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**HOROLOGICAL
HISTORY**

**PRACTICAL TREATISE
ON WATCH REPAIRING**

PRACTICAL TREATISE ON WATCH REPAIRING

THIRD EDITION

by N. B. SHERWOOD

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**HOROLOGICAL
HISTORY**

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TABLE OF CONTENTS

I. The Bench and Its Accessories; The Vise and Oilstone	1
II. Lathe Appliances; The Jacot Lathe; The Depthing Tool; Expanding the Web of a Wheel	9
III. The Spreading Tool; Its Use; The Rounding-Up Tool; Stud Remover; Opening the Regulator; Roller Remover	16
IV. Replacing Broken Teeth; Graining; Polishing Blocks	23
V. Polishing Steel Work; Polishing Pivots; Superiority of Conical Pivots	31
VI. The Cutting Engine; To Cut An Escape Wheel	37
VII. Replacing Broken Arbors; Hardening and Tempering	41

CHAPTER I

The Bench and Its Accessories; The Vise and Oilstone

The object of the following remarks is to give to the trade instruction on not only the truly theoretical, but purely technical art of watch making and repairing. If a work is intended to reach the workman at the bench and be of any use, it must combine the lowest as well as the highest branches; he must be offered the small things, that in the daily routine of watch repairing are of so much importance. In preparing this work the author has had in view the immediate wants of his readers, and he feels justified in assuming that he knows them, as he was once in the country repair trade, remote from a city, and in a situation where a work of this kind would be hailed with delight.

We will imagine a good workman, even in a small country town, with a limited stock of tools, and still smaller stock of materials. He finds that a pallet jewel has got loose, or some ignorant workman has so topped the escape wheel, and altered the escapement, that it is almost impossible to make the watch keep decent time. What, then, shall he do? If he puts in a new escapement entirely, the cost will be more than the customer is willing to pay, and he must, in such a case, "botch" up the work, and, it may be, succeed in ruining the watch; he certainly will do so if he attempts to do any repairs with the hope of a good result, at the ordinary price of repairing. Again, the writer feels the necessity of offering a knowledge of the "little things," that go far toward the making of a good workman, to the young men who are now

learning the trade. We must say a few words as to our shortcomings in this article.

It will be apparent to any watch repairer that an article on the subject of watch repairing, if it enters at all into details, must necessarily be one of constant repetition; not that the subject is limited, but for the reason that one process so runs into another that it seems to be telling the same story over as we progress in the delineation.

The need existing for the series of articles we contemplate is well shown in the correspondence we have had with the repairers from Maine to Oregon and Michigan to Florida. The numerous questions asked as to the smallest trifles (the watchmaker would call them), and the suggestions offered, indicate to us that a work on mechanical manipulations, as applied to the watch trade, would be of importance to the whole Horological community.

There are workmen who stand in no need of a work of such minute detail as to what they know, and they may feel disposed to under-value the knowledge sought to be conveyed; yet they cannot help recollecting a period in their lives when they would have given much for just such a resume of the work at the bench as this is intended to be. There is not extant a work that, like Hollzapffel's *Mechanical Manipulation*, applied to general mechanics, is directly applicable to the watch and jewelry trade. We may regret the fact, but of all the works in existence, not one treats on the smaller things—that is, the constant affairs occurring in the ordinary routine of watch repairing.

Of what value would a learned discussion on the subject of the lever escapement be, to the man who is repairing the ratchet work on the barrel, or replacing a new centre pinion? The polishing of a square on the barrel arbor may be of more importance to one individual than the most perfect mathematical demonstration of all the escapements. In springing, the watch repairer very frequently has trouble that might be

avoided, provided he had the smallest hint from some one who has learned by experience the best method of springing. The man who prides himself on the fact that he can learn nothing from others has a perfectly just estimate of his own abilities, and he can learn nothing, simply from a deficiency of brains. It is the same old story, that the world was wiser hundreds of years ago than now; as if the accumulated wisdom of ages, added to the person's own individual experience, did not furnish a better basis of knowledge. There is no one man that possesses all the knowledge that is so very useful at the bench, and it must be remembered that there is no one who cannot give some information in regard to his mode of doing certain work, even to the best workman. He may tell many things of no interest, perhaps, to some individual reader, and yet interest a hundred others. Inevitably, the story of a monotonous occupation at the bench must be somewhat stale to him who has wrought at the trade for a number of years. This fact constitutes the very first difficulty in treating the subject as minutely as it really should be treated, for there are many, very many, who have had only the education in the trade that an ordinary country jobbing shop could afford. While the proposed article is intended expressly for such, the author has a consciousness that even the skilled workman may find in them something that will not only interest, but instruct him. With these preliminary remarks, we shall launch out on the subject of watches and clocks, and the repairs of the same.

The very intense ignorance of the watch-carrying public is a source of great annoyance to the repairer. Good, bad, or indifferent, as the case may be, each owner seems to think that the repairer should make it keep time—a result the *time-piece* was never *intended to accomplish*; and we speak from experience when we state that a hasty judgment in regard to the performance will, in some instances, give the workman more trouble than the whole value of the cost of repairs. That

the ordinary Connecticut clock keeps *time*, on the average, is taken as a standard by which the commonest English lever is rated, and, unfortunately for the repairer, the clock is in many instances the best timepiece, and thus he will be blamed for work that he, or any one else, in no possible way could improve.

The young man who, having worked at the bench three or four years, starts for himself, say in a place remote from the centre of trade, will occasionally overreach himself in his eagerness to acquire trade, by heedlessly taking in jobs that he has not thoroughly examined, and therefore has no just data on which to found a price adequate to the time and labor he must necessarily bestow on the work. The work of ordinary shops, at the present day, is rendered easier than in former days, from the fact that the general run of watches are Swiss. Once in a while the repairer is called upon to tinker up a poor quality of English watch, made in Coventry, that no skill can make run well; the labor bestowed on it is wasted, and both the customer and workman are disappointed. There are in the Swiss cheap watch some points that a repairer may well take heed of, as his time is of some value. It is to be remembered, also, that the class of watch purchased in different localities will vary with the means and knowledge of the inhabitants. In a Broadway store one may see every variety of watch, from the highest to the lowest, while in some repairing stores only the very best class of work is brought in. The object of the foregoing is to bring before the minds of our readers the intention we have in this work, and we ask the reader to use his own judgment in the reading, for there is no one but can add something to the general stock of knowledge.

The first requisite the repairer needs is a good bench, conveniently arranged for laying away both tools and materials. The best bench we have ever used was a single, white, seasoned, pine plank, say one and a half inches thick by twenty inches wide; the length will be determined by the

conditions of the window at which the work is to be done. We are speaking now of a good bench, within the reach of any one. When there is a desire to have the surface level, the plank may be gained and battens let in before the top is traversed by the plane, which will insure it against warping. After the top has been made perfectly level by traverse planing, it should be smoothed off with sand paper, and then varnished with three or four coats of gum shellac varnish, which will give it a fine surface that is not liable to absorb oil, thus preventing the top from presenting the unseemly appearance caused by oil and dust; and washing with soap and water is practicable, thus enabling the workman to always have a clean bench upon which to do his work.

Here, in the very initiation of the subject, we can not fail doing the apprentice a benefit by urging upon his attention the necessity of absolute cleanliness in all his work; an attention that will, during a few years of active work, more than repay whatever little trouble it may involve; the habit once acquired will never be abandoned. The top of the workbench having been prepared, a small bead should be bradded* on to the front edge and a flange on the back and ends. The proper height for most artisans is about thirty-two inches, this height allows of a good-sized driving-wheel for his lathe, if he contemplates mounting one on his bench. The supports should be firmly fixed to the floor, and for the sake of rapid work, a nest of shallow drawers should be suspended beneath the bench, on the right hand side of the workman. These can be made, and divided internally, as the circumstances may dictate, in reference to convenience and durability—the partitions being thin and the spaces adapted with care to the various small tools and the material boxes. With a bench thus arranged the workman can do a larger percentage of work than where he relies on the bench for a depository of all the tools.

