Master WATCHMAKING

SHOP TRAINING
JOB GUIDES

LESSON 15

Replacing Factory Balance Staffs

—

Sections 350 - 359

CHICAGO SCHOOL OF WATCHMAKING

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MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 15

Sections 350 to 359

REPLACING FACTORY BALANCE STAFFS

SEC. 350—The Balance Staff

The balance staff is sometimes referred to as the balance arbor. It is usually made of tempered steel. The balance wheel is attached to the balance staff and the pivots of the staff rotate in the balance jewel assemblies previously described.

Replacing a balance staff properly, together with the truing and poising of the balance wheel, affords an opportunity for the watchmaker to demonstrate his ability as a master workman. It is in this part of the watch that the unskilled workman most often delights in giving horrible examples of "botchwork." While you may come in contact with some of the "botchmaker's" art at other points—such as attempting to splice a mainspring in the center—it is in and around the balance and balance staff that such a person seems to delight in showing the **improper** methods of making repairs. In a great many instances, these errors have been made by using material that did not fit. Perhaps an attempt was made to substitute another make of balance staff. If the staff was too long or too short the balance cock was bent up or down. If the hub of the staff was too small for the balance, soft solder was used to fill in the gap. If the hole in the roller appeared to be too large for the balance staff it was remedied by using glue or cement to hold the roller in place. If the collet shoulder was too small the collet was pinched together, throwing the hairspring out of true and giving a poor holding for the collet. If the hole in the jewels appeared to be too small the pivot was ground or filed by hand until it entered the jewel hole. If the hairspring was too strong for the balance it was weighted down with an excess of washers or soft solder. These examples are not suppositions, but are actual cases as well as many other examples of what an ingenious "botchmaker" will do (when compelled to figure out a method to make repairs) when it would have been much easier to do the work properly in the first place, without danger of placing the watch in such condition that it could not run or be timed properly until practically rebuilt by a master watchmaker. Over a period of years there have been a great many attempts made to prevent poor quality watch repairing. Some states have licensing laws which are set up to protect the public against these practices. However, the one way to be certain that the public is adequately protected is by properly educating the watchmaker to make repairs correctly. The educator can only show the student the correct procedure. The student must practice until he is proficient; and at this time let me remind you again that proficiency can only be accomplished by practice. Do not attempt to make repairs on watches other than those you have for practice work. It is surprising what liberties some people will take with another person's watch rather than admit, even to themselves, that they do not know how to correct a very minor defect.

This lesson is difficult, not because the work is hard to understand but because to do balance staff work properly, you will also require instruction in truing and poising the balance. If a factory balance staff has a pivot that requires polishing or needs to be reduced slightly in diameter, it must be done on a watchmaker's lathe. There are times when the collet shoulder, balance shoulder, or roller table post require slight alterations, and these also require a watchmaker's lathe to complete properly. The purpose of this lesson is to teach you to replace a staff even though you have not had the instruction on lathe work. You must understand this part of staff replacement in order to understand when and how to make alterations with a lathe. This lesson is comparable to learning the letters of the alphabet. After you have mastered the alphabet you learn to combine these letters with each other to form simple

words. Then as your education advances your vocabulary increases and you can read or write with ease words which would be difficult if it were not for the proper procedure used to teach you the elementary principles of reading and writing.

SEC. 351—Types of Balance Staffs

Genuine factory staffs are, as a rule, accurately made and easily replaced. When we refer to any piece of watch material as being genuine we mean it was made by the factory which made the watch originally for the particular model of watch in which it is being placed. Any other material, although it would fit properly, is referred to as imitation material. Use genuine material whenever posible. Take your time. Remember the pivots on balance staffs are only two to three times as thick as a human hair and being made of tempered steel can be broken easily.

The dimensions of balance staffs vary for different models even in the same size and make of movement. One of the older American factories, now out of business, had eight models all of the same size, each using a balance staff of different dimensions. This is usually due to a change or refinement in the model. For this reason it is well for the beginner to note the general types of balance staffs used in the different makes and sizes of watches which he handles. Some hubs you will observe are thicker than others or are cut on a different angle. On still others the collet shoulders may vary in diameter for the same models or different models of the same size. In selecting a replacement for a broken staff you must be able to judge which particular number of an assortment is the one required. The final proof of your correct selection is if all parts fit properly and when replaced in the watch, there is the correct amount of sideshake and endshake.

