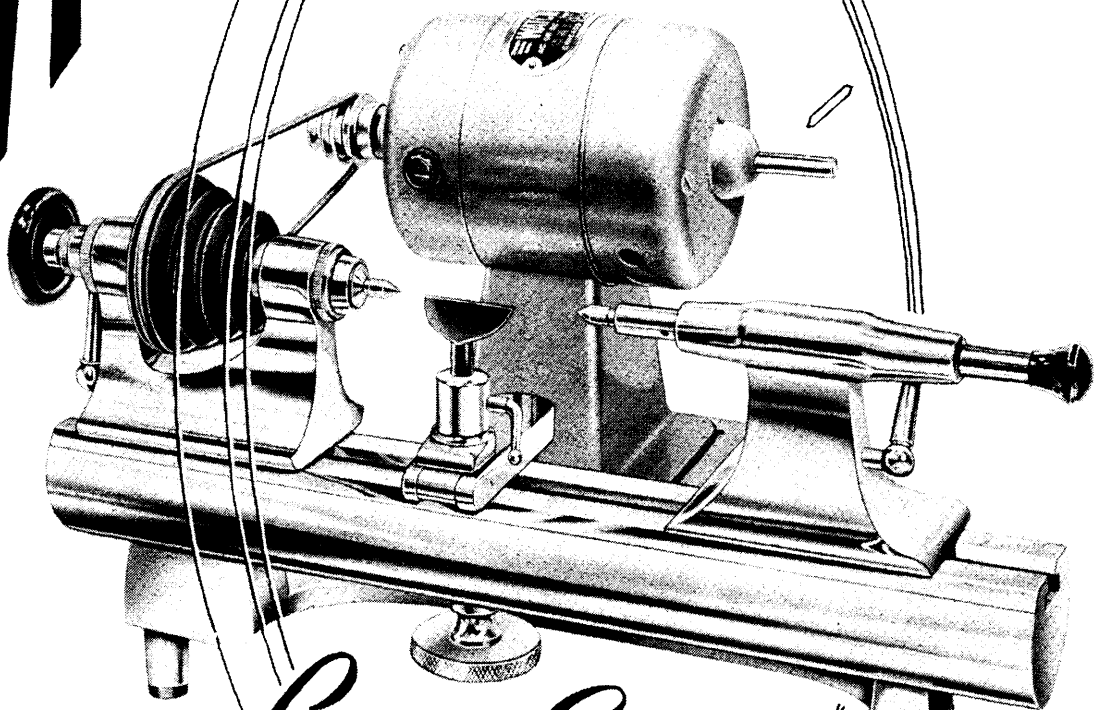
Master Watchmaking



Lesson 31

LATHE WORK

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

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You may hear it said that today with interchangeable parts and the low cost of watch material it is a waste of time to make parts such as stems and balance staffs. But there are many old watches you will handle where it is impossible to obtain the correct material, and even on some newer watches not all repair parts fit perfectly. To justify the term Watchmaker, you must be able to repair all makes and models of watches, and your success as a Watchmaker depends upon your ability to make or alter the required parts for the watches you are repairing.

SEC. 520 -- Making a Square Shoulder Pivot

It is best to harden and temper your own material for practice. Select a piece of drill rod, harden, polish, and temper it to a deep blue. This is the color required for pivot and staff work.

1. Place hardened and tempered rod in chuck allowing it to extend approximately 6 mm. Grind the end with a Hard Arkansas slip, keeping it at right angles to the work and moving it rapidly back and forth as illustrated by arrows in figure 31-1.

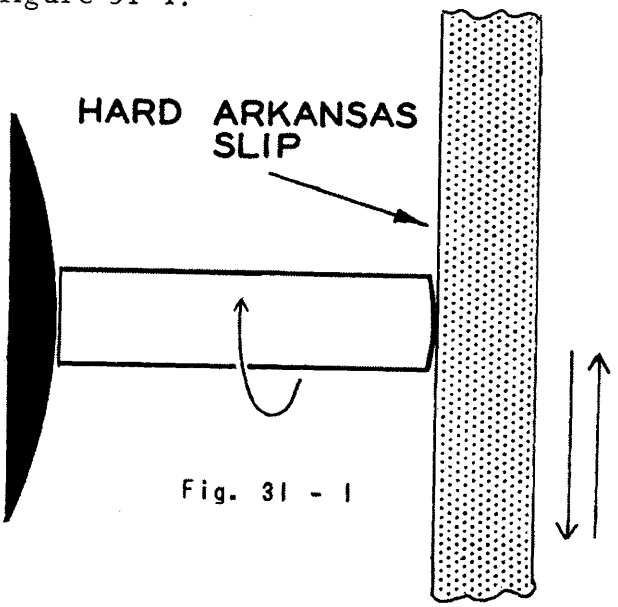


Fig. 31 - 1

2. Burnish end of rod with hardened steel pivot burnisher, figure 31-2.

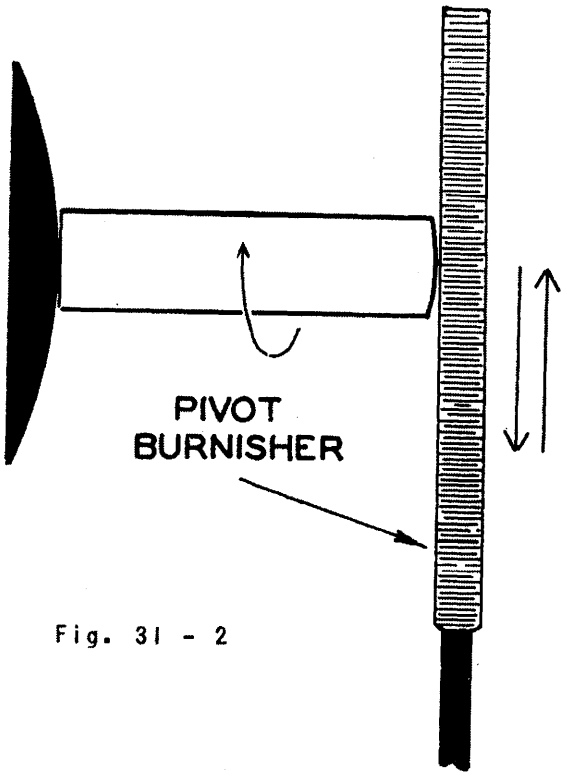


Fig. 31 - 2

3. Turn a square shoulder on end of rod approximately 4/100 mm larger than the diameter of the finished pivot, figure 31-3. This will allow for grinding and polishing.

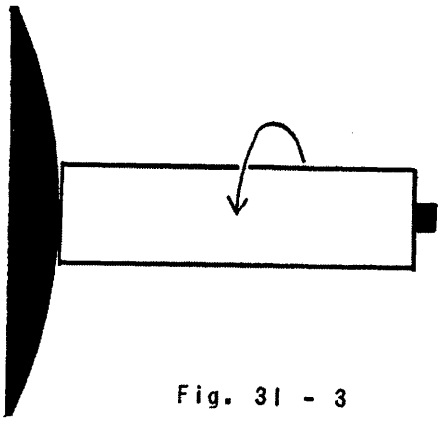


Fig. 31 - 3

4. Cut square shoulder back to a length of approximately 3 times the <u>finished diameter</u> of pivot figure 31-4.

Example: Diameter of finished pivot to be .3 mm.
.3 mm multiplied by 3 equals .9 mm, the length of the pivot.

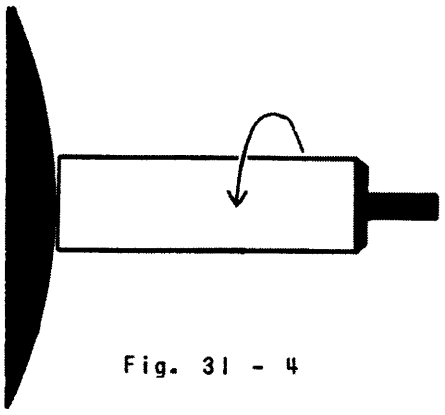


Fig. 31 - 4

5. Bevel corner, figure 31-4. This is a square shoulder pivot in the rough and it now must be ground and polished. Grinding the pivot will reduce its diameter slightly. Therefore, we allow about 3/100 of a millimeter for grinding and 1/100 millimeter for polishing, depending on the finished diameter. Not much grinding will be required if you are careful to cut a straight, smooth surface.

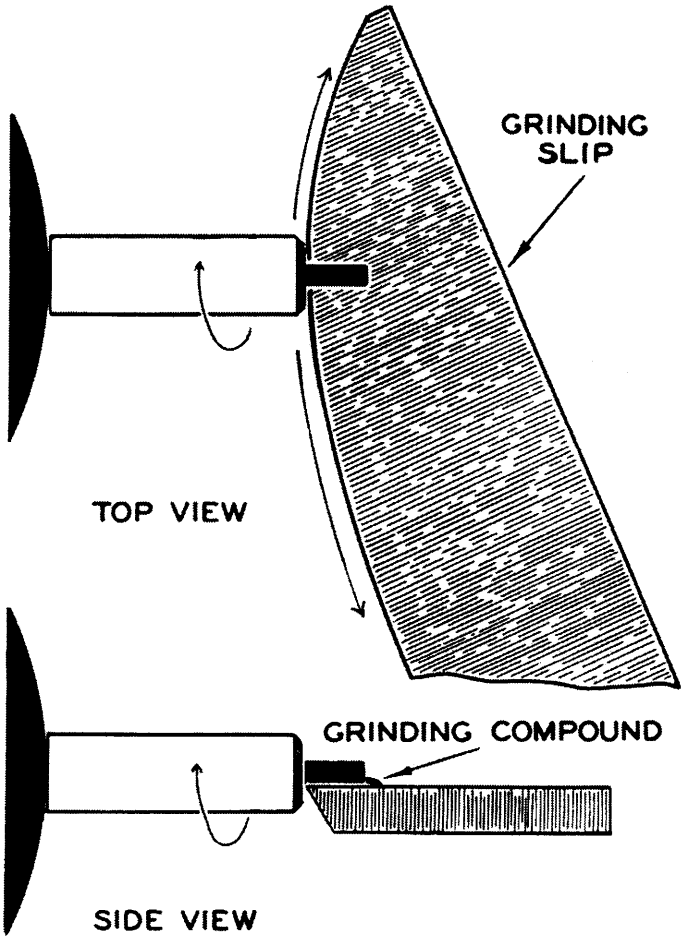


Fig. 31 - 5

SEC. 521 -- Grinding and Polishing

There are several methods of grinding and polishing pivots. The method we will use is oilstone powder with the iron grinding slip, which we made in Lesson 27. For polishing we will use Diamantine with a boxwood slip.

1. Mix a small quantity of oilstone powder with oil until it is the consistency of thick cream. Place a little of this compound along the curved edge of the grinding slip and place slip on the underside of pivot as shown in figure 31-5. Run the lathe in reverse.

2. Move grinding slip rapidly backward and forward until pivot attains a dull gray finish. The grinding compound can be removed with pithwood in order to examine the work. Insufficient grinding will not leave a smooth surface. Excessive grinding will round the corner. Grind to within 1/100 mm of the finished diameter. This will allow for polishing.

3. Figure 31-6 illustrates a boxwood slip which has been impregnated along the top edge with Diamantine #2. Run your lathe at high speed when polishing and in the direction of arrow, figure 31-6, until you have a high polish.

4. Figure 31-7 illustrates the finished pivot.

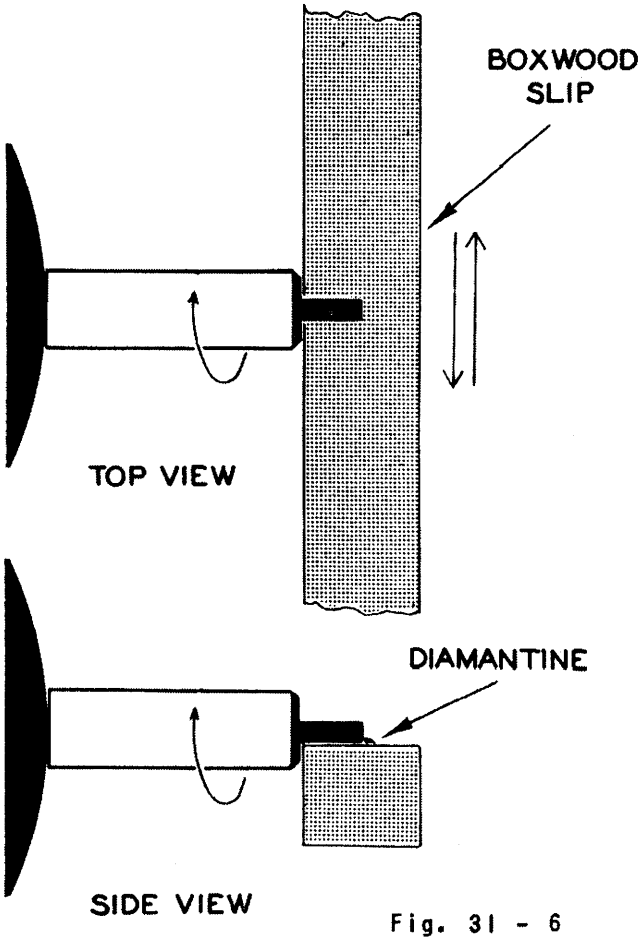


Fig. 31 - 6

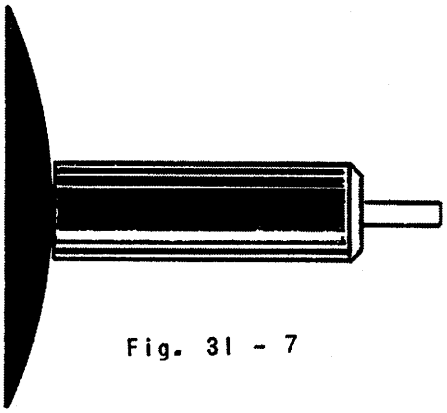


Fig. 31 - 7

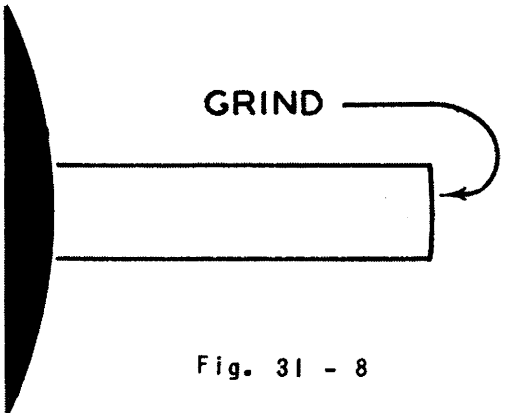


Fig. 31 - 8

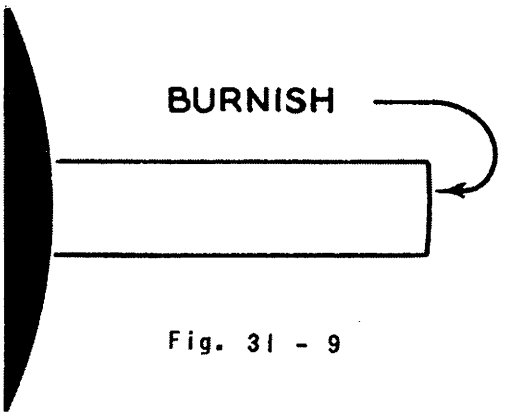


Fig. 31 - 9

You should be thoroughly familar with the function of the square shoulder pivot from your previous lessons, and as a good workman you should examine each square shoulder pivot in every watch you repair. Do this before cleaning the watch and if, under a double loupe, a pivot is found to be scratched or rough, it should be refinished in the manner described. Never overlook this fact and if in doubt, polish the pivot with Diamantine or pivot burnisher.

SEC. 522 -- Making a Cone Pivot

The first step in making a cone or balance pivot is to grind and burnish the end of the wire.

1. Grind end with an oilstone or Hard Arkansas slip, figure 31-8.

2. Burnish end with pivot burnisher, figure 31-9. The lathe is run at high speed and the burnisher held squarely against the metal.

3. Turn a square shoulder on the end of the rod approximately 3/100 millimeters larger than the finished diameter of pivot, figure 31-10.

