HOOK SCRAPING

The scraping technique I will discuss is called hook scraping. It is an ideal method because it produces a smooth and edgeless surface and fine bearings with tolerances of 50 millionth or less can be produced. A great deal of practice is required to master the hook scraping technique, but the benefits are worth it.

To produce the hook, you start with a very slight amount of pressure. As you proceed into the cut you increase the pressure which causes the depth of the cut to run across the curve of the blade. After crossing the center of the cut you release the pressure, a very small amount of twist is also applied to the blade. The twist should begin at the start of the cut and follow through to the end of the cut. The trick in developing the hook is coordination of the three movements, applying and release of the pressure and the slight twist with the forward stroke of the blade. Maintaining a rhythmic pace also helps.

The size of the hooks should be about 1-in. long with heavy pressure for rough scraping, and about 3/8 in. long with light pressure for the finish cuts. The more material to be removed, the larger the scraper. For very fine cuts use a small scraper (Fig. 7).

An example in scraping is a 7-by-10-in. angle plate using a 2-by-3-ft master surface plate.

Before starting the scraping you should study the geometry of the part and determine what approach to take. In this example of the angle plate, the best approach would be to scrape the large part for flatness only and adjust the geometry with the small part. If the angle plate is set on the small side the squareness error would be amplified by reading on the large side. There will be less scraping on the small side to adjust the geometry.

Before starting any scraping job, the first thing to do is to apply red lead to the part and then scale it off. Scaling is the procedure for taking an even cut over the entire surface leaving about 25% of the red lead showing. The purpose of this cut is to prepare the surface for a blue reading on the surface plate and to remove any scratches, tool marks, or any other imperfections undesirable in the finished job. More than one cut may be necessary, so take as many as needed. The direction of the cut should be

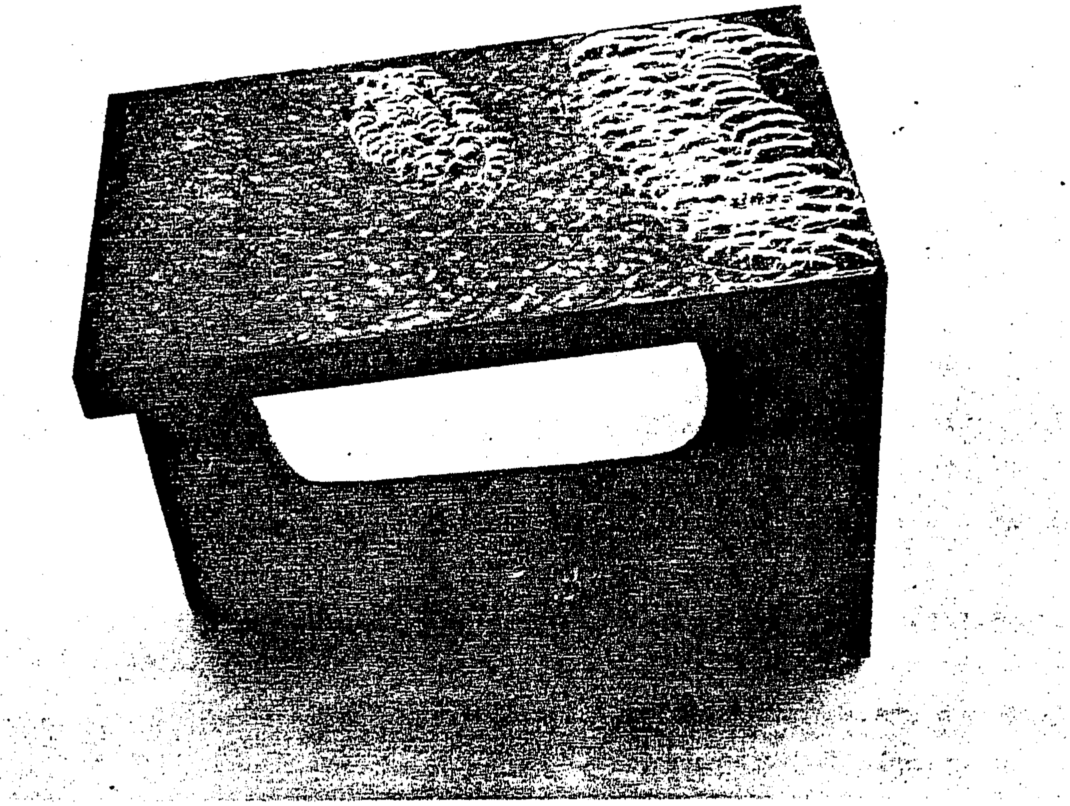

FIG. 7. Large and small hooks.

changed by about 45° each cut to prevent chatter. Use of a large hook in scaling will be faster and generate larger spots (Fig. 8).

