numerous fine holes are punched into it. Instead of making these round with a needle, it is better to use the point of a pen-knife, which causes the little holes to be triangular. The holes should be pricked both vertically in the direction of the radius of the filter, and horizontally at right angles with the former; part of the holes should be pricked from the outside inward, and the other in the opposite direction. A still better way to purify mercury by filtration, according to the same author, is the following: Select a glass tube of about the thickness of a lead pencil, and about a yard long. Expand one end to the shape of a funnel, and the other to a tulip-shaped bulb, or expand this end to a wave-like form such as is customary when rubber tubing is to be stretched and tied over the end of a tube. A piece of linen or chamois is firmly tied over the latter end, and the tube is then suspended. On pouring the mercury into the funnel, it will be pressed through the pores of the filtering medium with a pressure considerably exceeding that of the atmosphere.

CENTER OF OSCILLATION.—The center of oscillation is that point in a vibrating body in which, if all the matter composing the body were collected into it, the time of the vibration would not be affected. In a straight bar suspended at one extremity, the center of oscillation is at two-thirds of its length, and in a long cone suspended at the apex at four-fifths of its length from the apex. From the irregular form of the pendulum the position of its center of oscillation is not so easy to calculate, but it is always situated below the center of gravity or center of mass of the pendulum. In constructing a pendulum it will be sufficiently near to assume the center of oscillation to be coincident with the middle of the bob.

PENDULUM WIRE.—Always examine the pendulum wire at the point where the loop of the fork works over it. You will generally notice a small notch or at least a rough place worn there. Dress it out perfectly smooth, or your clock will not be likely to work well. Small as this defect may seem, it stops a large number of clocks.

COMPENSATING PENDULUM.—In adding mercury to or taking it from the jar in adjusting, it is convenient to have a hole through the cover of the jar, and by introducing a piece of glass tube eight or ten inches long it will fill with mercury as high as the top line of the jar, and by placing the finger on the top of the tube, the tube can be lifted with its charge of mercury, and in this manner, small quantities can be taken out when necessary. Usually the amount put in a jar is a little under the amount required, and afterward additions are made, which is more readily done than taking from the jar; all mercury added should be pure, clean and dry.

NOTES ON THE BENCH AND TOOLS.

TOO MANY FANCY TOOLS.—A great many watchmakers have too large a number of fancy tools, which they do not know how to use. A good watchmaker can do satisfactory work with a good lathe with all the chucks, a good vise, centering tool, a good set of pincers, drills, full set of files, and other small tools generally used by a watchmaker in repairing English lever, Swiss chronometers, split seconds, and all foreign watches. A watchmaker must have handled some of the above-mentioned timepieces; and a great deal in repairing watches must lay with the ingenuity of the workman.

THE EYEGLASS.—The usual form of a watchmaker's glass is a convex lens one inch in diameter, mounted in a horn. Although sometimes extra strong glasses are used for special purposes, the focus for general work ranges from two to four inches. Some workmen find the muscular exertion of supporting the glass irksome, and attach it to a wire held in the mouth or behind the ear, or to a light spring coiled around the head. Eyeglasses for lightness may now be obtained mounted in cork. Holes are often drilled through the mounting to prevent the glass being dulled by the collection of moisture on it. There is a very superior achromatic glass with two plano-convex lenses, which has the double advantage of giving a perfectly colorless view with a flat field. Watch jewelers use a glass with double lenses, half an inch in diameter and with a very short field.

PLIERS, TWEEZERS, ETC.—It is advisable to have a considerable number of these, as their strength should always be proportional to the force that has to be applied to them. For example, if a pair of sliding tongues is used when a hand-vise is needed, the former will be strained beyond its limit of elasticity, and the tool becomes nearly useless. The same might occur with any other form of pliers or tweezers. In the hands of a good workman, they will last for a long time, but if used unintelligently, without proportioning the size of tool to the force that has to be applied, taking up the first that comes to hand, all the tools will soon become unsatisfactory and the work itself will suffer. It is very desirable to have one or more pairs of brass pliers and tweezers for handling metal work without the risk of scratching.

FILES.—Watchmakers often fix files into handles by driving them firmly into round holes in the handles; this practise leads to the handles being cracked, and the following method is preferable: Take an old worn out file or a piece of iron of the same form as the tail of the file to be fitted; heat it several times to bright redness and drive it, when so heated, into the handle, taking care to maintain it perpendicular. A hole will thus be formed of the required size in which the file will hold without there being any occasion to apply excessive force in fixing it in position.

THE BENCH.—This should be fixed in front of a large window that affords a good light. The various hooks, recesses, etc., for holding the bows, files, hammers, etc., as well as the drawers, should be well in sight, not only in order that the hand can at once take hold of whatever tool is required but also to enable the workman to restore them to their places immediately after use. By doing so he will have no occasion to retain on the bench any but those tools that are very frequently or continuously in use.

THE STOOL.—The stool used by workers at the bench is worthy of consideration. Those with cane seats are to be preferred. The height of the bench and stool should be so related that the muscles of the chest are not too much cramped, especially if the workman is engaged on an operation that occupies a long time and obliges him to maintain a stooping position. The stool with a screw is advantageous in this respect.

MAKING ODD TOOLS.—Says a correspondent: I have adopted the plan of making any tool I happen to need for any special purpose, so that by making these at the time I happen to want a tool that I cannot purchase, I have accumulated quite a variety of odd tools; among them are a varied lot of millers for milling and raising jewels, and deepening the countersink holes for jewel settings and screw-heads; also a tool for holding a roller, to set the jewel pin, and one for holding the hairspring collet, and a pair of tweezers for holding jewels while cleaning, etc.

ROUNDING-UP TOOL.—This most ingenious tool is one of the most useful to watch repairers. By its aid a 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 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.

SELECTING THE CUTTER.—Some little practise is required to select exactly the cutter required for the rounding-up tool. Care must be taken not to use 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 held firmly, but not too tight 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.

LEFT-HANDED SCREW PLATES.—Screw a piece of steel of the desired size in an ordinary right-handed screw plate. Then file away to a feather-edge, and harden it. A good left-handed screw plate may now be cut with the top so made, if it is turned the reverse or left-handed way.

COMPOSITION FILES.—These files which are frequently used by watchmakers and metal workers for grinding and polishing and which in color resemble silver, are composed of 8 parts copper, 2 tin, 1 zinc, 1 lead. They are cast in forms; treated upon the grindstone; the metal is very hard and is worked with difficulty with the file.

A SURFEIT OF TOOLS.—Some repairers encumber themselves with a great variety of useless or worn-out tools, pliers for instance, of which two or three pairs are quite sufficient. A watch-repairer should never use hardened tooth pliers; they spoil the work and are not necessary; a pair of long-nosed pliers, softened with a good point, filed up occasionally, and small at the points, will be almost constantly in use; they are much more reliable than tweezers for all such work as picking up pins, or for many other purposes for which tweezers are commonly used. A greater variety of tweezers are necessary, as those with long thin points, that must be used for such work as putting a chain on the fusee, or getting the pivots into the holes when putting a repeater together, should only be used for some such purpose, as the limbs are so weak that a pin is held in them with difficulty. Very good tweezers are now being sold, made light and stiff by giving the middle part of each leg the form of the segment of a tube.

STAFF PUNCH.—The staff punch is a useful tool for driving pallet and other staffs and colletted wheels to correct position. It may be made from a piece of polished steel. A large hole is first drilled transversely near one end and a smaller one of a size to allow of the passage of ordinary pivots is then drilled from the end to meet it. The mouth of the smaller hole is chamfered and rests on the shoulder of the staff to be driven; the pivot passing into the larger hole is secure from damage during the operation.

RIVETING STAKE.—The ordinary riveting stake is too well known to require description. Another form is circular, with a shifting table or stake round which holes of various sizes are arranged in a circle so that any particular hole may be brought exactly under a suitable punch moving in a vertical guide. A set pin fits a hole in the edge of the table to secure it correctly to position with relation to the punch. A somewhat similar tool is used for closing holes in watch plates. There are no holes in the table and the punches are cupped so as to stretch the material of the watch plate toward the hole. Sometimes the punches are formed with a punch center to insure their acting concentrically round the hole in the plate.

FLY CUTTERS.—The usual form of fly cutters has a single cutting edge used for cutting the teeth of brass wheels. Fly cutters are at present frequently made double. A piece of steel fitted to the cutter holder so as to project equally on each side is turned to the form the cutter is to be. The steel is thinned on opposite sides till the faces are just coincident with the center of the holder, and after being filed back from the edge, to give requisite clearance, is hardened and tempered.

USE OF A SECTOR.—Suppose a pinion of 8 is required for a wheel of 75 teeth; the wheel is placed between the limbs of the 75 mark and the proper size for the pinion is then the distance between the limbs at the 8 mark. Of course, if the pinion is in hand and the size of wheel is required the operation is reserved; the pinion is placed between the limbs at the 8 mark and the distance between the limbs at the 75 mark gives the size of the wheel.

CHAMFERS.—The best form of chamfer for making the oil sinks around pivot holes is a steel wheel mounted on a notch, cut diameterwise, in the end of a properly made shaft. The wheel projects slightly, and when the tool is rotated with a reciprocating motion the wheel cuts a hollow of circular section, the radius corresponding to the size of the wheel. For cutting the edge of the wheel is left quite square, but when rounded it serves as a burnisher. Two wheels of the same diameter, one to cut and one to burnish, are usually mounted in the opposite ends of one shaft. Different diameters produce different sized chamfers, wheels from one-tenth of an inch to a quarter of an inch diameter being commonly used.

UPRIGHTING TOOLS.—The chief requirements in an uprighting tool are that the holes in the arm and in the table shall be exactly opposite and straight one with another and also perfectly perpendicular with the table. If the holes are in line a true runner fitting them should pass from one to the other without binding. The readiest way for testing if the runners are perpendicular to the table is first to ascertain that the runners are true in themselves, and then to fasten to each of the runners in turn a piece of wire extending horizontally to nearly the edge of the table. The point of the runner is pressed on a plate and on rotating the runner the wire will clear the face of the table exactly the same distance all round, if the tool is correct. Uprighting tools are not used so much now as formerly, for as accuracy of drilling is more absolutely insured if the work rotates, the mandrel is now generally preferred where extreme exactness is required. From the readiness, however, with which the work may be adjusted in the uprighting tool it is not without its advantages.

SCREW-DRIVER.—A screw-driver for watch-maker's use should be as light as possible, consistent with strength, properly proportioned to the work, with well polished point of a width nearly equal to the diameter of the screw heads to be operated upon, and of a thickness to fit the slits with only sufficient taper to secure it from breaking. A tool with a blunt taper will ruin the best of screws. Screw-drivers made from pinion wire collect dust in the ridges, and are therefore objectionable. A better form is readily made from square steel twisted while hot.

SCREW TAPS.—When making a screw tap the upper part is generally left larger than the screw part, and in turning the tap care should be taken to make a long curve between the two, for if a square shoulder is turned there the tap is very likely to break usi ne.

EMERY GRINDERS.—Shellac, melted together with emery and fixed to a short metal rod, forms a grinder used for opening the holes in enameled dials. The grinder is generally rotated with the thumb and forefinger, and water is used to lubricate its cutting part, which soon wears away. The grinder is reshaped by heating the shellac and molding the mass while it is in a plastic condition.

DEPTHING TOOL.—Accuracy of construction is absolutely essential in the depthing tool, and before venturing to use a new one, it should be tested. The centers should be turned end for end and transposed, ascertaining after each change if there is any deviation in a circle described by the points; also if the points when they meet coincide exactly. If possible, a comparison should be made with an approved tool by trying both a large and also a small wheel and pinion. The adjusting screw had better be removed so as to see that the joint works smoothly and that the spring has perfect control over it. If the joint is stiff and appears to be dirty, the joint pin may be taken out and the joint cleaned thoroughly.

Joint Pusher.—Quite a convenient tool is a joint pusher, a round piece of tempered steel, generally in a wooden handle, for forcing small pins into or out of position. A tight pin is started much easier by impact than by pressure, and a good plan is to have a punch or joint pusher with a square body which is clasped in the vise not tightly, but just so as to hold it in the position. If then the work is held in one hand against the point of the joint pusher the other hand is at liberty to give the head of the joint pusher a light tap with a hammer.

Drawplate.—Every watchmaker should possess a plate for drawing round wire so as to be able to obtain it of any required diameter. It can be had at any ordinary store. In bushing holes in a brass plate it not unfrequently happens that the brass used for the bouchon is not of the same color as the plate. To avoid such a difference, cut off a piece from a plate of the same color and round it by hand, making one end to taper. Fixing the drawplate in the vise, pass this end through one of its holes and gripping it in the hand vise, pull the brass through the plate. Continue this operation through successive holes until the requisite thickness is attained. No special precautions are necessary, further than keeping the holes well greased and annealing the brass from time to time so as to counteract the hardening caused by the operation. Such a plate can also be used for steel wire and plates with holes of special form; for example, those for drawing click and pinion wire are well known in the trade.