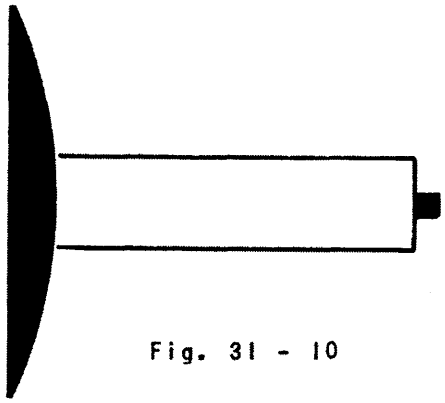


Fig. 31 - 10

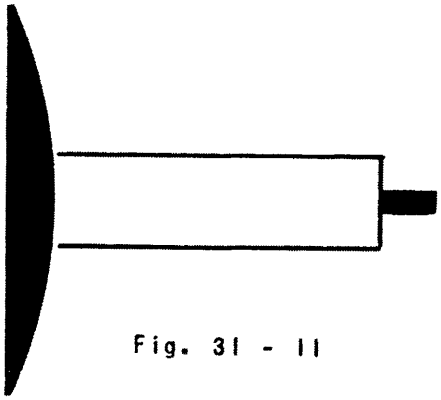


Fig. 31 - 11

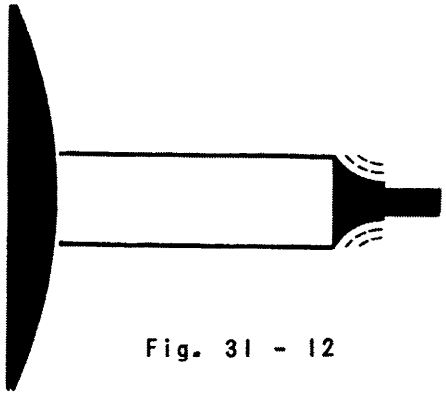


Fig. 31 - 12

4. Cut back and make a square shoulder pivot 2-1/2 times as long as the diameter of the finished pivot, figure 31-11.

Example: Diameter of finished pivot to be .12 mm
.12 mm multiplied by 2.5 equals .3 mm, the length of the pivot.

5. The cone of the balance pivot is cut after you have made a square shoulder pivot. Do not try to cut the pivot and cone at the same time. The dashed lines in figure 31-12 illustrate the shape of the cone as it is being formed. Some workmen use a round graver for this purpose. The length of the cone is left to the discretion of the watchmaker but is approximately the same length as the pivot.

6. The oil cut in figure 31-13 is left to the discretion of the watchmaker but keep it about the proportion shown. Bevel corner, figure 31-13.

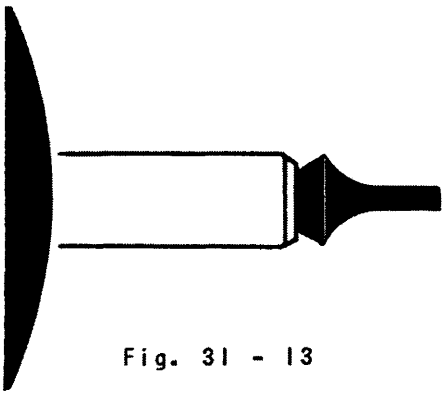


Fig. 31 - 13

7. Round the straight edge of the iron grinding slip slightly by draw filing at A, figure 31-14.

8. Place oilstone powder mixed with oil on grinding slip and while holding in position B, figure 31-15, run lathe in reverse moving grinding slip forward and backward rapidly. The cone is determined by the angle at which you hold the grinding slip. A, figure 31-15, illustrates the angle which will give a longer cone. B illustrates a shorter cone. It is only by practice that you will be able to grind the pivot and cone at the same time. If pivot is properly cut, it will not require much grinding.

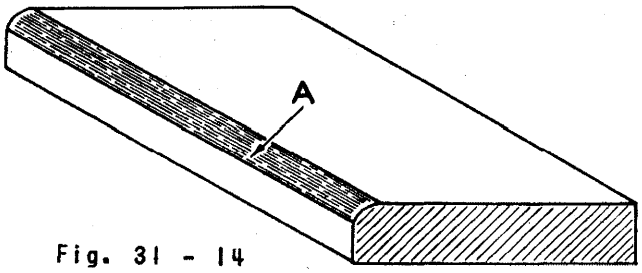


Fig. 31 - 14

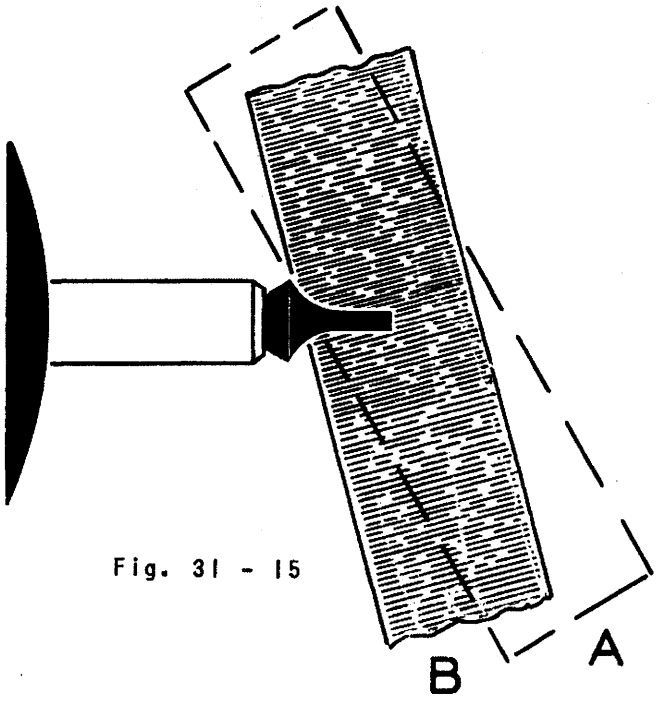


Fig. 31 - 15

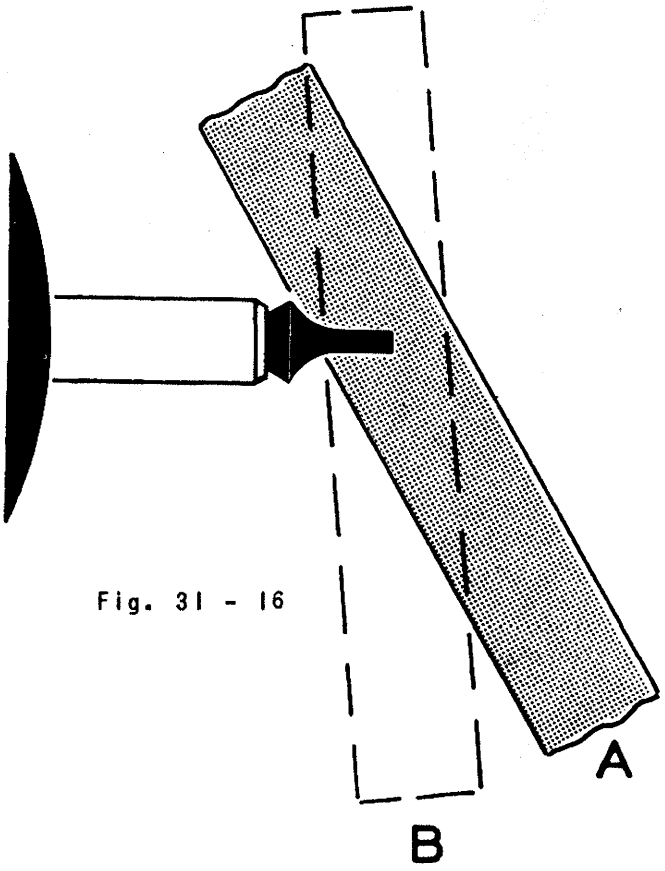


Fig. 31 - 16

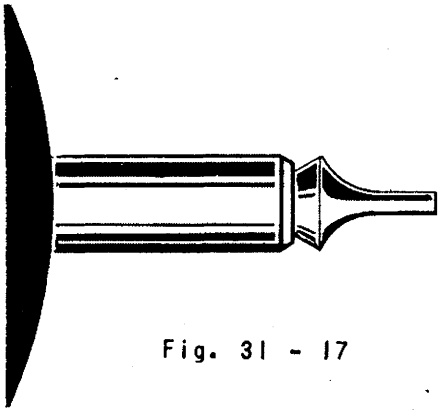


Fig. 31 - 17

9. Polishing is done with a boxwood slip impregnated with Diamantine to which a little rouge may be added, figure 31-16. Move boxwood slip rapidly back and forth as in figure 31-16. In order to polish the pivot and cone at the same time, shift the boxwood slip to different positions as at A & B, figure 31-16. This will give a high polish to the pivot.

Figure 31-17 illustrates the finished pivot.

Figure 31-18 illustrates a pivot which is too short.

Figure 31-19 illustrates a pivot with too short a cone.

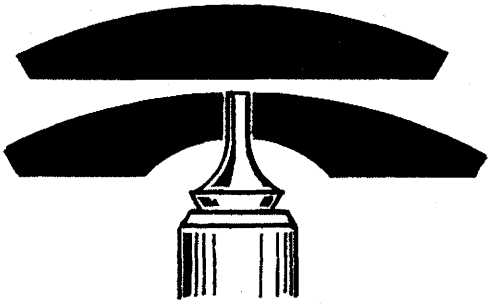


Fig. 31 - 18

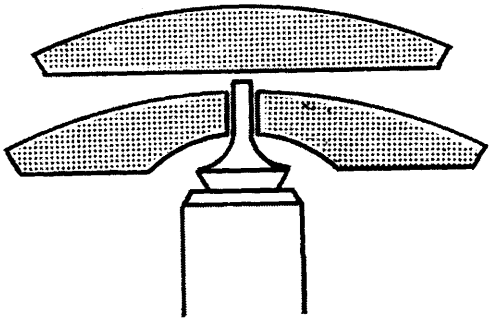


Fig. 31 - 19

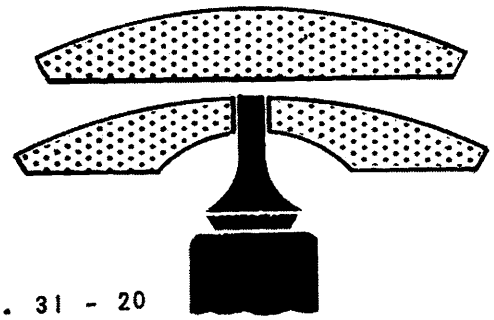


Fig. 31 - 20

Figure 31-20 illustrates a pivot which is too long.

SEC. 523 - Straightening Pivots

In former years, a watchmaker took a great deal of pride in his work, especially when called upon to make a balance staff for a repair job. Factories seemed to delight in seeing which one could make the hardest balance staff, much to the dismay of a poorly trained workman. An exceptionally hard balance pivot broke more readily than a soft one. A soft one would bend in most cases before it would break. Balance staffs in modern watches are not generally as hard as the ones used formerly.

At times you will be able to straighten bent pivots, and if properly executed, straightened pivots will give good service. For this purpose, an old pair of tweezers ground to the shape shown in figure 31-21 will prove very

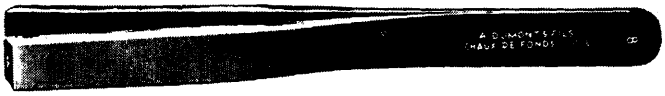


Fig. 31 - 21

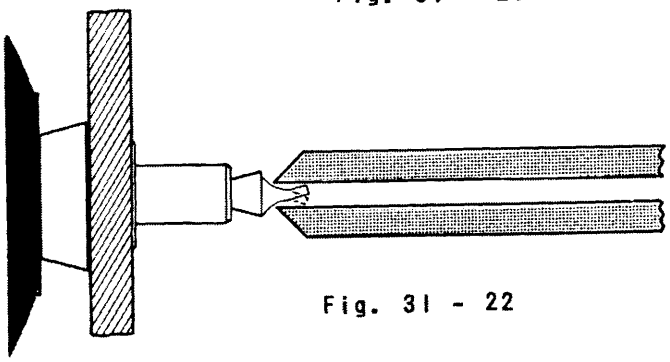


Fig. 31 - 22

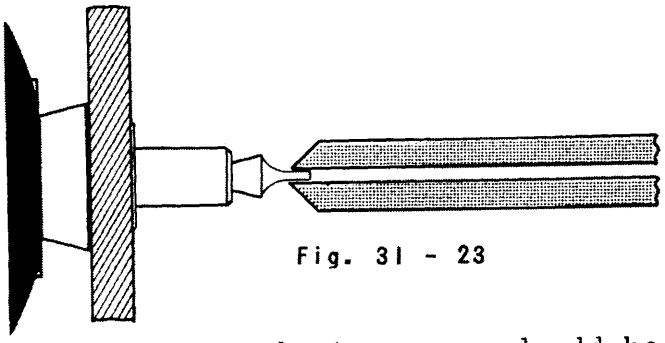
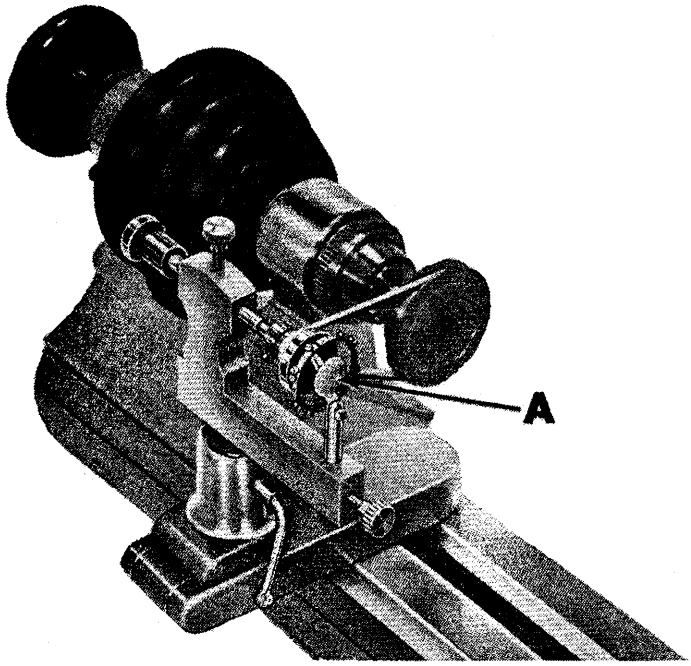


Fig. 31 - 23

satisfactory. The tweezers should be hardened and tempered to dark straw and the inside of the jaws highly polished. To be able to straighten balance pivots it is necessary to have a large selection of chucks. It is not always necessary to remove the roller table if the roller table has been fitted tightly. Figure 31-22 illustrates a pivot that is bent slightly. To straighten, place tweezers high upon the cone parallel with the balance staff, figure 31-22. Be sure the staff is running true. Reverse the lathe motor and run it at fairly high speed. Close jaws of tweezers until you reach the position shown in figure 31-23. If it straightens immediately, the chances of the pivot functioning properly are good. Do not feel badly if the pivot breaks as it will be a constant cause of trouble if the pivot does not run true. After straightening, the pivot must be burnished on the end and repolished. Train pivots are straightened in the same manner.

SEC. 524 - Reasons for Polishing Pivots

In the general repair of watches, cleaning, etc., it is good practice to burnish the ends and the sides of all balance pivots. The highly polished balance pivot decreases friction and, in most instances, the watch to be repaired will take a better motion. Most factory material is precision made and the majority of staff replacements can be made quickly and easily with genuine material. In replacing a factory balance staff, it is good practice to carefully check the pivots and be sure they are burnished and polished before replacing in the watch.



COURTESY OF THE NORTH AMERICAN WATCH TOOL AND SUPPLY CO., CHICAGO, ILLINOIS

Fig. 31 - 24

The pivot polisher illustrated in figure 31-24 is an excellent tool for burnishing and polishing cone shaped pivots. The T Rest has been removed and the pivot polisher inserted in its place. The drive pulley is mounted in a #50 wire chuck and a small rubber belt is used to connect the drive pulley and the pulley on pivot polisher. The small thin plate at A is one of several interchangeable plates required to accommodate different sized pivots. The plate is thin enough to allow the pivot to extend through the hole, the cone resting on the inner side of the plate. A small, hardened steel burnisher is used to finish the end and side of the pivot. Some watchmakers fasten the pivot polisher to the bench and operate it with a bow.

SEC. 525 - Making a Balance Staff

The ordering and replacing of a balance staff in a modern watch is done quickly and easily because of the standardization of watch material. At times you will find it necessary to make alterations on a new factory made staff. It may be that the balance shoulder, collet shoulder or roller post are too large. It is seldom that you will find a staff needing all of these corrections but in order to have the "know how", it is necessary to practice making balance staffs. There are times also when you will be called upon to make a balance staff for a watch, usually one for which no material is obtainable.

The difference between making a practice balance staff, a balance staff with a sample, and a balance staff without a sample varies only in the method in which the dimensions are obtained. Balance staffs are always made from high quality steel wire or drill rod, which has been hardened and tempered to a deep blue.

1. Place wire in chuck and let it extend a little more than the length of the finished staff.

2. Grind the end with a Hard Arkansas slip. Burnish end with hardened steel burnisher, figure 31-25.

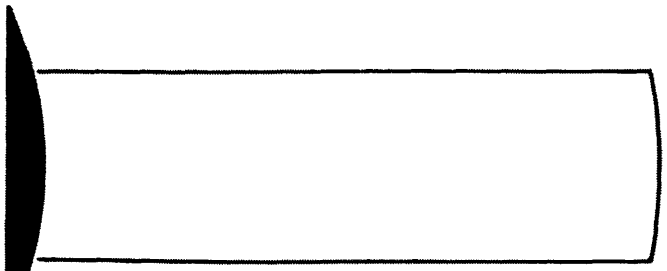


Fig. 31 - 25

3. Cut a square shoulder on the end of wire for the balance shoulder, figure 31-26. It is good practice to use the balance wheel for this diameter. As we must grind and polish each section of the balance staff, it is advisable to allow approximately 4/100 millimeters for this purpose (pivots excepted).