When a watch comes to you for repairs it should always be tested to see if the balance staff is broken. Grasp the arm of the balance wheel with tweezers and endeavor to move it from side to side as in testing for sideshake. If the lower end of the staff can be moved from side to side and also up and down, the chances are that the lower pivot is broken although it may act in much the same manner if the lower jewel is broken. The same test is used for the upper pivot. Often when a watch receives a jar or a fall hard enough to break the balance staff, one or more of the balance jewels may be broken also, so do not rely on such a superficial examination. Only by removing the balance and examining the pivots and jewels with a double loupe can the watchmaker make a fair and intelligent estimate.

SEC. 352—Removing Hairspring

1. Remove the balance with hairspring from the watch
2. Remove hairspring

The hairspring is attached to the balance by means of a collet. The collet is a small circular split brass collar into which the inner end of the hairspring is pinned. The hole through the center of the collet is enough smaller in diameter than the collet shoulder on the staff that it will hold securely when forced into place, usually with a staking punch.

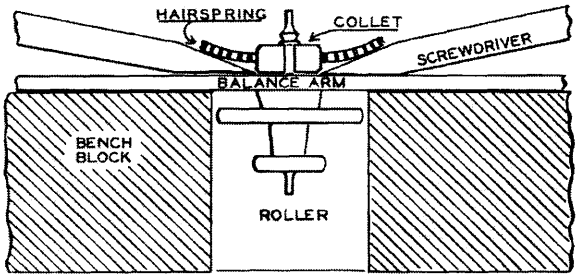


Fig. 15-1

Figure 15-1 illustrates the method of using two screwdrivers to remove the hairspring and collet. However, this method is dangerous as a slip of the screwdriver may cause irreparable damage to the hairspring. Figure 15-2 illustrates the method used in removing the collet by means of a small tool which can be made from a piece of mainspring. The arrow at A represents the twist given the tool in order to spread the collet enough to release the tension, and the arrow at B describes the turning of the collet around the collet shoulder, at the same time pulling slowly upward. The balance is held between the thumb and middle finger left hand while the right hand manipulates the tool. If the tool should slip, it would not be in position to damage the hairspring. Figure 15-3 illus-

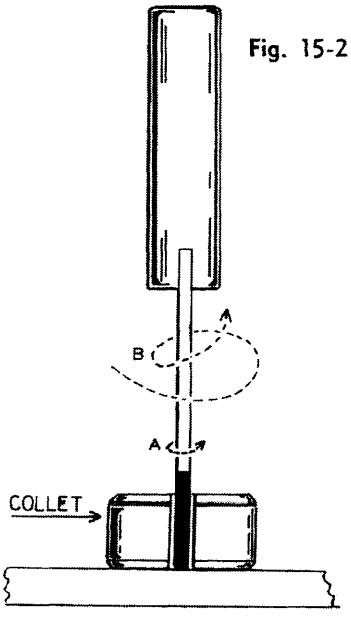
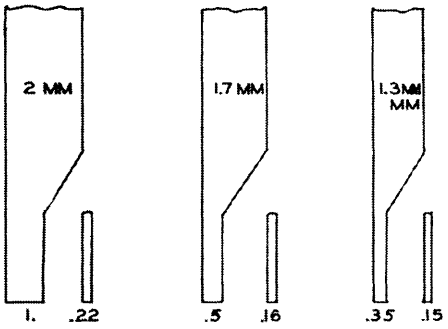


Fig. 15-2

Fig. 15-3



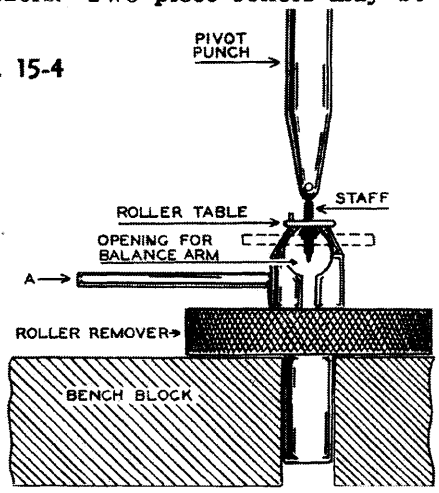
HAIRSPRING REMOVING TOOLS
MATERIAL--MAINSPRINGS
APPROXIMATE DIMENSIONS IN MM.

trates the dimensions of three of these tools which can be made from pieces of mainsprings, the thickness of which is given. As a mainspring is made from tempered steel, it is best to grind the material with a small grinding wheel or an oilstone.