Drifting Tool.—This appliance is very useful for making holes of round, oval, square or any required form. It takes the place of a punching machine for light work; but for heavier work it will be necessary to resort to the punching machine. There are several constructions in use, but the most usual is essentially the same as that of the tool just described. The screw works vertically in a strong bridge, that is fixed to the bed in which the counterpart of the punch is held. Great use is made of this machine in factories at the present day, almost every part of a watch being in the first instance roughly shaped by its means. Indeed, this metal is often left as it comes from the punch, and very perfect crossings of wheels, etc., are thus produced. Steel does not cut well in the press unless it is soft and homogeneous, and the final dimensions of the object can be more clearly approached according as these conditions are satisfied. Attempts have been made to cut levers, etc., of the exact dimensions required, but it is better to leave a slight excess of metal to be afterward removed by a mill cutter or other means. The crossings of steel levers and cylinder escape wheels are punched out, but the metal used is of special excellence.

Truing a Grindstone.—The best way to restore the roundness of a small grindstone is by wearing it down. I had such an untrue grindstone, and tried all kinds of ways, but found the following the best: I fastened the two sides of the shaft in a block of wood, sufficiently tight to keep it from wobbling, and then took a piece of charcoal, which I held carefully against the stone to mark the raised and uneven places. I next took a sharp hammer, something like a mason's, and trimmed the high places down, continuing until the stone ran fairly true. This operation is so simple as to be not worth explaining. I then removed the stone to its frame, took a piece of hard steel and turned the stone, which became nice and round in a short time. As the watchmaker's grindstone is not large, any fair-sized hammer (of course the sharp or so called *pene* end) may be used. If the frame of the stone is sufficiently strong the work of dressing may be performed without removing the stone.

Diamond Broaches.—These broaches are made of brass, the size and shape desired. Having oiled them slightly their surfaces are rolled in fine diamond dust until entirely covered. Place the broach on the face of an anvil, and tap with a light hammer till the grains are imbedded in the brass. Great caution is necessary in this operation, so as not to flatten the broach. Very light blows are all that will be required; the grains will be driven in much sooner than would be imagined. Some roll the broach between two pieces of smooth steel to imbed the diamond dust. It is a good way, but somewhat more wasteful of the dust. Broaches made in this way are used for dressing out jewel holes.

Sliding Carrier.—This useful adjunct, the sliding carrier, although not generally supplied with a Jacot tool, may with advantage be fitted to it. It is often handier than the screw ferrule, and saves time when used, instead of covering or cementing. A small steel plug or arbor is fitted to one of the centers. The ferrule of steel runs on a collet of hard brass, and is kept in its place by a small washer. The collet is pierced to move freely on the steel arbor, and its projecting end slit, and then pinched together, so as to grip the arbor sufficiently tight to remain in position when in use, and yet not so tightly that it cannot be moved to and fro without trouble. Holes may be made at convenient positions in the ferrule to receive the carrier pin. The shake between the crossings is not objectionable with small-sized wheels, but for large and heavy balances, etc., two pins and a large ferrule may be used. To compensate for the room taken up by the projecting end of the collet, a little is sometimes taken off the boss of the Jacot tool.

TO MOUNT A GRINDSTONE.—Small though a watchmaker's or jeweler's grindstone be, it is after all not a very large job to mount it correctly, in such a manner that it shall not "wobble" to and fro, or hang out of true. The hole is to be at least one-half or three-quarters of one inch larger than the axis, and the former as well as the latter must be square. Then make wedges for each side, all of which are to be equal and sufficiently thin, so that a wedge passes from each side through the hole. These wedges are to be inserted from both sides. If the hole through the stone is regular and equal, the wedges will fix the stone as it ought to fit. But if it is not at right angles to the stone, it is to be made so, or else the wedge must be made accordingly, so that they will equalize any irregularities.

OILSTONE.—An oilstone thoroughly saturated with oil is often cast aside, but if it is soaked in benzine for two or three days it will be as good as ever. The ordinary animal and vegetable oils are not so suitable for use with the oilstone as petroleum especially for setting small tools. A mixture of glycerine and alcohol is even better than petroleum for watchmakers' tools, or glycerine alone may be used. Glycerine has the advantage of neither evaporating nor clogging, as oil is apt to do.

NOTES ON THE LATHE.

USE OF LATHE.—As to lathes, I have found that there is a necessity of about two lathes; one a Swiss, light-running lathe for cementing any pivot work, and I prefer these because they run lighter and easier than American lathes; and yet, if confined to but one, I would use a small American, with a good assortment of split chucks, particularly those with the smaller-sized holes, for holding balance staffs, wheel arbors, etc., which come in use almost every day, for taking off the burr from the point of a balance pivot, which has come from a collapse of the case; driving the end-stones down on the end of pivots, even sometimes to the extent of heading them on the inside of the hole jewel. These small-size split chucks I have found extremely useful for the last-named purpose, and I am not so "sentimental" but that I oftener use these split chucks, even for setting fine balance pivots, rather than take time to cement them; and while I do not advise the use of a split chuck for this purpose in every case, yet with a little experience one can tell when a staff is held so that the new pivot, when set, will "line" and be true, and of clear beat or swing. To make a very nice pivot the cementing process is preferable, and yet, for nearly a year, my old No. 1 American lathe was not set up (for reasons irrelevant to mention), and during that time I employed a very skilful workman to do my pivoting, and this man would not think of ever doing a nice job unless he cemented it; and I can assure you that he put more pivots out of line and out of true, in the course of a few months, than I had done in all my life. Speaking of "sentiment," I will say that too many young workmen use the lathe too much, and seem to depend on a fine-looking lathe and handsome tools, and spend too much time in using the lathe and in decorating their bench with a fine display. But do not construe this as meaning that one can do nice work with a jack-knife and handsaw; for I do most certainly believe in a good and substantial set of tools.

BOW LATHE VS. FOOT LATHE.—Some workmen still insist that there is nothing equal to the bow lathe, and I am willing to admit that some of the finest of work has been produced by this means. Others, however, claim that continuous motion will produce as good work and do it quicker. The writer is of the latter opinion; he also claims that a split chuck in a lathe of American or foreign make will not hold a piece *absolutely* true. Such chucks will, no doubt, do well enough for ordinary work, but when a fine staff or pivot is to be turned, he agrees with the manufacturer of the leading American lathe, that nothing equals a *well-centered* cement chuck. He has tried almost every make of lathes, and has come to the conclusion that for the finest kind of work the Swiss or cement lathe is most suitable on account of its lightness and the facility with which the wearing parts may be adjusted; or a cement brass may also be used with an American lathe; and it must be borne in mind that if the chuck is removed from the lathe it must *always be carefully recentered* when replaced, no matter how true it may seem to run.

CARE OF LATHE.—To prevent the rusting of the lathe, some use an oily cloth to wipe it with, which is a very good plan when one's perspiration is very corrosive. The lathe should be left under a glass cover, when practicable, as it answers all purposes as a protector, and has the advantage of looking nice. When it is not, a piece of chamois skin or cotton flannel should be thrown over it when not in use, especially when leaving the shop in the evening. The heavier the foot wheel used the more regular will be the motion of the lathe. The swing treadle produces a more uniform motion than the common foot treadle, the advantage of which is obvious. I use clock oil for oiling my lathe, but oil with a little more body might not be objectionable. The oil cups should always be closed after oiling to prevent chips from working into the bearings. There is nothing to be saved in springing a chuck by pressing work into it which is too large for it, or clamping upon it work which is too small. Better use wax on such jobs than spoil a $1.25 chuck.

A NICE UNDERTURNING.—To introduce a nice underturning on a pinion, balance staff, etc., remember the following points: 1. The object in hand must run between good centers, without any side shake; every tremble is ruinous to the graver point and the pinion or staff, which will bend easily. 2. The graver used must be ground carefully, so that it will attack well; as soon as it cuts no turnings, stop at once and grind the graver, as otherwise the turned place will simply polish, after which it is quite difficult to make the graver catch hold again. 3. The graver rest must stand at an almost right angle to the running-bar of the lathe, and be set as closely as possible to the object to be turned.

TURNING.—Hardened steel that has been let down to a blue temper requires certain precautions. If the graver is found not to cut cleanly, it must at once be sharpened, and no attempt should be made to remove more metal by increasing the pressure of the hand, because the steel will burnish and become hard under a point or edge that is blunt, and the portions thus burnished are sometimes so hard as to resist the best gravers. The only way of attacking them is to begin at one side with a fine graver point, which must be sharpened for each stroke; at times it becomes necessary to temper the metal afresh before it will yield. It is asserted that by moistening the point of the graver with petroleum, it becomes more able to attack hard substances, and that a mixture of two parts petroleum and one part turpentine enables it to turn very hard steel with comparative ease. Indeed, for all turning, it is a common practise to moisten the graver with oil, water, turpentine, or by simple introduction into the mouth.

NOTES ON STEEL AND ITS TREATMENT.

TEMPERING STEEL.—It is known that soft steel increases its volume when it is hardened, and it is easy to arrive at the conclusion that the steel is less dense in proportion as it approaches the condition of iron. If, therefore, a piece of steel is heated in the open fire and an air current passed over it, then the outer part of the metal, in consequence of its decarbonization, partakes less of the nature of steel than formerly; thence follows that the interior part of the article, compared to the outer, becomes too large, and the workman is consequently exposed to the danger of seeing it burnt. But when the piece is surrounded with a mixture suitable for effecting cementation, or exposed to a fire, which may also operate with a steel-forming effect, containing animal charcoal, then the opposite phenomenon will result. The outer part, instead of being decarbonized by the fire, becomes richer in carbon than the inner portion, in consequence of which, in place of cracking during the cooling, it will become harder and more dense.

CRACKS IN STEEL.—The cracks which often appear when steel is dipped into water do not always seem to be due to the sudden contraction which the latter experiences, while the interior portion remains expanded by the heat, and retains its increase of volume for another moment after the exterior has been brought in contact with the water.

RUST.—Nuts are oftentimes so tightly rusted upon screws that other means than unscrewing must be made use of to loosen them; kerosene or naphtha, even turpentine, will, in a short time, penetrate between the nut and stem. Next, heat them in the fire, which will quickly loosen them.

HARDENING STEEL. — In hardening, bright steel should not be exposed naked to a fire or flame. It may with advantage be placed in a covered box containing bone dust or animal charcoal in some other form, or another plan is to smear soap all over the article to be hardened. Water or oil is the medium generally selected for plunging the article in to cool it. Petroleum is recommended, if extra hardness is desired. Either mercury or salt water will give great hardness, but the steel is rendered brittle. Oil is the best medium for hardening steel, if toughness is required.

TO FROST STEEL WORK.—After the work has been prepared with a surface free from scratches, it is rubbed with a short backward and forward motion on a small glass slab, with a thickish paste of oilstone dust and sweet oil. Before mixing this paste look over the powdered oilstone with a very strong magnifier and carefully remove all the black atoms which, if left, would inevitably scratch the work. The work is cleaned and finished by rubbing in a circular direction with pith; or instead of rubbing with pith, the work may be carefully breaded and immersed in benzine.

TO PREVENT RUST.—Dip iron or steel articles in a mixture of equal parts of carbolic acid and olive oil, rubbing the surface with a rag. Others rub the metal with a mercurial ointment, leaving a thin layer over the entire surface. It is stated that, if iron be dipped in a solution of carbonate of potash or soda in water, the surface will be protected against rust for a long time, and objects can be protected for any period by burying in quicklime. Rubbing the surface with plumbago has a similar effect, and Barff has pointed out that, by exposing iron to the action of steam, heated above the boiling point of water, a coating of magnetic oxide of iron is formed, which is equally serviceable.

TO KEEP STEEL FROM RUSTING.—To keep steel articles from rusting, cover them with powdered quicklime. If they must be exposed, place near them a small open vessel containing chloride of calcium. By immersing rusted steel articles for a few minutes in a strong solution of cyanide of potassium, they will be cleaned much easier. Steel or iron that has been immersed in caustic soda will resist rust for a long time. Spots of rust on chronometer springs and other steel pieces are generally rubbed with a piece of brass, but some say the best plan after cleaning the spots is to apply a little spirits of ammonia to them.

A SOLVENT OF RUST.—It is sometimes very difficult and occasionally impossible to remove the rust on certain iron articles. This, however, is quickly done by immersing them in an almost saturated solution of chloride of tin. The length of their exposure in the bath is according to the thickness of the layer of rust; generally speaking, 24 hours are sufficient. The solution must not contain a large amount of acid, as this would attack the iron. After withdrawal, the articles are rinsed, first in water, next in ammonia, and rapidly dried. The pieces are of a matt silver color; a simple polish restores their general appearance.