* Fastened using a small nail.

No one can fail to be struck with the tedious searching for some tool among the mass of stuff lying before the workman, that happens where no system of order is observed. Directly in front of the artisan, and under the bench, should be a drawer with a tin bottom, being pierced in the centre with a number of fine holes, under which a tin bottom is fitted like the top of a blacking box. The object of this arrangement is to catch any filings or clippings of work in silver or gold. Some little distance below the gold drawer a frame should be fitted on runners, and have a bottom of strong leather (good sheepskin is well enough), the object being to afford a depository to catch any article that may drop from the bench. The workman will get in the habit of drawing the "skin" out every time he sits down before he attempts to execute any work. Any watchmaker knows the vexations attending the dropping of a screw, wheel, or any small article where he is compelled to get on the floor and institute sometimes a laborious search, which in many cases proves unavailing, to restore the lost article. These accompaniments to the bench may be made as taste may incline, but we should recommend that neatness in the arrangements should be observed, for any man can work faster and better at a well-arranged, neat and clean bench, than at one of the slouchy, dirty things too often seen, that look like twin brothers to a jobbing locksmith's bench.

If the workman determines to mount a lathe, it should be placed to his left, far enough to enable him to work with plenty of room at the ordinary repairs, and yet not so far off that he has to move his seat any distance, or get up in order to use the lathe. This much for the bench. We have been more minute than may be considered necessary, but when the fatiguing nature of the work is considered, any mode of shortening the duration is of benefit.

The next important point is in regard to tools and material, and no consideration of price should be regarded in getting the very best of both. It must be well known to every jobber

that he is often offered tools that, if good, are far below a fair price; the same with material, and if he happens to be remote from any dealer, he may cheat himself by attempting to save a dime in his purchase, for it is a rule that the price bears a certain relation to the quality. For instance, there are both Swiss and English tools of the very best quality, but they are high. Now if the workman should reject one of these, and choose a pair of pliers, for instance, he is more than likely to get a malleable or cast iron tool, simply case-hardened, liable at any time to fracture, and this may happen at a time when its use is imperatively demanded. The same may be said of the hollow pin vise and pin tongs. One of the most important tools on the bench is the vise. Formerly, the common vise was the only one in market, but of late years there have been introduced into market various forms and patterns of parallel vises, some having a moving jaw to hold taper or uneven objects.

The Swiss and Americans are the principal producers. Of all the styles, we give our preference to the smallest-sized Parker vise, with an adjustable jaw, and capable of being revolved on an axis to any angle convenient for working; it is made of cast-iron, with steel-faced jaws, planed on and tempered equal to the best Stubbs. The Swiss parallel vise is made apparently of very coarse steel, left generally so hard that the jaws are liable to fracture when pinching hard with a light bearing. On all accounts, the American vise is the best, while its cost is not so much higher than the Stubbs' Cotter vise, and not so high in price as the Swiss parallel. One should be chosen that closes evenly in the jaws, and we prefer a perfectly smooth face to the steel, instead of one cut in file teeth, as for all the ordinary work in the watch or even clock repairing business, the bite will be sufficient to hold the work without marring.

The vise should be firmly screwed to the bench, at a convenient distance to the right of the workman, and should be furnished with a pair of false jaws made of, say hard sheet

brass, and so fitted that they will slide on—not drop on—and when they meet they should be filed down to sharp joining corners. Sometimes in operating on work constructed from soft material, it is advisable to mount the vise with wood or lead false jaws, or even a strip of hard leather may be used, one on each jaw; this material serves admirably in cases of gilded work, etc. Another very important adjunct on the bench is a first-class oil-stone; it may be Arkansas or Turkey, though we prefer the former. Like all other parts of the bench appliances, it should be kept clean, and should never be used without oil, as particles of steel are apt to stick in the face of the stone, and thus leave places of no action; the same thing occurs to the machinist's files, and is called "cat faces." If the workman has a lathe, he may easily attach a small Arkansas stone to a chuck and use it as a grindstone, either on the edge or face. In fact, for getting the correct angle and flats for cutting tools, the circular grinder is infinitely superior to any other tool, as the object to be sharpened may be held in one position while the grinder is doing its work; whereas, in using the flat stone, and moving the object, neither the parallelism nor angle can be maintained, owing to the motions of the hand and arm. For fitting up very fine drills, the circular cutter is of the greatest utility, and may be made to supersede entirely the straight stone, from the accuracy with which the work can be done, and the delicacy of touch the workman has in doing the abrasion.

The oil-stone has been cited as a sharpening tool only; the bench should be furnished with appliances for flattening both steel and brass work, for bringing them to the gray, and for polishing. As these conveniences can easily be made by any intelligent workman, we shall take great pains to give a full description of both tools and processes.

CHAPTER II

Lathe Appliances; The Jacot Lathe; The Depthing Tool; Expanding the Web of a Wheel

We will suppose that the artisan has got his bench perfectly arranged, and is ready for work. He will find that in his odd moments, when not fully occupied by custom work, he may successfully make many small tools that can seldom be found in the stores of material dealers; for he may, with the use of a little shellac, work up his squares of arbors, as well as the flats of the steel work that he may be required to replace or even repair. Let us take the ordinary dead-centre lathe—the common verge, as it is called—and we can, by a few appliances, make it quite as useful as the ordinary vise, and the work can be done much truer than by any means that can be employed on the vise; and for this reason the watch repairer should have a common steel lathe, dead centre, or some other appliance to answer the same purpose, and he will find that he can save a great many hours' labor, and do much better work. We will illustrate, for instance, the value of such a pair of centres. Let it be supposed that we desire to finish up the square on a fusee, barrel or arbor; we may find some difficulty if we attempt to file the sides of the square flat. Even if we achieve this feat, we shall find that, instead of perfect flats, we have rounded surfaces, if we have depended entirely on our hands to do the work. Suppose, however, we place an arbor between a pair of dead-centres, allowing it no end-play, but perfect freedom to revolve. Now, if we have, in the first place, made a flat on the sides, we may apply a file to the surface thus made, when it

is swinging between the centres: and it is obvious that the surface will follow the direction of the instrument, whether a file or polishing tool. Diagram 1 will give an idea of the application, and may suggest many more that at the bench will be very valuable.

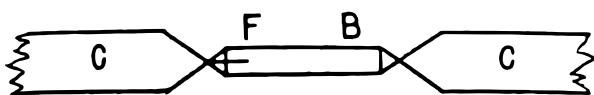


Diagram 1.

The two centres, C, are supposed to be fixed in their respective places, while the arbor, B, is free to revolve, and the square, F, can be finished up with perfectly flat sides. The file being applied to the flat, F, the freedom of motion will enable the article to meet it at any position the hand of the operator may move it; and in polishing, the value of the process will become apparent, for it cannot have escaped the notice of any workman that, though he may have filed a surface flat, he invariably rounds it in the polishing. When thin work is to be done (brass or steel), a small attachment may be made to the lathe by any workman, such as is given in Diagram 2—C being, as before, the centres, and the brass cradle being swung between them. If the piece to be filed is fastened by shellac on the surface, S, it is evident that if the work has been in the first place started right, the work will accommodate itself to the file at whatever position that may assume.

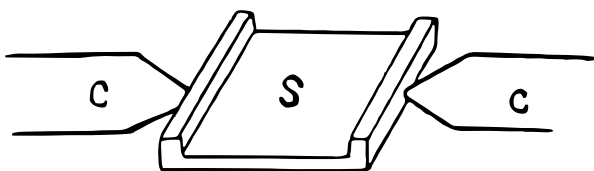


Diagram 2.