SEC. 353—Removing the Roller Table

In the lesson on setting roller jewels, the three most common types of roller tables were described. There are many types of roller removers on the market, but the Rex roller remover described hereafter will do the job in most cases. Figure 15-4 illustrates the procedure. The roller remover is placed in the die plate of the staking tool or on a bench block. Holding the knurled edge of the roller remover between the thumb and forefinger, open the jaws of the tool by means of the small handle at A. Place the inverted balance over the jaws of the roller remover with the arm of the balance through the opening of the jaws. Carefully tighten the jaws until the roller table is in the position shown. Place the pivot punch, which is furnished with the tool, over the pivot and tap lightly with a brass hammer. This will loosen the roller table enough to be removed with the tweezers. Two piece rollers may be removed by the same method. However, the impulse roller will loosen first and will move up against the safety roller. Another light tap will loosen the safety roller, after which both rollers may be removed.

Fig. 15-4



SEC. 354—Removing the Balance Staff

Many watchmakers make a practice of driving out the balance staff without undercutting. This is done by placing the hub of the balance in a hole large enough to receive it without binding in the die plate of the staking tool, and after centering, punching it out with a pivot punch. This is poor practice and the work of inefficient workmen, for since the staff is made of tempered steel and the upper edge of the balance shoulder is riveted over the arm of the balance, this method has a tendency to enlarge the hole in the arm. In time the arm will be bent to such an extent that it will be difficult to true.

For all practical purposes, a balance staff can be removed from the wheel using a balance staff remover; however, the best method requires the use of the watchmaker's lathe. It will be beneficial to the student if we explain this method now and to demonstrate its value.

Figure 15-5 illustrates a balance staff with the roller removed but still riveted to the balance wheel. The staff in turn is held in a lathe chuck, the latter not illustrated. The staff, which is solid black, shows that portion which is left after part of the hub has been cut away. The dotted lines indicate the hub before it was cut away. Notice that it has been cut below the balance shoulder which is indicated by the dotted line. As you can see, this leaves a very thin rim over the balance arm. Figure 15-6 illustrates the method used to remove the remaining metal. The graver is sharpened to a long point and the cut is started at

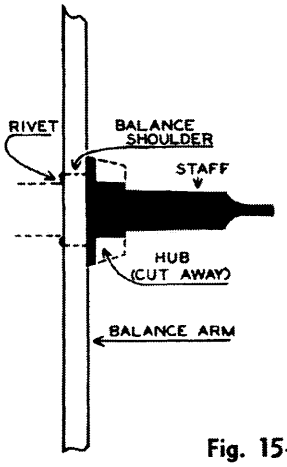


Fig. 15-5

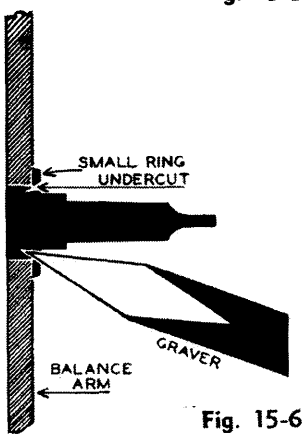


Fig. 15-6

the base of the previous cut. The instant the cutting edge of the graver reaches the balance arm the remaining metal will separate from the staff in the form of a small ring. The wheel can be ready removed over the roller post. As soon as the student has access to a watchmaker's lathe, he should use this method, as it is without a doubt the safest.

Figure 15-7 illustrates a staff remover which is used in conjunction with a staking tool. Remove staff as follows:

1. Select a hole in the die plate of the staking tool large enough to admit the hub of the staff. Make certain the hub does not fit too tightly; it must have a little side play.
2. Center hole selected with center punch.
3. Place balance and staff over hole in die plate.
4. Place staff remover over the arms of the balance and slip punch over upper end of balance staff.
5. Tighten knurled nut so that the balance arm will be held securely in place.
6. Strike punch A sharply with a brass hammer until the slight gap at C is closed. The staff will now be free of the balance arm.
7. Release nut and remove staff remover. The old staff should fall through the staking block. The methods described pertain to the removal of balance staffs which have a riveted edge to hold the balance wheel securely in place.