MAKING A DRILL.—After having made the drill, the greatest possible care must be exercised in the hardening and tempering, not to overheat it. The following method dispenses with the hardening. Select a round pivot broach; as sold they will be found to be tempered to the correct degree of hardness. By means of the split gauge, measure the part of the broach which is the exact diameter required for the intended hole, and break off the steel at that point; the small piece is used; it must be broken off if too long, and cemented into a drill stock with shellac; an ordinary drill stock will do, or a piece of brass joint-wire serves the purpose. Soft solder may be used instead of shellac, and, if carefully heated, the temper will not be drawn. The piece of tapering steel is now formed into a drill by grinding down the sides with a piece of Arkansas stone, and the end shaped up to a cutting angle. The thick end of the broach forms the cutting end, and the ordinary taper of a broach will be quite sufficient to give clearness to the drill, which may be sharpened by grinding until the hole is used.

SHAPE OF DRILL.—After the operator is satisfied that his drill has a truly central point, he must see to the getting of his cutting edges in position, which is largely influenced by the material he desires to drill. If it is brass, he may make the cutting edges at about right angles; if he desires to cut copper, he may make them about an angle of 75°, and at the same time give them a little more clearance, so that the drill will not be so likely to bind; he will find, if he has to drill pretty far into soft metal, that it is somewhat difficult to keep the drill from binding, unless he is careful and gives it a good clearance.

TO DRILL STEEL OF BLUE TEMPER.—At first not much difficulty will be experienced in drilling blue tempered steel, but when the drill has reached a certain depth, and the metal seems to oppose a gradually increasing resistance, the operation must at once be stopped. If the blade of the drill be examined with a glass, it will be easy to see which point has ceased to cut, producing instead a series of bright rings at the bottom of the hole that are very difficult to remove. Exchange the drill for one of a different form; or, without reducing its width, change the form of the blade. If it was arrow-headed, for example, make it semicircular or semi-oval, or chisel-shaped with sloping edges. All that is essential is that the form be so changed that the bright portion of the surface shall be gradually removed, and that no attempt be made to act on the whole bright surface at once. Until this hard portion is removed, the blade will require frequent sharpening. Some recommend that the hole be moistened from time to time with dilute nitric acid, which is washed off and renewed when a shiny surface is produced. Oil may with advantage be replaced by turpentine as a lubricant for a drill blade.

The formation of hard, shiny surfaces is attributed to three causes: 1. To the cutting edge being rounded, rolling, as it were, and hardening the surface of the metal against which it continues to move; 2. To the drill being made of poor steel or imperfectly hardened, so that small particles break off and are imbedded in the metal operated upon; 3. To a deficiency in the supply of oil, or a too great velocity of rotation of the drill.

TO DRILL INTO HARD STEEL.—Make your drill oval in form instead of the usual pointed shape, and temper as hard as it will bear without breaking. Then roughen the surface where you desire to drill with a little diluted muriatic acid, and instead of oil, use with your drill turpentine or kerosene in which a little gum camphor has been dissolved. In operating, keep the pressure on your drill firm and steady, and if the bottom of the hole should chance to become burnished so that the drill will not act, as sometimes happens, again roughen with diluted acid, as before; then clean out the hole carefully and proceed again.

HARDENING STEEL.—In the case of delicate pieces, it is necessary to avoid the use of the blowpipe, as the current of air causes the surface to scale, and, as is well known, the metal being unevenly heated, will be distorted in hardening and will not be uniformly hardened. It is better to enclose the article between two pieces of ignited charcoal, or in a metal tube, or to bring it in contact with a sufficiently hot piece of metal, etc. An excellent plan is to heat the article in a bath of hot lead, or of lead and tin in proportions dependent on the temperature required. The heating is thus exceedingly uniform, and if operating in a dark room, the temperature can be accurately judged.

HARDENING PUNCHES.—Punches are pickled by dropping upon their surface a drop of muriatic acid; they are then rubbed off with a brush, washed and anointed with fat. When fairly clean and without flaws they are annealed pale yellow, and they then possess sufficient hardness to be driven cold into softened steel.

HARDENING WITHOUT DISCOLORING.—When it is required to harden an object without discoloring the surface or destroying the polish, it may be placed in a tube, and completely surrounded with powdered wood charcoal, or preferably, animal charcoal. The whole, after being heated is plunged in water without the steel being in any way exposed to the air. The powder must be heaped up as a precaution against access of air. On being taken from the water the steel is at once placed in alcohol, and if at all dull it will generally be only necessary to rub the surface with a little rouge. It is essential that the animal charcoal be previously heated in order to expel moisture, as otherwise it would adhere to the surface and produce marks and irregularity in the hardness.

AGENTS FOR HARDENING STEEL.—In regard to hardening steel there is at present considerable controversy and any number of methods. A correspondent says that he has at different times and for different purposes tried castor oil, linseed oil, sperm oil, petroleum, fresh water, salt water, and mercury. The first three named oils, in his opinion, gave the same results. Fresh water gives the same degree of hardness, but does not leave the steel as tough as the oil does. Petroleum renders the metal a trifle harder than the other oils do, and at no apparent cost in regard to brittleness, while either salt water or mercury renders the metal so very brittle as to be suitable for only large or medium sized drills, and is no particular advantage in hardening such a piece as a balance staff.

TO HARDEN A STAFF.—When a repairer is working for future contingencies and making a supply of balance staffs, his chief consideration is how to harden them nicely. Let him do as follows: Take about a dozen blank staffs, lay them in a hollow in a piece of charcoal and cover them with a thin piece of soap, and by means of a good-sized alcohol flame and blowpipe heat them to a cherry red, and then plunge them quickly into linseed oil. In preparing this operation, see that as the flame is directed the soap melts rapidly and covers the pieces with a thin, black coating, which will serve to exclude the air while heating. If it is properly done the sudden cooling causes this shell to chip off and leaves the blank staff perfectly white; but should the result not be satisfactory, a little rolling between the fingers will remove it, or should a better polish be desired and the repairer has an American lathe, he can quickly and nicely polish them with a fine emery stick.

BLUING.—Before the operator places the articles to be blued in the bluing pan, he should have this well warmed to disperse all moisture. Steel for bluing should be finished with medium rouge and the last few rubs given not with a metal polisher but with a piece of boxwood or horn and plenty of rouge and oil. Pieces that have been cleaned in dirty benzine (that is, benzine charged with oil) will become specky in bluing. Difficulty is often experienced in bluing soft screws, but an eminent authority says that a good even color may always be obtained if they are finished with a slightly soapy burnisher.

POLISHING STEEL PIECES.—Large steel pieces, such as in lever and repeater racks, which are not solid, and springs should be shellaced to a brass block and polished underhand; a flat surface is first obtained by rubbing with fine emery on a glass plate; afterward with coarse rouge on a bell metal block. The work is then finished off with diamantine on a zinc or grain tin block. The diamantine should be well beaten up on glass with as little oil as possible. Such parts as rollers and collets are polished in the same way. Levers are pressed into a piece of willow held in the vise and polished with a long, flat bell metal or zinc polisher, moving the polisher instead of the work.

STEEL FOR WATCHMAKERS.—Cast steel is preferable for most horological purposes, such as pinions, staffs, pivots, etc. It is the only kind that can with certainty be highly polished, turned perfectly round, and that does not get distorted in the smoothing. Moreover, when wear does occur, it exhibits less irregularity.

TEMPERING CASE AND OTHER SPRINGS.—Draw the temper from the spring, and fit it properly in its place in the watch; then take it out and temper it hard in rain-water (the addition of a little table-salt to the water will be an improvement); after which place it in a small sheet-iron ladle or cup, and barely cover it with linseed oil; then hold the ladle over a lighted lamp until the oil ignites; let it burn until the oil is nearly, not quite, consumed; then re-cover with oil and burn down as before; and so a third time; at the end of which plunge it again into water. Main and balance springs may, in like manner, be tempered by the same process; first draw the temper, and properly coil and clamp to keep in position, and then proceed the same as with case springs.

TEMPERING SMALL STEEL PIECES.—The tempering in kerosene gives excellent results. The pieces are first heated on a coal in the usual way, then coated with soap, and raised to a cherry red; they are then plunged into kerosene, and no fear need be entertained that the liquid will take fire. The pieces annealed in this manner do not warp, small though they be, and remain entirely white.

GILDING STEEL.—Polished steel may be beautifully gilded by means of the ethereal solution of gold. Dissolve pure gold in *aqua regia*, evaporate gently to dryness, so as to drive off the superfluous acid, re-dissolve in water and add three times its bulk of sulphuric ether. Allow to stand for twenty-four hours in a stoppered bottle and the ethereal solution of gold will float on top.

ENGRAVING ON STEEL.—Lightly heat the metal and cover it with a layer of beeswax; hold it over a smoking flame to blacken the wax so as to better see the lines drawn upon it either with a pin, pen, or point. This done, run nitric acid, diluted with twice its volume of water, over the lines laid bare. Be careful to spread the liquid of a uniform thickness. The operation will be finished in about three minutes.

BLUING STEEL.—In order to blue steel easily, the following will give satisfactory results: First blue the object without any special regard to uniformity of color. If it proves to be imperfect, take a piece of dead wood that does not crumble too easily, or of cleaning pith, and whiten the surface with rouge, without having it too dry. Small pieces thus prepared, if cleaned and blued with care, will assume a very uniform tint.

ETCHING LIQUID FOR STEEL.—Mix 1 oz. of sulphate of copper, 1-4 oz. of alum, and one-half a teaspoonful of salt reduced to powder, with 1 gill of vinegar and 20 drops of nitric acid. This liquid may be used either for 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 part you wish to protect from its influence with beeswax, tallow, or some similar substance.

BLUE COLOR ON IRON OR STEEL.—To remove the blue color imparted to iron and steel by exposure to heat, rub lightly with a sponge or rag dipped in dilute sulphuric, nitric, or hydrochloric acid. When the discoloration is removed, carefully wash the article, dry it by rubbing, warm it, and give it a coat of oil or it will rapidly rust.

HAMMERING STEEL.—Watchmakers who are called upon to manipulate exceedingly small pieces of steel can somewhat increase the body and homogeneity of the metal by cold hammering. After annealing, the object is hammered with light, uniform blows, again annealed, and the same operation is repeated one or more times, according to the degree of malleability already acquired by the metal. Steel thus prepared has more body; the particles composing it are more closely pressed together; it files and turns well, can be heated more easily, and is not distorted, or only very slightly, in hardening, provided the requisite precautions are taken.

TO ANNEAL HARDENED STEEL.—It may sometimes happen that hardened steel parts require a few finishing touches, which cannot be given because they are too hard, and their polish would be ruined by annealing them, as it turns blue, and the piece requires then a renewed polish, which consumes a great deal of time. The most practical way is to cover it with the oily dirt from the oilstone, after which it can be annexed with impunity, that is, the flame is with the blowpipe directed to the part required. The article is afterward cleaned in benzine.

WHITENING IRON.—To render iron as white and beautiful almost as silver, take ammoniacal salts in powder and mix it with an equal quantity of quicklime. Dissolve in cold water and mix well. When done, immerse the red heated article in this bath and it will become as white as silver. Be careful not to burn the article by overheating.

NOTES ON GLASS AND ITS WORKING.

CEMENT FOR BRASS UPON GLASS.—C. Pusher recommends in the *Ind. Bl.* a very tenacious cement for fastening brass upon glass, which is said to be very useful for cementing brass burners upon the glass bulbs of kerosene lamps, since the kerosene cannot penetrate the cement, nor chip off in heat (water will attack it superficially only). This cement is prepared by boiling one part caustic soda and three parts colophony (yellow rosin) in five parts water. A soap-like product is obtained, which is kneaded with gypsum, say about one-half its weight. The cement obtained hereby hardens in 30 to 45 minutes.

TO CUT GLASS WITHOUT A DIAMOND.—Scratch the glass about the shape you desire with the corner of a file or other hard substance; then, having bent a piece of wire in the same shape, heat it red hot and lay it upon the scratch; sink the glass into cold water just deep enough for the water to come almost on a level with its upper surface. The glass will rarely ever fail to break perfectly true.

ETCHING ON GLASS.—Fancy work, ornamental figures, lettering and monograms are most easily and neatly cut into glass by the sand-blast process. Lines and figures on tubes, jars, etc., may be deeply etched by smearing the surface of the glass with beeswax, drawing the lines with a steel point, and exposing the glass to the fumes of hydrofluoric acid. This acid is obtained by putting powdered fluorspar into a tray made of sheet lead and pouring sulphuric acid on it, after which the tray is slightly warmed. The proportions will, of course, vary with the purity of the materials used, fluorspar (except when in crystals) being generally mixed with a large quantity of other matter, but this point need not affect the success of the operation. Enough acid to make a thin paste with the powdered spar will be about right. Where a lead tray is not at hand, the powdered spar may be poured on the glass and the acid poured on it and left for some time. As a general rule, the marks are opaque, but sometimes they are transparent. In this case, cut them deeply and fill up with black varnish, if they are required to be very plain, as in the case of graduated vessels. Liquid hydrofluoric acid has been recommended for etching, but is not suitable, as it leaves the surface on which it acts transparent. The agent which corrodes the glass is a gas which does not remain in the mixture of spar and acid, but passes off in the vapor. To mix fluorspar and sulphuric acid and keep it in leaden bottles under the idea that the mixture is *hydrofluoric acid* is a gross mistake.