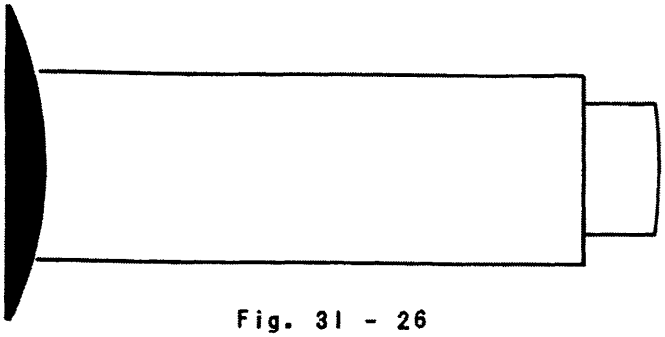


Fig. 31 - 26

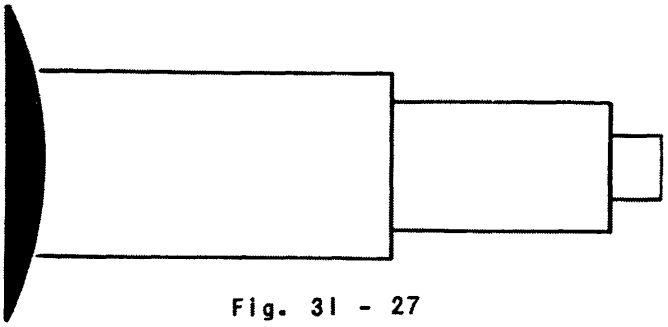


Fig. 31 - 27

4. Cut this shoulder back to proper length as in figure 31-27. This length and all lengths given in this section are obtained with a millimeter gauge from measurements given on your master work sheet.

5. Cut a square shoulder on end of wire for collet as in figure 31-27.

6. Cut collet shoulder back to proper length, figure 31-28. This length is actually determined by the thickness of the arm of the balance wheel, as there must be enough metal left up and above the arm of the balance wheel to allow for riveting as indicated by the dotted line in figure 31-28.

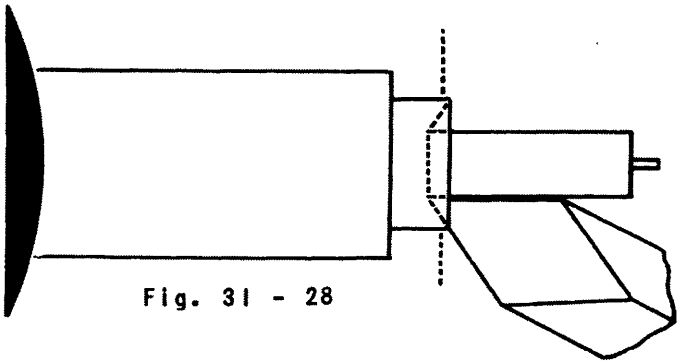


Fig. 31 - 28

7. The undercut is made, after the collet shoulder has been ground and polished, by holding the graver in position as shown in figure 31-28.

8. Cut a square shoulder pivot on end of wire, which is 2-1/2 times as long as the finished diameter of the pivot, in figure 31-28. Remember to allow approximately 2 or 3/100 mm for grinding and polishing.

9. Cut cone and oil cut and grind and polish pivot as shown in figure 31-29.

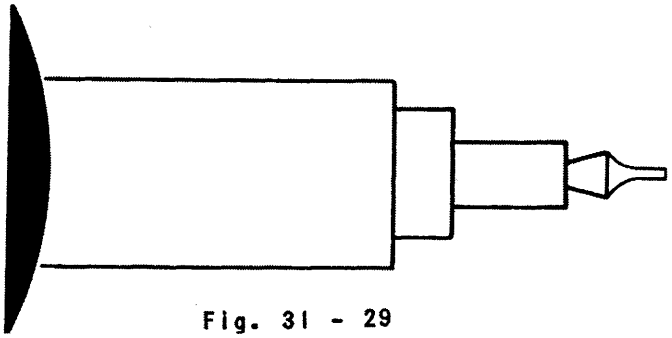


Fig. 31 - 29

10. Bevel corner of collet post as shown in figure 31-30.

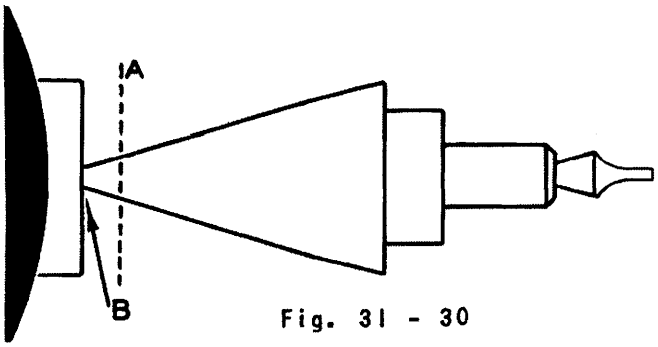


Fig. 31 - 30

11. Make a tapered cut as shown in figure 31-30 so that we may break the staff off from the wire. The dotted line at A is the length of the finished staff measured from the end of the finished pivot. Notice that the cut extends beyond dotted line A, figure 31-30.

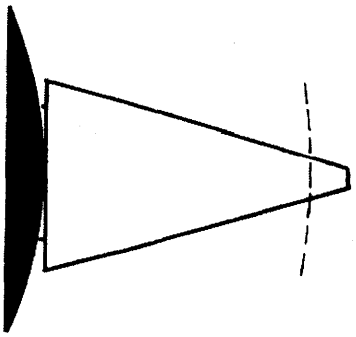
12. Break off unfinished staff at B, figure 31-30. The next step is to finish the end to the correct length of our balance staff. This method requires the workman to have a complete range of chuck sizes.

13. Catch the balance shoulder in the chuck of the proper size as in figure 31-31. Relieve the tension in the draw-in spindle of the lathe and while running the lathe in reverse hold the middle finger on a T rest and true the balance staff. Quickly grab the draw-in spindle with the left hand, which will tighten chuck on balance shoulder.

14. With a Hard Arkansas slip or oilstone, grind off the end of the unfinished staff to the proper length as illustrated by dotted line in figure 31-31. Burnish end. This may necessitate removing the staff from the chuck several times in order to measure the length with a micrometer.

It is impractical to use wire chucks to make this end of the balance staff because the staff will not run true. In order to have the staff run true, use a

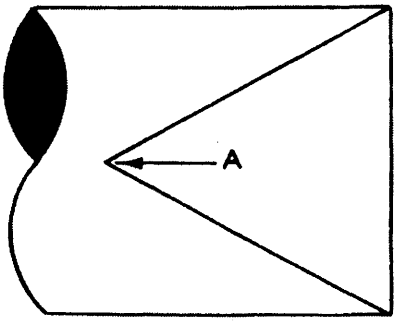
Fig. 31 - 31



cement chuck which has been hollowed out.

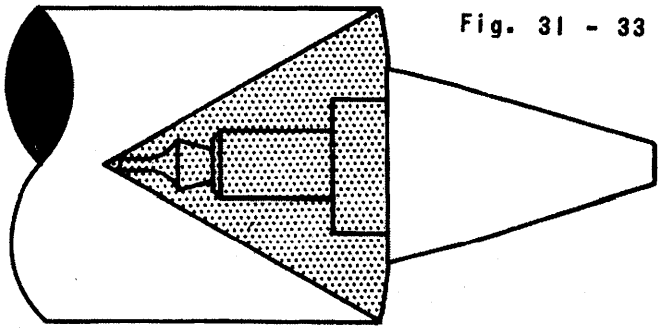
15. Place cement chuck in lathe and make a deep cone shaped cut as in figure 31-32. The center of the cone indicated by Arrow A must be tested with a needle in order to insure this point being absolutely centered. Do not proceed until it is correct.

Fig. 31 - 32



16. Heat the cement chuck with an alcohol lamp and fill hollow with shellac. Then warm balance staff by placing it in warm shellac until the cement adheres to the balance staff, figure 31-33, the same way as it did the jewel settings in Lesson 30.

Fig. 31 - 33



17. Place T Rest as close as possible to balance staff and while cement chuck is still warm, true end of staff using pegwood or fingernail. Let cool.

18. Turn a square shoulder on end for roller post as illustrated in figure 31-34 and mark the length of roller post as illustrated by dotted line.

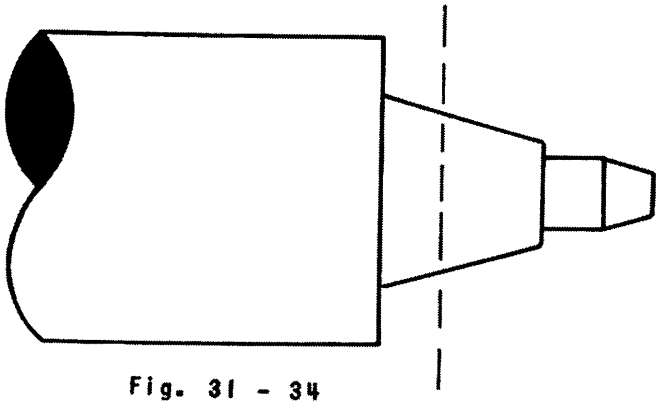


Fig. 31 - 34

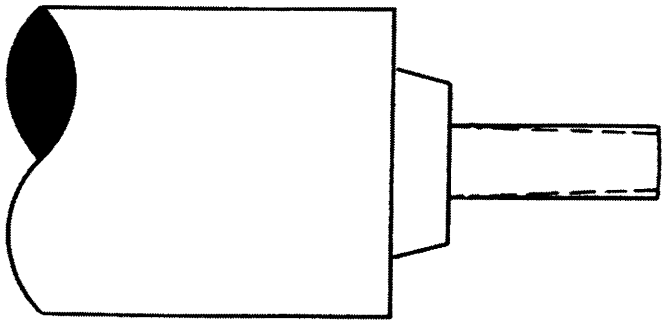


Fig. 31 - 35

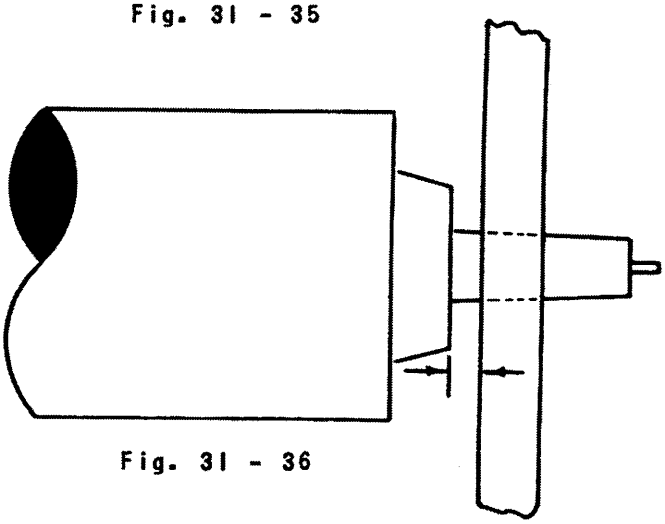


Fig. 31 - 36

19. Finish cutting roller post with a slight taper which should measure approximately 2/100 mm from front to back, figure 31-35. It is possible to use a micrometer if you know the exact measurement but in balance staff work, it is much better to try the roller table on the end of roller post and grind and polish the post until the roller table fits approximately one-half of the thickness of the roller table from the base of the hub as indicated by arrows in figure 31-36.

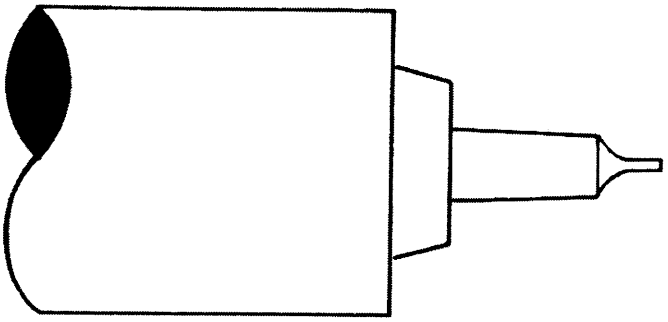


Fig. 31 - 37

20. Grind and polish hub.

21. Cut square shoulder pivot on end of roller post 2-1/2 times the diameter of the finished pivot allowing approximately 2/100mm for grinding and polishing, figure 31-36.

22. Cut cone, grind and polish pivot as in figure 31-37.

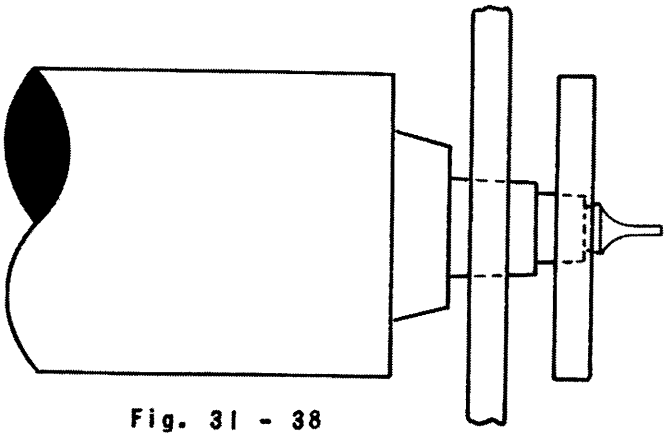


Fig. 31 - 38

23. Warm cement chuck with alcohol lamp, remove balance staff, and clean in alcohol. In fitting a combination roller, the same procedure is used as in figure 31-36- In fitting a two-piece double roller, two shoulders have to be cut as in figure 31-38 and both the impulse roller and the safety roller should fit to within one-half of the thickness of each roller from the shoulders, figure 31-38. The above instruction was given without mentioning any grinding or polishing except for the balance pivots. Remember it is necessary to grind and polish the balance shoulder, the collet shoulder, and the roller post. Therefore, you must allow approximately 3 or 4/100 mm for grinding and polishing.

SEC. 526 - Making Staff to Sample

Figure 31-39 illustrates the proper method of removing the balance staff from the balance wheel by cutting away the hub and then undercutting. Use this method on all watches which have riveted staffs in order not to mar the balance arm.

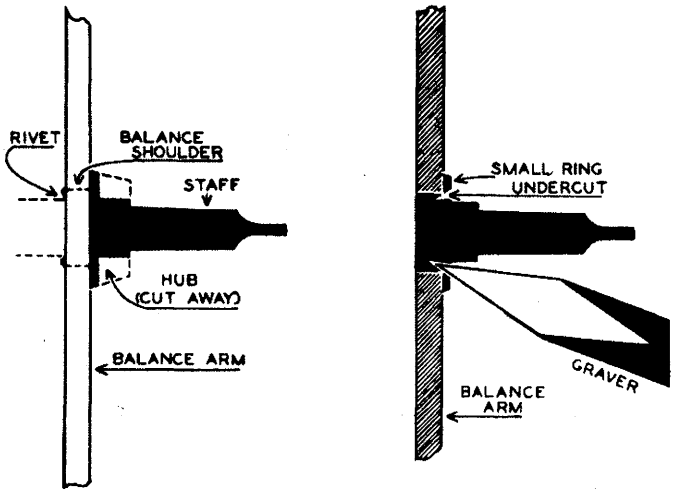
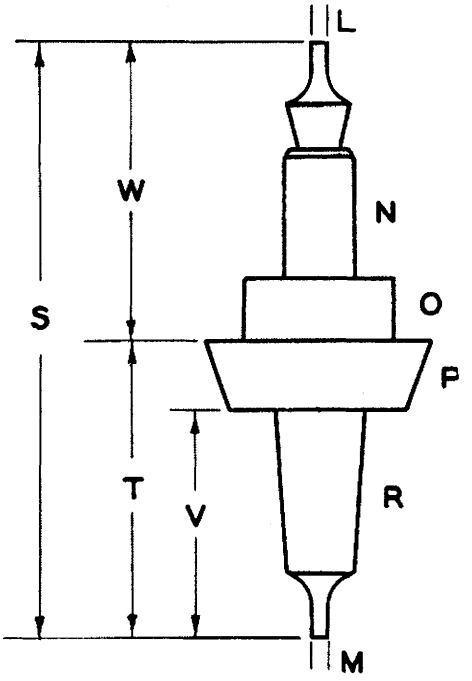


Fig. 31 - 39

In making a balance staff to a sample, make a sketch as in figure 31-40 and fill in the dimensions of the pivots, balance



L UPPER PIVOT _____MM
M LOWER " _____MM
N COLLET SEAT _____MM
O WHEEL " _____MM
P HUB _____MM
(The diameter of the hub should be less than the width of the balance arm)
R ROLLER SEAT _____MM
S LGTH. OVERALL _____MM

Fig. 31 - 40

shoulder, collet shoulder and roller post. To determine the correct length of balance staff with broken pivot, allow approximately 3/10 mm for each broken pivot. This will give you the total length overall.

1. Select wire, place in chuck, and proceed as in Section 525. Grind and burnish end of wire.

2. Hold sample balance staff in position shown in figure 31-41. The dotted line A represents the distance from the end of the pivot to the balance wheel shoulder.