This form of tool may be used for almost every part where parallelism of the two sides is required, and the file will leave a

flat surface. The reader must have observed the sharp corners and beautiful level surfaces given to the polished sides of the Swiss wheel, and that too, of those occurring in a very low class of watch. It is to get just such a surface ready for the final polish that the watchmaker may use the above.

This little attachment is so easily made, and so obviously useful, that we shall expect to hear of its adoption from many who have not been in the habit of using it. Let the conical holes for the centres be deep enough to prevent the work and tool being thrown out of the lathe by the use of the file or polisher. In small steel work it is invaluable; as the flats of the barrel work, and so on, may be filed, stoned, and finally polished, without removal of the piece. The workman may make the swing of any size and length to accommodate the dimensions of the pieces he wishes to work on, and as the thing is so easily made, he may have a number of different sizes and depths. In placing the centres on which it is to vibrate, it must be taken into consideration that the nearer the surface to be worked is placed to the line of the centres, the truer will be the work, as it will vibrate much more easily than when the surface falls below the centre.

Other attachments will suggest themselves to the workman if he will study the capabilities of the tool as an instrument to be used in the vise for various purposes; and we will give one or two examples that will open the way to a full comprehension. We predicate, however, that the repairer has no standing lathe; that is, he must use a dead-centre tool. If he is in the vicinity of a machine shop, he can very cheaply obtain a few spare centres, and on the ends turn up a button, somewhat like the figure.

By drilling a series of holes around the common centre, as shown at A, he will have a back rest with which he is enabled to true up any pivot or staff; the holes must vary in size and be chamfered until the chamfer forms a very thin edge, with the back of the button, B. It will be at once comprehended that

the back spindle must be elevated, or rather thrown above the centre by as much as the holes are from the centre. With a few spare spindles, the repairer can make for himself a great number of small conveniences that can not be purchased.

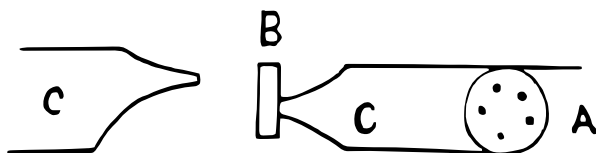


Diagram 3.

The very making of such tools will be a source of profit, indirectly, as the maker will, by the exercise of his mechanical powers, find some relief from the monotony of watch repairing. Every workman is familiar with the Jacot lathe, and where work is to be done on the dead-centre principle there is nothing better; but it is confined to a very small class of work, and therefore not so well adapted for general purposes as the ordinary lathe, with the attachments we have spoken of. The depthing tool is all-important, and the beginner, when he has a good watch down, should always spare time enough to try the depths with the tool; the practice will familiarize him with the standard of depths adopted by the best makers.

There is a very ingenious use to be made of the depthing tool somewhat aside from the object for which it was originally intended. Suppose we wish to top an escape-wheel with pointed teeth. We first place on one of the common arbors sold in the stores, a small hub of bell metal, and turn it off true and parallel on its own centre. This arbor, with its hub, is swung between one pair of centres in the depthing tool, while the escape-wheel is swung by its own pinion in the opposite; and it will be seen that the hub may be brought in contact with each tooth successively. With a bow and a small amount of crocus and oil applied to the hub, the topping can be done with a degree of precision not attainable by any other means.

In purchasing the depth tool, it should not be taken for granted that the tool is true; it should be tried, and if on trial the marks made by the four centres do not correspond when they are projected to their full length, and again when closed, the instrument may be considered defective and unreliable—in fact, worse than none at all, as it is so apt to betray the workman in a very important item of watch repairing. The workman would do well to attach to the depth tool a small right angle made of a thin piece of brass, and screwed to the side of the tool in such a manner that, with a notch cut in the upright portion, he can get a species of banking pins when he is examining the depth and action of an escape-wheel and pallet, in case either have to be replaced. This banking piece is of great assistance, and can be so easily attached that it is inexcusable for any to be without it.

Another very important adjunct to the bench is a good set of staking tools; by this we do not mean the ordinary hollow punches used by hand, with the common pinion stake, but a much better arrangement, that any workman may accomplish, if he is willing to devote some of his spare hours not only for his own improvement, but for the tools on his bench, and the increased facilities such tools will afford him in the prosecution of his business. Besides the mere staking on of a wheel, the same tool may be used for closing holes and expanding wheels. It often happens that a Swiss watch will be brought to the repairer that is persistent in a habit of stopping. This class of watch is often the low price variety, it is true; but this fact does not lessen the trouble the workman has, for his trade in general does not allow him to select his class of work. The watch is examined, and if the workman has been posted in his trade, he generally finds a faulty depth between the fourth wheel and escape-pinion. In nine cases out of ten he will find the wheel too small, or else that it is six-sided, and therefore the depth is wrong in every point of the wheel, except at the extremities of the arms or crossings, which have

served to keep the web to its true place while it was being cut. The first step of the workman will be to ascertain whether the wheel is too large or too small; if too large, the first and only thing is to top it, and then round up the teeth with a Swiss rounding-up tool; but every watch bench does not boast of such an article, and we have seen the Swiss workman, after the topping, round-up the teeth with a common round-up file. Of course his work was not so well done as he could have done it with the proper tool.

Taking the other horn of the dilemma, we find the wheel too small; in such a case it is evident that the web should be expanded, and as the amount is so infinitesimal we may apprehend no difficulty from the pitch of the wheel teeth, provided we can expand the web equally, and leave the circumference nearly a perfect circle. We have seen this process of expansion effected by a hammer on the anvil block of the vise, and then the teeth rounded up by means of a block of wood placed upright in the vise, and the wheel held in the fingers of the workman—he occasionally trying the wheel between the centres to ascertain if it was true. This, undoubtedly, is a reprehensible mode, as no accuracy can be ensured; and again, the polished surface is marred by the contact with either the hammer or the anvil block. Now in the staking tool we are about to describe, the whole object can be effected with almost a certainty of precision, and in one-half the time required under the old style. Suppose we take one of the common old style of Swiss uprighting tools, and even should it not be true it would make but little difference. There is always a square on the under section by which the tool is to be held in the vise, and as the long bearing for the lower centre is not required, the round portion may be cut off and thus render the tool more handy to be employed in the vise.

The lower hole may be bored out to a large diameter or left as it is, and we would recommend that in the selection of the tool the artisan should choose one in which the two

centres accurately fit the upper hole, as then he will have two arbors to carry his punches; for he will never need to use the lower spindle for any other purpose. These conditions being assumed, the workman will first take out the centres that come in the two arbors, and ream out the hole in the end with a taper reamer; which, be it remembered, together with all the other operations, are completely within the scope of an ordinary village watch repairer, even if he is remote from any machine shop. Having reamed out the end of what we may designate the plunger of the punching press (for it becomes this and nothing more), he may fit in the taper any number of hollow, closing, swedging*, and riveting punches, fitting them with accuracy, and in the case of the hollow punches, drilling them after being fitted from the lower hole with a drill fitted in the other mandrel, on which he may place a pulley, and revolve it either by means of the bow or a foot wheel; of course the drill will have to be ground, and formed in accordance with the mode by which it is to be driven. It will be necessary to get the drill perfectly true with the centre of the mandrel, and then it can be reversed to the upper hole to drill the dies.

The dies are made of steel wire (Stubb's), much larger in diameter than the lower hole; the end of the wire is to be turned up to a shoulder, and then the piece is cut off to a suitable thickness, say from an eighth to a quarter of an inch above the shoulder; there should be one made of a much larger diameter, about one-half an inch thick, so large that if a wheel's pinion should be dropped in a hole near the periphery, the web of the wheel may be brought directly under the centre.

* Process in which the dimensions of a piece are altered by forcefully pressing the piece into a die.