DRILLING GLASS.—A thick plate of glass is perforated by using a revolving brass tube which is kept filled with water during the drilling; finely pulverized emery is added to the water. A thinner glass plate can be perforated in a simple manner by spreading a moist disc of clay upon the glass; a hole of suitable size is then made through the clay, laying bare the glass. Melted lead is then poured into the hole, whereupon the glass springs off at once and opens the hole of corresponding size. This method is based upon the sudden heating of the glass, which causes the circular hole.

DRILLING GLASS.—For drilling holes in glass, a common steel drill, well made and well tempered, is the best tool. The steel should be forged at a low temperature, so as to be sure not to burn it, and then tempered as hard as possible in a bath of salt water that has been well boiled. Such a drill will go through glass very rapidly if kept well moistened with turpentine, in which some camphor has been dissolved. Dilute sulphuric acid is equally good, if not better. It is stated that at Berlin, glass castings for pump-barrels, etc., are drilled, planed and bored like iron ones, and in the same lathes and machines, by the aid of sulphuric acid. A little practise with these different plans will enable the operator to succeed.

TURNING GLASS IN LATHE.—Black diamonds are the best tools for turning, planing, or boring glass where much work is to be done. With a good diamond a skilful worker can turn a lens roughly out of a piece of flat glass in a few seconds, so that it will be very near the right shape. A splinter of diamond may be very readily fastened in the end of a piece of stout brass wire so that it can be used for drilling or turning glass. Bore a hole the size of the splinter and so deep that the diamond may be inserted beyond its largest part, but leaving the point projecting. Then, by means of a pair of stout pliers, it is easy to press the end of the brass so that it will fill in around the diamond and hold it tight. Diamonds are sometimes cemented in such holes by means of shellac, or even solder is run around them. This answers for some purposes, but not for drilling or turning.

TO MOUNT PHOTOGRAPHS ON GLASS.—Dissolve ½ oz. of Nelson's No. 2 gelatine in 5 oz. of water, and place in a flat dish, keeping it warm. The print should be trimmed rather smaller than the glass to allow for stretching. It is then immersed in the gelatine solution. At the side of the dish have another containing water at about 115 deg. F., and in this place the glass till ready. Lift up the print by both ends and lay it face downwards with a curl—similar to when floating paper—on the glass. Smooth gently into contact, drain off excess and press down with a squeegee. When dry, place a piece of white paper over the back with stiff starch paste or gelatine, and after again drying, mount on the strut back with glue. The glasses and struts can be obtained from any photographic dealer. If preferred, the print and glass (warmed) may be placed together in the gelatine solution and brought into contact under the surface, or a pool may be poured upon the glass, which is laid flat on the table and the print laid upon it. "Opalines" improve the permanency of the print considerably. Old negative glasses, a size larger, may be cleaned and used, the edges being painted with flowers or covered with some design in stamped paper, etc.; if some spotting and working up is required upon the print, it should be done with oil paints or a lead or chalk pencil, otherwise it will be dissolved away when mounting.

INK FOR ETCHING ON GLASS.—An ink or writing fluid that can be used for etching directly on glass, may be made from the following ingredients, which are kept separate until the ink is required for use: a solution of ammonium fluoride, some sulphate of baryta, and sulphuric acid. When required, a portion of the sulphate of baryta is moistened with the fluoride solution, a few drops of the sulphuric acid are stirred into the mixture, and the thin fluid paste is at once applied to the glass with a pen, with which the desired characters are written. The etching will be found to be sufficiently legible after the ink has remained on the glass for an hour. This preparation will corrode steel pens, but is otherwise free from objections.

FASTENING LETTERS ON GLASS.—For fastening glass letters, figures, etc., on glass (show windows), so that they, even when submerged in water for several days, will not become detached, use an India-rubber cement. The best for this purpose consists of one part India-rubber three parts mastic, and 50 parts chloroform. Let the mixture stand for several days in low temperature to dissolve the parts. It must be applied very rapidly, as it becomes thick very soon.

CLEANING POWDER FOR SHOW WINDOWS.—A good cleaning powder which leaves no dirt in the joints, etc., is prepared by moistening calcined magnesia with pure benzine so that a mass is formed sufficiently moist to let a drop appear when pressed. The mixture is to be preserved in glass bottles with ground stoppers, in order to retain the easily volatile benzine. A little of the mixture when to be used is placed upon a lump of cotton and applied to the glass plate.

NOTES ON POLISHING IN WATCH WORK.

POLISHING.—Those who have not had much experience in polishing, may with advantage use a lap for straight pivots and shoulders. The lap and pinion are rotated in opposite directions by means of two bows held in the right hand, the lap being centered in the back limb of a depthing tool, and the pinion in the front limb. An arm is fixed to the depthing tool to hold it in the vise, and a piece of brass wire clasps the runners of the front limb, so that the operator can move the pinion to and fro with his left hand. A soft steel lap at first and a fine lap afterwards are generally used. They should be turned true to the edge and the face slightly undercut. Above method, however, is useful only for those who have no American lathe, as a neat lap holder accompanies this lathe. It may be angled in any direction, and is also suitable for damaskeening.

The tools used for producing the beautiful polished and square surfaces to be found in watch work may be divided into two general principles: first, where the work is rigid and receives a reproduction of a previously squared surface, and, secondly, where the work is "swung," or arranged so as to yield to unequal pressure in polishing. Polishers for steel are either of soft steel, iron, bell metal, tin, zinc, lead or boxwood. They must in all cases be formed of softer material than the object to be polished; for instance, bell metal, which brings up a good surface for hard steel, is unsuited for soft. Polishers used for brass are generally of tin or boxwood, with willow for finishing. The polishing medium is either emery, which is used for gray surfaces, oil-stone dust, rouge or diamantine, used with oil. Brass surfaces are generally "stoned" preparatory to polishing; that is, rubbed square with blue stone and water of Ayr stone and water or oil.

Success in polishing depends much on the mode of mixing and using the polishing agent. Oil stone dust is often recommended and employed, but in the opinion of THE CIRCULAR it should never be used by watchmakers. It is very dirty, and it is impossible to make anything flat with oilstone dust and a steel polisher. Watch finishers used to be fond of preparing their work for gilding with steel polishers and oilstone dust; but it was only necessary to rub a flat stone over the piece to see how uneven it was.

POLISHING MATERIAL.—The polishing materials are oilstone dust, crocus-antimony and diamantine. The oilstone dust should be well mixed with refined sperm oil, as should also the crocus-antimony. The diamantine should also be well beaten up and mixed in a similar manner on glass and with a glass beater, but it must be used with as little oil as possible. One thing must be borne in mind, however, in regard to any polishing material, it must be absolutely free from all dust or grit, or good results will be impossible. I keep polishing materials ready mixed in small, round wooden boxes, which I procured at the druggist's and fit them inside with thick flat glasses.

Polishing Pinions and Arbors.—The pinions and arbors are to be polished highly; some workmen burnish the arbors, but a high polish can be got very quickly with a zinc polisher and diamantine. The faces of the third and fourth pinions are finished with the ordinary facing tool, but as the large pivot on the center arbor precludes the use of such a tool, it is faced square down to the arbor; the pinion is placed in the turns, and small turns that fit into the rest holder carry a roller mounted on an arbor; this roller is brought to bear against the face of the pinion, and the pinion is rotated backward and forward with the bow. The roller first used is steel, to bring up the face flat and square, after which soft metal rollers are used for finishing.

Polishers.—Among the several tools used by the watchmaker and repairer, polishers are of a good deal of importance. The polisher for square pivots and shoulders consists of a strip of soft steel or iron about six inches long and about three-sixteenths square, with end curved, and the edge that faces the shoulder should be filed back at a very slight angle. A similar strip of bell metal will also be required. They should both be filed into shape with a medium coarse file drawn crosswise so that the grain made by the file will serve to hold the polishing material. The edge also should be very sharp and clean cut, so that a sharp corner may be well polished. They should be refiled as often as they become worn smooth. For conical pivots similar polishers are required, with the edges left straight and the corners rounded so as to exactly conform to the shape of the pivot, and they should be made so that either can follow the other without any perceptible difference.

Polishing Roller Edges. — Roller edges for lever and chronometer escapements are often polished by means of a rotating disk or mill of bell metal. The roller on an arbor is fixed to the slide rest of the lathe in a pair of turns or specially adapted holder. When brought into contact with the mill, it is turned with the bow or the thumb and finger, and the slide rest traversed the while so as to move the roller in a plane parallel with the face of the mill. After the edge is polished, if the corners of the rollers are to be chamfered, the holder is turned first one way and then the other to an angle of 45°.

NOTES ON ENGRAVING IN WATCH WORK.

Light in Engraving.—The engraver has only the eye to guide him in the various devices of his art, and as the result depends upon the skill of the operator, that eye should be a pretty correct one. Good light is very necessary in engraving; gaslight being extremely tedious and trying, globes filled with water are used, which, being placed between the workman and the gas jet, steady the light and throw it more clearly upon the work. Besides this, the light is perfectly cold, as no heat passes through the water globes.

Stoning a Graver.—When stoning the belly of a graver the blade should be held as lightly as possible between the thumb and second finger, the tool being barely touched by them, they being used simply as checks on either side of the tool to keep it in position. The only pressure that should be applied to the tool is that steady power supplied by the tip of the forefinger to its point, holding it down firmly upon the stone. Pressure applied to any other portion of a graver blade while stoning its belly only hinders the work in hand as to speed, and also diminishes the average certainty of securing for it a surface that shall be perfectly flat.

Gravers.—As regards gravers, I would have plenty of them—a good assortment of shapes and sizes, and, above all, the best quality obtainable. In sharpening or grinding be sure and get the face flat, and if you have never been able to accomplish the latter feat, take an old graver and practise for an hour or so, for you will never be able to do any kind of good work unless a properly ground graver is used.

Gravers made by different makers will be found to be of different lengths, and very often in those of the same make will be found a like variation. To overcome any difficulty this circumstance may produce graver handles of different lengths should be procured. The hands of no two persons, any more than their faces, will be found to correspond exactly, and therefore no rule as to size of handle and length of blade of graver that is the most comfortable to hold and easiest to use can be laid down. The party must "fix" the tool to the hand. It will be found upon inquiry that, as with most things, habit has a good deal to do with the matter. The length of tools and the form given to them in setting up, will be found to vary perceptibly among engravers, no two men "fixing" them, in either particular, exactly alike.

Good Advice.—The writer finds in a horological exchange the following sound advice to persons learning the art of engraving: "There is no greater hindrance to progress in learning to engrave than in trying to cut with a badly-set or a half-sharp graver. Such a practise speedily engenders some of the worst evils—'constraint' and 'restraint'—in the use of the graver, by which is meant that the wrist becomes stiffened, the easy motion of the hand impaired, and the ability to hold a graver lightly materially crippled, and thus the power to cut strokes clean, true and free, is largely destroyed."

Graver Blade.—A graver blade having its cutting edges at right angles one with the other, as they must be if the graver is square, will make too wide and shallow a stroke. It will be found that from the edge of the graver on one side to the corresponding edge on the other side, crosswise, as it is fitted into the handle, measures one-third more than it does across either of the flat sides of its belly. For certain kinds of work, the tool to be used should be diamond in shape endwise, and the distance from edge to edge crosswise of the blade should be equal to a width of a side of its belly.

Engravers' Border Wax.–Beeswax, one part; pitch, two parts; tallow, one part; mix.

GOLD AND SILVER WORKING.

JEWELRY REPAIRING.

SOME manufacturers do not care to be troubled with repairs, and when they do take them, they are handed to some inferior workman, who is "good enough for such jobs." This is a mistake ; it takes a man of considerable skill and long experience to make repairing pay, as otherwise the accidents will consume all the profits that would otherwise be made. The repairer must be on the alert for all the tricks that are often used to patch up a piece of work which has been repaired several times ; he must know how to distinguish an old gilt article from a colored one, and be able to find all the weak points and thin places before attempting to solder or repair in any way, or he may find himself in "a peck of trouble" before he has been working at the job for five minutes. A few suggestions showing how to avoid these traps for the unwary are as follows :

Upon receiving a colored gold article to be repaired, especially if it is an old one that may reasonably be expected to have been repaired several times before, the first thing to do is to ascertain whether it has been repaired with soft lead solder anywhere, as if this is the case and you attempt to hard solder without removing the lead, the result is that the soft solder burns through the surface of the gold and thus destroys it in such a manner as to prevent a good job being made of it. If upon examination you find soft solder present, remove as much as possible by scraping, and then immerse the article in a solution of four parts muriatic acid to one part water. This should be done in an earthenware pipkin, and not a metallic vessel. Making the solution warm will remove the solder more quickly, but it is not altogether necessary, as the cold solution will do it and is more convenient, the warm acid giving off more fumes than the cold. When the solder is gotten rid of, the article should be boiled in clear water in a copper pan, to remove all traces of acid.