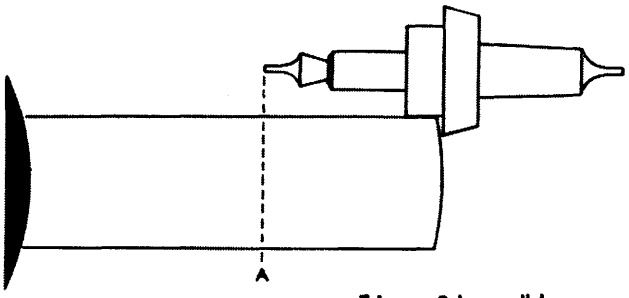


Fig. 31 - 41

3. Turn balance wheel shoulder. Grind and polish.

4. Turn collet shoulder allowing enough metal to extend through the arm of the balance wheel for riveting. Grind and polish.

5. Undercut balance shoulder.

6. Turn cone shape pivot and oil cut. Grind and polish.

7. Cut off staff as in Step 11, Sec. 525.

8. Grind to proper length, Step 14, Sec. 525.

9. Cement staff in cement chuck.

10. Hold sample balance staff in position shown in figure 31-42. The dotted line A represents the distance from the end of the pivot to the roller table shoulder.

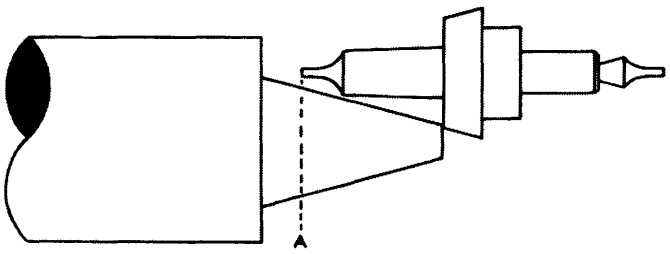


Fig. 31 - 42

11. Cut roller post. Grind and polish. Fit roller.

12. Grind and polish hub.

13. Cut pivot, grind, and polish.

14. Remove from cement chuck and clean in alcohol.

SEC. 527 - Making Balance Staff Without a Sample

Making a balance staff without a sample is an accomplishment enjoyed by all good watchmakers. The actual process of making a balance staff is the same as given in Sec. 525. It is advisable to make a sketch the same as in Figure 31-40 and fill in the dimensions as you obtain them. Before ascertaining the dimensions, make sure the upper and lower balance jewels and cap jewels are correct and the balance cock is not bent up or down but is parallel with the pillar plate.

To obtain the different dimensions proceed as follows:

Use a millimeter gauge or a degree gauge which measures in hundredths of a millimeter.

1. To get the overall length of a balance staff, measure from the outside of the upper cap jewel to the outside of the lower cap jewel A, figure 31-43. Subtract the thickness of both cap jewels, B and C, figure 31-43, which will give the over-all length of the balance staff exclusive of endshake, which can be adjusted later. This is written as LOA (Length Over-All). Mark the result on your sketch.

2. Measure the distance between the center wheel and the pallet bridge D, figure 31-43 (or the upper plate and balance bridge in case of a full plate

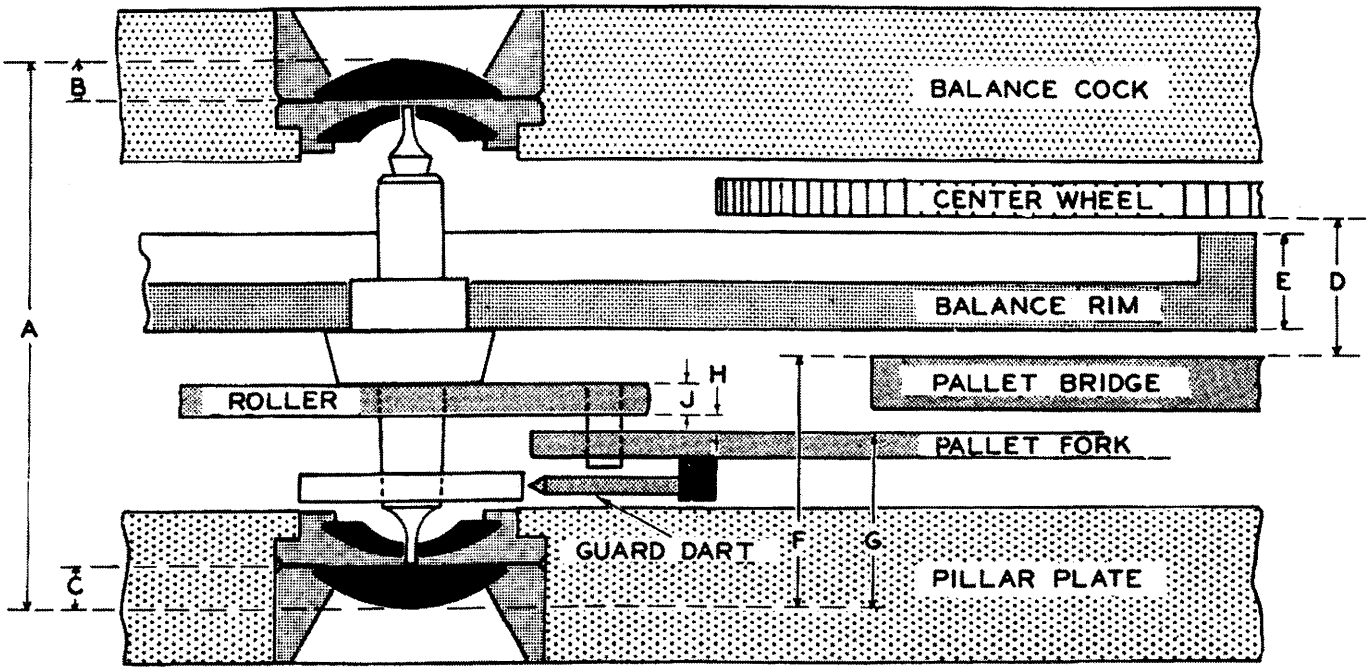


Fig. 31 - 43

movement). Measure the thickness of the balance rim E, figure 31-43. The difference between the measurements D & E divided by two will give the clearances between the lower edge of the balance rim and the top of the pallet bridge, and the top of the balance rim and center wheel, (or the lower edge of the balance rim and the upper plate, and the top of the balance rim and balance bridge in case of a full plate movement).

The remainder of the instructions will use, as an example, a three-quarter plate or bridge model movement, and measurements will be taken with the cap jewels in place.

3. Using the sketch you made of the balance staff, mark in the measurements as you determine them. From the outside of the lower cap jewel to the top of the pallet bridge, F, figure 31-43, plus one-half the difference between the thickness of the rim of the balance wheel and the space between the center wheel and the pallet bridge, (result of Step 2), minus the thickness of the lower cap jewel, C, figure 31-43, equals the length of the balance staff from the end of the lower pivot to the balance seat, T, figure 31-40.

4. From the outside of the lower cap jewel to the top of the pallet fork, G, figure 31-43, plus one-half the thickness of the impulse roller for clearance, H, figure 31-43, plus the thickness of the impulse roller, J, figure 31-43, minus the thickness of the lower cap jewel C, equals the length of the lower half of the balance staff from the end of the lower pivot to the underside of the balance hub, V, figure 31-40.

5. Subtract the result obtained in Step 3, T, figure 31-40. from the L O A of the balance staff, S, figure 31-40, and the result will be the length of the balance staff from the end of the upper pivot to the balance shoulder, W, figure 31-40.

6. The difference between W and V, figure 31-40, equals the thickness of the hub, P, figure 31-40.

7. Determine the diameters of pivots by measuring the jewel holes with a jewel hole gauge or balance pivots which fit correctly. Make the straight part of the pivot 2-1/2 times as long as the diameter, the cone the same length, and the back cut at your discretion. Back cut may be made extremely short if necessary to leave the collet seat long enough. Diameter of the back cut should be slightly less than the diameter of the collet seat.

8. Drop the collet on a tapered pin and mark the location, figure 31-44. Measure the diameter of pin at this point with a micrometer and multiply the result by the constant 1.05. This result will be the finished diameter of collet seat.

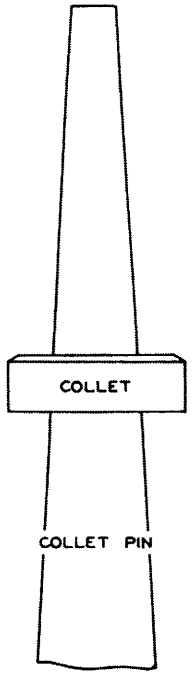


Fig. 31 - 44

9. The roller seat should have a slight taper (taper toward the lower pivot) and have a finished size that will permit the impulse roller to be pushed within half the thickness of the roller.

10. After all dimensions are obtained and entered on the sketch, proceed to make balance staff (Section 525).

SEC. 528 - Making Punches for Washer

At this time we will make punches to be used in poising balance wheels. As you proceed with watch repair work, make these punches to fit different size balance screws as you encounter them. The following dimensions are suitable for a 16 size Elgin Watch:

1. Turn down a square shoulder about 4/100ths mm larger than the threads of the balance screw, figure 31-45.

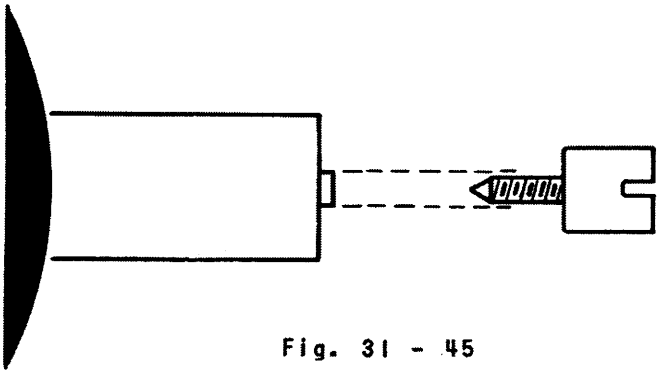


Fig. 31 - 45

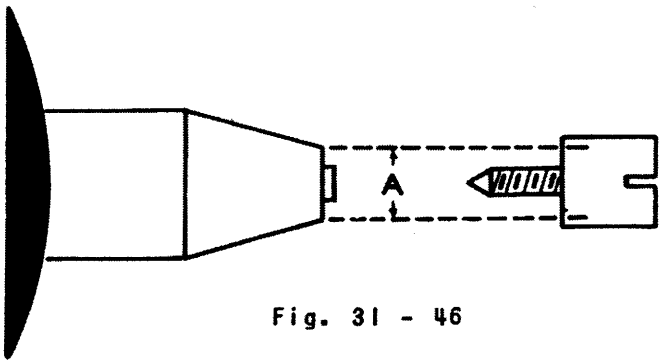


Fig. 31 - 46

2. Bevel corner of rod so that diameter illustrated at A is slightly smaller than the head of the balance screw. figure 31-46. Cut off pilot as shown in figure 31-47. Harden and temper to a straw. The shorter the pilot the less trouble you will have in removing the washers. Obtain a small lead block or melt some lead in a small material can. Punch washers from very thin material such as dial washers, figure 31-48.

Fig. 31 - 47

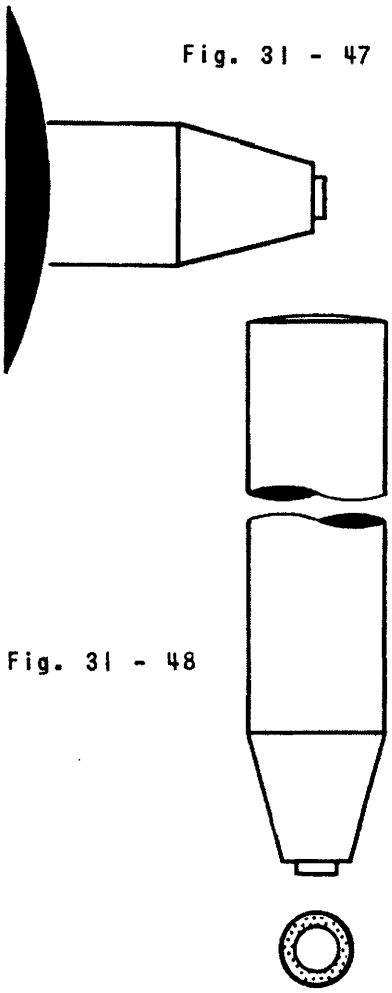


Fig. 31 - 48

These washers are slipped under the heads of the balance screws when poising wheel. At times, when we are undercutting screws, it is a good policy to add washers to the opposite screws in order to keep the weight of the balance more equal, and you will not have to make as many adjustments when bringing the watch to time. These punches can be made in any size you desire and a workman may make his own timing washers. In some cases where a pair of heavy washers is needed for a bracelet watch, thin gold or platinum can be used. Because platinum is the heaviest metal known, washers made of this metal will have greater effect upon slowing up a watch. Keep these punches handy and use the washers when poising a balance wheel or regulating a watch.

SEC. 529 - Carboloy Gravers

Carboloy is the hardest metal made by man. It is a very useful tool for the watchmaker. A carboloy graver will cut the hardest of balance staffs or stems. It is extremely useful in removing a balance wheel by cutting away the old hub, figure 31-39. This method is without a doubt the safest and most practical way of removing the balance wheel from the staff. Before the advent of the carboloy graver, the watchmaker was confronted at times with a balance staff which was too hard to be cut with an ordinary graver. At times he would have the hub cut half way through and discover that in the cutting process the steel had become burnished making a great deal of extra work in sharpening the graver or drawing the temper in the staff. With the carboloy graver you can disregard the hardness. Keep your carboloy gravers sharp and use them only where it is impractical to use the ordinary graver. The carboloy graver illustrated in figure 31-49 has a removable handle. Carboloy gravers must be sharpened with a diamond charged lap or wheel. Remember that because of the extreme hardness of the carboloy graver the point will break quite easily. Therefore, do not force the graver when cutting.

Fig. 31 - 49

SEC. 530 - Fitting Pinions to Watches

It should be an easy matter by now to replace a pinion in a watch. We are not often compelled to make a pinion from pinion wire as most pinions can be obtained in the finished form from a material house.

Although the average finished pinion ordered from a material house should fit there are times when the pivots have to be ground and polished to fit the bearings or jewels. Some pinions may have a square shoulder pivot on one end and a cone shape on the other. Figure 31-50 illustrates the end of a blank pinion. Blank pinions come with any number of leaves desired such as 6, 7, 8, 9, 10, and 12. The diameters are gauged by a Stubs Gauge.

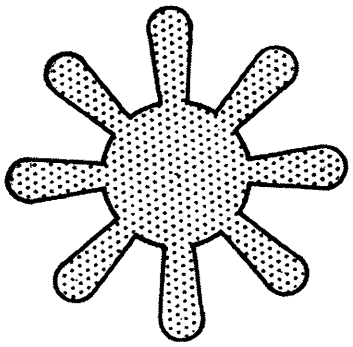


Fig. 31 - 50

Pinions to fit watches can be cut from pinion wire as follows:

1. Select a blank pinion with the same number of leaves as the sample and the same diameter as measured with a Stubs Gauge.

2. Obtain over-all length.

3. Obtain height of wheel shoulder.

4. Turn pinion wire to fit wheel.

Figure 31-51 illustrates the pinion leaves cut down to a tapered shoulder on which the train wheel is to be driven friction tight.

Figure 31-52 illustrates the pinion leaves cut down for a wheel which requires rivetting. The shoulder protrudes through the wheel enough to be rivetted after undercutting.