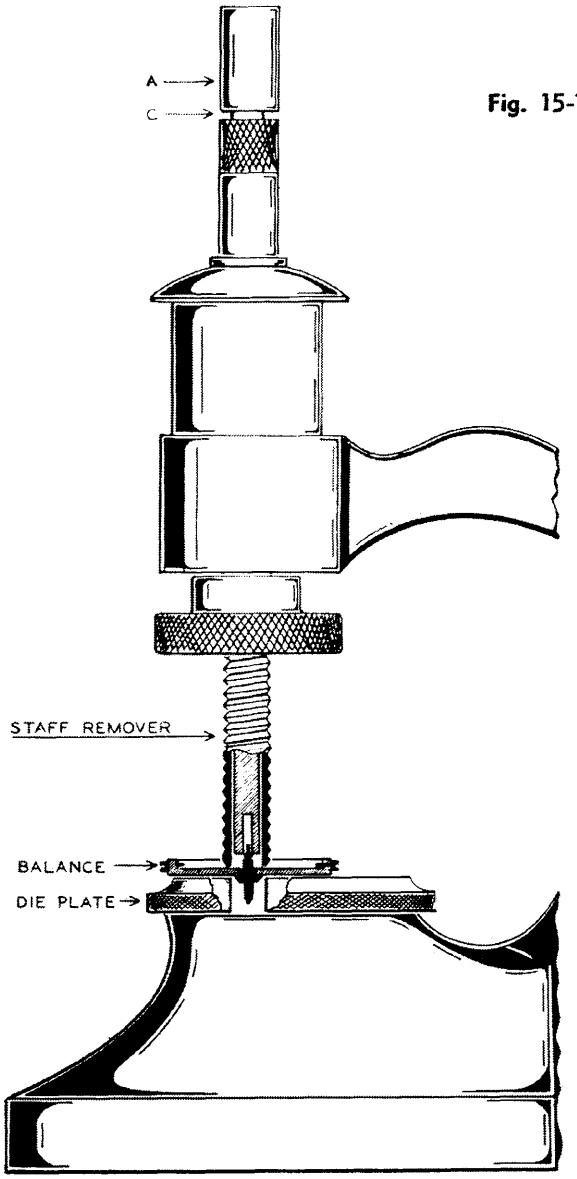


Fig. 15-7

The most common type of friction staff is used in some models of Waltham watches. It is quickly recognizable by the supposed hub of the balance staff which, if blue, is not part of the balance staff; moreover, the staff is a friction staff. The blued hub is riveted to the arm of the balance wheel and the staff is removed as in figure 15-8. It is an easy matter to remove the old staff and replace it without disturbing the truth or poise of the balance wheel.

1. Select hole in die plate, which will support the blue hub, yet one which is large enough to permit the friction staff to fall through.
2. Center hole and lock die plate in place.
3. Select pivot or cone shape punch and place over staff.
4. A few slight taps with a brass hammer will drive the staff out.

Another type of friction balance staff is found in the 992 Elinvar Hamilton watch. Figure 15-9 illustrates this staff which, when assembled, looks similar to the one piece 16s double roller staff. Therefore, a groove, A, figure 15-9, has been added as a mark of identification. The

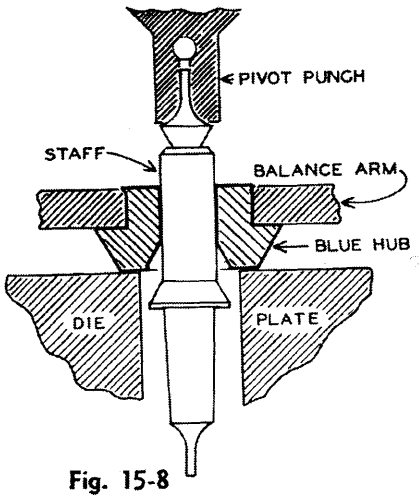


Fig. 15-8

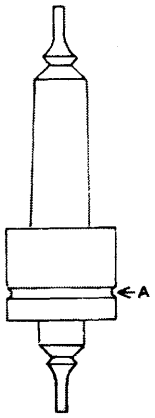


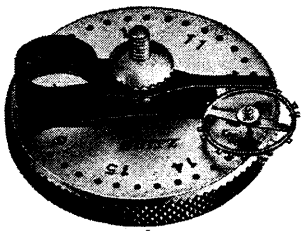
Fig. 15-9

procedure used in removing this type of balance staff is the same as the procedure used in removing the Waltham friction staff.

SEC. 355—Pivot Straightening

Many watchmakers endeavor to straighten pivots when they are bent rather than replace the staff. At times it is possible to straighten a pivot which is only slightly bent by placing it in a watchmaker's lathe and spinning true with the aid of a special pivot straightening tweezer. Figure 15-10 illustrates a pivot straightening

Fig. 15-10



device which is a part of the friction jewelling tool described in the previous lesson. The tool is a round metal plate set with 33 jewels from .08 mm to .16 mm, each hole ¼ of 100th larger than the preceding hole diameter. To straighten a bent pivot proceed as follows:

Example: Bent Pivot—diameter .10 mm

1. Place bent pivot in a hole of larger diameter, perhaps 12 or 13, according to the curve of the bent pivot.
2. Turn the balance carefully with a brush and press lightly on the high side of the balance with a piece of pegwood.
3. Repeat the above operation, each time placing the balance pivot in the next smaller hole until you reach hole 10. The moveable guide is used as an indicator and must not touch the rim of the balance.
4. The pivot should be polished in the lathe at this point.

