Master WATCHMAKING

Lesson 27

Tools — Hardening and Tempering

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

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SEC. 460—Reasons for Using Good Tools

In bygone years, it was necessary for the watchmaker to make a great many of his tools. Many watchmakers, especially old timers, consider tool making an essential part of an apprentice's or student's training. The student learned to file and shape tools from brass and steel, make screws, rivet parts, harden and temper wire from which to make staffs, pinions, setting parts, etc., thus becoming very proficient at tool and parts making. Most good watchmakers of this era could calculate a lost wheel and pinion; and if they had the proper equipment, make a wheel or pinion or any part of the watch including the jewels. In most cases, the tools made were not of exceptional quality due in part to a lack of machinery with which to make them. With the advent of modern machinery, the toolmaker became interested in making precision watchmakers' tools and the modern up-to-date teachings tend away from tool and parts making and are concentrated on watch repairing, using factory replacement parts and tools made by modern methods and machinery. It is an old adage that "any workman works better with good tools." Concentrate on obtaining the best tools, the proper materials for the proper movements, and then use these materials and tools, to do a better job. Quality work is the supreme achievement and it can be done better and faster with quality tools and materials.

There are times in every watchmaker's career when he may be called upon to devise a tool suitable for his own needs, or one that will do a job quicker than some tool already on the market. Such is the case of the collet removing tools mentioned in Lesson 15, Section 352. The three tools which you are required to make in order to complete this lesson are tools which are unobtainable. You will learn the types of files, the steel to use, how to file, how to harden and temper, etc.

SEC. 461—The Vise, Saw, Files, Etc.

The first requirement is a bench and a bench vise. The vise illustrated in figure 27-1 is a small bench vise suitable for the watchmaker which can be mounted on the extreme right hand corner of his bench. It is best, however, to mount the vise elsewhere as it is not used too often. When filing work which you

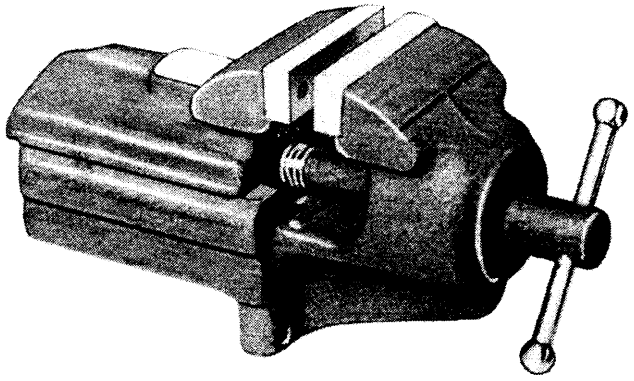

Fig. 27-1

do not wish to mar, it is advisable to form a pair of jaws out of copper similar to those in figure 27-2. These are placed over the jaws of the vise and the work is placed between the copper jaws. This will prevent marring of the work.

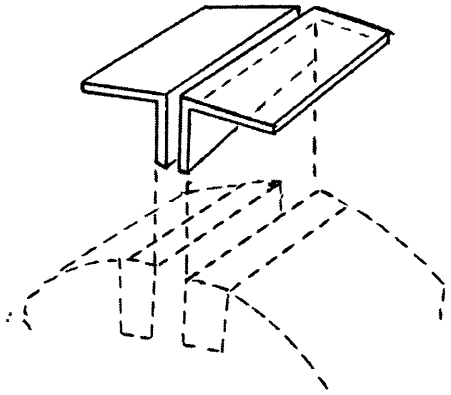

Fig. 27-2

Figure 27-3 illustrates a jeweler's saw frame which is a necessity for the watchmaker. It is much smaller than a hack saw. The small blades come in different cuts from 4 to 4/0, 4 being the coarsest and 4/0 the finest, figure 27-4. These blades are held in place by the clamps at **A**, figure 27-3, which are closed by means of the thumb screws **B**. The saw blade is inserted as follows: Place the head or top of the saw frame against the bench with the handle against your chest. Press against the handle, place saw blade in the lower clamp and tighten thumb screw. When pressure is released, the saw blade will be tight and have a high pitch when picked with your finger in the manner in which you would pick a string on a violin. The