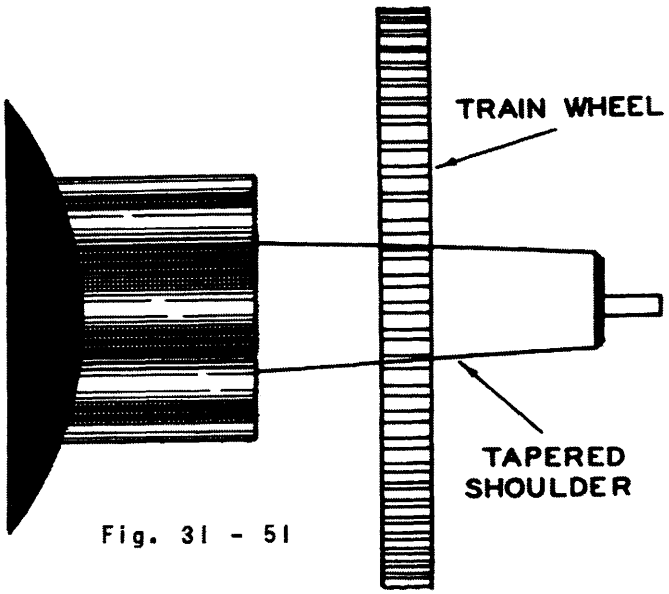


Fig. 31 - 51

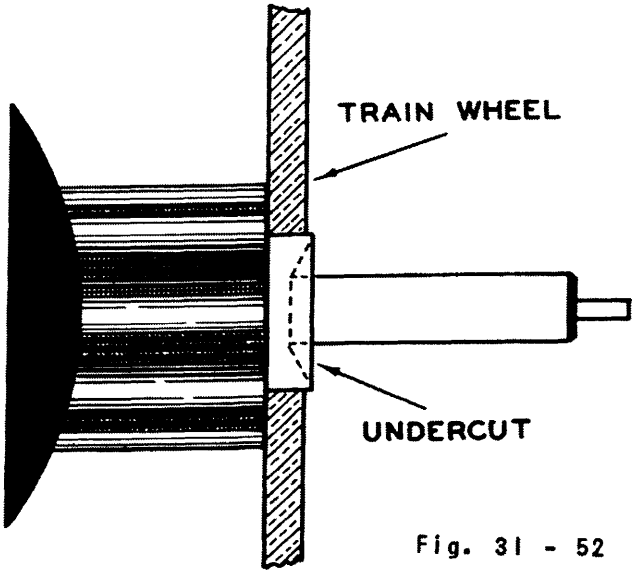


Fig. 31 - 52

5. Cut through leaves to match length of sample pinion.

6. Cut, grind, and polish pivots.

7. Replace wheel.

SEC. 531 - Pallet Arbors

Figure 31-53 illustrates two types of pallet arbors. A is a friction type having a tapered shaft which is driven into pallet fork. B represents a screw type

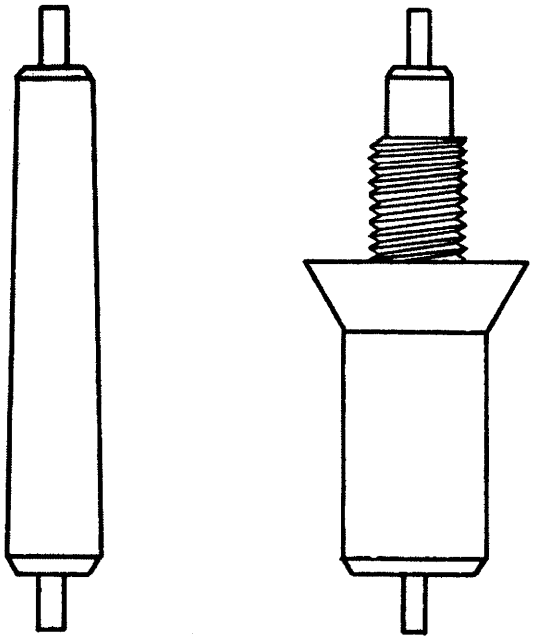


Fig. 31 - 53

pallet arbor. This is screwed into pallet fork and is easily removed by catching pallet arbor in a chuck and holding head of lathe with left hand, carefully turning pallet fork toward you. In replacing pallet arbors, it is necessary to ascertain the correct one to be used, using a micrometer. Any alterations of pallet arbor are made the same as for pinion or balance staffs using square and/or cone shaped pivots.

SEC. 532 - Making a Stem from a Sample

For stem work it is desirable to have a good slot cutting graver as illustrated in figure 31-54. This graver can be made from a regular graver #0, the tip to measure approximately .50 mm. It is also possible to make a graver from a piece of square drill rod. However, a carboloy graver is recommended in preference to all others.

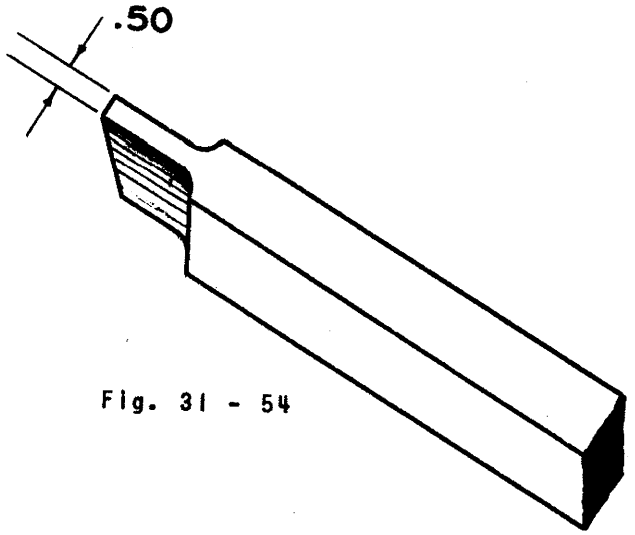


Fig. 31 - 54

1. Select a piece of drill rod slightly larger than the diameter of the finished hub of the sample stem.

2. Cut off as in figure 31-55, the length over-all to be slightly longer than the length of the finished stem.

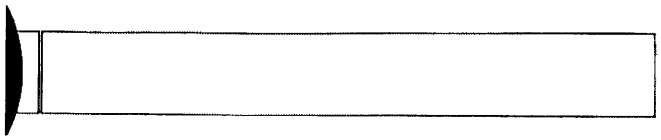


Fig. 31 - 55

3. Place in lathe and cut thread (Lesson 29, figure 29-34). This thread should be slightly longer than the sample, figure 31-56, and of the same tap size as crown to be used.

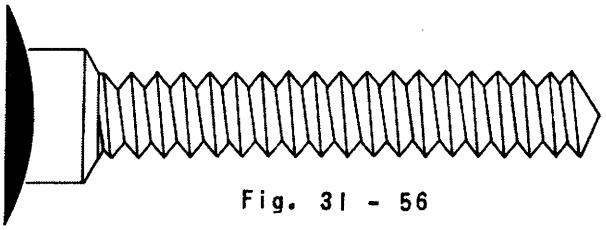


Fig. 31 - 56

4. Place threaded portion in lathe chuck and cut off to correct length using sample for length A, figure 31-57.

5. Remove, harden, and temper to a blue.

6. Place threaded portion in lathe chuck, figure 31-58, and turn outside diameter to the diameter of the hub.

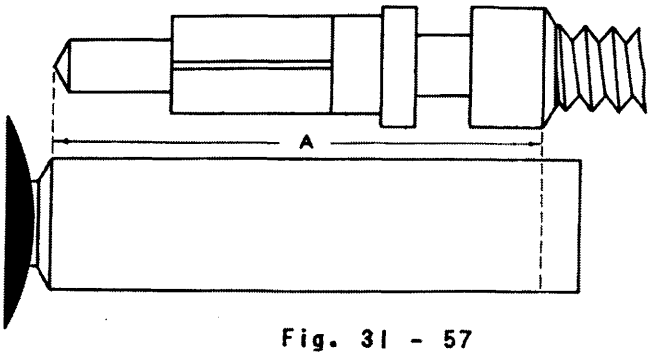


Fig. 31 - 57

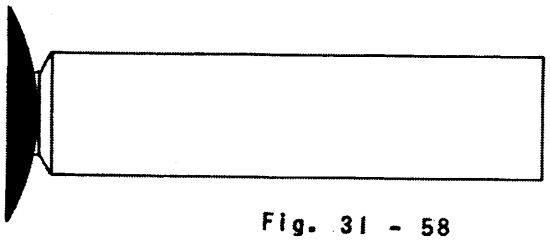


Fig. 31 - 58

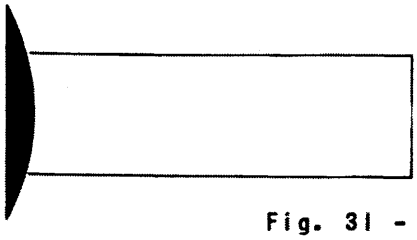


Fig. 31 - 59

7. Remove from lathe and place hub section in lathe chuck allowing the length required for the winding pinion shoulder to extend from chuck, figure 31-59.

8. Turn pilot, figure 31-60, using old stem pilot as guide for length.

9. Turn diameter for winding pinion using old stem as guide to length, figure 31-61.

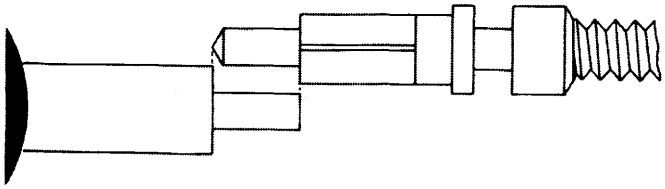


Fig. 31 - 60

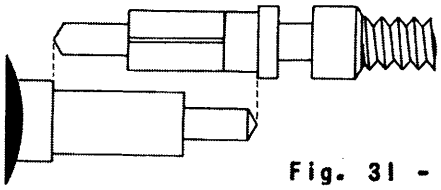


Fig. 31 - 61

10. Measure the width of the square on the old stem and multiply by the constant 1.39. The result is the diameter to turn for the winding square. This constant can be used for any size winding square. To find the exact diameter of a circle circumscribed about a given square, multiply the length of one side of the square by the constant 1.41. However, for our purpose, we use the constant 1.39 which will allow the corners of the square to be slightly rounded as in figure 31-62.

Example: Length of one side of square equals .95 mm. .95 multiplied by constant 1.39 equals 1.32 mm.

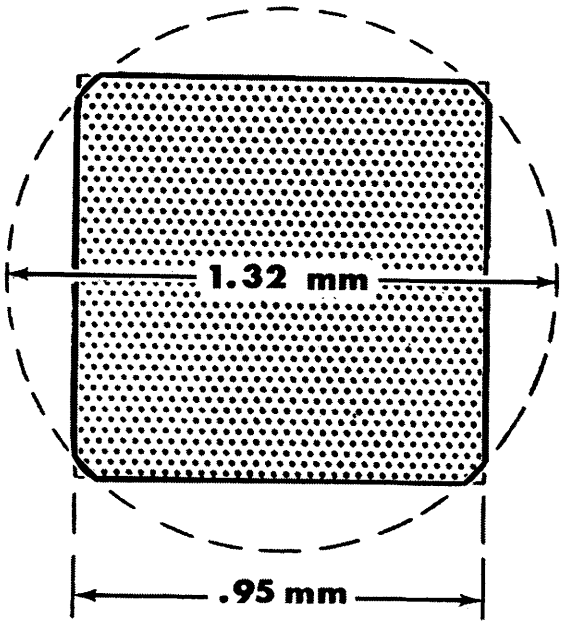


Fig. 31 - 62

11. Turn clutch shoulder to diameter using old stem as a guide for length, figure 31-63. Polish all surfaces finishing with 4/0 emery buff.

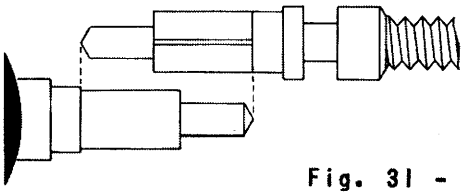


Fig. 31 - 63

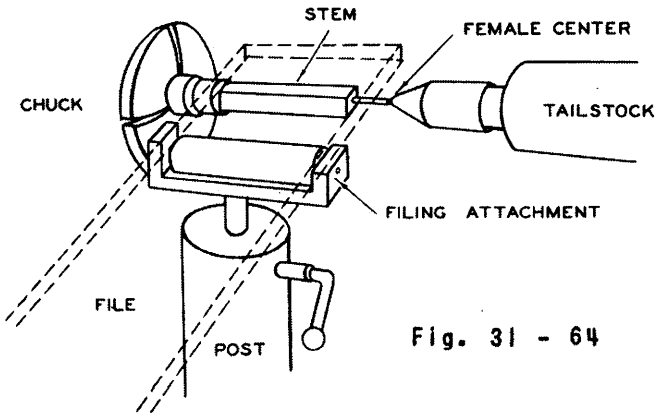


Fig. 31 - 64

12. File square on stem. This can be done using a file attachment as illustrated in figure 31-64. Figure 31-65 illustrates the four end positions of the stem as the square is turned using the index plate in the head of the lathe as a guide. The square can be measured with a micrometer and left several hundredths of a millimeter larger than the finished square. To finish draw file square to proper thickness. Remove from lathe, placing winding pinion shoulder in lathe chuck and cut slot, figure 31-66.

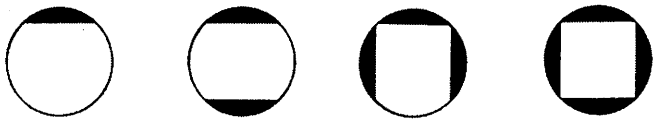


Fig. 31 - 65

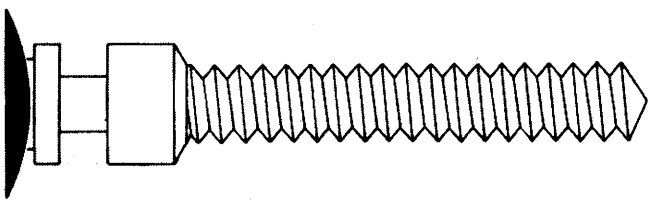


Fig. 31 - 66

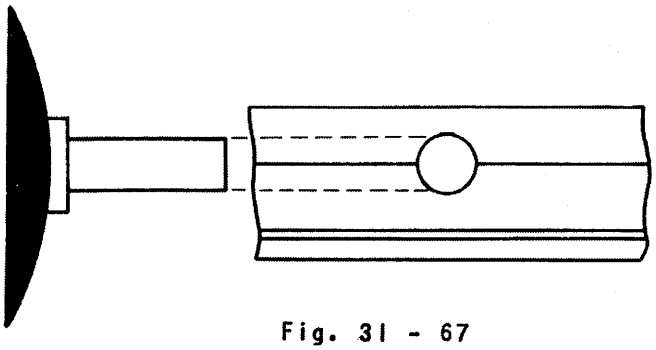


Fig. 31 - 67

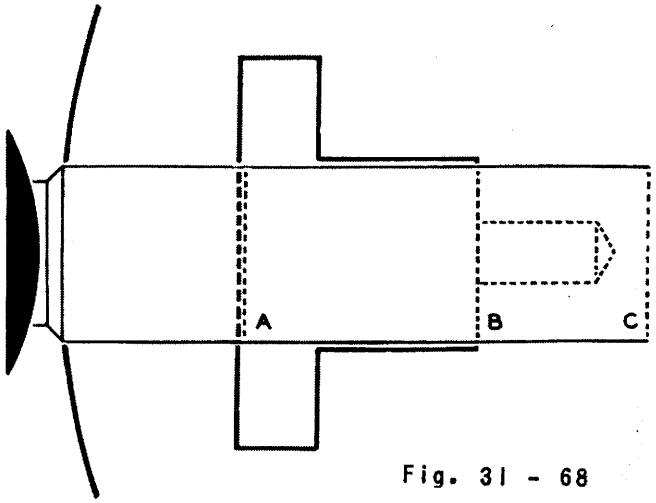


Fig. 31 - 68

SEC. 533 - How to Make a Stem Without a Sample

1. Turn down a metal plug until it just enters hole in plate, figure 31-67. At times it is necessary to round up the hole in the plate with a broach before making this plug.

2. Select a piece of drill rod slightly larger in diameter than the plug and of sufficient length for a complete stem.

3. Thread the end of stock the same tap size as the crown to be used and long enough to extend outside the watch case.

4. Remove from chuck and place threaded portion in a chuck of correct size. Hold pillar plate in position shown in figure 31-68 with the outer edge of pillar plate at the base of thread. Make

a mark with the point of your graver as indicated by dotted line A. This will be the winding pinion seat. Make a mark with the point of your graver as indicated by dotted line B. This will be the pilot seat. Allow sufficient length from this mark for the length of the pilot and cut off as at C, figure 31-68.

5. Remove, harden, and temper to a blue.

6. Place threaded portion in a chuck and turn the outside diameter to the diameter of the plug or until it fits the hole in plate snugly, figure 31-69.

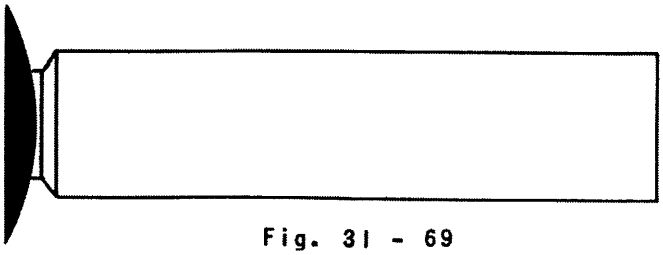


Fig. 31 - 69

7. Remove stem from lathe and catch up on full diameter of hub, figure 31-70.

8. Turn pilot to correct diameter and length, figure 31-70. If necessary, a plug can be made to ascertain the diameter of the hole in plate for pilot.

