Master WATCHMAKING

Lesson 12

FACTORY SET TRAIN JEWELS

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

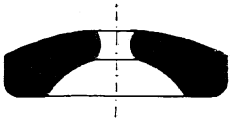
INTRODUCTORY INFORMATION

In previous lessons the part played by jewels in watches was briefly touched on. In the next three lessons you will study jewels in more detail with emphasis on their use and replacement.

Most jewels are used as bearings and these are of two main types: 1. bezel or burnished-in jewels, which have beveled edges, and 2. friction jewels, which have straight sides.

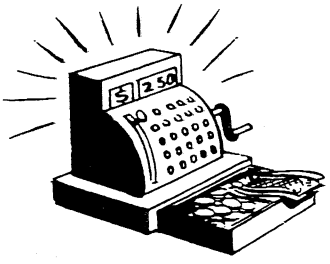
1. A Bezel or Burnished-in Jewel

Before 1930, bearing jewels were of the first type. In Lessons 12 and 13 you will note a variety of settings have been devised for these jewels. Many of them are still in use. However, it is not always possible to get a replacement jewel setting because the manufacturer is now out of business. In such cases, you must make your own replacement setting, which requires considerable work, or do as the modern repairman does -- replace the jewel with a friction jewel or friction bushing and jewel.



2. A Friction Jewel

Both watch manufacturers and repairmen now make extensive use of friction jewels because they have proved to be very serviceable and are much easier to install in plates or bridges. Friction jeweling will be discussed in detail in Lesson 14.



An average charge for replacing broken jewels is from $2.50 to $3.50. It is usual to add $1.00 to $1.50 more for center jewels.

The cost of jewels varies with the type: Train, balance hole and cap jewels in settings run from 50¢ up, depending on their quality and manufacturer. Friction jewels cost from 30¢ to 50¢.

Many material supply houses will fit friction jewels individually to plates or bridges as required where the repairman lacks friction jeweling equipment to do the job himself. A labor charge is added to the cost of the jewel for this service.

In setting jewels of any type, pay particular attention to which side of the plate or setting is used. The top side of a plate or setting is the side toward you as you look at a watch that has not been disassembled. The under side is the side nearest the wheels.

KEY POINTS OF LESSON ASSIGNMENTS 41, 42:

- Why jewels are used in a watch.
- The types of jewels.
- How to test sideshake and endshake.
- How to measure the hole in a jewel.
- Different types of train jewel settings.
- How to use a staking tool.
- How to burnish-in jewels.

ASSIGNMENT NO. 41: Study Sections 285 through 294. Read Sections 303 and 304.

Study Questions:

1. What is the purpose of jewels?
2. What types of jewels are used in the average watch?
3. Why is it important that there be endshake and sideshake in train jewels?
4. What determines the amount of sideshake?
5. How are jewel holes measured?

Recommended Practice:

1. Examine various watches for number, type and location of jewels.
2. Make the tests for sideshake and endshake suggested in Sections 291 and 292.

ASSIGNMENT NO. 42: Study Sections 295 through 302.
Read Tools and Materials of the Trade, pages 17 through 21.

1. What are the differences in the train jewel settings discussed in this assignment?
2. How is a train jewel setting held by screws replaced?
3. What is a staking tool? What are some of its uses?
4. What can you do if a replacement setting is not available?

Supplementary Information:

Sections 295 and 297: It is sometimes possible to get replacement settings for this type if the watch is of current manufacture. When ordering, you should give all measurements and also include old settings as a sample. If not available, make a new setting or replace it with a friction bushing and jewel. See Job Sheet L14-J4 for procedure.

Section 299: This type of setting is generally found in older watches and usually cannot be replaced with a factory replacement. It is necessary to either make a new setting or replace it with a friction bushing and jewel. See procedure in Job Sheet L14-J5.

Section 300: This type of setting is still being used, but it is not always possible to get a replacement setting. In such cases, the common practice is to friction jewel the old bushing (Sec. 335, Lesson 14). Also see Job Sheet L14-J6.

Section 301: This type of jewel is no longer in common use. It can be replaced with a friction jewel or a friction bushing and friction jewel. See procedure in Job Sheets L14-J4, L14-J6, L14-J7, and L14-J8.

Recommended Practice:

Remove and replace an upper train jewel and setting, preferably one held by screws. Follow this general procedure:

a. Let down power of mainspring.
b. Remove balance bridge and balance wheel and lay in safe place, bridge down and wheel up.
c. Remove pallet bridge and pallet.
d. Remove train bridge.
e. Remove setting from bridge and follow steps in Section 296.
f. Replace train jewel and assemble movement in this order: Train wheels and train bridge. Pallet and pallet bridge. Balance and balance bridge.

REQUIREMENT: Answer Test Questions for Lesson 12 and send in for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 12

Sections 285 to 304

FACTORY SET TRAIN JEWELS

SEC. 285

By now you should be well acquainted with the majority of terms used in watchmaking. Additional tools required in most cases will relate to the lesson at hand. From now on your course becomes more intense. We will present each lesson in a more concise form.

SEC. 286 — Purpose of the Jewels

The purpose of jewels in watches is a mystery to most people. They may be able to talk glibly of "17 jeweled" watches or perhaps of a full jeweled timepiece but, as a general rule, they have no idea where the jewels are located nor what purpose they serve.

SEC. 287 — Jewels as Bearings

Bearings for pivots in the earlier watches were holes drilled in the plates or bridges with metal bushings. Such is the method used for train pivots in some grades of movements manufactured today. Some of the modern watches use metal bushings which are fitted friction tight into the plates or bridges. These bushings can be easily replaced when the pivot holes are worn. When bushings are used, there is more friction and wear as compared with the modern bearings of stone or the so-called "jewels" of the watch. Occasionally students have added fourteen extra jewels to the train and escapement of a seven jeweled movement, thus making it into a twenty-one jeweled timepiece, and invariably were surprised to find that it was necessary to replace the original mainspring with a much weaker one in order to get the proper motion, this being due to the reduced amount of friction in the train and escapement.

Sapphires, rubies and garnets are the most common stones used to make jewels. Cap jewels in some of the older models of high grade watches and chronometers were made of diamond chips and while these are really diamonds, their intrinsic value is not as great as many are inclined to imagine although they serve the purpose as well as an expensive, brilliant cut diamond. Diamonds are not used in the average watch manufactured today.

For average purposes, synthetic sapphires and rubies make the best jewels for bearings in watches. Garnets are usually used in the cheaper grades of watch movements. It is not necessary that watchmakers attempt to manufacture their own jewels.

SEC. 288 — 7 Jeweled to 23 Jeweled Watches

Seven is the minimum number of jewels in most standard American watch movements. These jewels are as follows: one upper cap jewel, one upper balance hole jewel, one lower balance hole jewel, one lower cap jewel, two pallet stones and one jewel pin or roller jewel. A 15-jeweled watch has an additional four pairs of plate jewels, one each for the upper and lower pivot of the pallet arbor, one for each end of the third, fourth and escape pinions. These jewels are named according to the position they occupy. Thus we have the upper 3rd jewel, 4th jewel, upper escape jewel and upper pallet arbor jewel. On the pillar plate, the opposite jewels are the lower 3rd jewel, lower 4th jewel, lower escape jewel and lower pallet arbor jewel.

By adding an upper and lower center jewel, the total number of jewels is 17. A pair of cap jewels added to the ends of the pallet arbor or the escape pinion would make a total of 19 jewels. A pair of cap jewels added to both the pallet arbor and escape pinion will make a total of 21 jewels. A 23-jewel watch has an additional pair of jewels in the mainspring barrel or at the ends of the arbor (see Lesson 6).

In some watches, jewels are not always matched in pairs and it is quite common to find movements with 6, 9, 11, 16, 17 or 19 jewels. There are also other combinations with which you will become familiar as you progress with your repairing.

SEC. 289 — Types of Jewels

The following list of jewels are used in the average watch:

Train jewels or plate jewels
Balance hole jewels
Balance cap jewels or end stones
Pallet stones
Roller jewel or jewel pin

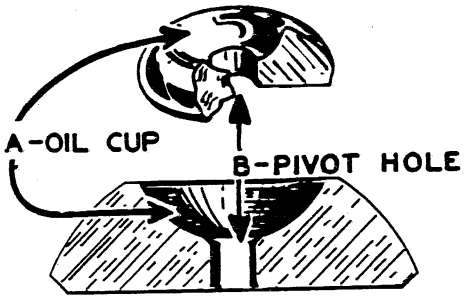


FIG. 12-1

SEC. 290—Train or Plate Jewels

Figure 12–1 illustrates a drawing of a train jewel with a section removed, and a cross-section of this same jewel. A is the oil cup; B is the pivot hole.