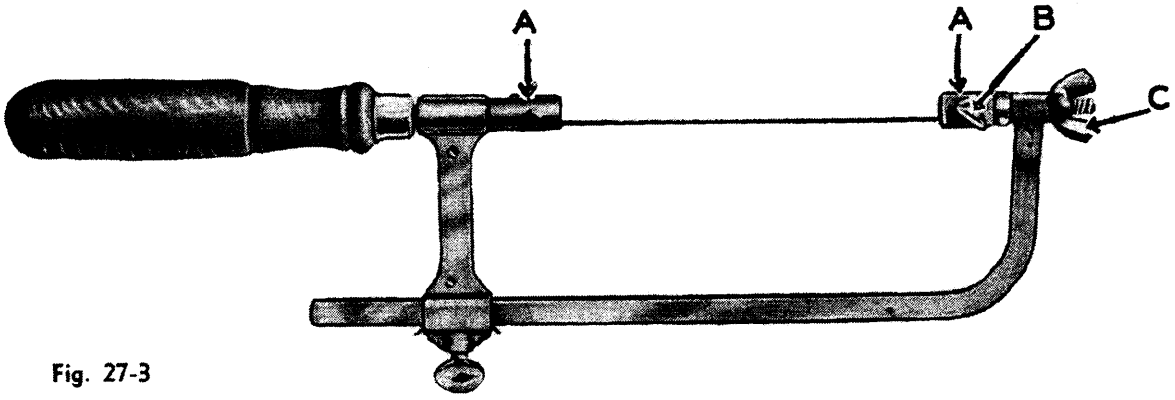

Fig. 27-3

teeth of the saw blade should **point toward the handle.** Further adjustment can be made by means of wing screw at **C.** These saws will cut soft steel, brass, nickel, gold, silver, etc. The work should be held securely in a bench or hand vise and the saw frame pulled down or toward you at which time a slight pressure is

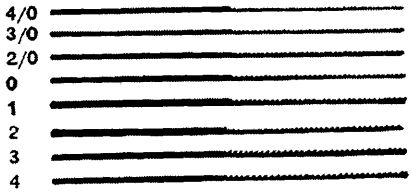

Fig. 27-4

exerted. When reversing the direction of the saw frame, the pressure is released until the downward motion is again started. In sawing flat pieces of steel or brass, etc. in which you wish to follow a line or pattern, the saw frame is held in a vertical position and the work should be held over a wood filing block, figure 27-5. After sawing, the work is usually finished with a file and polished if necessary.

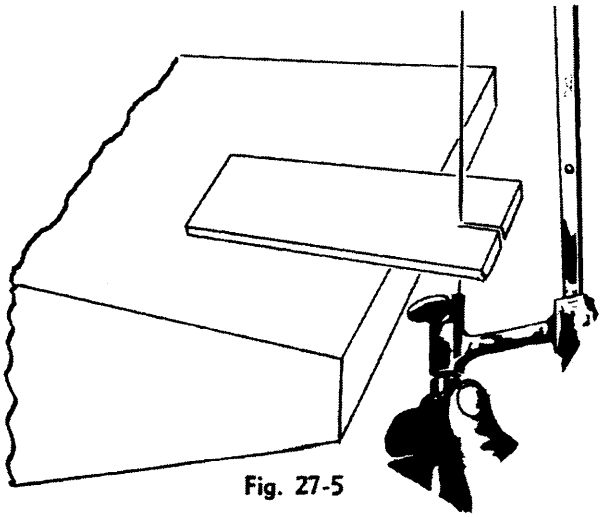

Fig. 27-5

For the watchmaker 6 emery buffs of 6 different grades of emery from 2 to 4/0 are generally used to polish steel, figure 27-6.