If upon examination of the balance staff the pivot appears to be cut, the jewel is probably broken or cracked. After replacing the jewel, it is possible in some cases to regrind and polish the pivot satisfactorily, but in most cases it is better to treat a staff which has a cut pivot exactly as you would treat one with a broken pivot. When in doubt, put in a new staff; it is the mark of a fine workman.

Occasionally you will find a pivot which has become riveted on the end due to a jar or fall forcing the pivot directly against the cap jewel. When this occurs it is difficult to remove the pivot from the balance jewel and in some cases it is necessary to remove the cap jewel if possible and stone off the rivet with an oilstone slip. This will in all probability save breaking the hole jewel, but will require a new staff. Figure 15-11 gives the nomenclature of the ordinary balance staff. Throughout your career the proper names and dimensions of the parts of the staff will be referred to frequently.

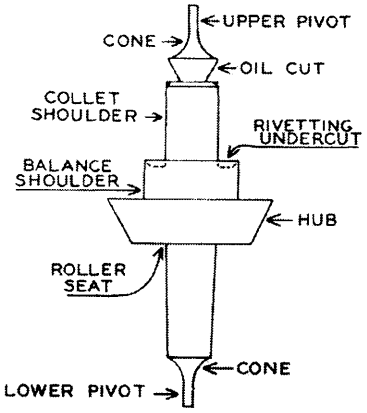


Fig. 15-11

SEC. 356—Matching the Balance Staff

In selecting a new balance staff for a watch it is necessary to know the make, size, and model and then match the staff accordingly. As stated previously, there may be several different models of watches in the same size of the same make. For instance, we may have a 16 size watch which requires a staff with a short hub and another model which may require a long hub, or we may have one with a large collet shoulder and another with a small collet shoulder. You will soon become familiar with the different models and eventually you will recognize the most common numbers by looking at the staff.

After you have selected a staff which you believe to be the correct model, make the following comparisons:

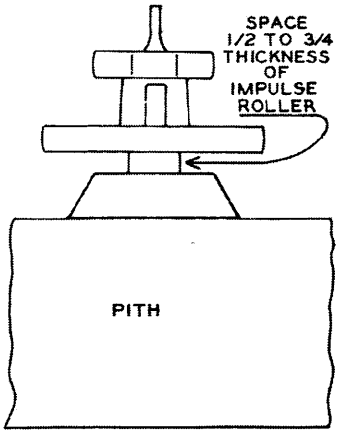


Fig. 15-12

1. Lay the old and new staff side by side and examine under a double loupe.
2. Test roller in position on roller post, figure 15-12. Roller should slip over post until the space between the hub and the impulse roller is approximately ½ to ¾ the thickness of the roller table.
3. Set balance in place on the balance seat. It should fit snugly without any side play. The shoulder should extend high enough above the arm of the balance to be riveted securely, figure 15-13.

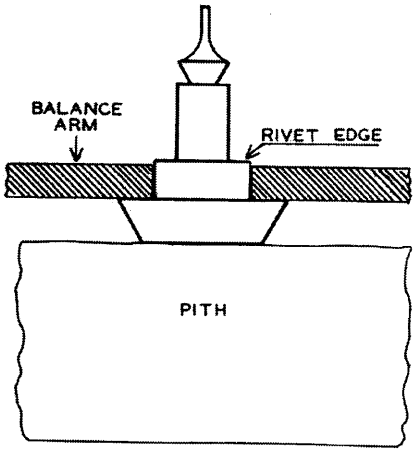


Fig. 15-13

4. Measure the collet shoulder of the old staff with your micrometer and compare with the diameter of the collet shoulder of the new staff. Measurements should be identical.
5. The length of the new staff should be identical with the one to be replaced. Allow about 0.25 mm for each broken pivot.
6. Compare pivot diameters by measuring with the micrometer.
7. Figure 15-14 illustrates another way to test the pivots for size. This test and all of the previous tests should be made before riveting the staff to the wheel. The pivot should enter the hole in the jewel and tip approximately 5 degrees to either side to allow the proper amount of sideshake. If the pivot is too large it will not tip from side to side and if it tips too far over, the pivot is too small for the hole in the jewel.
8. Place staff in lower jewel and replace balance cock. Test for endshake.
9. It is necessary at times to remove the cap jewels and ascertain if the pivot extends through the balance jewel far enough to reach the cap jewel without the cone of the pivot binding in the oilcup. A balance pivot

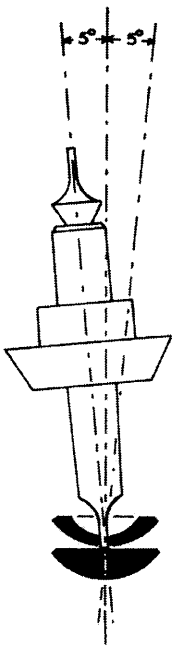


Fig. 15-14

should extend above the upper surface of the balance jewel approximately its own diameter.