Figure 12–2 illustrates a square shoulder pivot used in conjunction with a train jewel. These square shoulder pivots are highly polished and must have sideshake and endshake in order that they may rotate freely.

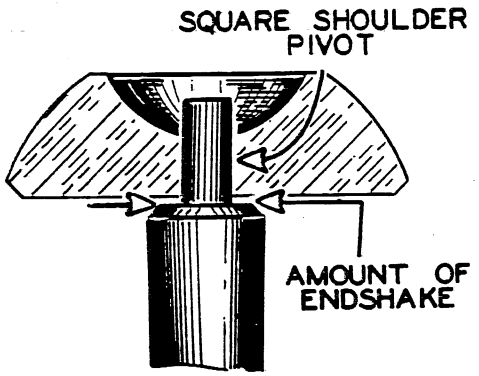


FIG. 12-2

SEC. 291—Sideshake

Sideshake is the freedom between the sides of the square shoulder pivot and the hole in the jewels. The amount of sideshake varies according to the diameter of the pivot. Example: The amount of sideshake in a pallet arbor is less than that in a center wheel. Sideshake is hardly perceptible. It is tested by grasping the pinion with tweezers and endeavoring to move it from side to side. It may be perceptible with your double loupe. In better grade watches, the sideshake can scarcely be seen or felt. If you find an excessive amount of sideshake, there is a possibility that the jewel is broken or that the pivot is cut.

SEC. 292—Endshake

Endshake is tested with the power off. Grasp the pinion with your tweezers and endeavor to move it up and down. This endshake is perceptible on all wheels and pinions including the balance. The space between the face of the train jewel and the shoulder on the pivot, figure 12–2, is the amount of endshake.

To get an idea of the proper amount of both endshake and sideshake, test as many wheels and pinions in different watches as possible.

SEC. 293—Measuring the Hole in a Jewel

Holes in train jewels or balance jewels can be measured by a jewel hole gauge. By slipping the fine needle point in the hole of the jewel and pressing the face of the jewel against the stop, the indicator will register the hole size on the index, figure 12–3. This reading is in hundredths of a mm. Diameters of pivots are measured with the metric micrometer.

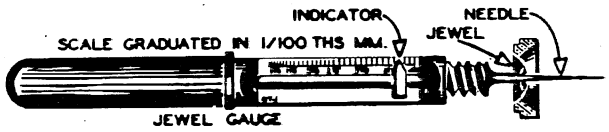


FIG. 12-3

SEC. 294—Determining the Amount of Sideshake by Measurements

Procedure:

1. Measure pivot with metric micrometer and mark down the reading.
2. To ascertain the size of hole in jewel which will allow the proper amount of sideshake with the pivot you have measured, refer to the following chart:

Diameter of Pivots in Hundredths of a mm.	Size of Hole in Hundredths of a mm.
.10 mm.	.11 mm.
.11 "	.12 "
.12 "	.13 "
.13 "	.14 "
.14 "	.16 "
.15 "	.17 "
.16 "	.18 "
.17 "	.19 "
.18 "	.20 "
.19 "	.21 "
.20 "	.22 "
.21 "	.23 "
.22 "	.24 "
.23 "	.25 "
.24 "	.26 "
.25 "	.27 "
.26 "	.28 "
.27 "	.29 "
.28 "	.30 "
.29 "	.31 "
.30 "	.32 "
.31 "	.33 "
.32 "	.34 "
.33 "	.35 "
.34 "	.36 "

.35	"	.37	"
.36	"	.38	"
.37	"	.39	"
.38	"	.40	"
.39	"	.41	"
.40	"	.42	"

SEC. 295—Train Jewels in Setting

Train jewels in American watches are usually set in metal bushings made of brass, oreide, or low carat gold. These settings are usually held in place by jewel screws. Figure 12–4 shows this type of setting: A is the plate, B is the setting, C is the train jewel and D the jewel screws.

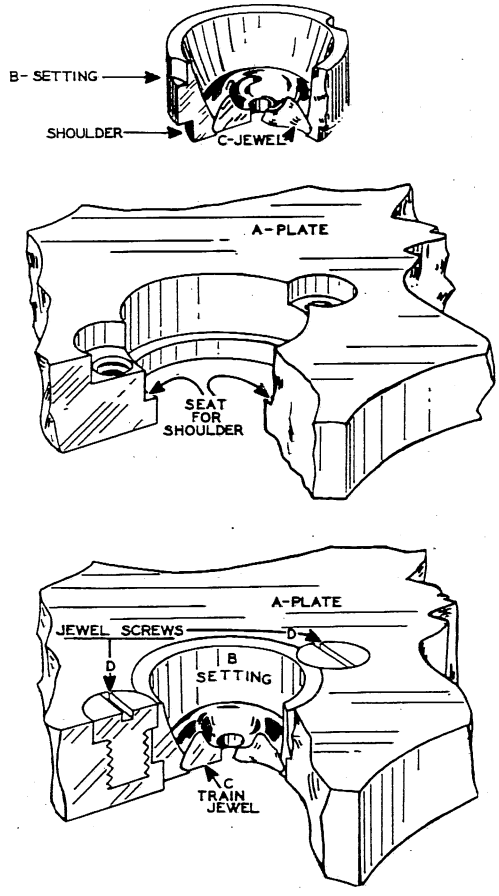


FIG. 12-4

SEC. 296—Replacing Factory Train Jewel

Replace a train jewel setting held by jewel screws as follows:

1. Remove jewel screws.
2. Place plate or bridge over hole in bench block. Be sure hole in bench block is slightly larger than the setting.
3. Force setting out with jewel pusher.
4. Measure pivot with micrometer.
5. Compare measurement with chart, Section 294.
6. Select the proper hole size.

In a shop, you would then select from your stock of material a jewel in a setting with the proper hole diameter which corresponds to the name and size of the watch for which the jewel replacement is to be made.

Without a stock of train jewels, you would order from your supply house as follows:

1 Train Jewel in setting
Name of Watch:
Size of Watch:
Description of jewel (whether upper or lower—center, third, fourth, escape or pallet):
Size of hole desired in hundredths of a mm.:
Send sample whenever possible.

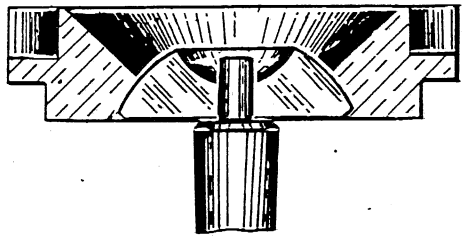


FIG. 12-5

When you have selected the proper jewel for replacement, be sure to test the jewel on the pivot before replacing in watch. The pivot in figure 12–5 fits a little snugly and, in all probability, would cause trouble.

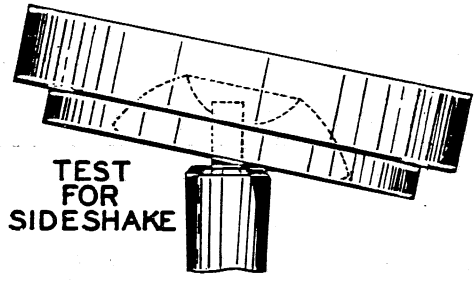


FIG. 12-6

In figure 12–6, the jewel setting is tipped. This shows a slight amount of freedom, which is actually sideshake, between the pivot and hole of the jewel.

The depth of the shoulder determines the amount of endshake and must therefore be correct.

Figure 12–7 illustrates a method of determining whether or not the shoulder on the new setting is exactly the same as the shoulder on the old setting. Figure 12–8 shows the old setting in comparison with one in which the shoulder is cut too deep. Figure 12–9 illustrates too shallow a shoulder. The only way a student could rectify these errors would be to return the setting to his supply house with complete instructions, thus enabling them to make the corrections. When you have progressed into your lathe work, you will learn how to correct a setting that does not conform to your requirements.