Now, before attempting to hard-solder the part to be repaired, cover the work with a solution of borax rubbed fine in water and mixed with charcoal dust into a thin paste. Apply this all over the article with a camel's hair pencil, then anneal gradually, being careful not to make it too hot. Afterward boil out in a weak mixture of nitric acid and water, and then dry in hot sawdust—fine boxwood sawdust is the best, as it does not give out resinous compound that common woods are liable to do. You will then be able to solder in the ordinary way with either gold or silver solder as the case may require. If the article is strong enough to stand recoloring, use gold solder ; if it is too far gone for this use silver solder and gild.

It happens sometimes that the article to be repaired has been so worn and patched as to make it quite impossible to use hard solder of either kind. In this case there is nothing for it but to soft-solder, and this may be done much neater and better than is often seen. The important thing to remember is that soft solder will not take where there is the smallest trace of dirt or grease. Commence, then, by washing out the work in hot soda water and soap, with a moderately soft brush, dry in hot sawdust and then scrape the parts to be soldered together bright and clean. If any part has to be added, such as a joint or a catch on a plate, put a coating of solder on the sides to be mitered together by warming them in the soldering gas or lamp, and rubbing a copper point, which has already been tinned over the surface, using a little soldering fluid or Venice turpentine. Then place the two surfaces together, using a a little fresh fluid, and warm them with a a small blast from the blowpipe until the solder runs, when the whole will be cleanly and soundly joined, provided the two surfaces fit one to the other. This method is far superior to that of putting small pellets of solder along the mitered edges in hard soldering and trying to draw it through, as it is generally a failure, the solder running about the outside surface and causing a deal of trouble afterward.

Now, if fluid has been used, the article must be washed out in cold water; hot water will only fix it on and make it dirty for finishing. If Venice turpentine has been used as a soldering medium, wash out in ordinary turpentine and dry in hot sawdust; after trimming up, polishing a little where necessary, washing out in hot water and soap, and again drying in hot sawdust, it will be ready for gilding, sand-blasting, etc.

SOLDERING.

THE *modus operandi* of soldering is as follows: A thorough cleaning of the surface to be united is always needful. This may be effected by means of acids, or with a graver or scraper, etc.; the cleaned surface must not be touched with the fingers, and the soldering should be done at once, if acids are employed; the objects should be thoroughly washed after soldering, and after drying they should be rinsed with alcohol. Before heating, if there are already parts united with solder, they should be covered with borax to prevent softening. Only a moderate heat should at first be applied, so as to melt the borax or sal-ammoniac, without displacing it. The violent frothing up, which is very liable to displace the parts or the pellets of solder, can thus be avoided. If a naked lamp-frame is used, or if it is directed on to the object with a blow-pipe, it should be, so to speak, large and soft, and the point should not be directed to the place of juncture until the solder is observed to have fused. The hard solders for gold, silver, etc., require a considerable degree of heat.

On a hard wetted surface, marble, for example, rub a piece of borax until a white liquid paste is obtained, or the powdered borax sold by druggists can be made into a paste direct. Having prepared the borax, the surfaces to be united are cleansed, either by scraping, or with diluted nitric acid; the acid may be previously heated to boiling, as it will then act more rapidly; and the surfaces are subsequently scraped. They are now covered with the borax with a paint brush, set in position, and small pieces of solder placed on the junction. As already observed, the heating must at first be gentle to avoid displacing the solder by the frothing of the borax.

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 of brass, with the addition of about 10 or 15 grains of tin.

SOFT GOLD SOLDER FOR 8 AND 14 KARATS.—A nice soft solder for 8 and 14-karat gold consists of 1½ parts fine silver, one-half 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 the latter melts, not volatilizes, and then cast.

GOLD SOLDERING.

THE article to be soldered is placed upon a bunch of old binding wire hammered flat, or on a piece of charcoal. If a breach or crack has to be filled, a small thin plate of the same quality of gold as the article under repairs should be used. Rub borax and water to a thin paste on a piece of slate, brush *one side* of the plate with this, and run small pallions (or pellets as they are also called) of suitable solder over it. The plate is then boiled in diluted sulphuric acid and hammered or rolled very thin. A bit of this gold plate of a shape to fill the breach is cut off. Any old soldering near the breach should be coated with a paste of rouge with water, and to preserve the polish and color of the article it should be covered with equal parts of borax and charcoal pounded up together and mixed into a paste with water. This "black stuff," which must be carefully excluded from the part to be soldered, is dried. Any stone or settings in the article should be covered with a thick paste of whiting and water;

some bury the part in a piece of raw potato, others in wet sand. If it is a ring that is being soldered on the opposite side of the settings, a piece of charcoal may also with advantage be placed through the ring. When all necessary precautions have been taken, the breach is boraxed and the piece of plate laid in and heat directed to it by means of a blow-pipe. Care must be taken not to apply too much heat. When the solder begins to flow, the plate will drop slightly, and the solder round its edges glistens. By following this method a strong job is made, the color of the article preserved, and very little cleaning is required afterwards.

Perhaps the greatest mistake made by tyros in soldering is that in their anxiety to see the solder flow they direct the flame too suddenly to it, and in consequence the dampness of the borax causes the solder, if used loose, to corn, and it will not run at all. The heat should be applied to the surrounding parts first, gradually approaching the solder, and stopped the moment the solder glistens.

Great care is required in dealing with very low quality gold rings when broken. File the edges flat, so that no light is seen when brought together. Cut a *very thin* piece of silver solder, a trifle larger than the section of the ends. Cover the ends with borax, and place the piece of silver solder between them. Apply heat with the blow-pipe till the solder begins to glisten.

GOLD SOLDER—For 18-karat gold: 18-karat gold, 12 parts; fine silver, 2 parts; brass wire, 1 part. For lower qualities of gold substitute for the 18-karat gold the same standard as the article to be soldered, and add the same proportion of silver and brass wire as given above. For the brass wire, pins are generally used, as they contain a little tin, which is an excellent ingredient for causing the solder to flow. Some jewelers use copper in place of the brass pins, and add a little zinc. Ordinary silver solder is quite unsuitable for gold work which has been colored.

SILVER SOLDER—To one ounce of standard silver add 6½ pwt. of white pins; melt the silver first with a good piece of borax.

JEWELERS' SOLDER.—Fine silver, 19 parts; copper, 1 part; brass pins, 10 parts.

WHITE SILVER SOLDER.—Equal parts of silver and tin; melt silver first.

SOFT SOLDER.—Pure tin, 2 parts; pure lead, 1 part: melt lead first.

SOLDERING FLUXES.—With hard solder, use borax; with soft solder, chloride of zinc, prepared by dissolving small pieces of zinc in spirits of salt until no more can be dissolved.

TO REMOVE SOFT SOLDER FROM GOLD.

ONE of the most serious evils the repairer has to contend with is the presence of soft solder on the piece under treatment, being the imperishable record of some botch; all this must be removed or destroyed before the article can be properly repaired. Workmen generally believe that annealing and boiling out will destroy it, while, in fact, it has the very opposite effect. The heat thus applied simply aids in driving it in and amalgamating the solder with the gold. We have often tried to remove the solder after the annealing process by scraping and filing, but invariably found that it had penetrated so deeply into the gold that it would be utterly impossible to eradicate it by any such means.

One of the common methods of treating this class of solder in the workshop is to remove whatever can be gotten off with the scraper, which consists of a three-square file sharpened at the point, and then to place the article for some time into strong muriatic acid. Nitric acid would answer much better, but it cannot be safely applied to articles of inferior qualities of gold, as it would act upon the alloy of which they are partly composed.

For colored gold, however, it can be used with advantage and safety. From a long practical experience in the matter of soft solder, we have arrived at the conclusion that there is no better way of treating it than that which we are about to point out. The solvent to be employed is a mixture of muriatic acid and crocus, and prepared as follows: To 8 ounces of muriatic acid add 1 ounce of crocus, and shake it well to increase a perfect intermixing: to one ounce of this mixture add 4 ounces of hot water, place in a pipkin and keep up the heat by means of a gas flame; then introduce your soft soldered article and you will soon be satisfied with the result.

STRIPPING ARTICLES.

SOMETIMES articles composed of copper, brass, or German silver which have been silver-plated require to have the coating entirely removed. Occasionally, also, the plater desires to replate old articles, the coating upon which has partly worn away; these require that the remaining portions of silver be removed, in order to obtain a uniform surface to deposit upon. The removal is called "stripping." To effect this, add a very little nitrate of soda (Chili saltpeter) to a quantity of strong and hot oil of vitriol, and immerse the articles in the mixture until all silver is dissolved. If the action becomes slow, apply more heat, and add more saltpeter at the moment of using. The copper will not be much acted upon, if the articles are not allowed to remain in too long.

Or, the silver may be removed, but more slowly, without the aid of heat, by suspending the article for a greater or less length of time, according to the thickness of the coating, in a bulky mixture of ten measures of strong sulphuric acid and one measure of concentrated nitric acid, contained in a large stoneware vessel. The liquid must not be diluted, but be kept as free from water as possible, by not immersing wet articles in it, and by keeping it covered from the air; otherwise it will attack the copper, brass, bronze, or German silver base of the articles. This will also remove nickel plating. As the liquid becomes weaker, very small portions of strong nitric acid are added to it. Its action is less rapid than that of the hot mixture above described.

In stripping an article for re-plating, the whole of the silver should be taken off, otherwise the deposit is apt to show lines. If the base of the article is composed of iron, steel, zinc, or lead, the above mode of stripping by acid cannot be employed, and the coating is best removed by making the articles the anode, in an ordinary cyanide of silver-plating solution until the silver is dissolved.

The articles to be desilvered are first cleaned in soda lye, next in a sulphuric acid bath and then entered in an ordinary silver-plating bath. The conducting wires are now fastened in a *reverse* way, making the article the anode. By this reversal, the silver is loosened from the article and deposited upon the silver plate. In this manner the desilvering is done so perfectly that not a trace of silver remains on the article. After all the silver has disappeared, the conduits are simply changed into their customary positions, and the process of silver-plating commences without other trouble.

TO POLISH METALS.

METALS are polished either by burnishing or buffing. The process of burnishing consists of rubbing down all the roughness with a highly polished steel or agate tool—none of the metal being removed. The action of the burnisher appears to depend upon two circumstances: First, that the harder the material to be polished, the greater luster it will receive; the burnisher is, therefore, commonly made of *hardened steel*, which exceeds in hardness nearly every metallic body. Secondly it depends on the closeness of the contact between the burnisher and the work; and the pressure of the brightened burnisher being, in reality, from its rounded or elliptical section exerted from only one mathematical line or point of the work at a time it acts with great pressure and in a manner distinctly analogous to the steel die used in making coin. In the latter case *the dull* but smooth blank becomes instantly the bright and lustrous coin, by virtue of the contact produced in the coining press between the entire surface of the blank and that of the highly polished die.

It by no means follows, however, that the burnisher will produce highly polished surfaces, unless they have been previously rendered smooth and proper for the application of this instrument. A rough surface having any file marks or scratches will exhibit the original defects, notwithstanding that they may be glossed over with the burnisher, which follows every irregularity, and extensive pressure, which might be expected to correct the evil, as in coining, only fills the work with furrows and produces an irregular, indented surface, which by workmen, is said to be *full of utters.*

Therefore, the greater the degree of excellence that is required in burnished work, the more carefully should it be smoothed before the application of the burnisher. This tool should also be cleaned on a buff-stick with crocus immediately before use; and it should generally be applied with the least degree of friction that will suffice. Cutters generally consider that burnishers for steel are best rubbed on a buffstick with the finest flour emery; for silver, however, they polish the burnisher with crocus in the usual way. Most of the metals, previous to their being burnished, are rubbed with oil, to lessen the risk of tearing or scratching them, but for gold or silver the burnisher is commonly used dry, unless soap and water or skimmed milk are employed. For brass furniture, beer or water, with or without a little vinegar, is preferred for lubricating the burnisher.

Buffing is performed by rubbing the metal with soft leather, which has been charged with very fine polishing powder. The rubbing is sometimes done by hand, but more frequently the buff is made into a wheel which revolves rapidly in a lathe and the work is held against it. The polishing powder that is selected must be chosen with special reference to the metal that is to be buffed. Thus, for steel and brass the best polishing powder is crocus or rouge. The hardest part of the rouge must be selected and great care should be taken to have it clean and free from particles of dust and sand, which would inevitably scratch the article polished and render it necessary to repeat all the previous process of filing, grinding, etc. Soft metals like gold and silver may be polished with comparatively soft powder, such as prepared chalk or putty powder (oxide of zinc).

When metals are to be polished on the lathe, the process is very simple. After being turned or filed smooth, the article is still further polished by means of fine emery and oil applied with a stick, and in the case of rods or cylinders, a sort of clamp is used, so that great pressure can be brought to bear on the part to be polished. The work must be examined from time to time, to see that all parts are brought up equally to the greatest smoothness and freedom from scratches, and as fast as this occurs, polishing powder of finer and finer quality should be used, until the required finish is attained.