CHAPTER III

The Spreading Tool; Its Use; The Rounding-Up Tool; Stud Remover; Opening the Regulator; Roller Remover

The die is supposed to have the tit for the lower hole in the centre. An improvement on this would be to make the tit and block eccentric, as shown in the diagram; the figures are drawn on an enlarged scale, but they show the whole principle. The holes, as indicated, should be large enough to take

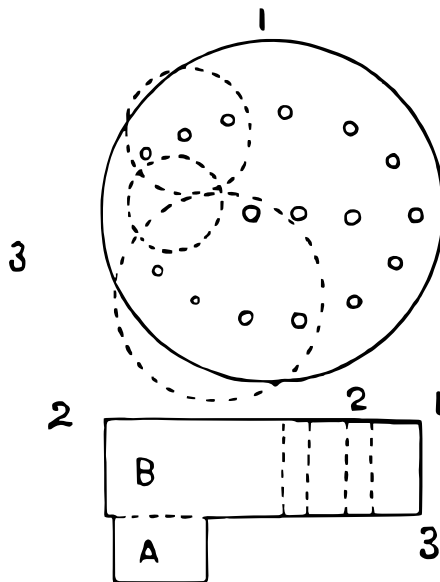


Diagram 4.

any pinion. The tit, A, is fitted to the lower hole, and the die, B, is turned up eccentric to A, but the surfaces 1, 2, and 3, 4,

are to be made perfectly at right angles with the axis of A. The holes that are to be drilled are shown on the face of Fig. 1, and by the dotted lines in Fig. 2; they may be drilled at any distance from the centre of A, observing that if put in curved lines much nicer gradation of distance can be obtained than if put in a straight line. Though the holes are large enough to take any pinion, the truth of the centre will not be lost in the subsequent processes, even if the pinion is much smaller than the hole, for the simple reason that when the web of the wheel has been brought under the centre of the punch (or what in fact may be called a spreading tool), the pinion rests against the back of the hole in which it may be placed, and this may be turned around with great accuracy as to truth.

The dotted lines on the face of Fig. 1 represent two wheels of different sizes; the lines in each case crossing the centre of the block B; now, it is easy to see that with the limited number of sizes of watch wheels, only a few holes will be necessary. The form of the spreading tool on its face, or rather edge, is represented in Fig. 3, and the shape of this edge is very much like a common cold chisel; the curvature should nearly correspond to the diameter of the wheel to be operated on. The block should be hardened and tempered, and then finely polished as truly flat as possible, and the holes should be slightly larger on the lower side than on the face.

Supposing now we have the tools all prepared, the following uses may be made of them. In a great many Swiss watches, of the cheaper class, the repairer will find an ugly fault of stopping, and on investigation he finds a wheel out of true, say (and it is most common) the fourth wheel; it will run partly around, but at some portion of its periphery it will be found to be out of depth with the escape-wheel pinion, and in nine cases out of ten the depth at that point will be found to be too shallow. There are only two ways to remedy this difficulty: either put in a new wheel, or spread the *low* side of the old one so as to bring the wheel true. The first step will be

to ascertain exactly where the low side is, and how much of an arc it subtends; this is to be done in the lathe, or still better, the depthing tool, as in the latter the action of each tooth on the pinion can be observed. Having ascertained the part, the wheel, with its pinion, is placed on the block in the staking tool, the lower side of the wheel being up; the centre of the web should be brought directly under the tool (Fig. 3); a few blows of the hammer on the spindle in which the tool is held will make a slight crease in the web, and the displacement of the metal will be sufficient to spread out the wheel to its true circle.

This, as a matter of course, must be done with caution, and repeated trials be made for fear of getting the wheel too large; with care, the job can be done without any subsequent rounding up of the wheel teeth. It may be thought that we have dwelt on this subject at too great length; but when we consider that the common practice is to hammer the web out, and then with a rounding-up file bring the wheel to size and truth by the eye alone, we feel that a more perfect plan is of great value, especially as the workman can make his own tools, at times when he is not engaged. Again, the young workman may find in the discussion of the subject some important hints that may lead him to find a cause of stoppage where he least expected.

In large cities, where tools are abundant, it perhaps would be better to spread the whole web and then bring the wheel to depth by means of the rounding-up tool. The most of the repairers in the country have not the facilities that are afforded in cities like New York, Chicago or Philadelphia, though they might have, were they to pay more attention to their tools, and lay out more money on them than is generally done; for a gradual accretion of tools tells but little in the long run, from the fact that the repairer will have made more from the purchase and use than the prime cost. The Swiss rounding-up tool should be one of the best, and though expensive, the price

is not excessive when the amount of elaborate work on it is considered. The attachments to the tool are quite as expensive as the tool itself.

This tool may be described as simply a milling tool, consisting of two lathes—one with a live mandrel, the other to hold the work in dead-centres. The cutters that do the work are set true on the live mandrel, which runs in a head-stock capable of a vertical adjustment, while the dead-centre lathe is based on a dovetail admitting of an end motion, regulated by a fine screw feed; thus the live spindle remains always in the same vertical line, and therefore an index may be used to get the wheel held by the dead-centres exactly true with the line of vertical motion of the live mandrel.

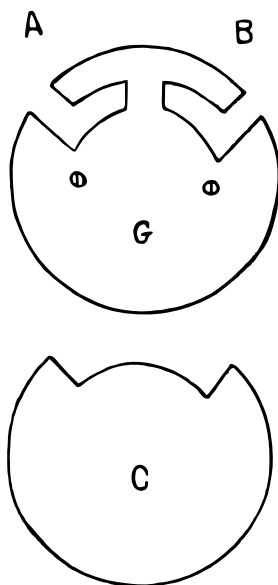


Diagram 5.

As in all tools, the cutter is above the work, and the correct diameter is obtained by stop screws resting on steel bearings, and which may be used to graduate to any size, from the smallest escape-wheel up to the largest barrel or main wheel.

There accompany the tool, five different arbors, with ten different centres, two of which are conical; the others are hollow, with a traverse hole to enable the workman to not only clean the centre, but to oil the pivot from the end. There is one very beautiful application of the screw principle that will strike every one who sees the instrument. The saw, or cutter, which is intended to round up the teeth, is made with a segment cut out of the periphery, as shown in the diagram; being placed on the live arbor, the saw is held in its place by a follower or washer, on which is a steel plate; this plate is cut away a slight distance from the edge, on two sides of a narrow neck, which is left by the under cut, as is shown in the small figure; directly back of these two horns, thus formed, there are two screws at A and B respectively, coming through the back of the brass washer on which this steel plate is screwed, the points of which take the two horns at the back. It is evident that if one of the screws is put in farther than the other, the neck will be twisted, and the edge of the plate stand at an angle to the plane of rotation. Now, if the corner represented at A is in advance just one tooth, it is evident that at every revolution the wheel will be rotated by just that much, so that the workman having the job in hand, after adjusting for size, may go on without once touching the wheel.

This process, as a matter of course, is not perfect as a matter of correct division, unless the teeth of the wheel were correctly divided in the first instance, for it will be seen that the whole element of truth has been determined in the first division of the wheel teeth. The vacant space left in the cutter's edge enables the steel plate to be varied to any angle; and thus, whatever the size of the wheel, or pitch of the tooth, the instrument will operate equally well.

There are many little appliances that can be added to the bench, that may be made by the workman at a trifling expense of time and money; thus it once in a while happens that in repairing a Swiss watch, the workman often damages the hair-

spring in taking out the stud, which almost invariably is put in with a pinch joint. Any watchmaker can make a simple instrument to effect the removal of the stud, without danger of injury to the hair-spring. Take a common pair of tweezers, and cutting off one end, the other is to be heated and turned down, and then filed up in the form of a pivot; the pivot thus formed should come inside the short end, which in its turn is filed with a notch to almost straddle the stud. The use is obvious; placing the short end under the cock, a slight pressure drives the stud out without any risk of injury to the spring.