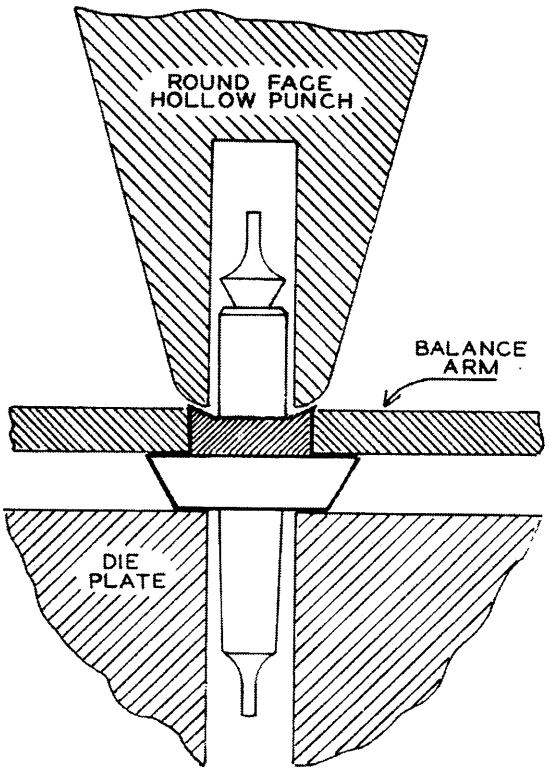


Fig. 15-15

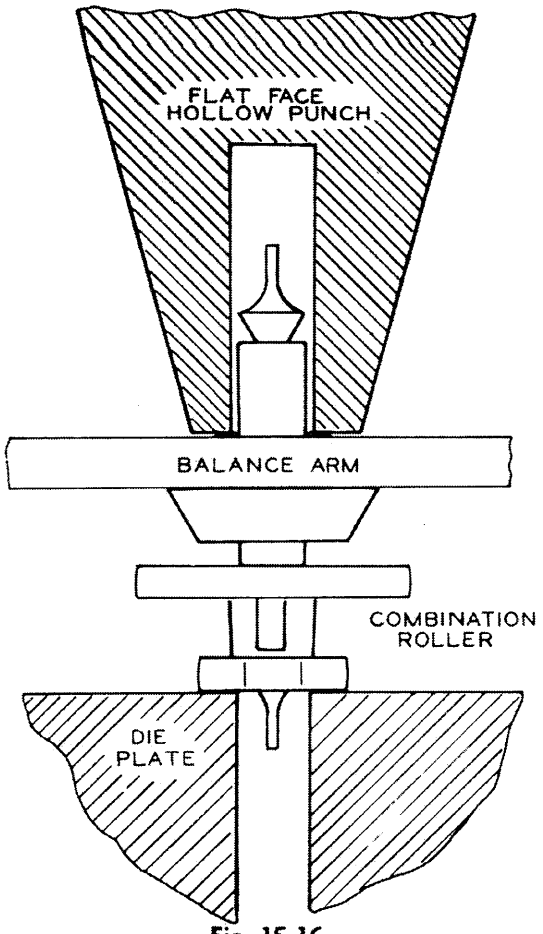


Fig. 15-16

SEC. 357—Riveting the Staff

Replacing a riveted balance staff is not a hard job, but each operation must be carefully executed, and the proper holes in the dieplate of the staking tool, together with the proper punches must be carefully selected.

1. Select hole in die plate which is slightly larger than the roller post.
2. Center this hole with centering punch.
3. Select a round face hollow punch and a flat face hollow punch which will slip over the collet shoulder freely. The round face hollow punch is used to spread the rivet and the flat face hollow punch will smooth and finish the previous operation. Figure 15-15 illustrates the staff in position in the die plate, the arm in position on the balance shoulder, and the round face hollow punch in position for riveting.
4. Tap the punch repeatedly with a brass hammer, at the same time turning the balance wheel slowly with the left forefinger. Do not use a crushing blow with the hammer. Many quick, light strokes of the hammer will do a better job.
5. Test by placing the thumb on the end of the riveting punch and exert as much downward pressure as possible. Try twisting the balance wheel around the staff. If no resistance is encountered the chances are that more riveting will be required. Rivet until secure, finishing with flat face hollow punch. This will require only several light taps with the brass hammer.

SEC. 358—Replacing the Roller

If the roller to be replaced is a combination roller, the previous operation requiring the use of the flat face hollow punch is repeated with the combination roller in place, figure 15-16. The roller jewel is usually placed at right angles to the arm of the balance wheel.