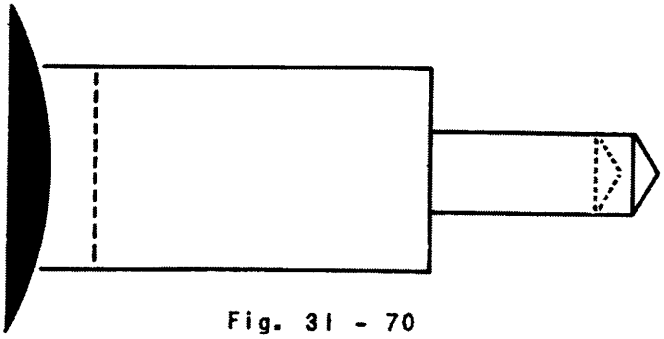


Fig. 31 - 70

9. Turn down winding pinion shoulder until winding pinion will just go on, figure 31-71.

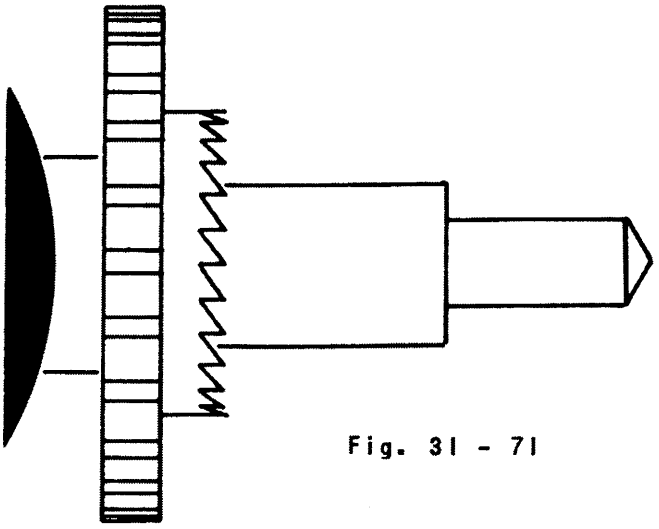


Fig. 31 - 71

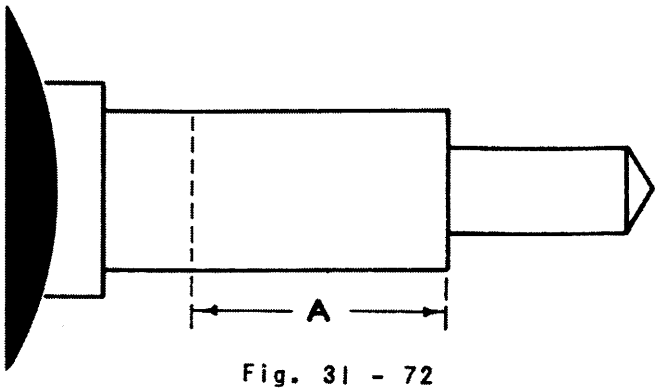


Fig. 31 - 72

10. Slide the clutch over a taper pin and measure the diameter with a micrometer at the point where the hole contacts the pin. Multiply this result by the constant 1.39. This result will give the diameter of section A, figure 31-72, from which the square is to be filed.

11. File square on stem.

12. Cut slot in stem. To locate slot insert stem into plate and with the winding and setting parts in place and in the winding position place a mark on either side of the point of contact between the setting lever pin and the unfinished stem. Be certain that the slot in stem is wide enough and deep enough to allow a minimum of play when set lever screw is tightened.

SEC. 534 - Repivoting

It is not often that we are called upon to repivot a pinion or a balance staff. This, however, was considered an accomplishment by the old master watchmaker but with today's standardized material it is more practical and profitable to purchase a new staff or pinion. At times you may find it profitable to repivot a pinion, especially in clock work.

1. Draw temper in pinion. Figure 31-73 illustrates the method by which a copper wire is crimped on to the pinion and heated until the pinion turns to a light blue.

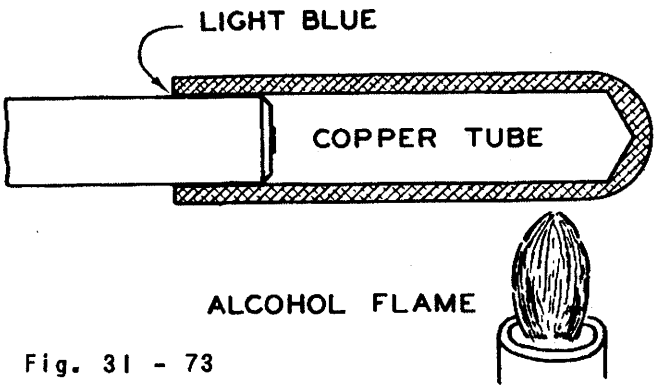


Fig. 31 - 73

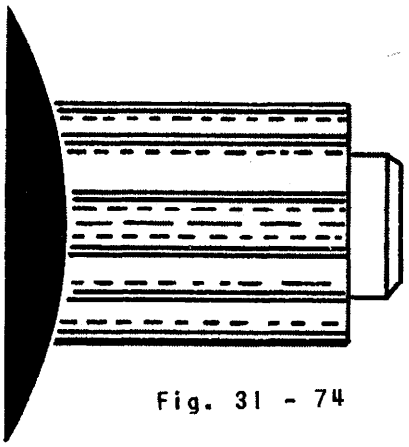


Fig. 31 - 74

2. Place pinion in lathe chuck and make certain it is running absolutely true, figure 31-74. If necessary, cement in a hollow cement chuck.

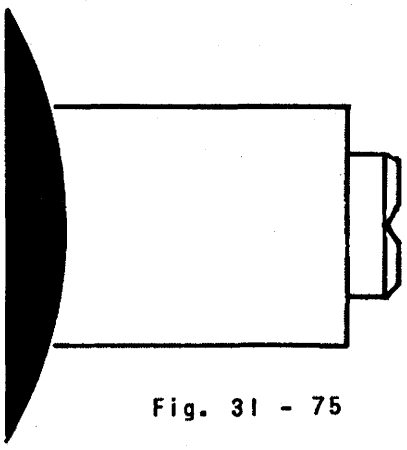


Fig. 31 - 75

3. Center, figure 31-75.

4. Drill hole slightly larger than the diameter of the finished pivot, figure 31-76.

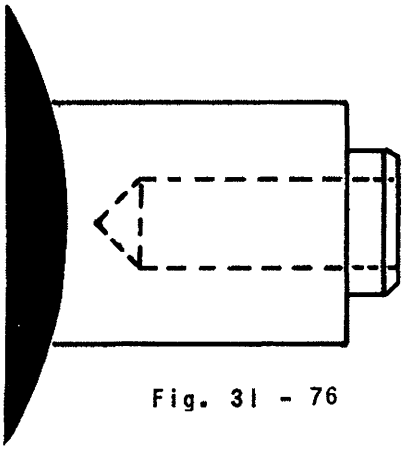


Fig. 31 - 76

5. Remove from lathe and take a blued pivot wire slightly larger than the finished pinion and chuck up the lathe. Turn down the diameter of this wire, figure 31-77, until it just starts into hole.

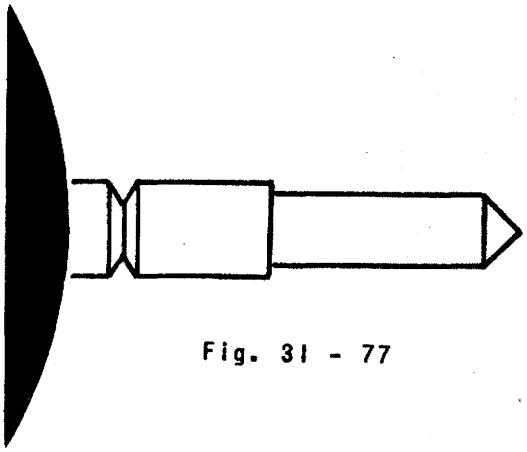


Fig. 31 - 77

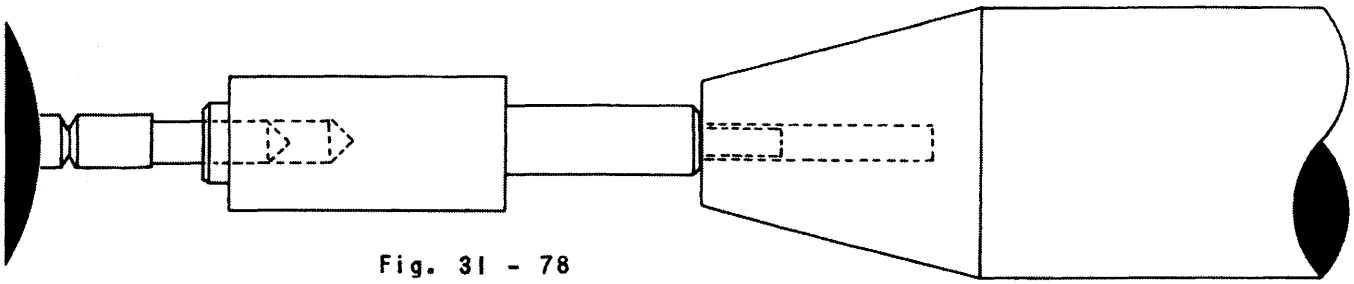


Fig. 31 - 78

6. Drive pinion into wire as in figure 31-78 using a flat face hollow staking tool punch. At times, it is necessary to reverse this process and drive the pivot wire in the pinion.

7. Remount pinion in lathe, figure 31-79, and finish pivot to the proper diameter and length, figure 31-80.

The same process is used to repivot a balance staff.

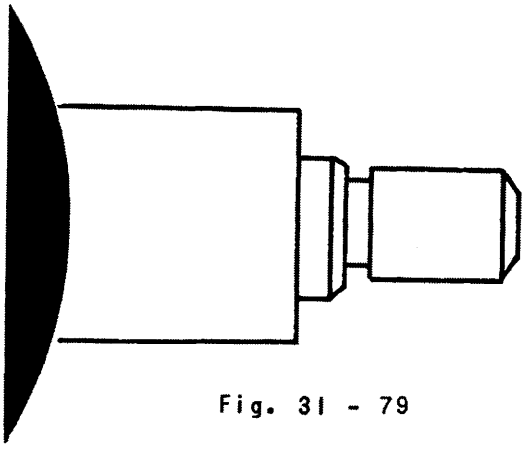


Fig. 31 - 79

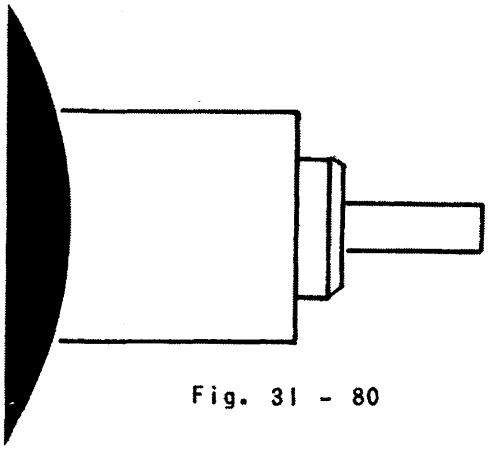


Fig. 31 - 80

SEC. 535 - Rebushing a Train Wheel

At times a train wheel which is out of true can be corrected with a rounding up tool and cutter. The rounding up tool which is used to round up the teeth in the wheel after the wheel is riveted to the pinion, is not used much by the watchmaker's craft here in the United States.

One of these tools is shown in figure 31-81. The wheel to be operated upon is placed upon a small table at A between two vertical runners with guard-pivot centers. The cutter is fixed at B to a suitable arbor chuck in a small head C, which is turned by hand-wheel D, a supplementary pulley E taking all strain off the axis. The three milled-headed nuts seen at F; G, and H are for adjusting; F for moving the lathe-head so that the cutter is in the same plane as the axis of the runners, a position which is determined by the pointer D; G for advancing the wheel against this cutter; and H for setting the plane of the wheel to pass through the axis of the lathe-head as indicated by the index K. The tool is accompanied by a number of cutters to suit the various sizes of teeth as well as of tables to support wheels of different dimensions.

An enlarged view of the mill cutter is shown in figure 31-82. Section A-B of the circumference is cut away and replaced by guide C-D made of spring steel and fixed to coincide with the edge

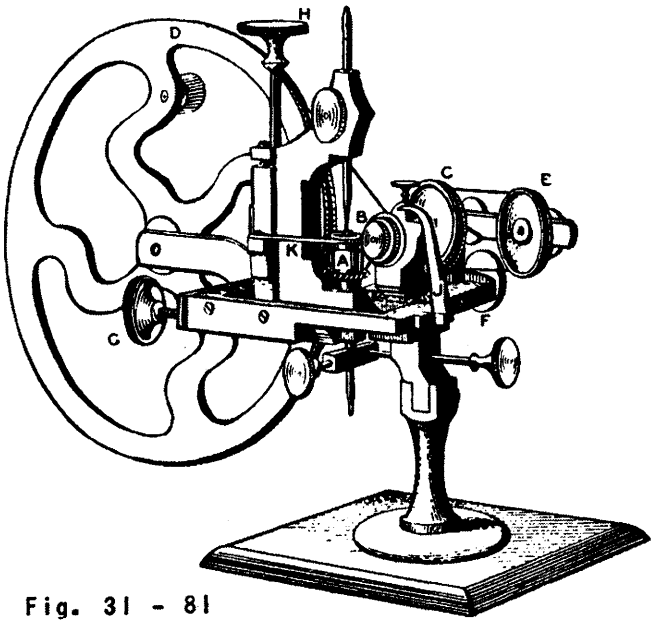


Fig. 31 - 81

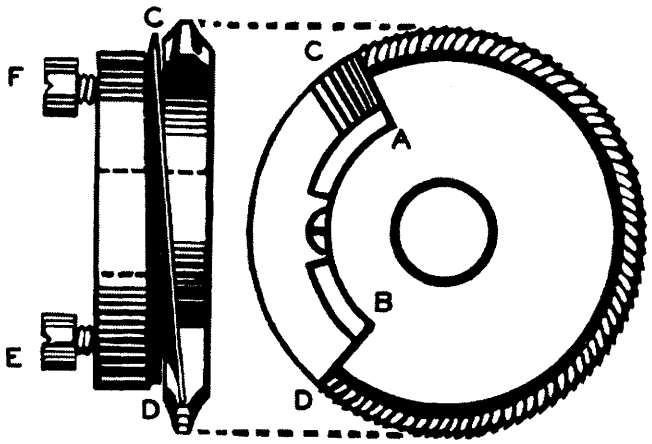


Fig. 31 - 82

of the cutter at D and inclined at C in order to compel the cutter to pass at each rotation into consecutive spaces of the wheel. Two screws are provided, E for setting the guide opposite the edge of the cutter, and F for placing the free end of the guide opposite to the space between teeth.

For the average watchmaker, it is possible to true up a train wheel in the following manner:

1. Remove train wheel from pinion.

2. Select a cement brass slightly larger than the diameter of the train wheel. Cut out a section as in figure 31-83 so that the train wheel will fit in without any side play.

3. Cement wheel in cement chuck, figure 31-84.

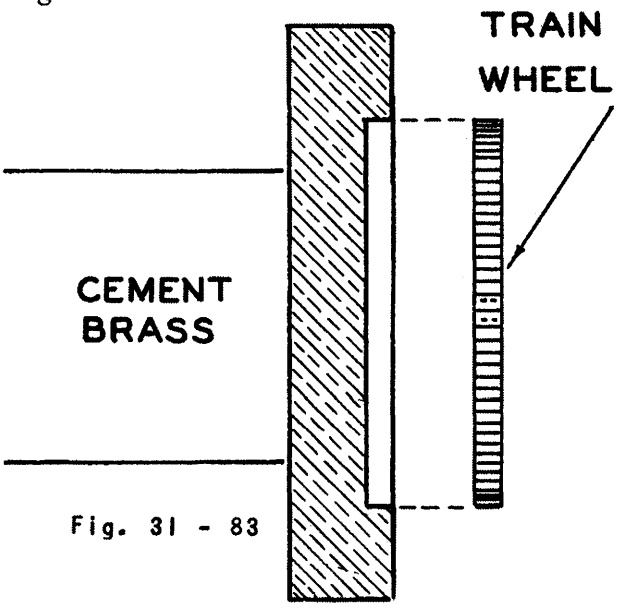


Fig. 31 - 83

4. Bore out center of wheel with boring tool, figure 31-84.

5. Remove wheel from cement chuck, boil and clean with alcohol.

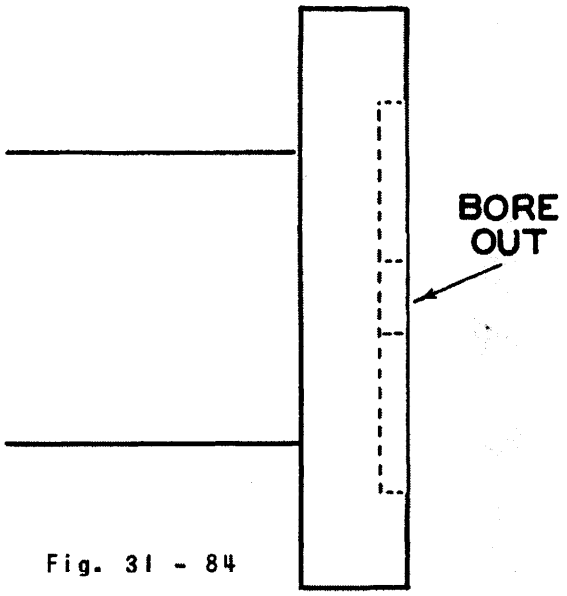


Fig. 31 - 84

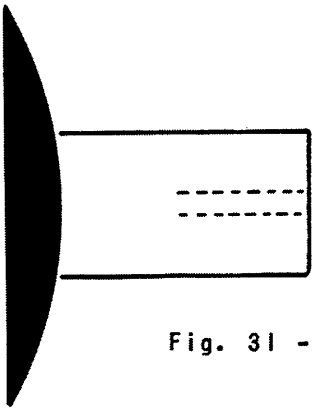


Fig. 31 - 85

6. Place a piece of brass wire in lathe, center and drill hole slightly smaller than the train pinion, figure 31-85. Turn shoulder until wheel just fits, leaving a small portion extending through wheel so that it can be riveted, figure 31-86.