It sometimes (indeed very often) will be noticed that in some classes of the Swiss watch the regulator is bound down entirely too tight by the steel cap that holds both the end stone and regulator. The fault can be remedied only by taking off a slight amount of the outside bevel of the cap, or opening the regulator. The first process is much the easier, and can be effected by very simple means. If the workman will take a pair of common pinion calipers, and file down the points small enough to enter the screw holes, he has a certain means of holding the steel cap, and can then reduce its diameter enough to free the regulator.

Such little adjuncts to the watch bench save time, and enable the workman to do better work, and that in a more workmanlike manner. For instance, a pair of old cutting pliers may be transformed into a useful tool by drawing the temper and filing in the jaws a series of small angular notches of different sizes; these will be found useful in taking off a roller without any risk of bending the staff, as the jaws will meet while the staff is perfectly free in the notch.

The repairer in a large city need not have a cutting engine, as the material shops are well supplied with every sized wheel required; but it will often occur that in case of a main wheel too much broken in regard to the teeth, no counterpart can be found by the watchmaker whose stock of material is limited, and this holds true of all other wheels. If, then, he resides

remote from the general centres of trade, he cannot do the necessary repairs, and is compelled to send the work off to the city. Now, no repairer should be without good tools, as the cost bears a very small proportion to the advantages to be derived. This applies more particularly to the repairer located in a village remote from the great centres of trade. He is limited in his facilities, while a workman in Chicago or New York City can always find an egress from his difficulties by sending his work out to some one who makes the particular job a specialty.

As an example, I received recently, a nickel barrel with at least ten teeth out of the main wheel. The barrel was beautifully grained on top, and the party sending it despaired of getting the finish as much as he did of making a new one, even without the graining. We think that this repairer would have been in a much better condition had he possessed the means of turning up the barrel, cutting the teeth, then rounding them up, and afterwards graining the top by a very simple tool, which I shall describe in my next chapter.

CHAPTER IV

Replacing Broken Teeth; Graining; Polishing Blocks

It behooves the workman at the bench to do his repairs in such a manner that the watch will not only run well, but that all the new work put in may be equal to the original. We mentioned in the last chapter the case of a nickel barrel grained on the top. Suppose that the repairer meets with a case where only one tooth of the main wheel is broken, and he is to replace the lost tooth. If he chooses he may drill for a bearing, and as the bottom of the tooth is on a level with the barrel, he has but little trouble in planting his centre for drilling; and, what is better, the hole may be planted below the centre of the teeth, and thus a larger neck be given to the blank. As a matter of course, if the operator succeeds in getting the neck of the blank just right to make it level with the top of the barrel, but little trouble occurs afterwards; if, however, the blank comes above the top, it has to be reduced to the general level, and here comes a difficulty that, to most workmen, is rather formidable; for if he files off the surplus stock he is very liable to mark the top of the barrel, and thus destroy the whole beauty of the work, however well it may have been done in other respects. If he stones off the surface, he is in trouble, as the work would not correspond to the rest of the movement, and if, as in the case cited, the top of the barrel is grained, the difficulty is still greater; for though the repairer may have a battery, and a full knowledge of gilding, in this case very few are posted as to the tools and process used and followed, in

order to obtain the beautiful grained surface that obtains so universally in the nickel movements.

This graining is not confined to the nickel movements, but is extensively used in brass work of fine marine chronometers, as well as clocks; and as it replaces, or rather answers the purpose of gilding, it is worthy the minuteness of description we propose to give. Every workman that has used the ordinary Scotch and blue stone well knows that he can produce a surface with either, showing nearly straight or circular lines; but it has a cloudy look, arising from the irregularity of the strokes, and the uneven distribution of the lines. Now, if the lines could be made perfectly straight, and what is more, evenly divided, as in any straight line ruling, the effect would be a clear, even surface, perfectly uniform in appearance. But, except in particular cases, the straight line work is not desired, and we will now come to the circular. If the lines, as made by the stone or other abrasive material, cross each other at uncertain intervals, the same cloudy surface, before spoken of, is produced. It is obvious, then, that to get the full beautiful effect of the stoning, it is necessary that some regular system of motion shall be observed in order to get the pleasing effect that is observed on the stop plate of an English fusee. The regularity of the lines give a faint idea of engine-turned work, as the principle involved in doing the work on steel, brass, or nickel. We shall select for the illustration the snail-formed piece on the top of the fusee, and which serves to make the stop.

If the reader will refer to the diagram, he will find a tool to be applied to the lathe that will answer our purpose of illustration. The swing rest to which we refer is so well exemplified in the diagram that a description is not necessary. Let B represent the geometrical centre of the lathe mandrel and E the rest and hub, for the reception of the ordinary T, in place of which, in the new arrangement, a T with two centres is substituted, as will be seen by reference to A; the swing, C, may

be of any dimensions that the lathe is capable of taking, for in every case the centre, B, and its height above the lathe-bed will be the point of departure; the stop screw, D, enables the workman to bring the polisher, P, as near as he chooses to the centre, B. The small arbor on which the pulley and polisher, P, are hung, is parallel, and passes through straight bearings, so as to be capable of an end motion, in order to polish.

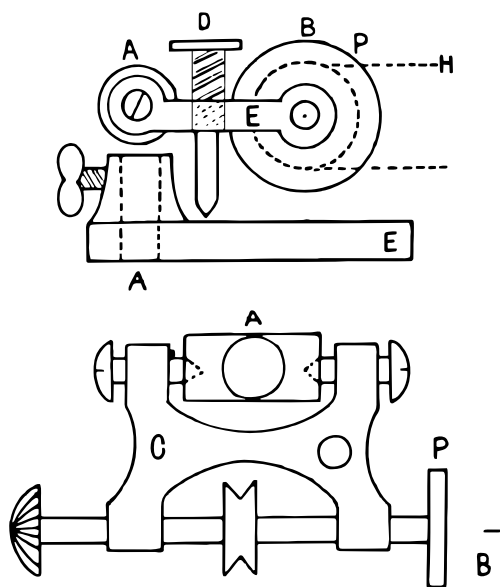


Diagram 6.

Suppose, then, that we take the grinder from the spindle of the swing rest and replace it by another, the face of which is so cut away as to leave but a narrow surface to come in contact for grinding purposes. The cuts we give will enable anyone to make his own tools for the purpose, and to do the work. If we take the ordinary lathe, and on the swing place a cylinder whose action is represented thus, it will be apparent that the plate to be grained will come in contact in the same places with the grinder, exactly in proportion to the relative speed of the two; and if the belts are tight, there will be but too little

variations in the markings. The grained marks will be narrow at the centre and wide at the periphery, because the motion of the periphery is much greater than at the centres, and thus any point there will have moved under the grinder a greater distance during any one revolution; it thus happens that the graining presents curved radial lines gradually increasing in width until they reach the edge of the plate or article under operation.

The grinder, as represented in the cut, is put on the end of the mandrel of the swing on the rest, and used the same as though it was intended to face up a pinion. If the face of the raised edge of the grinder is slightly bevelled, it may be set at an angle to the work, which must revolve much slower than the grinder.

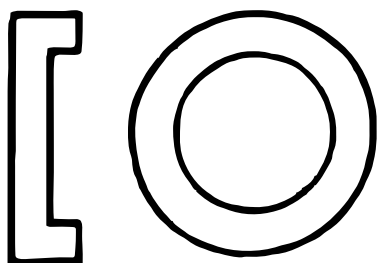


Diagram 7.

For steel work, oil-stone powder is used with oil, and tripoli with water for both brass and nickel. The beautiful mottled surface often seen in some work on the surface of the plate is produced by using a grinder in a lathe of the diameter of the intended mark. Now, if the grinder having been made to make one circle, is so placed on the plate that the next circle shall overlap the first, there will be an intermingling of the lines at the points of intersection. When the next circle intersects with both of those previously made, the effect is to leave a small space not marked by the grinder, while the commingling of the lines will give the clouded surface, by the

contrast. All this work on the plates may be performed with a drill bow and stock, though the work cannot be so uniform or good when done. In some clocks the stoning is done entirely by hand, and is subject to the caprice of the workman; as a matter of course, the work never presents the elegant appearance of that performed by the aid of the lathe, with a rest capable of holding the plate, and of being moved in relation to the grinder a definite distance, at will. This makes the surface appear very nearly as though it had been made by the aid of the rose engine lathe. The abrasive material used must be determined by the nature of the metals, both of the object and the grinder.