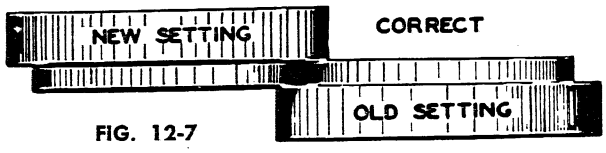


FIG. 12-7

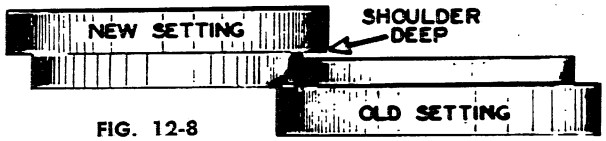


FIG. 12-8

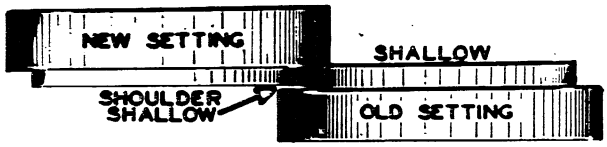


FIG. 12-9

SEC. 297—Raised Setting

Figure 12–10 shows sectional drawing of a train jewel set in a raised setting:

A—Plate
B—Setting
C—Jewel
D—Jewel Screws

Notice that the jewel screws are not set below the surface of the plate. A portion of the setting slightly

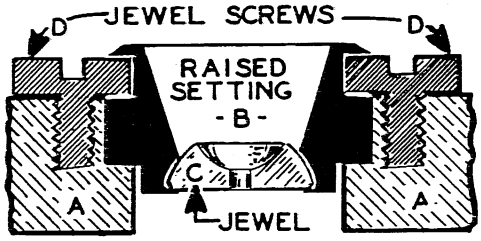


FIG. 12-10

larger than the diameter of the jewel screw is milled out. The portion of the jewel screw head which overlaps the setting keeps this setting in place.

SEC. 298—The Staking Tool

From now on your work will necessitate the use of a staking tool, not only for taking out and replacing jewels but for other jobs such as tightening roller tables, closing holes, endshaking of trains, closing pivot holes in non-jeweled watches, driving out staffs, pinions and arbors, staking balance train, wheels on pinions, driving on rollers, closing hour and minute hands, pressing on hairspring collets, indenting the safety pinion staffs, and many other jobs.

There are many manufacturers of staking tools. A staking tool is comprised of a frame similar to cross section figure 12–11 and an assortment of punches and stumps. Staking tools come with as few as 24 punches and 4 stumps and as many as 133 punches and 25 stumps. In the better grade staking tools the punches can be inverted through a hole in the die plate and used as a stump. This is a distinct advantage, and if possible, is the type of staking tool you should own. There are staking tools with a friction jewelling tool which can be readily attached. In modern shop work we recommend specific tools for specific purposes. In a later lesson you will be shown an excellent friction jewelling device which can be used for many jobs other than friction jewelling. In our opinion, it is a definite advantage to have these two tools as separate units.

As stated before, there are a number of staking tool punches and stumps but it is not necessary for you to learn the purpose of these in one lesson. In fact, the student acquires a more thorough knowledge of the staking tool by learning the use of the different punches and stumps in the regular order of his lessons.

The top of the frame, figure 12–11, is bored to receive any one of the punches and to hold that punch upright and at right angles to the hardened steel die. This die has a series of graduated holes drilled at such a distance from the center that it is possible to bring each hole directly under any punch that may be inserted in the punch guide. The die may be locked in

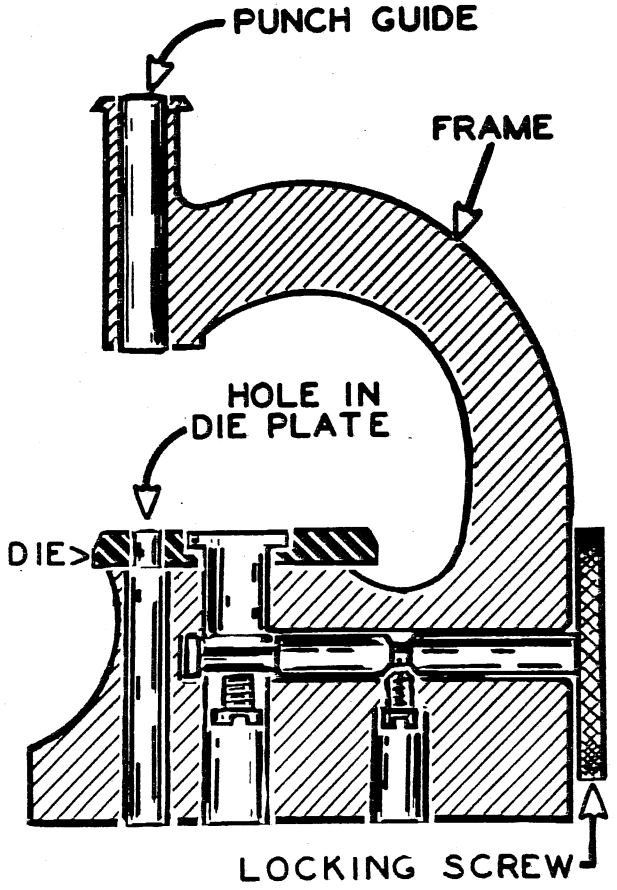


FIG. 12-11

position by means of the locking screw. On the upper part of the frame in the better grades of staking tools is a sustaining device which, with slight friction, holds the punch at any height.

With every staking tool there is a Centering Punch which is used solely for the centering of holes in the dieplate. Figure 12–12 shows the shape of the lower end of this punch and because the upper end is of a design found on none of the other punches, you should have no difficulty in identifying it. If you wish to center any particular hole, the die is unlocked by turning the locking screw and the die revolved until the hole desired is directly under the point of the centering punch. Now press the point of the centering punch firmly into the hole with the die still loose and while holding it there, lock in position with locking screw.

Do not use the centering punch for any other purpose as its needle-like point is easily ruined and rendered unfit for centering small holes.

The four shapes of punches used most are the flat face solid punch, round face solid punch, flat face hollow punch, and round face hollow punch. Figure 12–12 illustrates the following punches: A—centering punch, B—flat face solid punch, C—round face solid punch, D—flat face hollow punch, E—round face hollow punch and F—taper mouth closing punch. Examine your set and identify these punches. Notice there is a greater variety of punches B, C, D and E than of any other.

Having identified these punches, practice centering the different holes in your staking tool die.

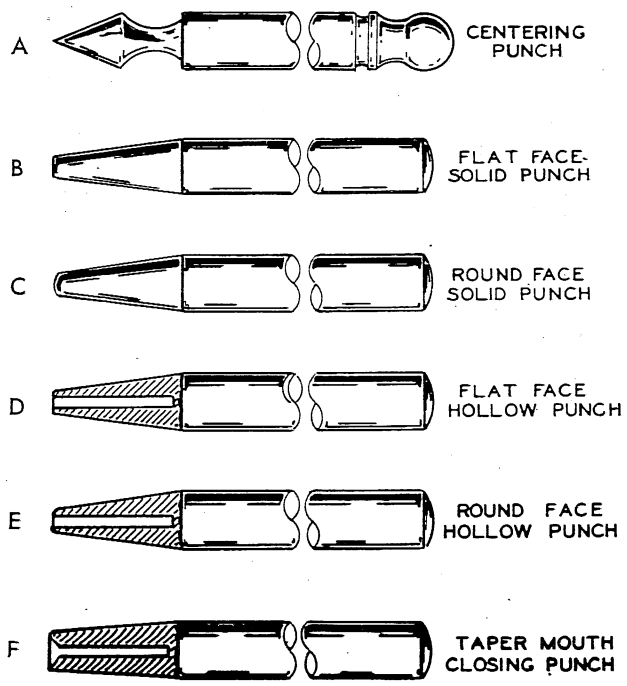
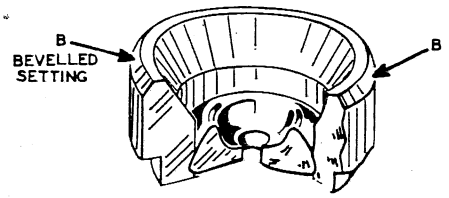
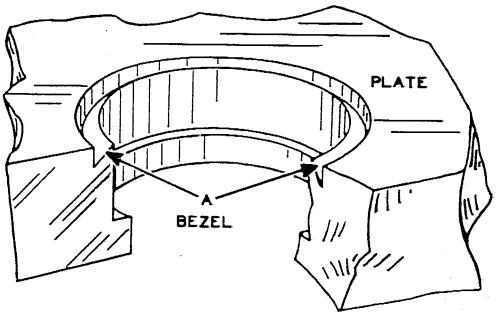


FIG. 12-12





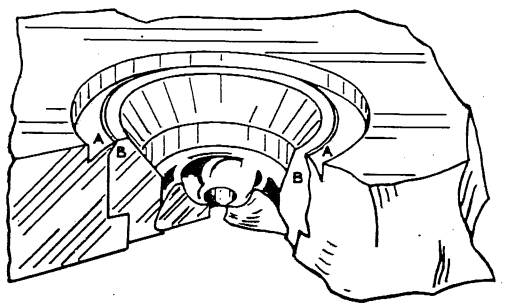


FIG. 12-13

SEC. 299 — Another Type of Train Jewel Setting

The type of jewel setting shown in figure 12–13 is generally found in the pillar plate of some American watches and is held in its place in the plate without the use of jewel screws. The opening in the plate, instead of having recessed places for screws, has a bezel around the edge as shown at A. The upper edge of the jewel setting is beveled slightly, see B, figure 12–13. After the setting has been pressed into position in the plate, the bezel A is burnished tightly over the edge of the setting B thus holding it in place without the use of screws.