In polishing metals or any other hard substance by abrasion, the great point is to bring the whole surface up equally. A single scratch will destroy the appearance of the finest work, and it cannot be removed except by going back to the stage to which it corresponds, and by beginning again from that point. Thus, if in working with a smooth file, we make a scratch as deep as the cut of a bastard file, it is of no use to try and remove this scratch with the smooth file; we must go back, and, taking a bastard file, make the surface as even as possible with it, and afterward work forward through fine files and polishing powder.

PARTING GOLD FROM OTHER METALS.

THERE are two principal methods of gold parting, termed the wet and dry. The wet methods are the sulphuric and nitric acid processes. The chlorine, cementation, litharge and sulphur are dry processes. In the wet process there should be two or three parts of silver to one of gold. The metals can be alloyed by fusing in a plumbago crucible. The melted alloy is poured into cold water to obtain the alloy in a flake condition, so that it can be readily acted on by the acids.

In the sulphuric acid the alloy is boiled with two or three times its weight of acid in a cast iron vessel. After the gold has subsided, the sulphates of silver and copper are decanted. Repeat the process, wash the gold, and boil again with acid. The gold is obtained in the solid form by washing, drying, melting and casting into bars or ingots. The silver is collected on copper plates or turnings introduced into the solution, and bar silver is obtained by washing, drying, melting and casting.

In the nitric acid process, a platinum vessel fitted with a lid from which issues a stoneware pipe for condensing and collecting nitric oxide and nitrous anhydride, which are given off from the decomposition of the acid by the copper and silver respectively. The granulated alloy is introduced into the platinum digested with nearly twice as much acid. The lid is luted on and the digester heated on a sand-bath. When the violent action has ceased, the digester is cooled and the liquor decanted. The residue of gold is treated with acid and the last operation repeated. The residue of gold is obtained in the solid form, as in the sulphuric acid process.

In the chlorine process the gold is melted in a clay crucible fitted with a lid, in which an opening for the introduction of a clay pipe, by which the chlorine generated by any of the usual processes is conveyed to the bottom of the melted mass, while the surface of the gold is covered with a layer of borax. The chlorine is absorbed by the metals that may be associated with the gold, converting them into chlorides, which are generally volatilized, except the silver, which remains fused as chloride of silver. As soon as orange-colored vapors appear the current of chlorine is stopped, for the chlorine attacks the baser metals first. The crucible is taken from the fire, and after 10 minutes the gold sets and the chloride of silver is poured off. The gold is melted and cast into bars.

HOW TO ANALYZE NATIVE ALLOYS CONTAINING GOLD, SILVER, PLATINUM, ETC.

May be the reader lives in a region in which auriferous native alloys are found combined by nature in the bosom of the earth, and, as is very likely to be the case, in absence of an analyzing chemist, he may be called upon to determine the different metallic substances of which a given sample is composed. It would never do for him to plead ignorance of the simple method for doing this, and it is therefore well to read the following carefully.

These affinities are well known in chemistry, and the analysis of a metallic compound, consisting of a variety of different metals, is an easy matter. Let us suppose that a metallic mass is made up of platinum, gold, silver, bismuth, lead, iron and copper; we then separate the constituent parts in the following manner:

1. The alloy must be comminuted by either filling or granulation; it is next digested in diluted nitric acid, until this agent exerts no further action on the residue. In order to be certain that the digestion of the soluble parts is completed, decant the acid from the residue, and pour small quantities of fresh acid, until all action ceases. Add the last acid to the former decantations; the residue, consisting of gold and platinum, must be washed with a small quantity of lukewarm water, which is also added to the decanted acids.

2. Pour quantities of cold water into the solution, until all turbidity ceases, then permit the precipitate to settle, after which dry it. This is the oxide of bismuth, of which 123 parts, dry, equal 100 parts metallic bismuth; the analyzer may, if he chooses, reduce it to its metallic state by mixing the dry precipitate with oil to the consistency of a thick paste, and fusing it briskly under a cover of charcoal dust.

3. Concentrate the fluid from which the bismuth was separated, by boiling it to about half its volume, and immerse into it a clean copper plate; the silver will then settle on the copper in a metallic state; collect the former from the latter by washing, and repeat the process of immersion, etc., until no more precipitate is formed. The silver may then be dried and reduced to a button by melting it with a little carbonate of soda.

4. Next separate the lead by dropping sulphuric acid into the fluid of the last process until precipitation takes place no longer. The precipitate obtained is sulphate of lead, of which 100 parts, when perfectly dry, equal 30 parts metallic lead.

5. The fluid is then mixed with liquid ammonia, by which a brown precipitate is thrown down; this is iron which was contained in the alloy.

6. We have now obtained four metals: bismuth, silver, lead and iron, from the same fluid. It should next be tested for copper. Pour into it a saturated solution of potash, and boil the fluid a little; the ammonia is volatilized thereby, and an oxide of copper is precipitated. To obtain the copper in a metallic state, dissolve this oxide in muriatic acid, and dilute with an equal quantity of water; then immerse into a clean iron plate, when the copper will adhere to it.

7. Next take the insoluble residue left in the first process, and dissolve it in aqua regia, a mixture of three parts of muriatic and one of nitric acid, till a complete solution is effected. Mingle this solution with a saturated solution of sal ammonia, and the platinum will become separated as a precipitate and leave the gold in the solution. The precipitated platinum is well washed and boiled in clear water to soak out the ammonia, and finally washed with alcohol, it is then ready to be welded to the metallic state.

8. To recover the gold, mingle the remaining solution from which the platinum has been separated with a diluted solution of sulphate of iron, a precipitate falls down, which is metallic gold; collect and fuse it with a little borax into a solid mass.

The analysis is now completed, and the combined weight of the obtained products will correspond with the weight of the substance submitted to examination, if the manipulation has been done carefully.

ALUMINIUM AND ITS ALLOYS.

Aluminium is now very largely employed in the industrial arts, says *Le Moniteur de la bijouterie*, etc., although for certain articles it is blamed for not being sufficiently strong, and the attempts to correct this defect will doubtless be successful eventually, so that this very light metal will be employed more and more, either in a state of purity or as alloy. The *Electrochimie* published the very interesting researches of Messrs. A. E. Hunt, J. W. Langley and C. M. Hall on this subject.

According to these specialists, silicium hardens aluminium considerably, diminishes its malleability, and augments its tenacity; it prevents aluminium from taking a high gloss, but guards that which it may have received. A metal thus alloyed with silicon of more than 3 per cent. is covered rapidly with a blackish coating disagreeable to the eyes. Where a polish is not necessary and the principal aim is to compound a light metal, an alloy of 6 to 8 per cent. silicium is of advantage. The silicium is found in it in a graphitic condition. If it were possible to mix the silicium in an amorphous state it would be possible to produce a metal possessing the required hardness without its being impaired in strength.

Small quantities of iron harden aluminium and make it magnetic, but at the same time its malleability is deteriorated and the alloy does not take a high polish. By melting equal parts of iron and aluminium an alloy desirable in all respects is produced, but it is shortly afterward reduced into powder.

Aluminium unites readily with copper, nickel, brass, etc., but the proportions of these metals must not exceed 3 per cent.; beyond this, the alloy loses a large part of its malleability.

Carbon combines with aluminium only at a very high temperature, and in proportions not to exceed 3 per cent.; it renders aluminium fragile and porous.

Sulphur combines with difficulty; it is but rarely found in the aluminium of commerce.

Lead is found sometimes, but in minute proportions, which exert no appreciable influence upon the metal.

Antimony does not unite with aluminium.

Chromium, however, enters readily into an alloy, makes the aluminium harder, but impairs its malleability.

Tungsten hardens aluminium. Platinum combines with it, but makes a brittle alloy and one of little homogeneity.

Silver, up to a proportion of 5 per cent. increases the elasticity and hardness of aluminium without injuring its malleability. The silver alloy is susceptible of taking a beautiful polish.

Tin makes aluminium brittle. A proportion of 2 per cent. of aluminium in tin makes the latter harder and more elastic.

Cadmium unites with aluminium and makes an alloy that is fusible and malleable, but wants strength. Bismuth forms brittle but quite fusible alloys.

The alloys with zinc are brittle and very crystalline; they make good solders for aluminium and are applied with Venice turpentine; deplorably the alloy does not spread well upon the metal, and the soldered joints do not resist a great strain.

FRENCH FIRE-GILDING.

As is known, says the *Metallarbeiter*, immense quantities of imitation jewelry, such as watch chains, necklaces, brooches, etc., are sent from the jewelry manufacturing centers of Germany to Paris, to be "fire-gilt" and returned to the German jewelers. The price of this gilding moves between 40 and 60 francs per kilogram, according to the gold coating. This proceeding essentially increases the price of the articles, because the French understand how to place an immense value on their skill, and it would, therefore, be well if the German manufacturer were to acquire this skill himself. The method is based on the fact that it is extremely simple to deposit with a correctly working galvanic bath the same quantity of gold upon a certain article as can be done by fire-gilding when applying and dissipating the gold amalgam.

The objection that a heavy galvanic precipitation is very brittle, and does not enter into the same intimate connection with the underlying metal as the coating of the fire-gilding does, is correct. In consequence of this defect it is apt to rise up in polishing, and scale when the article is worn, which can be prevented by the following treatment:

The articles are entered for from 30 minutes to one hour, according to the required thickness of the coating, in a medium rich gold bath, during which time they remain suspended to the action of a correctly regulated current; once or twice in the course of the work they are entered into a cyanide of mercury bath, in which they are exposed to the influence of a weak current, until well and equally quickened, for which from one minute to two minutes is sufficient. They are then carefully rinsed and returned into the gold bath. When the gilding operation is ended, they are quickened another time, and the mercury is then evaporated over a uniform charcoal fire, the articles lying upon a wire netting.

The following method is still more simple: The article is gold plated without intermission, until a sufficiently heavy precipitate is deposited; then quickened in an aqueous solution of proto-nitrate of mercury and dissipated. A yellow deposit will become green after the mercury is driven off; since, however, the gold plater must imitate the alloys of genuine gold jewelry, with the exception of a few articles like the sprays of lightning rods, etc., he has to imitate the color of 12, 13 and 14 karat gold, and gold plate the articles red, which is done by an addition of copper, to the gold bath. This addition of copper, however, must be made with care, because most of the baths, after having been used for a time, are inclined to become red; this caution must be observed especially in cases when the bath is to be used until exhausted, in place of being renewed. If the gold plater is using such a bath, he had better dispense entirely with the addition of copper, using a new bath for first gilding, and an old for finishing.

Articles gilt red in this manner more or less assume, after driving off the Mercury, the colors of above stated alloys; I say more or less because even a skilful workman will experience great difficulties in imitating a certain color precisely. Beside this, the demands of customers vary greatly, and it is well to keep on hand several small baths of different colors in which the articles, after having been scratch-brushed, are colored to shade. The coloring baths consist of the ordinary fresh gold bath to which, according to requirement, from ten to thirty per cent. of cyanide of copper and very small quantities of cyanide of silver are added.

A definite formula cannot be given because the different colors vary too largely, but the gold plater with even a little experience will quickly compose a bath approximating very closely to the shade desired. The following direction may serve him in composing his bath: To a new cold bath add sufficient cyanide of copper until a rose color is produced in gold plating, and when this has been obtained, an addition by drops, of silver, is to be made until the shade is as desired. A platinum wire is used as a rule, and as the coloring is the work of a moment, it is advisable not to hang in large lots, but always small ones at a time.

In spite of the most thorough cleansing by hand or revolving scratch brush, and subsequent polishing with bloodstone, strongly gilt small articles frequently show disagreeable-looking spots; these articles sometimes have hollows into which the cleansing apparatus cannot enter, and they will subsequently look dull and unsightly. In order to correct this, let the gold plater procure a revolving drum, into which are to be placed from six to nine pounds of very small brass or copper grains of about the size of half a pin head; into this is to be poured the necessary quantity of soap or licorice root solution, and next a corresponding quantity of articles, after which the drum is revolved either by hand or mechanical power. After revolving it for from 1½ to two hours, the articles are polished, and the plater will at first sight be satisfied that this is a far more satisfactory way of working than by scratch brushing. The friction of the small grains polishes the hollows as brightly as the outside, and beside this, a large saving of time is effected.

As is well known, the articles require a very thorough cleansing before they are galvanized, and it must therefore never be omitted to boil them in a potash or soda solution, and then dip them in a pickle or cooking salt and nitric acid, until certain that no filth of any kind adheres to them.

PRACTICAL ELECTROPLATING.

THE following solution for gilding to be used with a common battery is sufficient for a four gallon jar:

Chloride of gold	4. oz.
Cyanide of potash	12 oz.
Concentrated ammonia.	

Dissolve the chloride in pure boiling water, then by the use of a very small quantity of concentrated ammonia, precipitate the gold from the solution. Let the water stand until settled; pour off the water; repeat operation two or three times, taking care not to wash out the gold. Now dissolve the cyanide in hot water; this must be done in a vessel which is to hold the solution; pour in the gold and boil.