We have extended this subject so far in order to show the beginner that he may just as well do the work thoroughly as to do it in a shabby manner, leaving the general appearance inferior to the rest of the watch. In case the barrel should be gilded, it is an easy matter for the repairer to restore its surface, when injured from careless filing, or more reprehensibly, has become so through energetic scrubbing with the brush and chalk. This sort of work, however, requires the use of a galvanic battery.

As we have taken the case of a broken tooth in the main wheel, we will carry out the subject by taking up a case of a broken tooth in the centre wheel. Here the thinness of the stock in a great measure precludes the drill. In the English and American watches, where they are full plate, the centre wheel is always out of sight, and should a broken tooth occur it may be replaced very readily by filing out a small dovetail and fitting in it a piece of brass, just a trifle thicker than the thickness of the web of the wheel. If, now, the edges of the dovetailed recess are slightly chamfered, it will be obvious that a very slight blow of the hammer, the wheel being on a smooth stake, will rivet the false tooth in so that no solder will be required, though the web will be much stronger if the piece is soft soldered in, using the very smallest quantity of

the solder that will answer to just flow the joints, and nothing more. If the workman desires to do good work he will put the wheel on its centres and file down the piece of blank metal until it corresponds with the general circumference of the wheel; then with his equalizing and rounding up files he can make a perfect substitute for the lost dental. But now comes up the question of finishing the faces of the wheel, or rather getting the newly placed tooth exactly equal in thickness to the wheel.

The repairer must not suppose that he can carelessly rivet the blank in; for if he uses too much force he may stretch the web of the wheel, and render the depth at that part of the periphery defective, not only as to the new tooth, but for a number of teeth each side of the inserted one. If he has filed the dovetail with the large side up, so as to make the piece slip in almost level with the surface, he will find very little trouble in reducing it to a common level. Here, however, comes in another trouble; for if he files the tooth level, he must mar the surface of the rest of the web. This would be of but little consequence in a full plate; but if, as is the case in a three-quarter plate, the wheel is exposed, the job would be a botch. Now, it so happens that, the web being thin, the dovetail must be made more shallow, and solder is inadmissible.

In the Swiss watch, where the wheel is exposed, the tooth that replaces the broken one must be brought down to the general level, and it will be plain that the upper face must be finished off after the piece is riveted in. If the file alone is resorted to, the marks of the file teeth will show in strong contrast to the general finish of the watch. The majority of the three-quarter plate watches have hollow centre pinions, so that the length of the pivot of the pinion is but the thickness of the plate or bridge to which it belongs. Now, if, after having set in the tooth the repairer will take the pains to make a small lap for his lathe, or, in case he has no lathe, will make a polishing block (which we are about to describe), he can,

after putting in the piece that serves for the tooth, finish up the job so that no one can detect the replacement except with a strong glass.

The first supposition is that he has a lathe: Then the workman can make a type metal chuck, fitted to the mandrel perfectly true, but recessed enough in the centre to give play for the pivot in order to allow the wheel face to lie flat, and at the same time a slight lateral motion can be given. Having first made sure that the new tooth is securely fastened, the sides are filed down enough to permit of stoning off until no appearance of repair exists, and this too without driving the wheel off the pinion. The pinion may then be pressed into a piece of cork, and this will leave the face side out; the type metal chuck, having been faced true, is to be scratched on its grinding or polishing face with a somewhat coarse file, taking care not to file enough to alter the general truth of its plane: the wheel is applied by means of the cork, and by the use of at first rotten stone succeeded by rouge, the whole face may be brought up to its original condition. It must be observed that the end of the cork should be cut as truly flat as possible, and the recess, cut out to receive the pinion, may and should be large enough to insure perfect contact with the wheel surface and cork.

If no lathe is at hand the same effect may be produced by using a block of type metal, and after drilling a hole about two diameters larger than the pivot, facing it with the file, using the cork in the same way as if the work was in the lathe. The scratches, or rather the marks, should not be in one direction, but should be made by circular as well as straight motions of the file; this will give a patched surface to the grinding block. The cork should not, for the hand work, be long, as the end of the finger is to be applied to produce the required motion for polishing.

If the wheel is not on the pinion the case becomes more simple, as the glass plates can be used to advantage. This

method applies to all the wheels whose surface it is desirable to polish, and by the use of the glass and rouge a finish can be obtained equal to the original work. A very reprehensible manner of finishing the train is the practice of dipping the wheel in acid and then gilding; the matted surface is all that is gained, but the surface of the teeth is injured by the action of the acid.

The beautiful gloss obtained on Swiss wheel work is certainly preferable to the ordinary matted and gilded wheel. Aside from the superiority of finish, the corners are all left perfectly sharp, and the teeth are in the same condition as when the wheel was taken from the cutting-engine or rounding-up tool. The finish is so easily got that no repairer can be excused for neglecting, in replacing broken work, to make the quality of the surface quite as good as the original. We would like to impress on the apprentice or the young workman, that next to getting time, his object should be to so do the repairs that they cannot be discovered. He will not only please his customer, but render his trade a source of pleasure and pride.

CHAPTER V

Polishing Steel Work; Polishing Pivots; Superiority of Conical Pivots

We, in speaking to the apprentice, will endeavor to be as explicit as possible, and can only urge upon him the necessity there is for his using his own reasoning powers; true it is, that a mechanical fact cannot be altered by any amount of logic, but we wish to urge the beginner to reason on the application of any well developed and ascertained mechanical fact; and as we are writing for those just starting to learn the watch-repairing trade, we shall not make any apologies for going into detail.

Suppose, for instance, we have so far progressed that we are enabled to get a fine polish on brass; our very next effort should be to try our skill on the steel works. The method of this may be varied according to the circumstances; the surface having something to do with the way by which the finish is effected. In the first place, a few strips of bell metal, copper and tin are really useful, though not indispensable. If a perfectly dead flat is to be attained, such as the click, or the strap over the ratchet in a Swiss watch, the strip of bell metal should be wide enough to allow of motion in every direction, and the surface must be roughened by a file, the file marks to be at right angles to the length; or the surface may be made by circular strokes of the file; while this last will not grind down very rapidly, it enables the operator to get a much truer result and finer finish, and we may state that very rapid grinding is always more liable to destroy the truth of the surface than a

medium rate; though this must be taken with some grains of allowance, for long continued abrasion will be worse than a quicker process.

The surface of the polisher should be made as truly flat as possible. These metal polishers are sold by all the material dealers, and can be got of almost any size or shape. The case becomes different when a hollow conical or spherical concave surface is to be operated on. Here the lathe is an all-important tool, for the work may be setup on the chuck and leave the surface perfectly free to be acted on. Thus, suppose we need to re-polish the concave surface of the steel disk that usually is on the fusee arbor, we may chuck the work, either by the centre or outside; if we now take a piece of the bell-metal, and round up the end to about the convex required to fit the concave, we may in a very few moments get a polish equal to the original. It does not require that the bell metal should be absolutely necessary, for a small cylinder of type metal may be used; and we would here state that the cylinder should be short, so that the vibratory motion may be more easily obtained. If now we have chucked the piece; we first use the rounded end, with a little oilstone powder and oil, the process being precisely that of polishing the concave of a jewel; the same motions of the polisher must be made, and from the getting of the first surface the abrasive powders used must be increased in fineness until the final polish is achieved.