Fig. 27-6

Polishing any metal is the removing of surface roughness or scratches. When a piece of steel has been filed to the proper shape and we wish to polish it, we start with an emery buff No. 2. The work is carefully gone over with the No. 2 emery buff until all lines or marks left by the file have been removed. Clean the work carefully until all traces of scratches or marks left by emery buff No. 2 have been removed. Repeat the process with emery buffs Nos. 0, 1/0, 2/0, 3/0, and 4/0, being certain to clean the work each time another grade of emery is used. When you have finished with the No. 4/0 emery buff, you will have a piece of work with a high polish. This high polish is very necessary when we temper our work. The polishing of brass, nickel, gold, silver, etc., is not done with emery but with an electric polishing buff and tripoli to remove the scratches, and rouge to give it a high luster.

There are numerous types of files and hundreds of different shapes depending upon the type of work to be performed. There are files with a rough cut, bastard cut, 2nd cut and smooth cut in all sizes and shapes. For ordinary filing in brass and steel, a good flat file will serve our purpose, figure 27-7. For our work a 5-inch to 8-inch file with a 2nd or medium cut is preferred. The file is a cutting tool and should be used as such. To hold a file in the

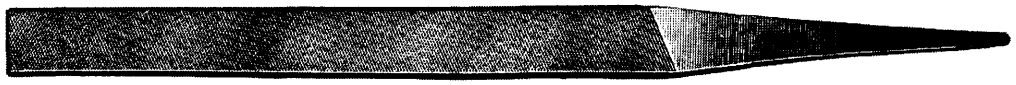

Fig. 27-7

proper position, grasp it firmly in the right hand with the end of the handle butting against the palm of the hand and the thumb resting along the top of the file. The left hand is used to guide the file when pushing it across your work and to regulate the pressure.

The stroke should not be straight across the work in flat filing but should be in a diagonal direction so that the file takes a shearing cut. After the completed forward stroke, the file should be lifted above the work and returned for the next forward stroke. Do not drag the file back across the work. Remember that the teeth of an ordinary file cut only when the file is moving forward. Keep your file clean with a file cleaning brush.

The watchmaker usually works in steel, brass, or nickel. Drill Rod or "Stubs" steel in rod or plates is high carbon steel which can be hardened. Low carbon steel cannot be hardened; consequently, it does not have much value to the watchmaker. Brass or nickel should be procured in the hard form as it is easily annealed.

SEC. 462—Making a Stripping and Seat Cutting Tool

In order to obtain practice in filing, polishing, hardening and tempering, we will make two jewelling tools. They are made from 3 mm square tool steel or drill rod approximately 100 mm in length, figure 27-8. Each step is accompanied by two illustrations. One gives the dimensions in millimeters or fraction thereof and the other is a projection illustrating each cut as it is made. For example: figure 27-8 illustrates a piece of square steel 100 mm long and 3 mm square. Figure 27-8P is a projection of the end to be worked upon. Figure 27-9 illustrates the same piece of steel with a section 20 mm long and 1 mm down from the front edge to be filed away. The projection, figure 27-9P, illustrates the piece of steel after this has been done. Follow each step carefully and work slowly.

1. Clamp the rod in vise allowing approximately 22 mm to extend beyond the jaws of the vise, figure 27-8 and 27-8P.

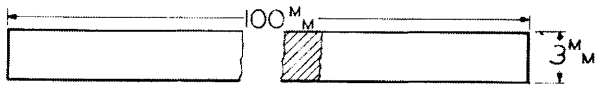

Fig. 27-8

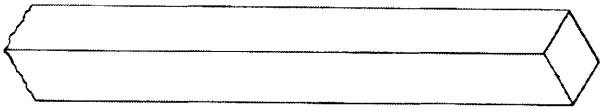

Fig. 27-8P

2. Scratch a line with the edge of the file approximately 20 mm from the end, figure 27-9.

3. Holding the file at an angle of about 18 degrees, file a bevel as in figure 27-9 and 27-9P. Figure 27-9P shows this section after it has been filed.

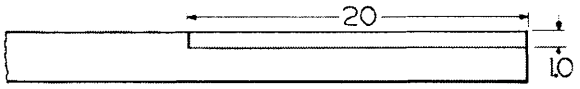

Fig. 27-9

Fig. 27-9P

4. Turn rod over in vise and file the lower side off as in figure 27-10 and figure 27-10P leaving the end measurement at .6 mm thick and the taper about 30 mm back from the end.