NICKEL SOLUTION.—To one gallon of water add from one to two pounds of nickel salts or crystals; boil and stir until cold.

SILVER SOLUTION.—

Chloride of silver	10 oz.
Carbonate of soda	12 oz.

Cyanide of potash, enough to take up silver. Make same as for gold plating.

BRASS SOLUTION.—

Sulphate of copper	3 lbs. 6 oz.
Sulphate of zinc	3 lbs. 6 oz.
Carbonate of soda	10 lbs.
Carbonate of soda	5 lbs.
Bisulphate of soda	5 lbs.
Cyanide of potassium	6 lbs.

Dissolve 3 lbs. 6 oz. each of the sulphate of copper and zinc in hot water; dissolve 10 lbs. of carbonate of soda in hot water, and add to the first. Let the mixture settle, then pour off the water and repeat two or three times; now dissolve 5 lbs. each of carbonate and bisulphate of soda and add; then dissolve 6 lbs. of cyanide of potassium in hot water; add the other substances, and set the mixture aside for two or three days before use.

COPPER SOLUTION.—

Sulphate of copper	10 lbs.
Carbonate of soda	17 lbs.
Carbonate of soda	5 lbs. 2 oz.
Bisulphate of soda	7 lbs. 6 oz.
Cyanide of potassium	5 lbs.

Dissolve first 10 lbs. of sulphate of copper and 17 lbs. carbonate of soda; pour together, wash, and repeat as in brass solution; now dissolve 5 lbs. 2 oz. carbonate of soda and 7 lbs. 6 oz. bisulphate of soda; add; dissolve 5 lbs. cyanide of potassium and add. Let the mixture stand two or three days, then use.

The above solutions may all be used with the aid of a dynamo or common Bunsen or Smee cells. The solutions may be placed in jars or tanks, over which two brass rods are stretched, connecting with the poles of the battery. An anode, corresponding to the solution in the jar, must be attached by means of a copper wire to the rod connected with the positive pole, while the cathode or article to be plated should be attached to the negative pole.

BRONZE.—This result is obtained by plating the article in copper or brass, and dipping it into a hot solution of sulphide of potassium.

OXIDIZED SILVER.—Plate the article in silver, and dip it into a solution of any of the following: bichromate of potash, bisulphite of soda, persulphite of soda, or chromic acid.

BRASS DIPS.—Equal parts of sulphuric and nitric acid, to which a small quantity of muriatic acid is added, must be prepared. Cleanse as if to plate; that is, dip into hot potash, then into cold water, before placing in the acid, where it must remain but for an instant, then at once into and shaken about in cold water, thoroughly washing off the acid; then into hot water and sawdust.

To secure the perfect cleanliness necessary to the article to be plated, there must be placed near at hand solutions of boiling hot carbonate of potash, plenty of perfectly clean hot and cold water and solution of cyanide of potassium.

OPERATION.—First place the article which is attached to a copper wire for a moment in the hot potash to remove all vegetable substance; then quickly plunge it into cold water, which should be running; then into cyanide; once more into cold water. The article is now chemically clean and ready to be placed in the plating solution. Judgment must now govern the plater when to remove the article and quickly into clear, cold water, and then immediately into the clean hot water and last into the boxwood sawdust, where it must be shaken until dry.

If the article should now be dim from an excess of gold, a small wire scratch-brush should be placed in the lathe and the article gently brushed, all the time being kept moist by frequent dipping into a solution of soap and water. Silver may be brushed in the same way, but it is generally burnished. Nickel, copper and brass are buffed.

GOLD SILVERING BY RUBBING WITH THE THUMB, OR A CORK, OR A BRUSH.—The results are better than those by the so-called whitening process, but not so durable. The method is useful for repairing slight defects upon more durable silverings. It may also be employed for producing a mixture of gold and silver 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 upon a slab. Avoid the light, however, as far as practicable.

FORMULA I.—

Water	Ounces	3½ to 5
White fusel nitrate of silver, or preferable, the chloride	"	7
Binoxolate of potash	"	10½
Bitartrate of potash	"	10½
Common salt	"	15

FORMULA II.—

Chlorate of silver	Ounces	3½
Bitartrate of potash	"	7
Common salt	"	10½

Pulverize finely in a porcelain mortar and triturate 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, add a little water so as to form a thin paste, which apply 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, providing 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 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 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 potash. This silvering will bear the action of the wire brush and of the burnishing tool very well. It may also be oxidized. Should a first silvering not be found sufficiently durable after scratch brushing, apply a second or third coat. This silver is not so adhering or so white on pure copper as upon 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.

ELECTRO GOLD AND SILVER PLATING.

COMPLAINTS are quite frequent concerning the non-durability of the ordinary gold and silver plating by contact or limited electro-battery, and to the wear when exposed to friction or weather, and unfavorable comparison has been made with the old fire gilding. The former, however, is generally acknowledged to have the richer appearance. The primary cause for the complaint lies in the fact that deposits of the precious metal by the galvano-electric system are not solid and compact. Electro-gilt ornaments, balls, eagles and other devices such as are used to decorate monuments, public buildings, etc., tarnish rapidly because of this unsound and porous deposit upon the metal case.

To produce substantial and lasting deposits by electricity, it is necessary to use dynamo-electric apparatus operated by steam or batteries of great power. The expense necessary to the purchase and operation of such a plant is practically prohibitory to the jeweler or watchmaker whose business is conducted upon a limited scale; and who, even if in a financial position to purchase and maintain these expensive apparatus, does not have sufficient work to realize a profit large enough to warrant the entailed expense. To avoid this expense and at the same time secure a good, lasting deposit by electricity, the following method is recommended as effective.

To the ordinary gold solution for electro-gilding add some mercury previously dissolved in nitric acid. This solution should be 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. This may be effected by pressing the mercury through a piece of wash-leather which will allow the mercury to pass through by squeezing. The leather will retain the lead and leave the mercury pure.

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 colbode (zinc) of any battery, and will receive a gold deposit of quicksilver appearance after the article has remained a sufficient time in the solution. When withdrawn, rinse in water and lay on a fresh fire made of small pieces of charcoal until the mercury has evaporated. This will take place very soon, as the quantity of mercury is 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. If the article is then scratch-brushed in beer it will assume a fine luster If a strong deposit of gold is required the operation may be repeated after each scratch-brushing. By weighing the article before its 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 should be left for about one-half minute or so longer on the fire than necessary for driving off the mercury, to deepen the color of the gilding.

Mix together two parts of saltpeter, one part of table salt and six parts of alum, with six and one-half parts of water and warm the mixture in a porcelain vessel. As soon as it begins to rise add one part of hydrochloric acid and bring the contents of the vessel to a boil, stirring in the meantime with a glass rod. The articles to be colored, suspended on hooks made of strong platinum wire or of glass, are first dipped in sulphuric acid and then entered into the slowly cooking solution last described and moved to and fro in it. In about three minutes they are taken out and dipped into a large vessel of water, so as to see what color they are. If the desired shade is not yet obtained they are dipped in again as often as necessary until it appears.

TO SILVERPLATE THINLY.

THERE are two ways by which a film of silver may be precipitated on an article, viz., by boiling and by the cold way.

TO SILVERPLATE BY BOILING.—Dissolve six parts of tartar and six parts of table salt in water, heat to a boil, and add to this liquor one part freshly precipitated chloride of silver; when this has dissolved, enter the article to be silverplated into the boiling hot bath, and connect it with a piece of zinc corresponding to its size. The galvanic current engendered in this manner causes the rapid precipitation of a uniformly thick silver film, which is almost as handsome as that obtained by the electro-chemical way. The articles may also be silverplated in this bath without the contact (touch with the piece of zinc); the time required in this case, however, is from 15 to 20 minutes, while by the use of the contact, somewhat less than one-half of the time only is necessary.

In place of the above detailed silverplating fluid the operator may also use one prepared for the electro-chemical way of silvering, to wit, a solution of cyanide of potash and silver, using also in this instance the contact with zinc. The principle of the two is identical, the difference consisting only in the circumstance that for the latter the electric current is produced specially, while with the contact the current is produced by the combination of the two metals.

Although the silverplating is uniform, it is of a matt luster; if desired to be of a peculiar gray, the so-called luster, enter the article coming immediately from the silverplating bath into another, a solution of 10 parts hyposulphite of soda in 100 parts of water, to which liquor was added a solution of 3 parts acetate of lead in 50 parts water, and heat to from 155° to 175° F. Sulphide of lead hereby precipitates upon the surface, which assumes an agreeable gray color.

A more durable film is obtained by dissolving one part chloride of silver in 8 parts caustic ammonia, to which solution is poured another of 5 parts cyanide of potash, 5 parts crystallized soda, 2 parts table salt, dissolved in 144 parts distilled water, boiling the whole for 15 minutes in a porcelain dish and filtering the liquor. Make the articles desired to be silverplated as clean as you can by pickling, scouring in a strong soda lye, rubbing with bright silver sand, etc. After having cleaned them, never handle them with your fingers, but make use of a pair of boxwood pliers.

SILVERPLATING BY THE COLD WAY.—A heavily diluted solution of nitrate of silver in the proportion of one part of this to at least 50 or 60 parts water may be used for silverplating by the cold way; in fact, the greater the dilution the slower the precipitation of the film, and at the same time the more tenacious it becomes. By wrapping the bright pickled article with a zinc wire and setting or hanging it into the fluid, the precipitation of the silver takes place quicker in consequence of the contact. The silver film forming at first is very thin, but soon increases in thickness, if the bath is kept at the same strength by occasionally pouring in a small quantity of a concentrated silver solution. When the film comes to be burnished, polish the well rinsed article first with prepared chalk, and next with the blood stone.

THE DUPLEX ESCAPEMENT.

THE perfection of the Duplex Escapement, which followed its adoption by one of our great American watch companies, is another example of "transformation," accomplished by the mechanical ingenuity of the American mechanic. The evolution of this escapement from the delicate old English model to the practical, hardy, accurate one, which has been so very extensively used in this country, is one of the horological accomplishments of the age. It may indeed be chronicled as the birth of a new escapement, the American Duplex. As such we will treat it, for it is this perfected duplex that the jeweler will most frequently have occasion to handle, the sales of the movement in many grades and sizes now running into the enormous thousands.

The first crude model of the Duplex Escapement was designed by Dutetre, a French watchmaker, during the first part of the last century, but its real inventor was Pierre LeRoy (about 1750), who, in course of his numerous experiments, while endeavoring to construct a time-piece sufficiently accurate to be used in determining longitude at sea, constructed it in substantially its present form. At about the same time he conceived the idea of the "spring detent" or "chronometer" escapement, which, as better suited for the construction of marine chronometers, he adopted, but not, as some claim, because he formed an unfavorable opinion of the Duplex Escapement.

No maker to-day would think of using the Cylinder Escapement in a watch from which more than a fair average rate was expected, while those who have practically studied the Duplex will agree that, when carefully made by competent workmen, it is capable of the finest results for a very long period. Some of the old style English specimens of this escapement have given rates for accuracy that have never been surpassed by any form of escapement.

M. Saunier, speaking of the Duplex, said:

"In the climate of England, the Duplex Escapement is more satisfactory than any other. Where the pivots are sufficiently fine as to require but little oil, the Duplex will continue in action and give an even rate much longer than either the cylinder or lever."

To construct this Escapement by hand, so as to get its best results, would require a very high degree of mechanical skill, which would make it impractically costly, both to build and repair. The American Duplex is the English model modified and perfected, and the accuracy of fit and proportion which made the hand-made Duplex so costly has been secured by a system of duplicating machinery that works with wonderful precision. In a recent test a thousand parts were found to be accurately interchangeable.

THE ESCAPE WHEEL.—The Duplex, as originally made, consisted of two sets of teeth (hence the name), the smaller or impulse wheel being above the larger rest wheel on the same arbor. In the American Duplex but one wheel is used, the smaller or impulse wheel, being replaced by short triangular pillars projecting upward from the web of the wheel, inside the "rest" teeth, which are in the same plane as the web and arms of the wheel. These teeth are so designated because, during that part of the balance's vibrations not included in the lifts, one of the long teeth rests against the roller or slot in the balance staff, while the impulse is communicated to the balance by the impulse teeth driving against the point of the impulse pallet during the "great lift." The escape wheels are made of fine brass, the points of the rest teeth being carefully smoothed and polished.

THE BALANCE STAFF.—In the American Duplex, the delicate ruby roller of the old model is supplanted in the lower priced watches by a notch made in the staff itself, which, being hardened and polished, meets every requirement. Repairers have found that, even after several years' running, the tooth and slot have shown no perceptible sign of wear.

THE IMPULSE PALLET.—This is a little steel finger by which the impulse is delivered by the impulse teeth of the escape wheel.

ACTION OF THE ESCAPEMENT.—It is not self-starting. When at rest the hairspring is in neutral position and the point of the rest tooth directly in the slot of the balance staff.