To remove a jewel setting just described, select a hole in the staking die that is somewhat larger than the full diameter of the jewel setting and center it using the centering punch. Select a flat faced solid punch, the face of which is smaller than the inner diameter of the jewel setting. Place the pillar plate over the hole in the die with the beveled side of the jewel toward the die. Bring the flat face of the punch down in contact with the jewel setting as shown in figure 12–14, adjusting the watch plate so the punch is in the center of the jewel setting. Hold the punch firmly against the setting and strike the upper end of the

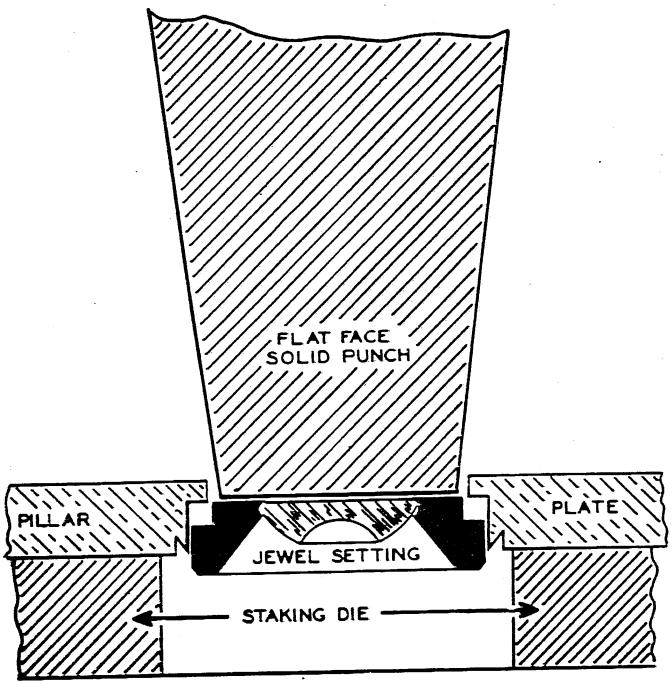


FIG. 12-14

punch a light sharp blow with a brass staking tool hammer. Do not strike too hard a blow and be sure that your punch is not large enough to bind in the opening in the plate as this may injure the shoulder. It is only necessary to drive the setting out of the plate and it is better to use a series of light blows than one heavy one. Never use a steel hammer on your punches. As the setting is driven out of the plate, it forces out the beveled edge of the opening to nearly its original shape.

To replace this type of train jewel setting, proceed as follows:

1. Measure pivot.
2. Compare measurement with chart, Section 294.
3. Select jewel from stock corresponding to name and size of watch.
4. Try pivot for sideshake (figure 12–6).
5. Measure diameter of setting and compare diameter with old setting, using micrometer.
6. Compare shoulders (figure 12–7).
7. Place pillar plate on staking die.
8. Press setting in place with flat face solid punch which is slightly smaller in diameter than the bezel (A—figure 12–15).
9. Select flat face solid punch slightly larger than the diameter of setting and tap slightly. This will force edge of bezel over jewel setting (B—figure 12–15).
10. Test jewel setting with pegwood. It must be tight.
11. It is good practice to run a burnisher around edge of bezel (figure 12–20).

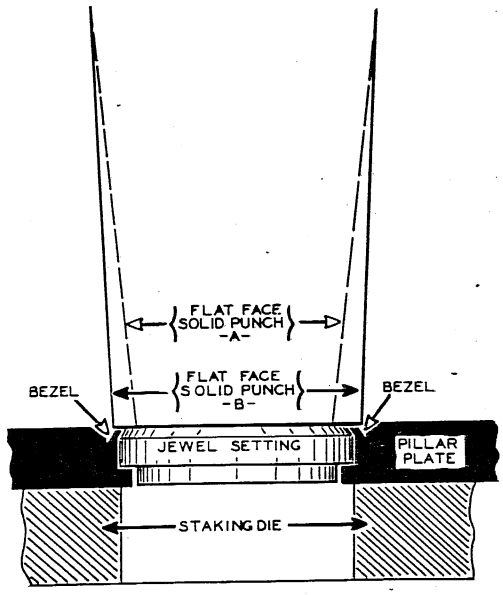


FIG. 12-15

SEC. 300—Friction Train Jewel Setting

It has been the custom of a few watch manufacturers to make the bearings in the plates of their seven jeweled movements in the form of metal bushings which are pressed into openings in the plate and held in place by friction.

Much the same plan has been adopted in fitting jewels in some watches. Figure 12–16 shows a drawing of a friction train jewel setting of this type. Here the opening in the plate has no shoulder and the settings are of such diameter that they are held in place friction tight. The edges of the settings are usually beveled.

To replace a broken jewel and its setting, it is only necessary to drive out the old one using a flat face solid punch as illustrated in figure 12–16. The new setting is replaced from the inner side of the bridge or plate, the beveled edge serving as a guide while placing it in position. If there is too much endshake, the jewel can be driven in enough to make the correct amount.

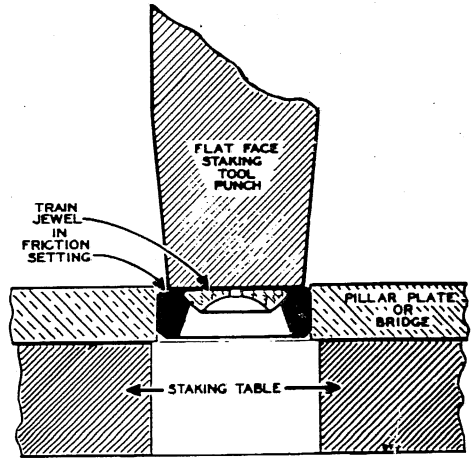


FIG. 12-16

If not enough endshake, drive the jewel a trifle toward the outside.

There are times when the plate or bridge will not rest solidly upon the staking die. If such is the case, a flat face stump can be placed in the largest hole in the die plate which has been previously centered. In this manner, the portion of the bridge or plate surrounding the jewel setting can be properly supported.

The cost of a complete assortment of train jewels in settings for all the different makes of watch movements is so great that only the largest shops attempt to carry them. It is best for the beginner to follow the plan adopted by the great majority of watchmakers and order such jewels as they are needed. Should a watch be brought to you for repairs and you find a broken lower 3rd jewel, order a new one specifying on your order the make and size of movement for which it is intended, which particular jewel it is and also be sure to send the old jewel setting together with the wheel and pinion on which the new one is to be fitted. In this way you will be able to secure a new jewel with correct sized hole, thickness and height.

Thus if you were to order a lower third jewel for a Hamilton 989:

"One only lower 3rd jewel Hamilton 989. Hole Diameter (24), sample enclosed."

In a future lesson on lathe work, you will be shown how with a small investment and at a considerable saving jewels in blank settings can be fitted to most style watches.