After scaling off, brush off the chips and applying moderate pressure use a medium India stone to remove the burrs raised by the scraper. Then apply red lead to the part, making sure the lead is even-colored and dry (Fig. 9).

Remove the cover from the surface plate and check the plate for any contamination. Dust, chips, or lint should be lightly wiped off with a clean towel or brushed with a paint brush. Apply a fairly heavy coating of blue on the plate, about twice the size of the part being worked. Make sure the blue color is even (Fig. 10).

Pick up the part with both hands and check and remove any chips or dirt that may be on it. Examine the red-lead surface of the part for any dust or lint. You may now lower the part lightly and evenly on the blued surface plate. An important factor when taking a reading on a part being scraped is that the part must be completely covered by the master at all times. Any deviation will cause a false reading. Do not place the part half way on the master and then slide it on. Do not slide the part off and on over any edge of the master. Any time the part is in contact with the master it must be completely covered by the master or a false reading will be taken.

With the part now on the surface plate, it must be slid back and forth to transfer the blue to the red leaded part. It is best to slide the part by holding it on one end only--thus a push-and-pull motion. Attention should be paid to push and pull in a line parallel to the surface plate so there will be no up-and-down influences on the part.

An important phase of taking a reading on a part is performing the rock test. This simple test should be performed at each reading. A good blue reading could be taken on a flat master even though the part is not flat. In the case of a convex part or high in the center, the part would roll over the high center when it is being rubbed, thereby giving a good blue reading. When the part is held on one end and moved sideways the point of maximum weight bearing will cause the part to pivot at that point. In the case as previously stated the part would rock in the center, which indicates a false blue reading and that the part is not flat. When the part is concave it would rock on the ends. Ideally, the weight of the flat part will average out on the ends of the center third of the length of the part, with consideration given to the shape of the part (Fig. 11).

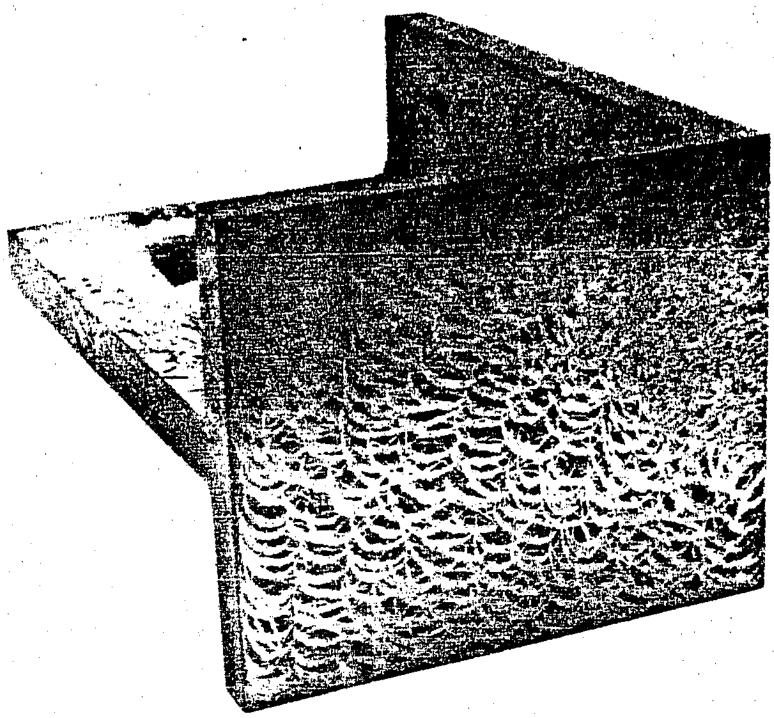

FIG. 8. A scaled-off part.