In replacing a single roller or the impulse roller from a two piece double roller proceed as follows:

1. Loosen die plate.
2. Select hole in die plate large enough to accommodate the roller jewel and the roller post when the roller is in place. The roller jewel should be placed at right angles to the balance arm.
3. Place flat face hollow punch in staking tool and carefully manipulate the staff and roller until they are directly under the punch. When you are certain that neither the staff or roller jewel will be damaged, tap punch with brass hammer until roller is tight against the seat, figure 15-17.

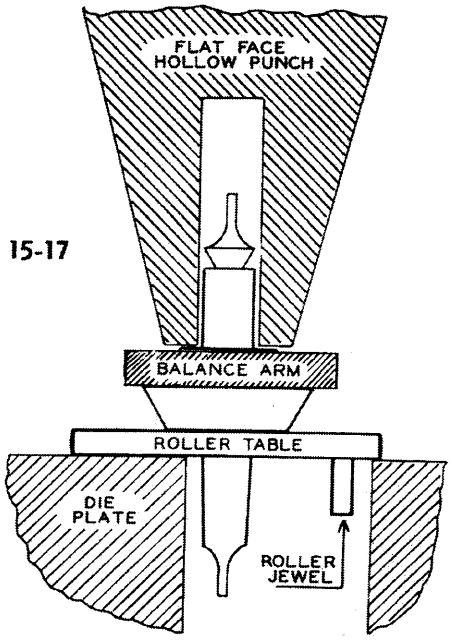


Fig. 15-17

SEC. 359—Replacing Friction Staffs

In selecting a friction staff, the same procedure is followed as in selecting a rivet type staff except that the post which enters the hub must just start into the opening in the hub. The difference must be made up by staking the staff in place.

1. Select a hollow stump which will allow the collet post of the staff to enter without binding.
2. Center stump with centering punch.
3. Drive staff into position using a round face hollow punch which fits freely over the roller post, figure 15-18.
4. Replace roller table as previously described.

It is not possible for the student to make the proper test of the balance wheel and staff in the movement at this time because we have not, as yet covered the truing of the balance in the flat.

Always make the following tests before replacing the hairspring:

1. Test endshake.
2. Balance wheel must clear pallet bridge, Dial Down.
3. Balance wheel must clear balance bridge and center wheel, Dial Up.

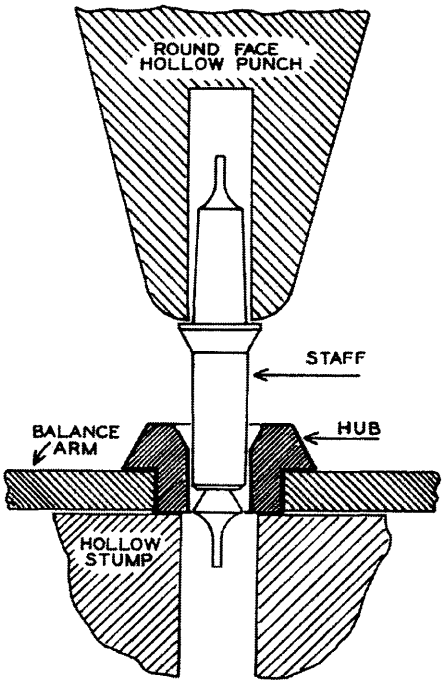


Fig. 15-18

4. Roller clears top of pallet fork, Dial Down.
5. With double roller, roller jewel must clear guard pin, Dial Down.

It is necessary to complete the next lesson on truing and poising before we can complete a satisfactory staff job.

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JOB SHEETS

UNIT	W 5
LESSON	15

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

W15-J1

REMOVING BALANCE STAFF: Rivetted Type

TOOLS, EQUIPMENT AND SUPPLIES:

Staking Tool - Brass Hammer - Tweezers - Staff Remover* - Lathe*
Graver* - Roller Remover - Hairspring Remover
*Dependent on staff removing procedure used.