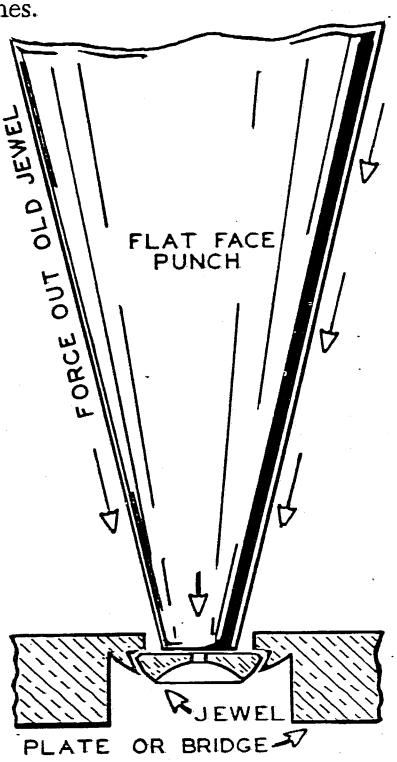


FIG. 12-17

SEC. 301 — Jewels Set in the Plate

You will find in some watch movements, especially those made in Switzerland, jewels set directly in the bridge or plate without the use of bushings or settings, hence the name "plate jewel." In figure 12–17 is shown a cross section of a Swiss type of jewel set directly in the plate. The seat for the jewel is cut directly in the plate as shown in figure 12–17, then a bezel is cut around the opening in order to have a thin edge to burnish over the jewel. Force out a broken jewel with a flat face staking punch.

After the jewel has been pushed out of the seat the edges of the bezel in most cases must be opened a little further until they are straight up and down. This is done with a bezel opener. Bezel openers usually come in sets of three which will cover practically all sizes of jewel bezels found in Swiss wrist and bracelet watches and larger sizes of movements, figure 12–18.

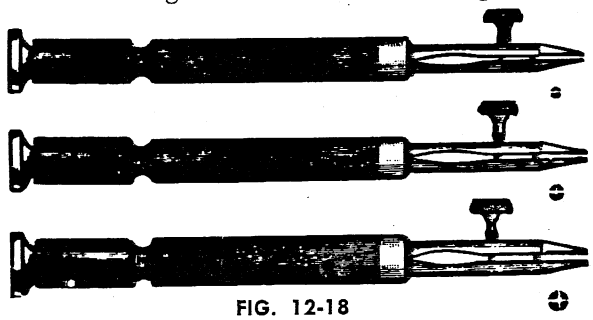


FIG. 12-18

In using the bezel opener, select one on which the jaws when closed will go easily into the old jewel seat and then gradually open the jaws by turning the screw, figure 12–19. Hold the opener much as you

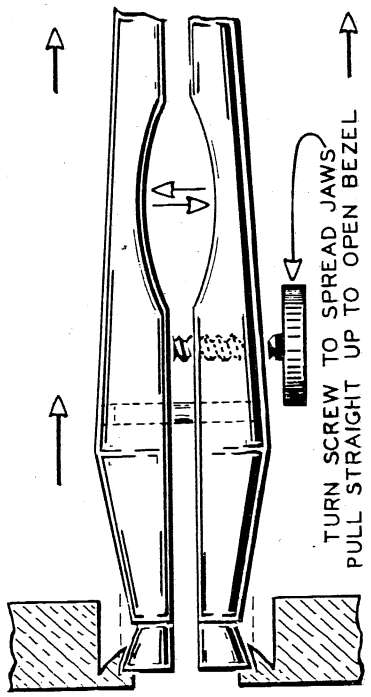


FIG. 12-19

would a screw driver and as the jaws come in contact with the bezel, twist it back and forth between the thumb and fingers keeping it as nearly upright as possible. As you do this, at the same time tightening the tension slightly by means of the screw, the bezel will gradually open until the sides of the seat are nearly straight.

Do not attempt to open the bezel by spreading the jaws of the bezel opener the full amount at one time but rather by applying a little tension after each trial. Be careful not to open the bezel too much. It is better to have the opening in the plate a trifle smaller at the bezel than at the bottom of the seat and then select a jewel than can be forced into the opening.

In selecting the jewel to fit this open bezel, there are three dimensions that must be taken into consideration: the diameter of hole to fit the pivot, the outside diameter to fit the seat in the plate, and the correct thickness which can be judged from the old jewel. As explained before, the pivots and holes in jewels are numbered by hundredths of a millimeter but the outside diameter is measured in tenths of a millimeter. If you have a selection of jewels all supposed to be of a certain outside diameter, you will find by using your micrometer that they may vary somewhat in sizes. Thus in a dozen No. 12 jewels, you will probably find sizes running from 1.15 to 1.25 mm. This gives you an opportunity to select a jewel to within a few hundredths of a millimeter of the size desired. A very convenient way of estimating the outside diameter of a jewel to fit the old seat is by means of your bezel opener. If you will insert the bezel opener and open the jaws until they will just fit without any sideshake in the jewel seat and then withdraw the bezel opener without changing the position of the jaws, it is easy to obtain the measurements in 100ths of a mm.

To replace a train jewel of this type proceed as follows:

1. Force out broken jewel with a flat face staking punch (figure 12–17). The bezel will be forced open to a certain extent.
2. Place bezel opener in seat of setting (figure 12–19).
3. Spread jaws of bezel opener carefully and pull straight out (figure 12–19).
4. Measure across jaws of bezel opener with micrometer. This measurement will be outside diameter of jewel.
5. Measure pivot and compare with chart, Sec. 294. This will be the hole diameter.
6. Select jewel from stock with corresponding outside diameter and hole diameter for replacement.
7. If not in stock, order from material house.

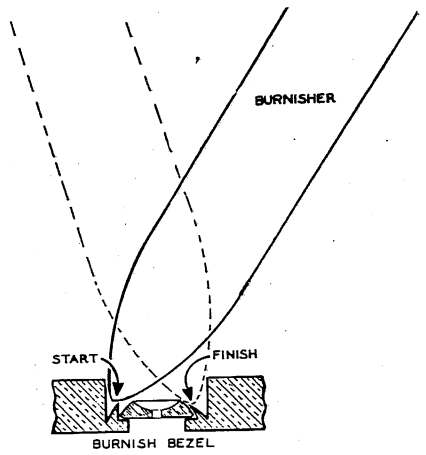


FIG. 12-20

8. Place train jewel in seat (figure 12–20).
9. Figure 12–20 illustrates a hard steel burnisher used to force bezel over jewel. The solid lines of burnisher illustrate the bezel at the start and the dotted lines illustrate the burnisher and the bezel which is now tight against the jewel.

In ordering a new jewel for the type of seat described in this section, it is best to send in the plate with the bezel opened together with the wheel and pinion for which it is intended. In this way a jewel of correct diameter to fit both the seat and the pivot can be furnished.

SEC. 302 — Swiss Watches

As already mentioned, it is very easy to select material for American watches if the sample of the old part is furnished together with the name of the manufacturer and the size of the watch. However, in ordering Swiss material it is necessary to have a little more definite information. There are literally thousands of names of Swiss watches on the market today, each importer perhaps having several different names although there are comparatively few different Swiss factories.

After the watchmaker has established a profitable repair business, it is well to have an assortment of unset jewels. They can be had with sized holes and assorted diameters and in the larger and more complete assortments with sized holes and sized diameters.

The replacing of broken jewels in timepieces is one of the paying services rendered by watchmakers and should be studied and practiced until you are thoroughly proficient in replacing any type with which you may come in contact. Do not be satisfied with merely getting the new jewel in the plate so the endshake is correct but with the appearance of having been secured in the bezel by means of a broken nail and a sledge hammer, but rather endeavor to have each job with a finish that stamps it as the work of a Master Watchmaker.

SUPPLEMENTARY INFORMATION

HOW WATCH JEWELS ARE MADE

Watch jewels are manufactured on specialized machines. Each machine performs just one operation. These sections will describe only the main operations in a long series.

SEC. 303 - A Brief Background

Before 1700 watches had no jewels. Wheel pivots simply ran in brass holes in the plates. Then in 1704 Nicolas Fascio, a Swiss watchmaker living in London, invented and patented a method for drilling holes in gem stones and ushered in the jeweling system.

For the next 200 years, natural gem stones were used for watch jewels. Since the purpose of such jewels is to provide a smooth, hard surface and thereby lessen friction, rubies and sapphires were principally sought because they rank next to diamonds in hardness. These watch jewels were made by hand and watchmakers likewise made their replacement jewels by hand.

But natural gems vary in quality and availability. As the number of watches increased, it became evident that a more certain and less costly source of jewels was needed. Efforts in this direction began as early as 1837.

Manufacturers tried first to produce suitable rubies by fusing chips of natural ruby. These efforts were not satisfactory. Then in 1902, Auguste Verneuil, a Frenchman, devised a flame-fusion process for making rubies and sapphires synthetically, which gave birth to a whole new industry. The furnace used for this process bears Verneuil's name.

SEC. 303A - Materials Used in Modern Jewels

The material used for synthetic jewels is the same as is found in natural jewels. It is crystalized aluminum oxide, known as corundum. To produce this, alum is roasted in silica trays in a very hot furnace (1,000 degrees Centigrade) to form a feathery white powder.