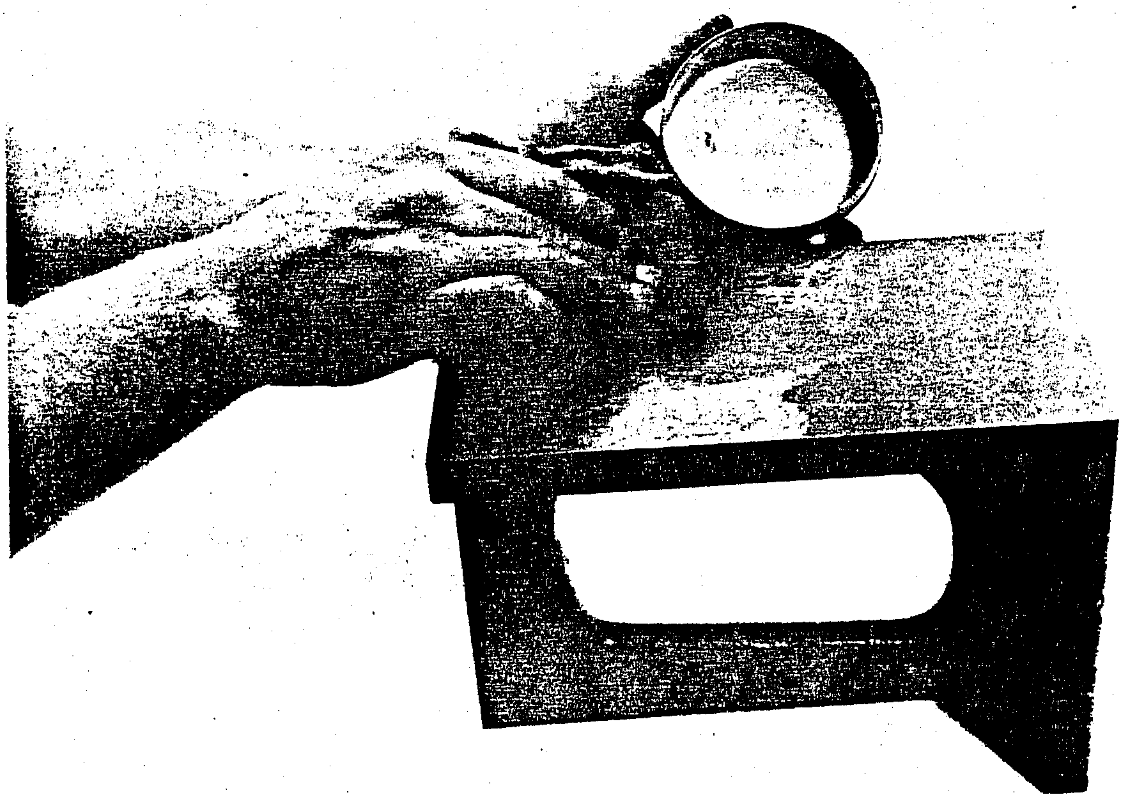

FIG. 9. Applying the red lead.

FIG. 10. Applying the bearing blue.

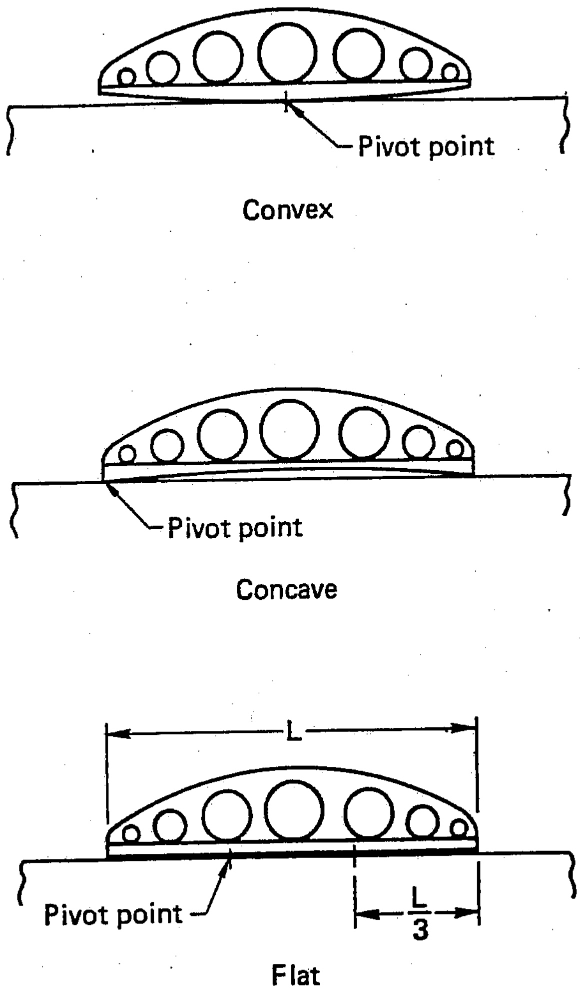

FIG. 11. The rock test.

The angle plate is heavier on one end, so the rock on that end will move out some but the lighter end should rock at its proper place in relation to the length of the part.

With the blue reading and rock test complete, remove the part from the master gage. Pick the part straight up to avoid false readings.

It is now time to interpret the blue reading and plan where to scrape. Since this is the large part of the angle plate, all we have to scrape for is flatness. The blue reading will be large blotches from 1/8 in. to 1/4 in. with large patches of red lead showing in between. At this stage of the rough scraping the objective will be to scatter out the large blue spots evenly over the entire surface. It is important to keep the cut heavy and the spots large at this point (Fig. 12).