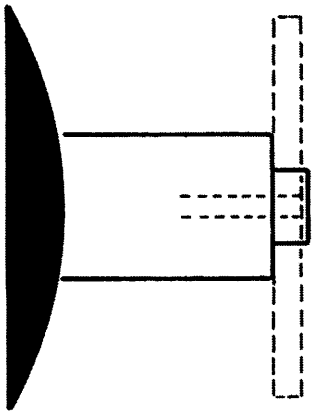


Fig. 31 - 86

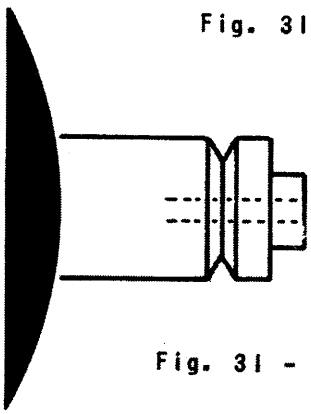


Fig. 31 - 87

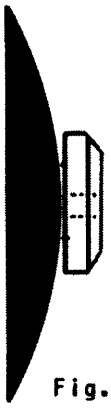


Fig. 31 - 88

7. Cut a groove leaving a short hub as in figure 31-87. Saw off, reverse in chuck of proper size and face off hub as in figure 31-88.

8. A. Stake wheel to hub as in figure 31-89. The punch used for this operation will leave indentations as illustrated by A, figure 31-90.

B. Broach out hole in wheel and replace on pinion.

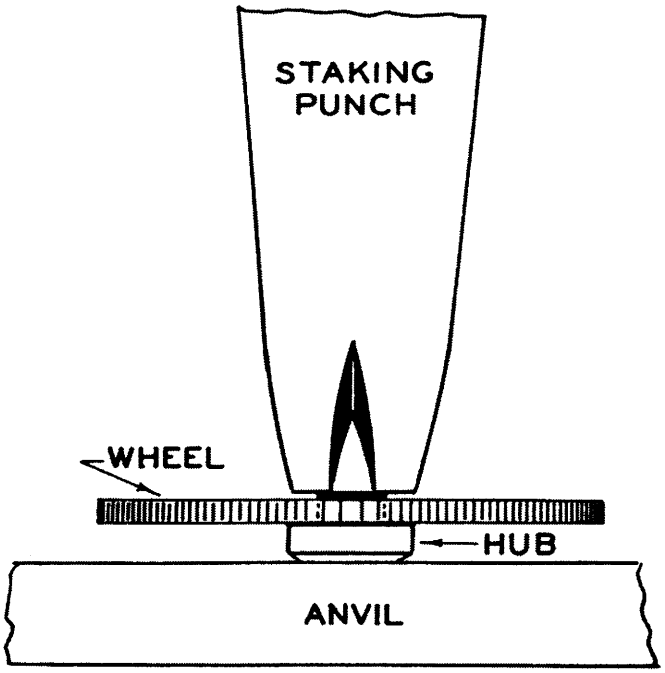


Fig. 31 - 89

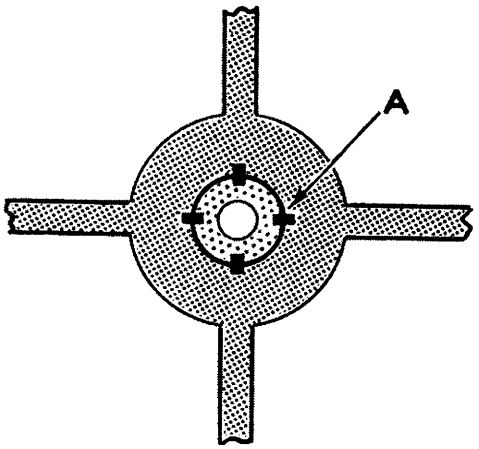


Fig. 31 - 90

SEC. 536 - Replacing a Hook in Barrel

When the hook in the barrel becomes broken or worn, the practical thing to do from the standpoint of time is to replace the barrel. At times this is impossible and it becomes necessary to replace the hook.

1. Locate center D, figure 31-91. This will be the center for the hook. It is found as follows:

$$\frac{A - B - C}{2} + B = D$$

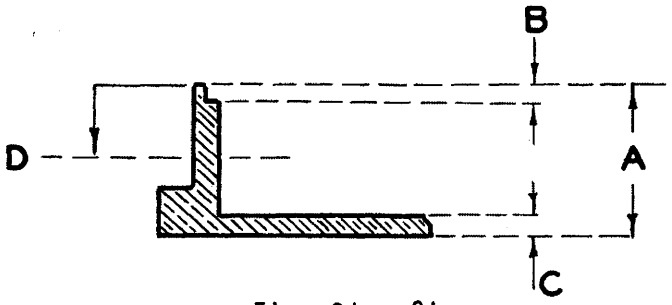


Fig. 31 - 91

2. Set a pair of dividers to this dimension and scribe a line on outside of barrel as shown at D, figure 31-92.

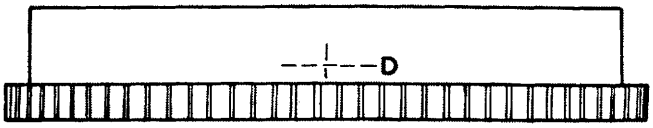


Fig. 31 - 92

3. Center punch barrel as in figure 31-93.

4. Select tap size, drill hole and tap barrel, figure 31-94.

5. Thread a piece of drill rod as in figure 31-95.

6. Turn diameter B, figure 31-95, slightly smaller than width A, figure 31-94.

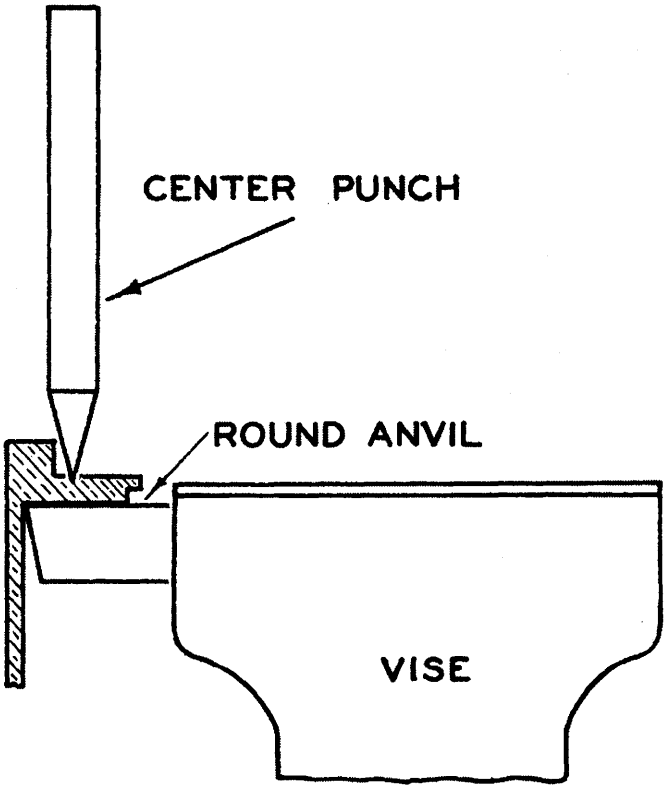


Fig. 31 - 93

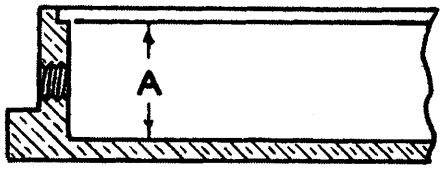


Fig. 31 - 94

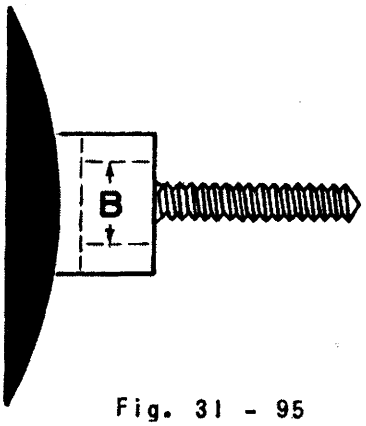


Fig. 31 - 95

7. Shape as in figure 31-96 to allow for the thickness of mainspring. The dashed lines illustrate the rim of barrel.

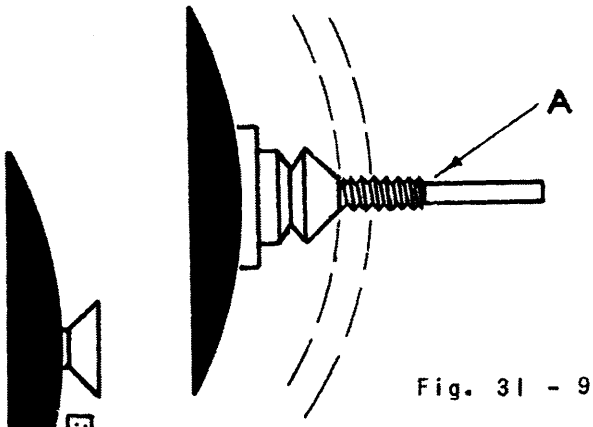


Fig. 31 - 96

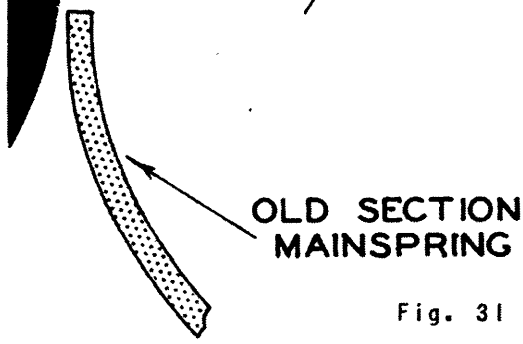


Fig. 31 - 97

8. Turn off thread as indicated at A, figure 31-96.

9. Cut groove, saw off end, reverse in chuck of correct size and finish end as in figure 31-97. The hook should now be slightly longer than the thickness of mainspring, figure 31-97.

10. Screw into barrel from the inside, figure 31-98.

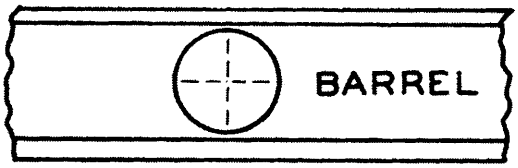


Fig. 31 - 98

11. Mark vertical and horizontal lines as in figure 31-98.

12. Remove and shape hook to fit hole in mainspring, figure 31-99.

13. Harden and temper to a blue.

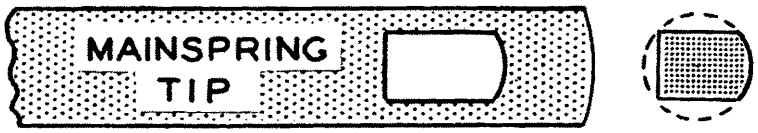


Fig. 31 - 99

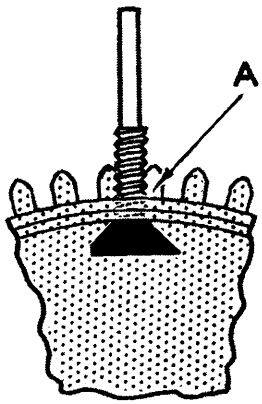


Fig. 31 - 100

14. Replace in barrel from inside. Screw in tightly and cut off excess at A, figure 31-100.

SEC. 537 - Calculating Lost Wheels and Pinions

To find the number of teeth for a center wheel. If the number of leaves in the fourth pinion goes into the number of teeth in the third wheel eight times without a remainder, the leaves of the third pinion multiplied by seven and a half will give the teeth for the center wheel.

If the leaves of the fourth pinion go into the third wheel seven and a half times without a remainder, the leaves of the third pinion multiplied by eight will give the center wheel teeth.

To calculate a missing third wheel and pinion. When the center wheel divides by eight without a remainder the quotient will be the number of leaves for the third pinion and number of leaves on the fourth pinion multiplied by seven and a half will be the number of teeth for the third wheel.

When the teeth in the center wheel divide by seven and a half without a remainder, the quotient will be the number of leaves for the third pinion, and eight times the leaves of the fourth pinion will be the number of teeth for the third wheel.

To calculate a missing fourth wheel and pinion. When the leaves of the third pinion go into teeth of the center wheel eight times without a remainder, dividing number of teeth in the third wheel by seven and a half will give the number of leaves for the fourth pinion.

When the leaves of the third pinion go into teeth of the center wheel seven and a half times without a remainder, dividing number of teeth in the third wheel by eight will give the number of leaves for the fourth pinion.

To find the number of teeth for the fourth wheel when the watch has an 18,000 train. This may be done by comparing the motion of the balance with that of another which is known to have an 18,000 train. The vibrations may be counted for half a minute or more.

An 18,000 train balance gives 300 vibrations a minute, or, if alternate vibrations are counted (which is more convenient), there will be 75 in half a minute.

When the watch is found to be an 18,000 train, multiplying the escape pinion by 10 gives the number of teeth for the fourth wheel.

To calculate a missing escape pinion. The teeth of the fourth wheel will always be divisible by either 8 or 9 without a remainder and the quotient will be the number of leaves for the escape pinion.

The number of teeth in the escape wheel will, of course, be fifteen in all modern watches.

It is seen that the calculations for the teeth and pinions in a modern watch train is a simple matter. For other trains that do not carry second hands the procedure is somewhat different.

SEC. 538 - Rule for Calculating Any Train of Wheels.

Trains are divided into two classes, simple and compound. Simple gearing consists of two or more wheels meshing directly into each other, each on its own bearings. Compound gearing consists of a series of wheels and pinions, two or more mounted on the same staff.

In simple gearing, the difference between the number of teeth in the first and last members of the train determines their respective revolutions, irrespective of the number of members or the number of teeth in the other wheels; the intermediate wheels simply transmit the motion from one to the other.

In compound gearing every member of the train enters into the calculations. To make these calculations three things are predetermined: The number of revolutions the last wheel in the train gives for one of the first; the number of members that constitute the train; the number of leaves to be given to each pinion.

Rule.--The prime factors of the product of each pinion and the number of revolutions of the last wheel, multiplied together and arranged in the number of groups corresponding with the number of wheels required, gives the number of teeth for those wheels.

For an example we will calculate the train, from the center wheel on, for an 18,000 train watch.

First operation: The number of teeth in the escape wheel is fixed at 15. Each tooth delivers two impulses to the balance; therefore, divide 18,000 by twice the number of escape teeth--30. Example:

```
30)18000(600
   180
```

The number of revolutions required of the escape pinion is, therefore, 600 per hour.

Second operation: We will select for the number of leaves in the pinions: 9 for the third; 8 for the fourth; 7 for the escape. The number 9 selected for the third is unusual. It is done for the purpose of demonstrating the adaptability of the rule to all cases.

Multiply the pinions and revolutions together:

```
  9
  8
 72
  7
504
    600
302400
```

Ascertain the prime factors of this number:

```
2)302400
2)151200
2)75600
2)37800
2)18900
 2)9450
 3)4725
 3)1575
  3)525
  5)175
   5)35
     7
```

This gives us as prime factors six 2s, three 3s, two 5s, and one 7.

We will take for our first group two 3s and three 2s:

```
  3
  3
  9
  2
 18
  2
 36
  2
 72
```

This gives us 72 teeth for the center wheel.

We will take for the next group one 5, one 3 and two 2s, which multiplied together will give us 60 teeth for the third wheel.

We now have left one 7, one 5, and one 2, which multiplied together gives 70 teeth for the fourth wheel.

This completes the train, which it will be seen is correct for the purpose required. The center wheel has 72 teeth and as the third pinion has 9 leaves the center will give it 8 revolutions. The fourth pinion has 8 leaves and as the third wheel has 60 teeth, it will give to the fourth 7-1/2 revolutions. Seven and a half times 8 being 60, the center wheel will give the fourth pinion sixty revolutions, which is correct for carrying a second hand. The escape pinion having 7 leaves and the fourth wheel 70 teeth, the fourth will cause the escape to revolve ten times. The number of revolutions will, therefore, be 10 times 60, or 600.

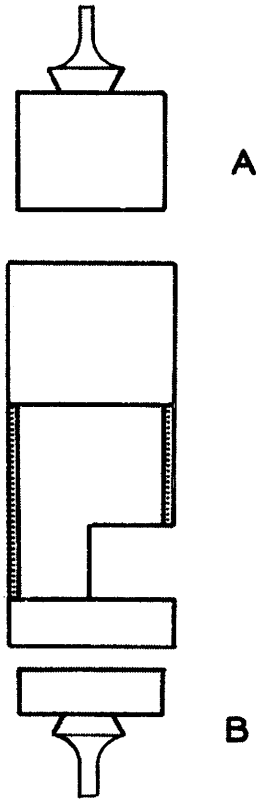


Fig. 31 - 101

SEC. 539 - Fitting New Cylinder Plugs

Figure 31-101 illustrates a Swiss Cylinder. The upper and lower pivots are made in the form of plugs A and B, which are fitted into the cylinder friction tight. The upper plug is the longer of the two and, in some cases, this plug may be driven out far enough to admit the turning of a new pivot. Cylinder plugs are driven out with a knee punch illustrated in figure 31.102. A cylinder stake or a hole in the die plate is used to hold the cylinder when removing the plug. The hole in the cylinder stake or die plate must be large enough to allow the entrance of the plug but not the cylinder. A few light taps of the knee punch is all that is necessary to drive out the old plug. The new plug must be made to fit friction tight without a taper. Use the micrometer to measure the old plug.