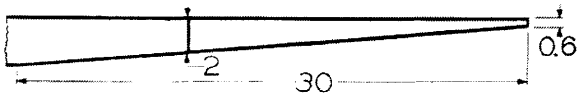

Fig. 27-10

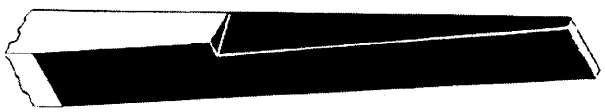

Fig. 27-10P

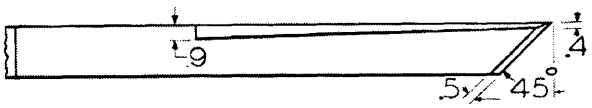

Fig. 27-11

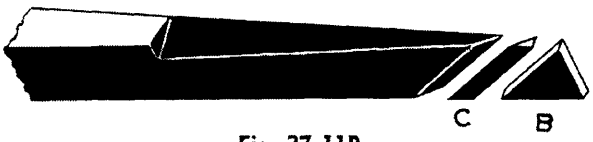

Fig. 27-11P

5. File angle of approximately 45 degrees as shown in figure 27-11 which will remove section **B**, figure 27-11P.

6. File second cut as shown at **C**, figure 27-11P.

7. Reverse steel and file tang which fits into handle as shown in figure 27-12 and 27-12P. Polish all sides of the stripping tool with emery buffs as described in Section 461 until you have a very high polish. It is not necessary to polish the tang.

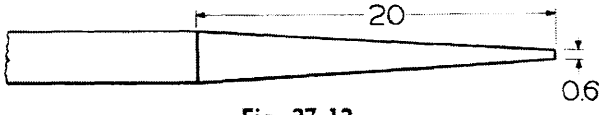

Fig. 27-12

Fig. 27-12P

8. Take another rod of the same length and diameter and repeat steps 1, 2, 3, and 4. The rod should then appear as in figure 27-13 and 27-13P.

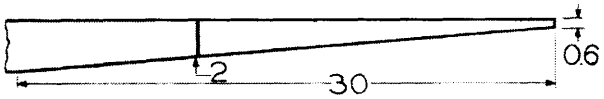

Fig. 27-13

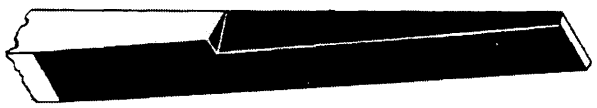

Fig. 27-13P

9. File off the under side and tip as shown in figure 27-14 and figure 27-14P. This will be used as a seat cutting tool.

10. File tang on the other end as in figure 27-12 and 27-12P.

11. Polish as in step 7.

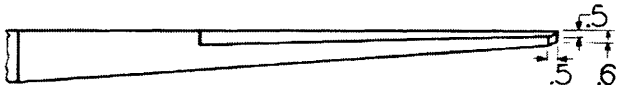

Fig. 27-14

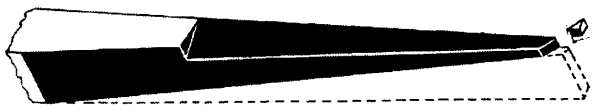

Fig. 27-14P

SEC. 463—Hardening

We are now ready to harden the tools. It is necessary to have some means of heat, preferably a bunsen burner, in order to obtain a red heat. Place a jar of cold water as close to the burner as possible. Wet the stripping tool with water and dip into powdered boric acid. The boric acid will form a glass-like covering over the steel and prevent "burning." In order to make the tool hard, heat it gradually until it is a bright cherry red and plunge it quickly and vertically into the water, holding it in the water until it is cool. A pair of heavy soldering tweezers is used to hold it. Remove from water and test with file. If it is hard, the file will not "bite" into the metal. If the file will bite, it is soft and it is necessary to repeat the process. Be careful when hardening tools such as the jewelling tools just made to apply heat to the bulkiest part of the stock first. Figure 27-15 illustrates a stripping tool. Apply heat at **A** until you are certain the stock is heated through thoroughly; then carefully let the flame heat toward the tapered end, first at **B** then back to **A**, back to **B**, down to **C**, back to **B** and **A**, and then reverse until section **D** of the tool from the end to **B** is cherry red. Quickly plunge into cold water and cool slowly. Test with a file.