Many kinds of stones can be obtained from this base by adding different coloring matter. Adding chromic oxide -- a metallic salt -- produces rubies. Titanium and iron are used for sapphires while cobalt and vanadium will produce emeralds. For many industrial uses, the white powder is left plain. Rubies are preferred for watch jewels because their red color makes them easier to see and to handle.

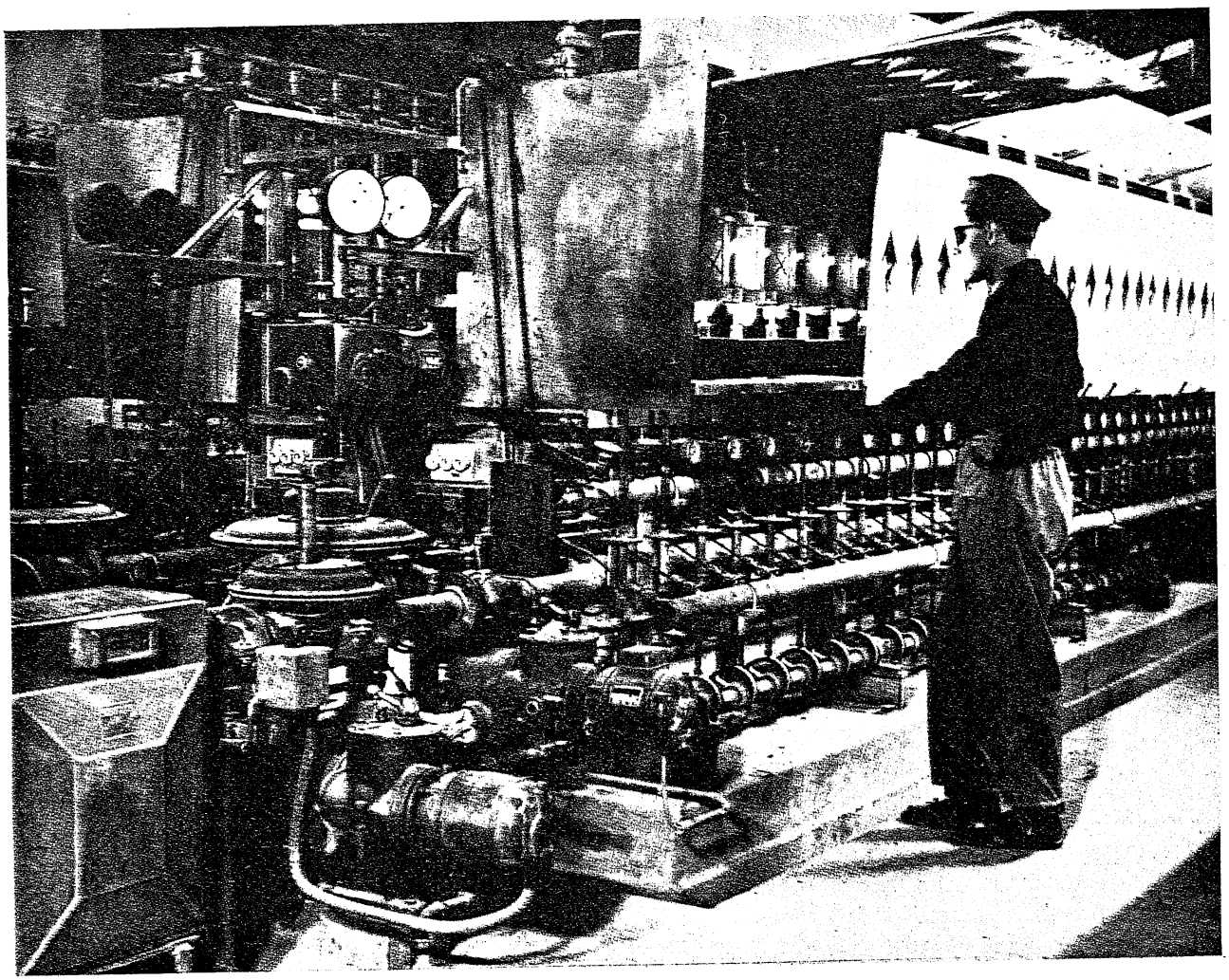


FIG. 12-21

SEC. 303B - Forming the Crystal in a Verneuil Furnace

The powdery oxide is poured slowly into a Verneuil furnace. (Figure 12-21 shows a battery of these at the Sadem factory in Switzerland.) The furnace has an oxyhydrogen flame of about 2,000 degrees Centigrade. As the powder passes through the flame, it fuses into drops. These fall onto and build up on a fireclay base or stick.

This continued action produces a mass shaped like a carrot, Fig. 12-22. The exact heat is important. The furnace technician watches through a door and raises or lowers the stick as necessary so the drop will cool a few degrees before the next one falls. In this way, a crystal is formed. The process takes several hours.

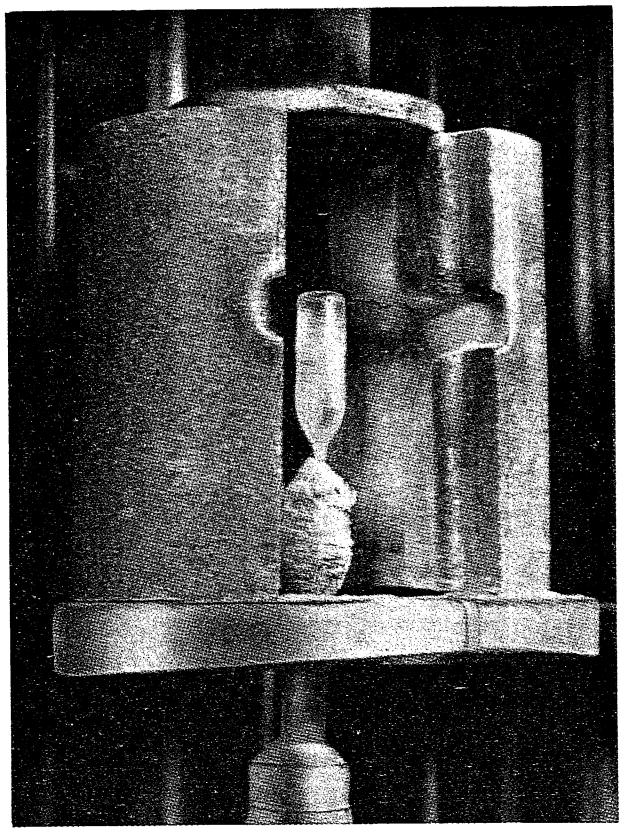


FIG. 12-22

The resultant mass is called a "boule". This is the French word for "ball" since the early boules were ball shaped. Now they are longer in shape and may weigh as much as 800 carats (a little over 5 ounces). Most are smaller, since there is a possibility of the boules developing strains inside and splitting when they weigh over 300 carats. A boule this size will be about two inches long and 3/4 of an inch in diameter. The average boule is about 1/2 inch in diameter, one to two inches long and weighs about 125 carats.

The boule is a single crystal, much more perfect than a natural crystal. It is

more uniform, more free of flaws, more easily polished, and considerably cheaper in the quantities required for watches.

SEC. 303C - Value of Jewels

The average jewel costs only 2¢ to 25¢ to manufacture, so that individually jewels are inexpensive. In sum total, however, they represent considerable sums of money. It takes 900 kilos (2025 pounds or more than one ton) of aluminum oxide to make just 1 kilo (2.25 lbs.) of jewels. For jewels of the finest quality, 1 kilo represents a value of 3,000,000 Swiss francs (about $775,000 U.S. -- 1972 value).

SEC. 304-Steps in Watch Jewel Manufacture

The boules are cut into uniform slices with diamond charged copper saws. The slices in turn are cut into small squares. These squares are then turned into round discs on special machines. These discs are called "blanks".