The lathe here gives the workman the additional advantage that he can polish up the outside as well without removing the work from the chuck. The same means cannot be used when a bevelled surface is to be polished, for the reason that if a cone were to be used the result would be to create rings on the surface; so it is necessary to use a polisher on the same principle as the opener in jewelery. The polisher may be of composition, or even, if the steel is well-tempered, a piece of soft iron may be used for the grinder, and type metal or lead for the polishers. In all cases the primary surface is

got by the use of either oil-stone powder or diamantine; and in using the latter, if the operator would float it off the same as diamond powder, he could succeed in getting a very good final polish. The outside edges are finished in the same manner, the grinders and polishers being formed into the shapes best suited for the work.

All this relates entirely to finishing of surfaces; and where the steel work of a movement has become dull and rusted, the repairer cannot gain a better reputation for thorough and careful work, than by restoring the surfaces and skilfully bluing whatever requires color. Although this course would consume time, it would amply repay in the end. We mentioned a mode of spreading the web of a wheel; since then we have seen a tool that is designed expressly for this purpose, and a description of it will not be out of place, as the tool is a perfect success. Imagine a common depthing tool with one of the heads made large enough to take in a small stake, the other head on the same side being fitted for any punch or spreading tool; the other side of the tool is fitted with the ordinary two centres that take in the wheel on its pinion. The use is simple; the wheel is swung between the centres and brought down so that the web may rest firmly on the stake; by the use of the opening screw the centre of the web may be brought directly under the punch. Now, by turning the wheel around with the punch for the index, or another centre in its place, the exact spot where the spread should be made can be perfectly defined. There is a flange at the bottom of the head that holds the die or stake that can be held in the vise, and the stake thus becomes solid. The tool is one that we should strive to get were we at the bench.

We do not suppose that any difficulty would be met with in converting it into a staking tool, the only change to be made being to remove the stake and furnish dies with hollow punches; and the assortment might run through a large range, for the hollow punches might be made from Stubb's wire of

just or very nearly the size of the hole in the head opposite to the die. There would be but little trouble, as the holes in the heads are in the same straight line. The value of the instrument is great, for the workman can ascertain the faults of the wheel, while he is bringing the part to be spread absolutely true under the punch. We have taken some little space to give an idea of the tool, for we think it is the most complete one we ever saw.

Another important point in watch-repairing is to ascertain that the pivots are sufficiently well polished, and, what is of equal importance, that they are round. There is a style of polishing the pivots by means of a burnishing file; this cannot be too severely condemned, for the burnisher will not leave the pivot round, as the pressure will not be equal at all points of the revolution when the pivot is turned with a bow; again, this burnishing file does not leave the shoulder of the staff or pinion in a fit condition to meet the amount of friction, however slight, that will occur when the shoulder rests against the jewel or plate. It can easily be seen that the edge of the file must have a shaving effect on the shoulder unless the corner of the file were rounded off; and this would leave the shoulder of a curved form that in the ordinary pivot is still worse, for if the side shake for the pivot is correct when the end shake is equally divided, it will not be correct should the shoulder be forced by any means up to the hole.

Now it may perhaps be well to make the remark that the jewel holes are not in all cases round; indeed, if one is found that is round, it is the exception, except in very small holes. If, then, the pivot is not round and the side shake very close, the merest tyro will at once perceive that there must be times when the pivot will find the low spots in the hole. For instance, if a triangular taper file were introduced into a hole that was truly round, the file would turn with the same ease as a perfect cylinder; but if the hole is not true, the corners of the file, as it is pressed into the hole, will take the hollow spots

and thus prevent rotation. This want of truth in both the hole and pivot is of more detriment to the good going of the watch than friction; for as the pivot is in almost every case taper, the end being the smallest, any alteration then in the end shake will cause the pivot to enter deeper into the hole, and the same results follow as in the illustration we give of the taper file.

It is for these reasons that a conical pivot, jewelled on the ends, is so very much superior, for it is evident that all the friction that exists is due only to the end of the pivot and the small arc it touches on the side of the hole. We will try to show how the conical pivot is much better, and then will proceed with our remarks on polishing pivots, together with the faces of the pinions.

The pivot is first turned down to a size that will allow the subsequent operations to reduce it to a proper degree of side shake in the hole. If the "turns," as the English watch-maker calls them, are used, the dead centres give a degree of truth, not so exactly attainable where a live spindle is used; though even here a very true pivot may be turned up if sufficient care is taken to make the back centre perfectly true; and the only imperfection that can arise will be due to the slight inaccuracies of the live spindle. The live spindle is driven with a bow; on the lathe bed a right angular piece is so attached that by loosening the hold-down screw, it can be placed at any distance from the chuck. This right angle may be bored out so large in the line of the centres that bushings may be put in and fastened by means of screws, and may be drilled to any size; and as they must be very thin in order to let the pivot project, they are counter-sunk on the back side. This counter-sink only takes the bevel, or rather chamfer of the pivot shoulder, and it follows then that the rest may be brought up to the work and the pivot turned to the desired size and polished both on the sides and end without removing the work.

It is plain that the pivot turned up and polished must be true; but we must account for the other centre that has got to

be or ought to be true when finished in the same straight line with the axis of the first pivot. We will assume that the back or centre rest has been removed from the lathe bed and the rest brought up to a chuck, in the face of which a female centre is sunk as truly as possible; a dog is screwed on the chuck, the end of which may take in the leaf of the pinion or tooth of the wheel. The centre rest is then brought up, and it is evident that a pinion or staff having been placed in the centre made in the chuck and the hole in the centre rest, the common hand rest may be used for the turning down the size, and then the polishing may be perfected.

CHAPTER VI

The Cutting Engine; To Cut An Escape Wheel

The preceding chapters have been devoted mostly to tools, with directions as to the making of some, and use of others. We shall continue to do so, for until the bench is well and completely furnished with tools the repairer is working to a disadvantage, for the simple reason that time is more valuable than the cost of the tools; and we will insist that the apprentice can do more with his spare money if he invests it in tools than he can if he expends it on dress. With these remarks we will resume the question.

It often happens that, even with a good stock of material on hand, there may come in a job when the repairer cannot find in his whole stock the piece he wants to do the work, that is of the right size, or, if a wheel, of the right pitch for the pinion into which it depths. Taking the wheel, then, for example, what can the workman do without a cutting engine? We admit that the occasions are rare when the engine is required; but they do occur, and we have seen many cases where a new wheel has been put in, that the workman has selected the nearest in size and pitch he could select out of his stock, or possibly out of the trunk of the traveling material dealer, and yet the train will not move freely when the wheel has been put in, and the customer and repairer are both dissatisfied.

The cutting engine is not a very expensive tool, and if there is a lathe on the bench the labor of cutting a wheel is reduced in relation to the speed attained in the cutter. The engine may be placed just back of the lathe, and a second band

from the pulley on the lathe arbor may be led to the cutter arbor of the engine.

The most common engine in this market is the Swiss, of various sizes and qualities. Some are fitted for cutting escape-wheels for cylinder escapements; generally, however, they are intended only for plain work. The cutters furnished are supposed to be suitable for the ordinary class of work in all its varieties; but the workman will find that there will be occasions where they fail, and he must resort to others of his own make, and if he has no cutter, or, as it should be called, a milling tool, he may make an extra mandrel to the engine; to this we will refer again.

Without a description of the ordinary mode of cutting wheels we would only lead the reader astray; for in the Swiss tool some little management is required, for the wheel to be cut must be centred by the hole that takes the pinion. It, in many cases, happens that the wheel is merely driven on the pinion arbor, while in other cases the wheel is staked on the pinion itself.

Now the cutting engine has a pump centre that takes the hole, and when the dividing plate is true there will be no difficulty in cutting a good wheel; but in the first place it is as well that we should describe the instrument, not in detail, but enough to give the idea as to the working. The pump centre takes the hole and the cutter arbor is carried in a swing frame that is brought up to the central arbor by means of a screw feed, and the blank is held between two pieces of metal that leave space enough for the depth of the tooth. The system of centreing is essentially different from the American—not so accurate, but far more universal in application, as any sized wheel may be cut. In the American watch factories the arbors that hold the wheels by the inside of the web are costly, and can be used for but one size each; but it is plain, however, that the wheel, in this case, will have a true web.