A slight rocking motion will start it, and the rest tooth will escape from the slot. The impulse pallet will then have reached a point 10 deg. in front of one of the impulse teeth of the escape wheel, and this pallet will then strike the impulse tooth and drive it forward, until the next rest tooth enters the slot in the balance staff. This operation is repeated at each full revolution of the balance, every second vibration, as will be seen, being dumb.

The energy imparted to the impulse thus must be sufficient to maintain the arc of motion of the balance during two vibrations. The arc traveled through by the pallet, while receiving this impulse, constitutes what is known as the "great lift," and its duration is measured by the arc embraced between the two points of intersection of the circle traced by the point of the impulse pallet with the impulse circle of the escape wheel, less 10 deg. for drop.

The pressure of the point of the rest tooth in the notch of the balance staff, from its entrance to its escape, is called the "small lift," and its duration is measured by the arc embraced between the two intersections.

In the Duplex, the escape wheel acts directly on balance wheel, and hence requires less power than a lever escapement; consequently, lighter mainsprings are used, and they can be tempered higher, allowing a more equal distribution of power than with a heavy spring, and there is a corresponding decrease of friction and wear. Having nothing but balance and escape wheels acting directly together for adjustment, obviates many difficulties that are encountered in the lever escapement, which requires the greatest accuracy to produce proper results—the utmost nicety of the locking, the drop, the slide, the impulse, the roller pin, the size of roller, the guard pin, the notch in fork; or, the pallet stone may be loose, the roller pin also not cemented upright or tight, guard pin bent, or many of the other fine points, not necessary with the Duplex Escapement, may be out of adjustment.

The Duplex will run much longer, without cleaning, than a lever. The oil on a lever escapement soon becomes heavy, and the result is a dropping off in motion and poor time, while the parts in a Duplex that require oil for action are so few that the thickening of the oil is not known by any action of the movement. In cleaning a lever escapement, the greatest care must be taken not to loosen either pallet stones or roller pin. These are held in place by

Fig. 1.

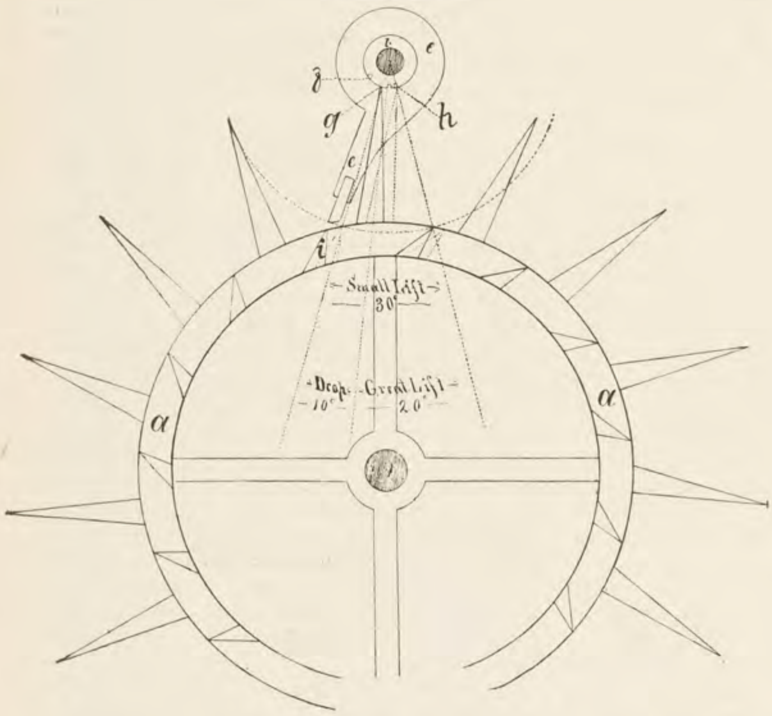
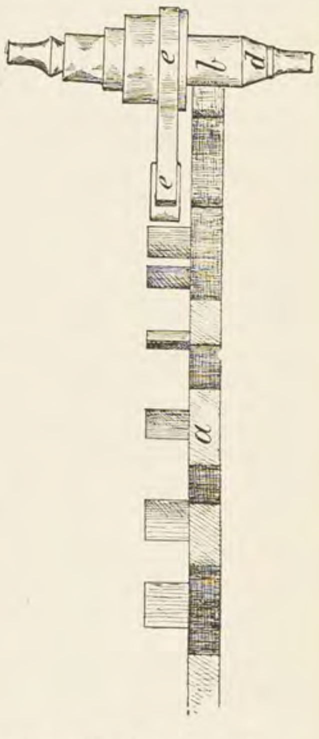


Fig. 2.



shellac, and if they are loosened trouble is at hand. With the Duplex, there are no parts to get out of order, and should any become broken they can be replaced without fitting.

The American Duplex is the simplest escapement made, and a remarkable thing with the Duplex over any other escapement is the fact that a compensation balance and isochronal balance or hairspring is not essential, for a neutral compensation exists between the several functions that cannot be aided by either. It is not effected by magnetism, and it has other natural advantages that no other escapement possesses.

A FEW HINTS FOR INSPECTING AND REPAIRING AMERICAN DUPLEX WATCHES.

TO prepare a Duplex watch properly, it should be thoroughly examined and adjusted from hair-spring to main-spring, not forgetting the hands and dial train, also winding and working parts of the case. First, locate defects of cause of stopping by tracing loss of power, beginning at hands, then escapement, and back toward barrel until found. Never attempt to start or wind a watch running before trouble is located. Note that crystal is not so low as to touch cannon pinion. Note that hands are free. Try and shake on cannon pinion and hour wheel.

HAIR-SPRING.—Next inspect hair-spring. See that it is not bent, is free from rust and oil, is flat, centered and leveled, outer coil vibrates between the regular pins and does not strike stud. See that hair-spring collet is not loose in staff. To separate balance and hair-spring from plate, do not unpin spring from stud, thereby destroying the timing and beat, simply push the stud out from opposite side of plate, or use plyers and lift stud from plate.

BALANCE WHEEL.—See that balance is true, arms and rim do not strike stud, regular pin or escape bridge.

BALANCE STAFF.—See that staff has sufficient, and not too much, end shake, by adjusting lower end stone screw under dial. See that slot in staff is not badly worn and is free from dirt.

IMPULSE FINGER (or pin).—See that impulse finger is smooth and polished on locking surface. See that impulse finger (or pin) does not strike long teeth.

ESCAPE WHEEL.—See that escape wheel is not bent, and that long teeth run in center on slot in staff. All short teeth must be alike and strike impulse finger (or pin) the same. If escape wheel pivot-holes are badly worn, causing too much side shake, either bush or close with hollow punch. If teeth are badly worn, bent or defective, do not attempt to repair them. A new wheel is invariably the best. See that escape wheel has enough, and not too much end shake. See that escape teeth do not strike the bridge. See that escape teeth do not strike fourth wheel pinion.

TRAIN WHEELS AND PINIONS.—See that train runs free; look for chip or dirt in wheel teeth and pinion leaves. See that wheels are true and teeth are not bent or broken. See that pinions are free and have end shake, and pivots are not badly worn or bent. Bush or close pivot-holes if too large. See that second wheel does not rub on barrel or top plate.

BARREL AND MAIN-SPRING.—See that barrel does not rub in the recess of bottom plate. See that barrel teeth are not bent and are free from chips or dirt. See that barrel is free on arbor. See that barrel cap is in place and time wheel fastened on cap has strong and equal friction. Always take out, clean and oil main-springs. See that main-spring has good strength and does not bind or rub on barrel cap.

DIAL.—To remove dial, use screw-driver and lift dial from friction posts. It is not necessary to take off hands, hour wheel or cannon pinion when removing the dial from movement.

DIAL TRAIN.—See that dial train is free and that no oil is left on minute or intermediate wheel. See that setting wheel is free between the plates.

JEWELS.—Examine hole jewels and balance end stones. (Lower balance end stone is set in screw from opposite side of plate, and used to adjust the end shake of balance staff.) Unscrew, examine, clean, and oil. Most jewels in American Duplex watches are held in the plates by being made in carefully made settings, friction tight. To remove, use peg-wood or jewel extracting tool from small end of setting.

CLEAN, OIL AND ASSEMBLE: Clean all parts of watch thoroughly with benzine, alcohol, chalk or other preparations, and assemble. Oil main-springs, pivot-holes, balance end stones with very little in slot in balance staff; but do not oil impulse finger or pin. Use good quality of oil, a small quantity in right place is sufficient. To easily assemble the single top plate movements where ratchet wheel and click are underneath plate—put ratchet wheel on barrel arbor square, insert small pillar screw or pin in hole above click, force same through and allow it to hold click back until wheels, pivots, etc. are in their proper position.

To Adjust the American Duplex Escapement: See that the escapement is in beat, and that the drop or lockings of long teeth on staff and short teeth on impulse finger (or pin) are safe.

To Put the Escapement in Beat: Have the slot in balance staff facing in a direct line with escape wheel pinions when the balance is free and at rest.

To Change the Beat: It is not necessary to take the movement apart. Simply insert a small tool into slot of hair-spring collet, and turn collet on staff in either direction until slot in staff is in direct line with escape wheel pinion.

To Adjust the Drop or Impulse: See that the upright teeth have from four to ten degrees of locking. If more or less drop then required, use tool to move impulse finger on staff in either direction as desired. When impulse pin takes place of finger, and it is necessary to change angle or locking or drop—take balance out and turn same on staff as required. See that impulse pin or finger does not strike long escape tooth. The short or impulse tooth imparts the great lift. The long or rest tooth imparts the small lift.

To Test the Depthing and Proper Action of Escapement: Turn balance backward and forward, looking at points described, as follows, viz.: When upright tooth escapes from impulse finger the next long tooth should jump to side of staff where it rests until the balance returns and allows long tooth to drop in slot. The balance next returns, allowing the long tooth to escape from slot, and the following upright tooth should jump to locking face of impulse finger. Continue this operation until all teeth have passed their respective points of contact. See that impulse finger, after having allowed short tooth to escape, does not strike same on its return. If impulse is found too long, and strikes, use oil stone and shorten. If the long escape teeth are found to be either shallow or deep (short or long), do not attempt to shorten or lengthen. This is a rare occurrence, and should be replaced with a new wheel.

SIMPLE TOOLS FOR THE DUPLEX MOVEMENT.

BEAT SET.

THE BEAT SET is used to change the beat of watch. Insert point into slot of hair spring collet, and turn same until slot in staff is on direct line with the escape wheel pinion.

IMPULSE MOVER.

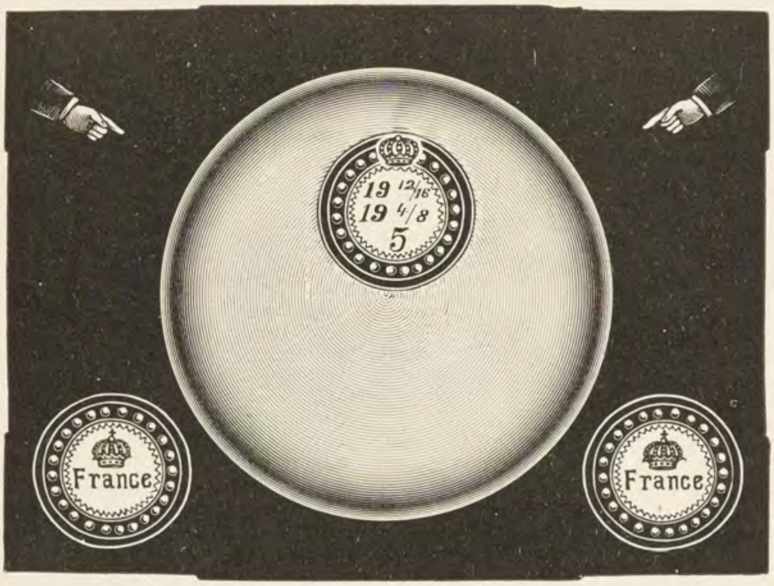
THE IMPULSE MOVER is used to change angle or length of drop from point of upright tooth to point of Impulse finger. Insert point of tool to cover Impulse finger and turn same either direction to give more or less drop, as desired.

INDEX TO HOROLOGY.

INDEX TO GOLD, SILVER, ETC

FRANCE

THE TRUE BLUE BEADED LABEL



THE
GENUINE
ARE
LABELED

FRANCE

Beware of Imitations.

= = WATCH GLASSES = =

ASK YOUR JOBBER FOR THEM.

SUSSFELD, LORSCH & CO.,

LORSCH BUILDING, 37 and 39 Maiden Lane,

NEW YORK.

LIQUID AMBER.

THE STRONGEST CEMENT YET DISCOVERED.

For Cementing Roller Pins, Pallet Jewels, Watch Glasses, Pearls, China, and Cut Glass

FOR SALE BY ALL TOOL AND MATERIAL JOBBERS.

SUSSFELD, LORSCH & CO.,

WHOLESALE AGENTS.