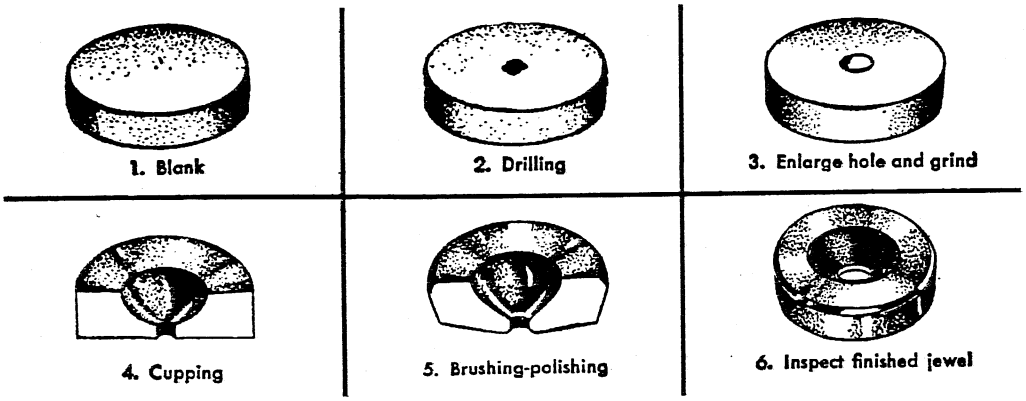
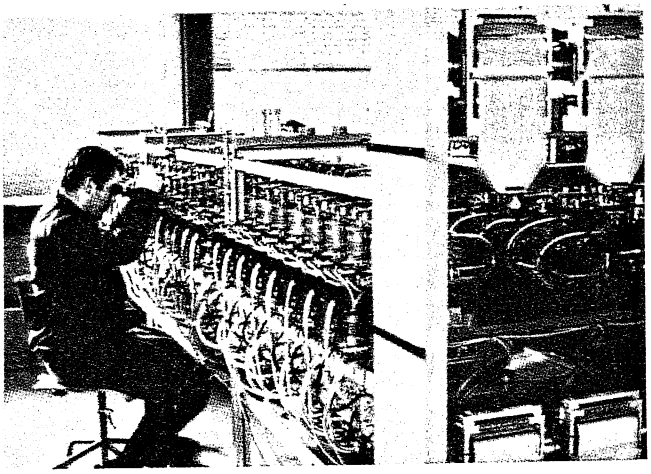


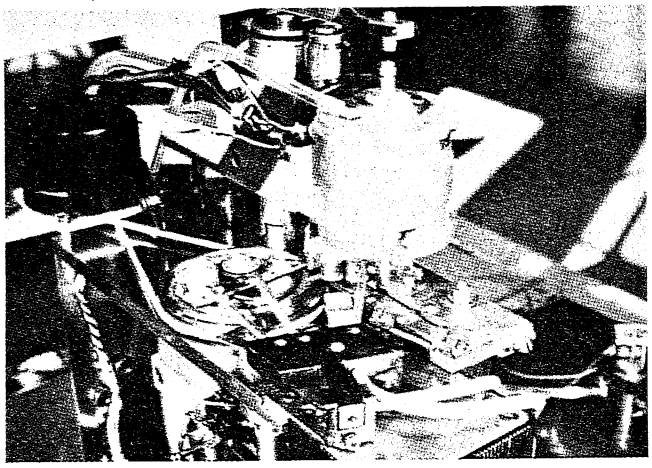
FIG. 12-23

This is the starting point for the actual manufacturing process, which in Switzerland takes place in special watch jewel factories. There are a number of these and all together they turn out over 700 million watch jewels each year (as of 1967). In the early days of manufacturing synthetic jewels, they were still produced by hand and a workman could turn out 200-250 a day. Now, thanks to automatic machinery, a workman can produce some 2500 each day -- ten times as much.



General view of an automatic drilling shop.

FIG. 12-24



Detail of an automatic drill.

FIG. 12-25

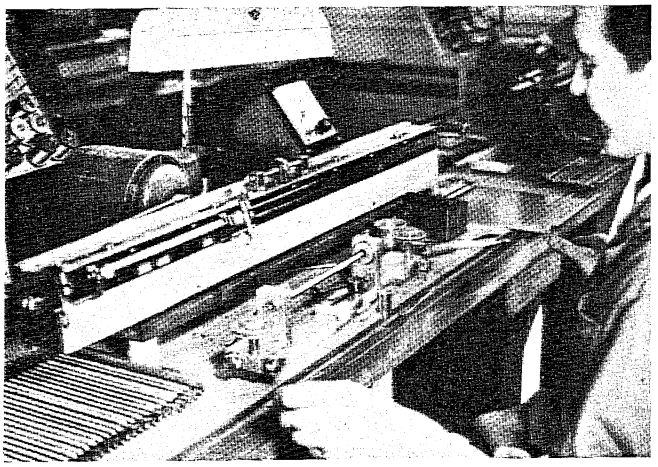
SEC. 304A - Drilling

The first manufacturing step is drilling. For this purpose, fine steel wire "bits" are charged with diamond powder and used to pierce the blank. At this step there is no attempt to obtain precise measurement. That comes later. For now, the purpose is just to get a hole through the blank. Drilling is normally done on automatic drilling machines, Figures 12-24 and 12-25.

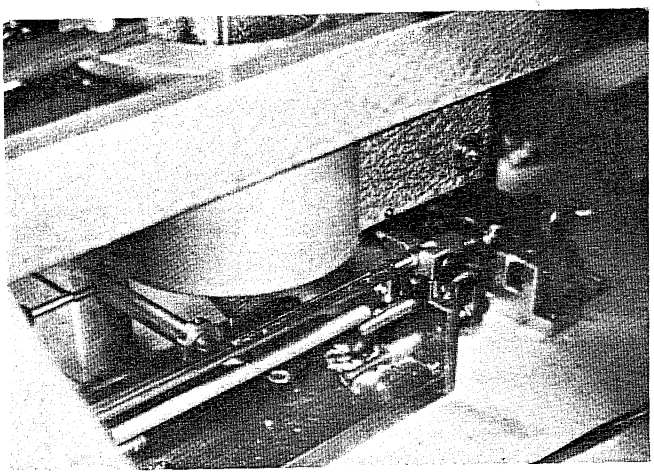
After the first working model of the laser beam was accomplished in 1960 by an American named T. H. Maiman, research was begun to see if it was practical to make these holes with a laser beam. (The term Laser stands for Light Amplification by Stimulation of Energy Radiation.) Laboratory results were favorable and later in the decade several companies were formed in Switzerland to set up the process for large scale production. It is hoped in this way to speed up this step in the jewel making process.

SEC. 304B - Enlarging

In the second step, the hole in the jewel is enlarged to the desired shape and surface finish. Unlike the initial drilling, this step requires exact measurements within



Machine for enlarging small holes.
FIG. 12-26



The gumming-up of an enlarging chain.
FIG. 12-27

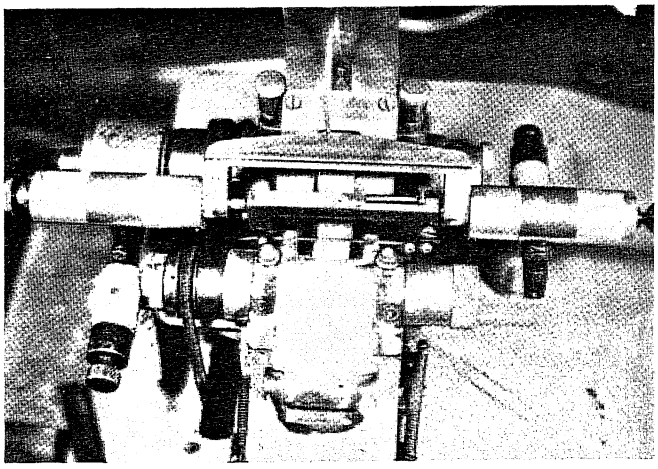
minute tolerances measured in microns. A micron is 1/1,000 of a millimeter. The average human hair is 50 microns in diameter. A micron is 1/50th of this or about 1/25,000 of an inch.

The enlarged hole must have perfectly polished surfaces to cut down friction to the lowest possible point. This demands a surface condition of the most exacting quality. In order to get this quality, the diamond powders used are carefully gradated to keep out oversize grains which might groove the desired finish.

Inspection of these surfaces is a most difficult task since the holes are only 1/10th of a millimeter on the average. The pointed instruments and gauges usually used in machining to give an impersonal surface check are useless in these tiny areas. They must be checked by eye. A light is therefore skimmed across the surface of the hole and the machining scratches are examined with a microscope and binoculars.