PROCEDURE

HOW TO REMOVE RIVETTED TYPE STAFF	REFERENCE
1. Remove balance cock and balance assembly.	Les. 8
2. Remove the hairspring, using hairspring remover.	Sec. 352
3. Remove the roller, using a roller remover.	Sec. 353
4. Remove the staff from the wheel.	Sec. 354

NOTE: When removing a staff, either the rivet or the hub should be cut away before removing the staff. Balance staffs may be made of steel which is harder than the arm of the wheel. When rivetted, the rivet is larger than the hole in the wheel and if this enlarged part of the rivet is driven through the hole, it will spread the hole. However, many watchmakers do not recognize the importance of this procedure and use a staff remover and staking tool to drive out staffs. We will explain three procedures. If the hub of the balance staff is too hard to cut with a regular graver, it should be softened before cutting on the lathe. This is done by heating the staff to a light blue but it must be done without heating the wheel or the arms of the wheel. A good method is to place a brass rod, into which you have drilled a hole, over the end of the staff and then heat the brass rod. This will transmit the heat to the steel. (Les. 31 - Fig. 31-73 is similar)

A HOW TO CUT AWAY THE HUB OF THE STAFF (Prefered method)	Sec. 354
1. Draw temper to a light blue.	Les. 27 - Sec. 464
2. Chuck up staff on collet seat.	
3. Cut away hub of staff.	Sec. 354 - Fig. 15-5 & 15-6
4. Select flat face stump with hole slightly larger than rivetted shoulder of staff and place stump in staking frame, center to frame.	

5. Place wheel, bottom side up, on the stump.

6. Using staff removing punch, tap gently to remove staff.

B HOW TO CUT AWAY THE RIVET OF THE STAFF (Alternate method)

1. Draw temper to a light blue. Les. 27 - Sec. 464

2. Chuck up staff on roller seat.

3. Using graver sharpened to long slender taper, cut away the rivet.

4. Place wheel on die plate with hub in hole slightly larger than hub.

5. Fit staff remover and punch in staking frame, tap gently to drive out staff. Fig. 15-7

C HOW TO DRIVE OUT STAFF USING A STAFF REMOVER AND STAKING TOOL

1. Place wheel on die plate with hub in hole slightly larger than hub of staff. Fig. 15-7

2. Fit staff remover and punch in staking frame and tap gently to drive out staff.

3. Examine wheel carefully to determine if hole has spread, best indication of this is a burr formed arround the hole on the bottom side of the wheel. The hole can not be closed but the burr can be smoothed out by laying wheel bottom side down on a flat solid stump and tap gently with flat face solid punch in size larger than the hole in the wheel. If burr is not removed there is a good chance you will not be able to true the balance wheel after staffing.

FOR COMPLETE PROCEDURE FOR REMOVING AND REPLACING STAFFS SEE JOB GUIDE SHEETS W17-J1 through W17-J3

REMOVING BALANCE STAFF WITH SULPHURIC ACID

EQUIPMENT AND SUPPLIES:

Glass jar with ground glass cover or wide mouth bottle with rubber stopper - Sulphuric acid (either chemically or commercially pure) usually obtainable at your druggist - Distilled water - Small brass or copper wire.

INTRODUCTORY INFORMATION:

Many modern watches use balance wheels which contain no steel. The balance staff which is made of steel can be removed without damage to the balance wheel by destroying it with a solution of sulphuric acid and water. The time required is generally from 4 to 10 hours depending upon the solution. The balance wheel will not be changed in any way using this method. However the solution must be handled very carefully as it can be dangerous, and the fumes will have a tendency to rust other steel tools or items in its vicinity. It should be kept in a glass or porcelain container in a safe place. Ordinary baking soda is used to neutralize the solution should it spill.

PROCEDURE:

HOW TO REMOVE A BALANCE STAFF USING A SULPHURIC ACID SOLUTION

1. Place 4 parts of cold distilled water into container.

2. Pour slowly 1 part of sulphuric acid into water.
   Example: 2 oz. distilled water.
   $\frac{1}{2}$ oz. sulphuric acid.

3. Remove hairspring.

4. Remove roller table.

5. Test balance wheel with small magnet. If wheel rim or arm is not attracted by magnet it is safe to use this method. NOTE: Do not touch staff with magnet as the staff is steel and will be attracted to magnet.

6. String balance on small brass or copper wire.

7. Immerse balance in solution and replace cover over wire. The wire will keep cover loose enough so fumes may escape.

OVER

8. When staff is dissolved, removed balance wheel from the solution and rinse thoroughly under running water.

9. Dry balance wheel.

NOTE: This acid solution can be used until it starts to discolor the balance wheel. It should be kept in a safe cool place. When disposing of the solution make certain that plenty of water is used when flushing it away.

UNIT	5
LESSON	15

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

W15 - J3

HOW TO REPLACE AN INCABLOC OR SHOCK-RESIST ROLLER WITH RECESSED GUARD ROLLER.

TOOLS AND EQUIPMENT.

Staking Set. Hollow Stump. Special Incabloc or Shock-Resist Punch. Brass Hammer.

PROCEDURE.

1. Place balance wheel over hollow stump with roller shoulder up.
2. Place roller table on staff with roller jewel at right angles to the balance arm.
3. Set punch in recess of guard roller and press or tap into place.