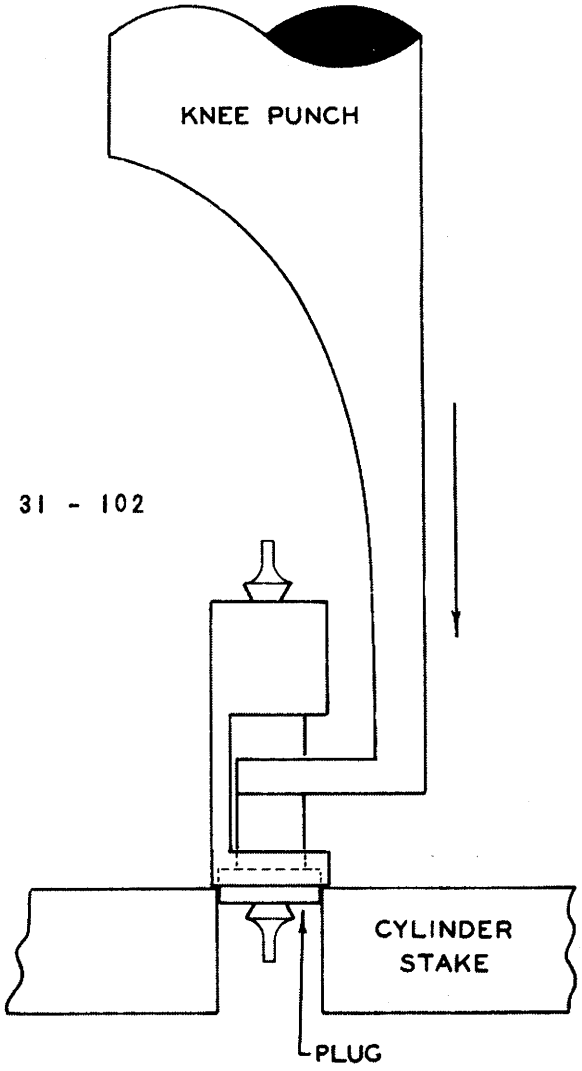


Fig. 31 - 102

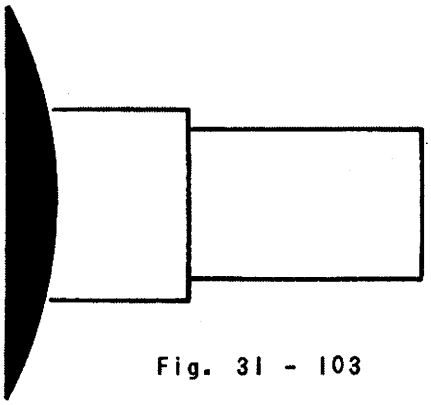


Fig. 31 - 103

1. Select a piece of blued drill rod slightly larger than the diameter of the plug.

2. Turn down outside diameter to proper dimension, figure 31-103.

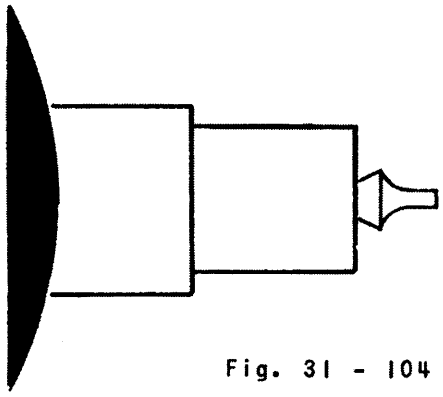


Fig. 31 - 104

3. Cut, grind, and polish a cone shape pivot on the end, figure 31-104.

4. Cut a square shoulder, the length to equal shoulder on old plug and cut off, figure 31-105.

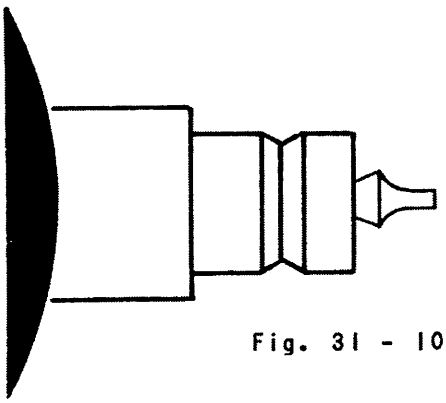


Fig. 31 - 105

5. Turn plug around in lathe and finish end, figure 31-106.

Fig. 31 - 106

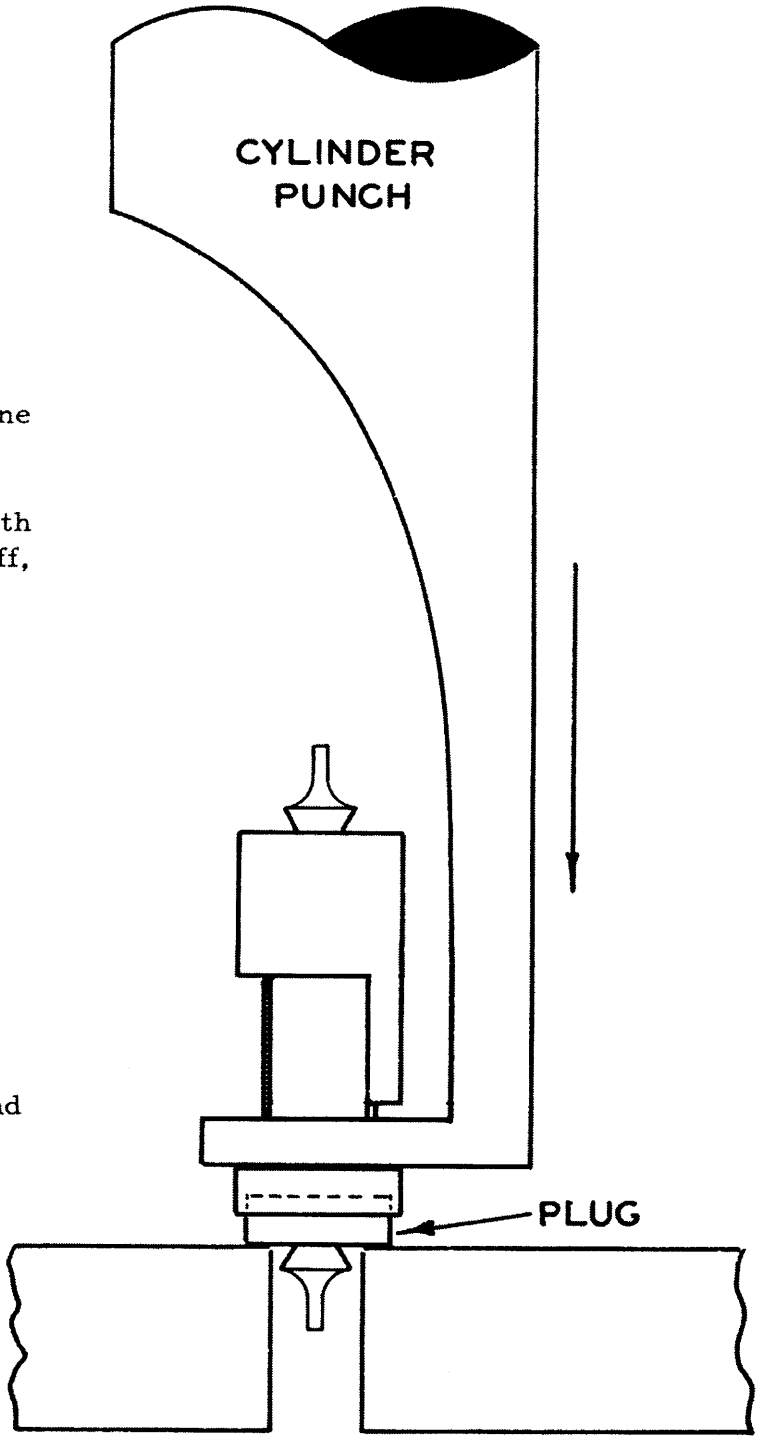


Fig. 31 - 107

6. Place plug in die plate of staking set or cylinder stake and with a punch shown in figure 31-107 placed across the inside walls of the cylinder, press plug into place.

SEC. 540 - Additional Tools

There are any number of additional tools used in watchmaking by men who have been at the bench a good many years. As you progress with your practical experience you too, will acquire additional tools. New tools will be developed and manufactured which will aid you in your work. You will become aware of other tools and material systems through the catalogues of the supply houses. Other watchmakers will recommend tools.

You should read magazine articles and acquire a good reference library of old and new books.

The following illustrations and descriptions are a few of many additional tools necessary at one time or another:

Figure 31-108 illustrates a balance chuck sometimes known as a "ballon" chuck. The pivot projects through convex face of chuck and a hardened steel burnisher can be used to finish end and sides of pivot.

Fig. 31 - 108

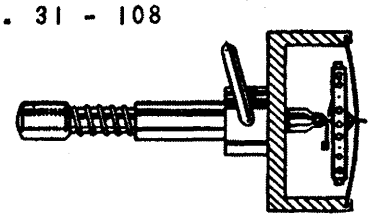


Figure 31-109 illustrates a wheel chuck. These chucks are used to catch up wheels on their largest diameters and come in different sizes with graduated steps.

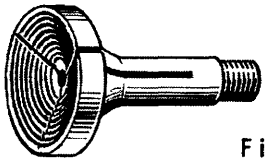


Fig. 31 - 109

Figure 31-110 illustrates a drill chuck for a watchmaker's lathe. It has a capacity up to 1/4".

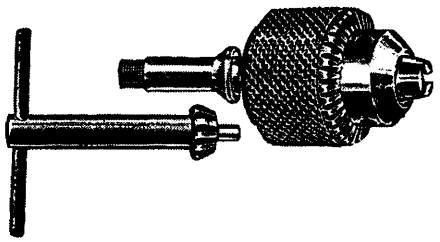


Fig. 31 - 110

Figure 31-111 illustrates a stepping device. It is used in the head stock of a lathe with a wire chuck. It affords a back seat in chuck for a jewel setting or other small pieces that lack thickness and require a shallow seat to set in.

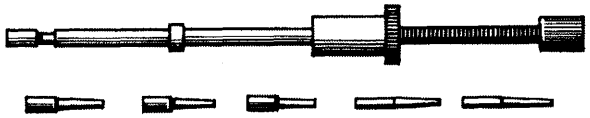


Fig. 31 - 111

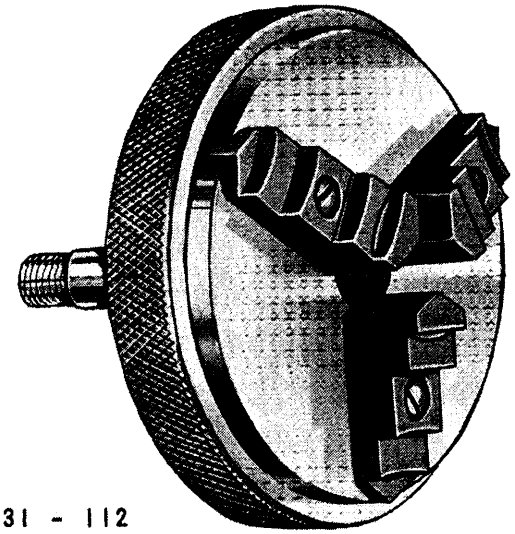


Fig. 31 - 112

Figure 31-112 illustrates a 3-Jawed Chuck with a self centering scroll movement. Jaws are reversible.

Figure 31-113 illustrates a slide rest with 3 slides. Top slide contains tool post. Dials are graduated in 1/100 mm.

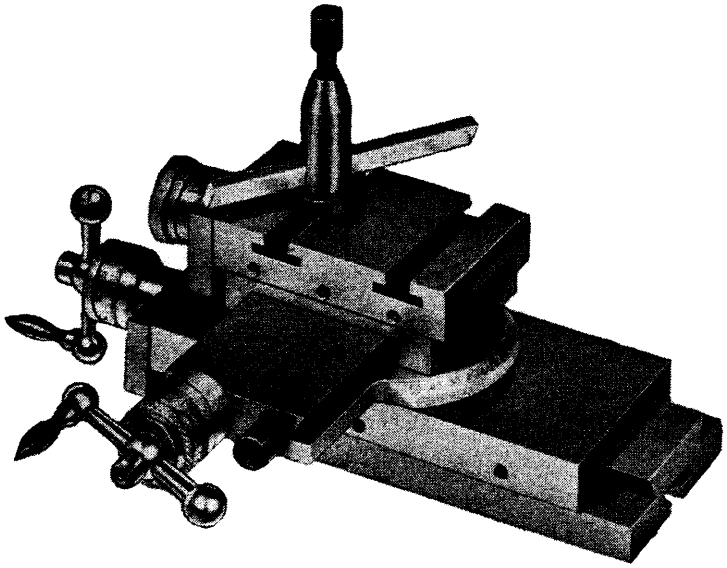


Fig. 31 - 113

Figure 31-114 illustrates a wheel cutting, grinding and drilling attachment.

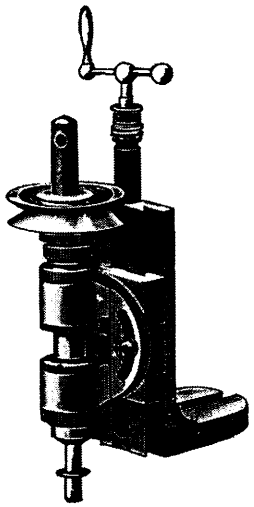


Fig. 31 - 114

Figure 31-115 illustrates the wheel cutting attachment bolted to a slide rest, adjustable to any conceivable position.

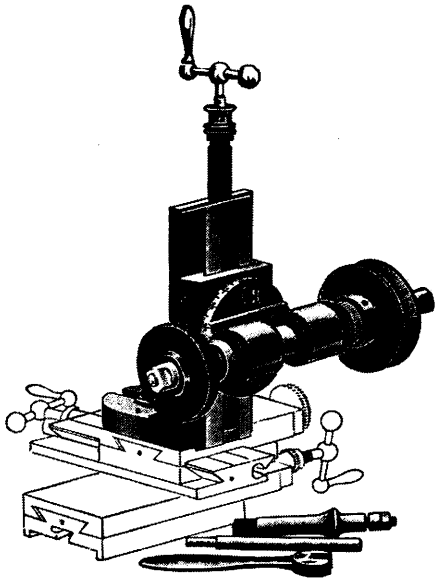


Fig. 31 - 115

Figure 31-116 illustrates an index for wheel cutter with index holes up to 360.

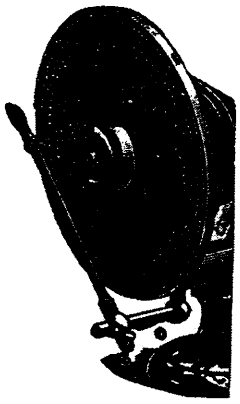


Fig. 31 - 116

Figure 31-117 illustrates a tail stock chuck holder.

Figure 31-118 illustrates an arbor chuck for mounting wheels, saws, laps, etc.

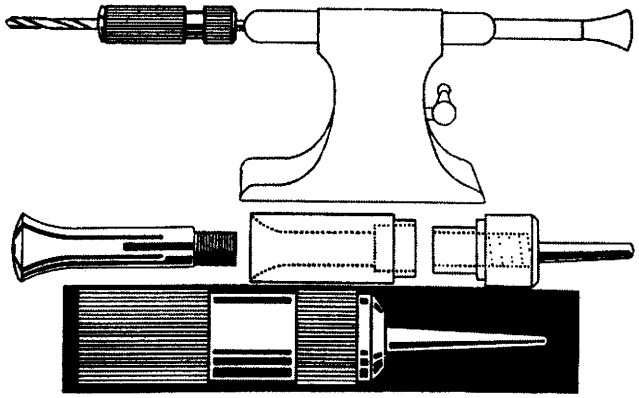


Fig. 31 - 117

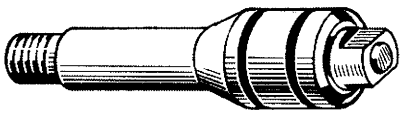


Fig. 31 - 118

Figure 31-119 illustrates a pivot drill chuck used with the regular taper chuck.

Fig. 31 - 119

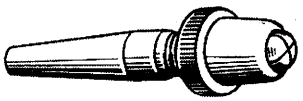


Fig. 31 - 120

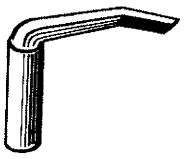


Figure 31-120 illustrates an "L" tool rest which is used in place of regular "T" rest with face plate or 3-Jawed Chuck.

These tools and many others will find their way into your shop as your work requires. Make it a practice to keep abreast with the times and endeavor to have the best tools possible in order to turn out the best work.

note:

(No job sheets are associated with Lesson 31)