SEC. 304C - Turning

A third operation is turning. This provides the outer dimensions of the jewels. Cylindrical grinding accomplishes the job. The jewels are placed caterpillar fashion on metallic or synthetic wire the exact size of the hole and crushed diamond

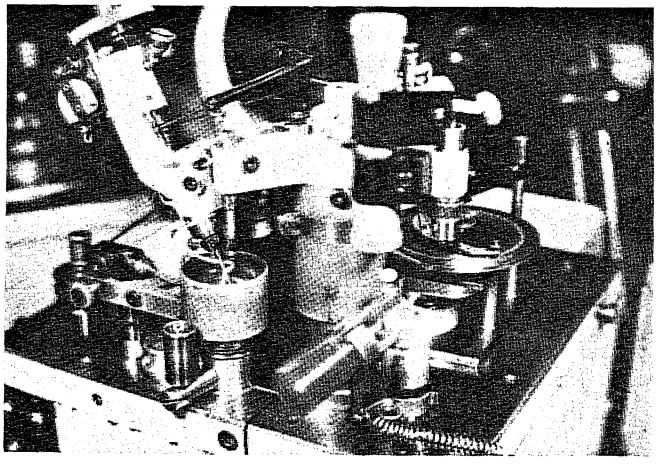


Detail of a turning machine.

FIG. 12-28

General view of a recessing shop.

FIG. 12-29



Detail of a recessing machine.

FIG. 12-30

is used on the grinding machine to shape the outer form of the jewel. It is vital that this outside edge be perfectly concentric with the hole in the center. In contrast to the hole, which is made as smooth as possible, the outer surface is more or less rough (depending upon the intended use for the jewel), so as to better hold it in place.

SEC. 304D - Forming the Oil Cup

The next process is to form a little recess or oil cup. This is done entirely on an automatic machine, Fig. 12-30. The turning tool is actually a very small grinding wheel about 1/2 mm. in diameter. This wheel, shaped like a lead pencil, turns at the rate of 30,000 revolutions per minute.

Lubrication is very important at this stage since it is necessary that the jewel be kept cool during the grinding process. Lubrication also serves to keep the wheel from becoming clogged with diamond paste. The preferred

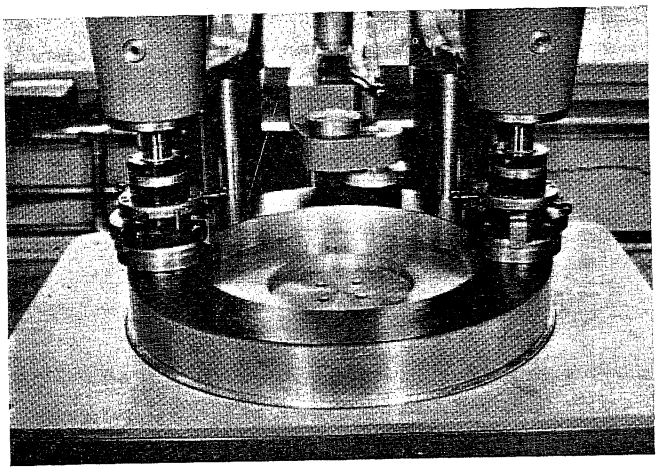
lubricant is vegetable oil mixed with other ingredients, although mineral oil is also used.

Most jewels have straight sides. In some it is desirable to slightly round the edges of the hole to produce an olive shaped jewel hole, which offers the least amount of friction.

SEC. 304E - Polishing

The jewels are now cemented onto plates for the polishing process. The first step in polishing is called brushing. The purpose of brushing is to form the rounded off angles, the domed surfaces and the various chamfers required by the type of jewel. A brush charged with diamond paste is used on the outside surface of the jewels as the plate holding them is turned in varying directions.

The second part of the polishing process is lapping, which is necessary to reduce the jewels to the desired thickness. Again, grinding wheels of various types are used for this purpose, Fig. 12-31.



Lapping machine for polishing the flat surfaces of the jewel.

FIG. 12-31

After each stage of these operations, the jewels are cleaned with a mixture of nitric and sulphuric acid, dipped into pure alcohol and dried.

In between the various operations the jewels must be continually inspected. Upon completion, the jewel is enlarged about 35 times and carefully examined to make sure it is perfect in every respect.

CHECK YOURSELF

Progress Check 12 — A Self Test Review of Lesson 12

After you have studied Sections 285 through 302, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of this test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.

	Section Ref.
1. A _____ mainspring is required when more jewels are added to the same size and model watch.	287
2. In an American 15 jewel watch the additional jewels will be found in the _____.	288
3. One jewel which has no counterpart is the _____ jewel.	288
4. Train jewels are also called _____ jewels, while cap jewels are also called _____.	289
5. The hollowed out portion of a jewel is called the _____.	290
6. In order that train pivots may turn freely in the pivot holes, there must be _____ and _____.	290
7. Sideshake is the freedom between the sides of the _____ _____ and the _____ in the jewel.	291
8. Endshake is the space between the _____ of the train jewel and the _____ on the pivot.	291
9. A _____ is used to measure holes in train or balance jewels while a _____ is used to measure pivot diameters.	293
10. The amount of sideshake varies with the _____ of the pivot.	291 294
11. Train jewels in settings for American watches are usually held in place by _____.	295
12. Besides identifying the movement when ordering replacement jewels, it is important to give the _____ and _____ of the jewel.	296
13. In a raised train jewel setting, the jewel screws are set _____ the plate.	297
14. The principal parts of a staking tool are: a. _____ b. _____ c. _____ d. _____	298

Progress Check 12 (continued)

Section Ref.

15. In addition to the centering punch which is common to all staking sets, the four most used punches are:

    a. _____
    b. _____
    c. _____
    d. _____

298

16. A _____ hammer is used with the staking set. 299

17. Train jewel settings which do not use jewel screws are held either by a _____ or by _____. 299 300

18. Where a jewel is set directly in the plate or bridge without the use of bushings or settings, it is known as a _____ _____. 301

==========

ANSWERS TO PROGRESS CHECK 12:

1. weaker
2. train
3. roller
4. plate
   end stones
5. oil cup
6. sideshake
   endshake
7. square shoulder pivot
   hole
8. face
   shoulder
9. jewel hole gauge
   metric micrometer
10. diameter
11. jewel screws
12. hole size
    description
13. above
14. frame
    punch guide
    die plate
    locking screw
15. flat face solid
    round face solid
    flat face hollow
    round face hollow
16. brass
17. bezel
    friction
18. plate jewel

Detach page or cut along this line — and send to the School for grading.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 12

Name: No.: Date:

Circle the correct answer or answers:

SUBJECT: Factory Set Train Jewels

1. A 7 jewel and a 21 jewel watch of the same size and model will require:

   Different width of mainspring | Different strength of mainspring | Different width and strength of mainspring | The same mainspring

2. How many additional wheels have jeweled bearings in a 15 jeweled watch compared to a 7 jewel watch?

   Four | Three | Two | One

3. Which one of the following jewels is NOT used as a bearing for wheels?

   Pallet stone | Train jewel | Balance hole jewel | Cap jewel

4. The train wheels of a watch should have:

   Endshake only | Sideshake only | Both sideshake and endshake | Neither sideshake nor endshake

5. Sideshake is defined as:

   The freedom between the outside diameter of the pivot and the hole in the jewel | Difference between the outside diameter of the jewel and diameter of hole in jewel | The space between the face of the train jewel and the shoulder of the pivot | Freedom of the jewel in the setting or plate

6. Holes in train jewels are measured with:

   A millimeter gauge | A ligne gauge | A micrometer | A jewel hole gauge

7. In selecting a jewel for a replacement, which one of the following is NOT done until after the other three?

   Measure pivot with micrometer and select jewel | Test jewel on pivot for freedom or sideshake | See if shoulder on setting is same as on the old setting | Place jewel in plate of watch

8. The top of a staking tool frame is bored to receive the punches and hold them upright and at right angles to the:

   Frame | Die Plate | Locking Screw | Punch Guide

9. Some American watches have a train jewel setting in the pillar plate which is held in place without screws by means of a bezel burnished over the edge of setting. This type setting is removed when broken by:

   Loosening setting with a large screw driver | Using a brass hammer, punch and staking tool | Pushing out with a piece of pegwood | Pushing out with the jewel pusher

10. The friction jewel setting differs from the one described in question 9 in that: (Circle all correct answers)

    It has no shoulder | Endshake can be adjusted by driving in or out | It is held in place by a bezel | It is held in place by friction

11. In replacing a friction jewel, if bridge does not rest solidly on the staking die, you can:

    Press jewel in or out with a jewel pusher | Use a bench block | Use a flat face stump | Use a round face stump

12. In the Swiss type jewel set directly in the plate without use of settings or bushings, the jewel is held in place by

    Two jewel screws | One jewel screw | A bezel burnished over edge of jewel | Friction