When steel is hardened by the method just described, it is sometimes referred to as glass hard. The significance is that it is brittle and will break easily. Every piece that has been

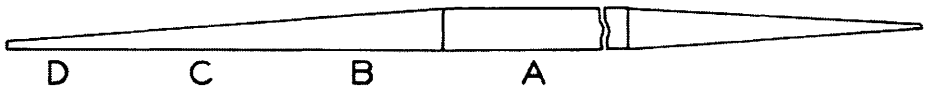

Fig. 27-15

hardened must be handled carefully. After your tools are hardened, they must be repolished using emery buffs 2/0, 3/0, and 4/0 in the order stated. Apply the buffs carefully in order not to break your tool.

SEC. 464—Annealing and Tempering

In order to toughen the tools, they must be annealed. This is known as tempering. Annealing brass, nickel, gold or silver is done by heating to a dull red and then plunging the stock into cold water. Annealing steel is done by heating the stock carefully and slowly and letting it cool gradually. Great care must be used to prevent overheating, and if you happen to overheat your work, it must be rehardened and repolished before attempting to temper it again. For the student, tempering is best done with an alcohol lamp, observing the colors which appear on the highly polished surface of the work.

Colors appearing when tempering	Degrees Fahrenheit (Average)	Tools
Light Yellow	430	Tools for cutting steel
Light Straw	460	Tools for cutting brass, nickel, gold and silver.
Medium Straw	470	
Dark Straw	480	
Reddish Purple	525	
Bluish Purple	550	
Blue	570	Click springs, set levers, balance staffs, pinions, arbors, screws etc.
Gray Blue	600	Soft

Fig. 27-16

The chart in figure 27-16 gives the temperature in Fahrenheit of the different tempers and the tempers to be used with the different tools and springs used by the watchmaker.

The first color to appear when annealing is a very light yellow which is barely visible. It is hard to differentiate between this light yellow and the succeeding light straw color. As you can ascertain by the chart in figure 27-16, the jewelling tools will be tempered to a medium or light straw. Figure 27-17 illustrates how this can be obtained when heated slowly over the

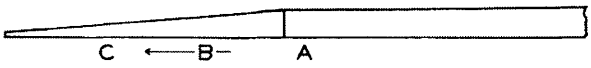

Fig. 27-17

flame of an alcohol lamp. Heat slowly the heaviest part first as at **A**. As the first color appears, move gradually in the direction of Arrow **B** until Section **C** is the desired color. The fact that from **B** to **A** may be a purple or blue is an advantage, as this part of your tool will be tougher. After the desired color is obtained, repolish and mount in small graver handle.

SEC. 465—Making an Iron Grinding Slip

For the purpose of grinding both square and cone shaped pivots, we will make an iron grinding slip as shown in figure 27-18. File straight edge **A** at an angle of approximately 15 degrees.

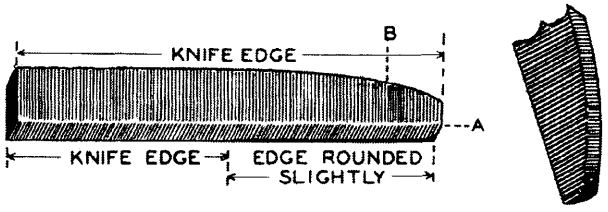

Fig. 27-18

File the other edge at the same angle but curved as shown at B. Finish carefully by leaving file marks at right angles to the horizontal edges on both top and bottom and also the edges.