In the common engine the wheel is centred by the hole and held between two surfaces that take the web; thus it sometimes happens that the cut edge of the wheel will be out of true, and where the wheel is forced on the staffs this would be of importance; but the truth of the centring becomes a matter of the highest consideration where the wheel is staked on the leaves of the pinion. As a matter of course, with the cutting arbor in a swing the cut cannot be in a perfectly straight line, for it must be in the curve which the centres of the swing and the periphery of the cutter will describe. As a wheel is very thin, this perhaps is of little account; but when the main wheel has to be cut the error may be serious, for there will be but two bearings on the centre pinion leaves, and it follows that the points of bearings will get worn down in a very short time, and the depth will then be wrong. With the exception of the main wheel the swing is good enough, for the small arc travelled by the cutter is hardly an appreciable quantity

There may be occasions where the repairer is required to replace a cylinder escapement wheel in consequence of a broken tooth. The question then comes up, how to cut the wheel if he cannot find in his stock a wheel of the requisite size.

To afford the facilities to do so, some of the finer Swiss tools have an upright attachment, consisting of a small lathe-head with a spindle on which is a pulley or collet; the spindle is capable of an up and down motion, and the lower end is so bored out that cutters of many different sizes may be inserted and run true. These cutters differ entirely from the cutters for ordinary wheel teeth; they are cylindrical, being in fact nothing but a fluted reamer, with the lower end made taper and terminating in a drill.

The action of this is obvious; the blank wheel having been turned up and the recess made to allow the semi-diameter of the cylinder to pass over the bottom of the recess perfectly free, it is placed on the pump centre on its seat on the mandrel

and clamped down, and the reader will at once see that on bringing the tool down while in motion, a milling operation takes place on the inner side of the flange, which is the stock from which the little anchor shaped teeth are formed. By careful pressure and milling, a round hole will be made through the steel, and on further pressing down the cutter the hole will be enlarged until it opens at the edge of the wheel, and the opening is made large enough to almost take in the greatest diameter of the cylinder for which the wheel is intended. The index plate is now turned ahead one division on the circle of fifteen, and the same process is gone through with in succession. As the shanks of the teeth are very weak, it is, in every case, better to form up the impulse angle on the edges of the teeth before the milling out is done, and the crossings should be done before the teeth are cut.

If the old wheel is on hand, the repairer who has a universal lathe may easily turn out a gauge in a piece of brass plate; the fitting should be very accurate, and in turning up the blank he has a guide for correct diameter, and so may copy the old wheel.

CHAPTER VII

Replacing Broken Arbors; Hardening and Tempering

We will now leave the subject of the tools used for repairing, and commence at the prime motor work of the train, and this motor includes the barrel, arbor, ratchet, and stop work. We will commence with the barrel arbor, as this is the centre of the old system. There are two kinds only of this arbor: one where the arbor and hub are one solid piece, and another where the hub is a separate piece, and pinned or screwed on the arbor. This last form is adopted only where the whole of the barrel rests on and is held by the barrel bridge, and the ratchet, which is solid with the arbor, is sunk in a recess in the bridge and there held down by a cap with four screws. This style is abominable, and should never have been used; but very thin watches were in demand, and to satisfy the market the Swiss makers sacrificed much of the quality and durability of their watches. Aside from the instability of the main wheel, the ratchet once being broken, an entire new arbor must be put in, which involves expense to the customer and sometimes great vexation to the repairer, who finds that the job has not paid him for his time, labor and material.

The question is, how to replace one of these arbors where the ratchet teeth are broken so badly that no filing can repair it. If the repairer has a large stock of arbors he may find one that has the ratchet of the size of the recess in the barrel bridge; the arbors are generally centred pretty true, and the mode of finishing the work will depend entirely on the tools and facilities the workman possesses. For instance, if he has

a lathe with a back centre, he may commence by dogging the end that is to constitute the square; and putting the work in the lathe, the workman first faces off the ratchet on the underside, at the same time turning up the shoulder that takes the barrel bridge; only some judgment is required to leave it large enough to be polished to a fit. The under surface of the ratchet should be perfectly flat and at right angles to the line of centres. In grinding and polishing there is apt to be left a rounded corner. We have found in our experience that if a very fine groove is cut in the corner, the grinding and polishing will bring the corner perfect.

We now turn up the shoulder of the bridge bearing until the barrel comes to just the right point of freedom from the bridge. It is well, though, to leave a little more freedom than is wanted, as the bearing for the barrel is yet to be turned, and it may happen that the shoulder will be cut away in the polishing and thus bring the barrel too close to the bridge. Having polished this last bearing, the barrel, with the bridge, should be tried by putting them together and screwing on the hub, and if the work is right the barrel will be somewhat firmly held in a lateral direction, but be free to rotate; if, however, there is the lateral shake it shows that the hub, when it butts against the shoulder is too far from the central boss on the inside face of the barrel. Of course the shoulder is to be turned up farther, and the neck may be made equal to the bottom of the thread that takes on the hub, and there may be a little allowance made, for the arbor is strong enough in this part.

Having satisfied ourselves of the proper degree of freedom between the hub and the shoulder of the part coming through the bridge, we next pay attention to the lower pivot that takes the barrel head; and here we will remark that the shoulder should be so turned that when the head is sprung in the barrel the hub should be exactly in the centre of the rotary plane of the barrel. If the workman has been successful in getting his lengths so far, he may reverse the arbor in the lathe and

face off the upper side of the ratchet perfectly parallel with the lower side, and of course, of such a thickness that when the cap is screwed down there will be an equal bearing over all the surface the ratchet is intended to embrace. As the ratchet and arbor do not move except when winding, the truth of the two surfaces of the ratchet is of more importance than high finish, and there is a surface below the highest polish that will give as good results when used on brass for a horizontal bearing. The upper part of the arbor is now turned down to the proper size for the square, and the arbor is finished in all except length; as the lower end is to be squared to take the stop work, the metal may be taken off smaller than the part that is to form the square for the stop, but it will be quite as easy to square up the whole length, and when the parts are put together, to drill the hole for the pin that holds down the stop. To produce the squares we refer back to Chapter II, and the only thing that remains to be done is to cut off for the length, and polishing the end of the square; the last may be done in various ways—in the lathe, or by the burnish file, though in a watch that has any pretensions to quality, the repairer would or should like to finish the upper end as finely as any other part of the steel-work in the watch.

It is not necessary, however, to have a live spindle lathe, for all the same operations can be done by a dead centre, with a collet and the bow; and perhaps in the polishing the bow is the best, from the frequent changes of position insured by the backward and forward motion.

We have now got our arbor for this class, and it becomes necessary to harden and temper; as the arbor is short, it will hardly warp in the hardening, but it will become necessary to take off the thin film of oxide that has been formed in the heating. We may confidently assert that the whole may be hardened without detriment to the surface, if, in the first place, the piece is carefully covered with clay, or any other substance that will prevent the access of the oxygen of the at-

mosphere, and then heated to the proper degree; on plunging in cold water, the clay will flake off, and the arbor will be hard, with little oxidization of surface. Of course, too much clay must not be put on; and again, the whole must be thoroughly dried before it is exposed to the heat for hardening. It is better to do the hardening before the centres are cut off, for when the work comes from the fire, or from under the blow-pipe, a leaden-blue will be found on all the polished surfaces; now polish some one part again, and draw the temper down to the point you wish. We prefer a deep straw color; and, getting this, the arbor can be put up in the lathe, and by the use of a hard graver the ends may be cut off after the polishing has been effected.

If the length and side shakes have been made right, the arbor is ready; but in polishing the upper side of the ratchet it must be observed that the face of the same must come perfectly level with the edge of the recess into which the cap that holds the ratchet drops.