SEC. 466—Hardening and Tempering Small Springs

Watchmakers can usually purchase all the necessary springs such as click springs, clutch, and lever springs, etc. It is also possible to ob-

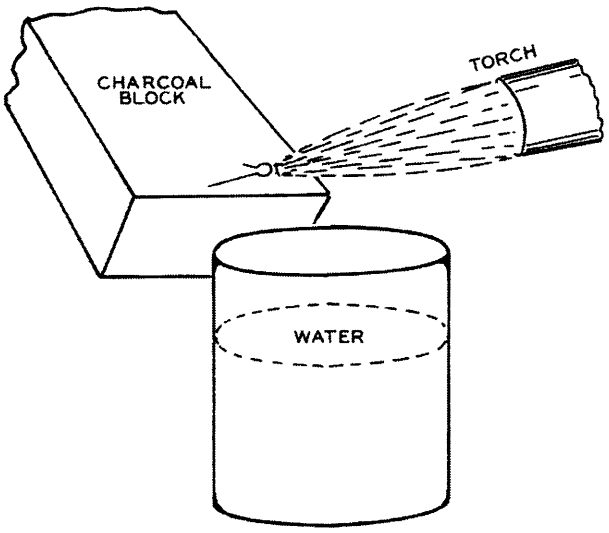

Fig. 27-19

tain click spring wire of assorted widths and diameters from which the watch repairman can shape his own springs. There are times when this is necessary, especially for old watches. At times it is necessary to alter the shape of the spring slightly in order to get the proper results. In order to reshape or form a new spring, proceed as follows:

1. Heat spring to a dull red and let cool slowly. This will anneal the spring.
2. Shape the spring to the desired form.

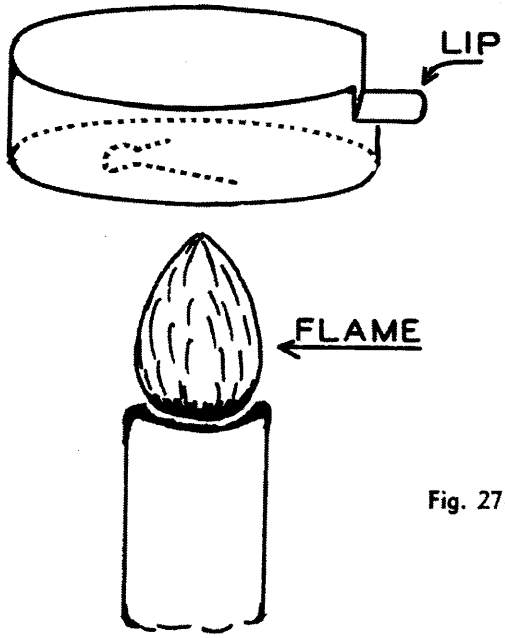

Fig. 27-20

3. Cover with soap and press lightly into a charcoal block, figure 27-19.
4. Heat spring to a bright cherry red with a blow-pipe or small torch.
5. Strike edge of charcoal block against the edge of a jar containing cold water. This will project the spring into the water and if properly executed, the spring will be "glass hard."
6. Remove and carefully polish the end of spring with your emery buffs.
7. Select a small material box and break the edge with a pair of flat nose pliers forming a small lip as in figure 27-20.
8. Place the spring in box and grasp lip with a pair of soldering tweezers and move box rapidly back and forth over the flame of an alcohol lamp.
9. Observe carefully until polished section turns blue and remove from the flame.

The above method can be used for annealing and tempering all small parts.

SEC. 467—Duplicating Broken Levers, Etc.

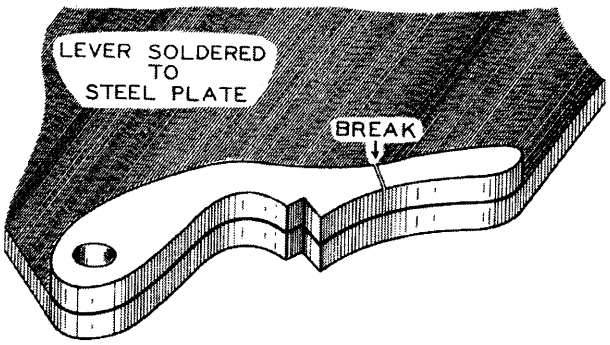

Fig. 27-21

Sometimes it is necessary for the watchmaker to make a small detent or lever. Figure 27-21 illustrates a broken clutch lever soft soldered to a piece of high grade steel. The two pieces can be matched perfectly in this manner and an outline made with a fine saw and finished carefully with small files of various shapes. The hole is also drilled at this time. After this much has been shaped, the process can be repeated on the back edge. Separate by heating over an alcohol lamp. Finish the top and bottom with emery and harden and temper to a blue. (Section 466).

SEC. 468—Soft Solder

Soft soldering is rarely used in watch repair work. Soft soldering a lever to a piece of steel as shown in figure 27-21 is permissible, however. To do the job properly, brighten the surfaces of the lever and the steel plate which come in contact with each other, using a fine file or emery. Cover each of the brightened parts with a soldering flux and a small amount of soft solder. Heat each part separately over an alcohol lamp until solder melts, and brush off the surplus solder while hot with a hard watch brush. This should leave each surface with a thin covering of solder. Put additional flux on steel plate, put lever in place, and reheat until solder turns bright. At this temperature the broken parts can be maneuvered into position. Set aside and let cool before proceeding with the shaping process.

SEC. 469—Soldering Bits in Enamel Dials

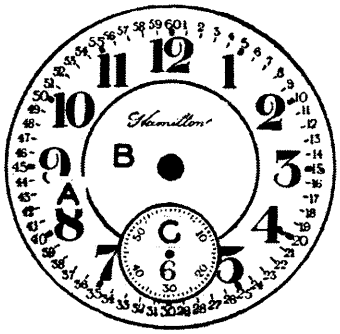

Fig. 27-22

The enamel dials used on high grade watches are usually made of two or three separate pieces which are soft soldered together. Such dials are known as **double sunk** dials. These different sections are shown in figure 27-22 at **A, B** and **C.** Figure 27-23 shows a single sunk dial with the two sections labeled **A** and **B.** The center bit and second bit are held in place with a special soft solder. This solder can be made of 3 parts of lead, 5 parts of tin, and 8 parts of bismuth. Figure 27-24 illustrates where the solder is placed. The copper center of the dial which is illustrated in the left half of the illustration is

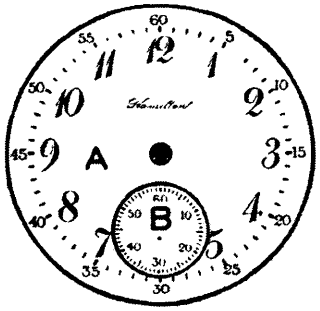

Fig. 27-23

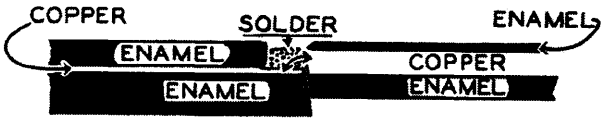

Fig. 27-24

represented by a thin white section extending beyond the upper section of enamel. The bit represented in the right half of the illustration shows the copper center of the bit in white. The edge of this bit must be brightened with a file as must the copper ledge of the dial. The solder is made to flow in the groove fusing the copper centers together as shown, which will hold the bit securely in place. Flux must be applied before soldering. The dial may be placed on a copper plate and warmed carefully until the solder starts to flow. Use a small brush and while the dial is warm, brush the solder around the groove as shown by Arrows **A** and **B,** figure 27-25. Be certain that the solder is below the enameled surface. Clean all soldering flux off with water and dry carefully with a clean, lintless cloth.

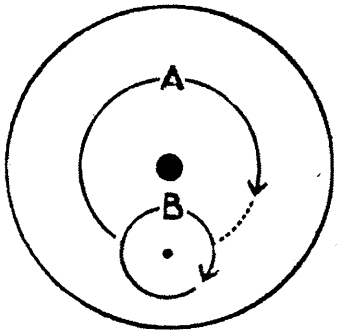

Fig. 27-25

note:

(No job sheets are associated with Lesson 27)