Do not try to cut only the spots. A random cut in the area of the spots where the rock test indicated the flatness condition is all that is necessary. If the rock test indicated high in the center then disregard any blue on the ends and cut only in the center area. Continue this roughing process until the rock test is proper and the surface is evenly covered with large spots.

The next step is to begin increasing the number of spots. If this process is started too early or before the large spots evenly cover the entire surface, you will have to go back to the roughing stage. A low area is very difficult to fill in when the spots are small. To increase the number of spots reduce the length of the cut to about 1/2 in. and with moderate pressure cut each large spot in two. Keep track of the flatness with the rock test. With the surface evenly covered with spots about 1/8 in. or smaller reduce the length of the cut to about 3/8 in. and ease up on the pressure. At this time attention must be paid to cutting the shiny point in the center of the blue spot. The widest and deepest part of the hook should cut the shiny point of the bearing, one hook for each shiny point. The rock test will move around somewhat, so pay attention to this area.

GAGING A BEARING

To gage the bearing, the first order of quality is that the entire surface be evenly covered with bearing points, and then the number of bearing points in a randomly selected square inch are counted. A gage quality bearing has 32 points per square inch. This includes gages such as master straightedges, surface plates, and squares. Bearings for precise machines,

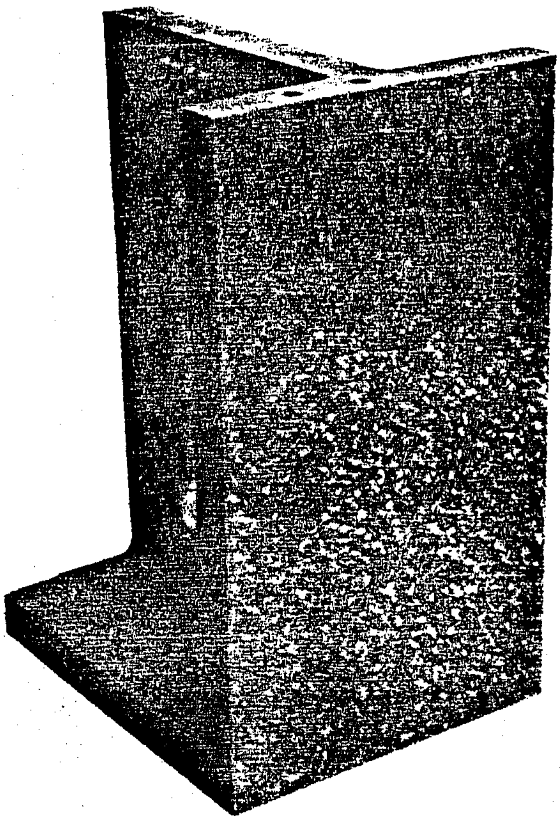

FIG. 12. Rough-scraped bearing.

such as measuring machines, grinders, and jig boring machines, should be 24 points or better. A 16-point bearing will generally suffice for production run machines, milling machines and lathes (Fig. 13).

In scraping a gage quality bearing, such as this example, false readings are quite common, so you must pay attention to the frequent need to break the edges of the part with the stone. Minute high points can develop on a sharp edge that will cause a false reading. Sometimes a shade must be used to reduce glare from overhead lights. The red lead must be very dry and the blue must be thin to avoid smears.

With the large part of the angle plate scraped flat, you must now scrape the small surface of the angle plate flat; you must also adjust the geometry of the angle plate. A master box square, electronic indicator, scrapers block, and a surface gage will be used for measuring the squareness of the angle plate.

Start the small surface of the angle plate by scaling it off and picking a rough bearing. This rough bearing should be large spots evenly spread over the entire surface. At this time it is very important to keep the bearing rough with large spots. If the geometry must be altered, it will change very rapidly with a rough bearing in comparison with a closer bearing.

Take a squareness reading from the master box square. Set the master box square on the surface plate and set the angle plate next to it with the large, finished surface vertical. Have both the square and the angle plate facing you. Place the surface gage on the surface plate and slide it to the master square. With the surface gage held tight to the lower edge of the square, adjust the electronic indicator finger to read on the scrapers block, holding it tight towards the top of the square at a height that will also read on the angle plate. The higher you can read on the angle plate the more you amplify the error (Fig. 14). Move the scraper block and the surface gage to the angle plate and take an indicator reading (Fig. 15). Write down any deviation from zero and then move back to the square to make sure that the original zero setting repeats.

You must now analyze the reading and determine where to scrape. Suppose the indicator reading was plus 0.001 in. This means the top of the angle plate is leaning towards you by 0.001 in. To cause the angle plate to tilt back, you will have to remove material from the small surface towards the back side. Next, consider how much material to remove. The base is 7 in. and you were indicating at about 9 in. from the base, so the ratio is a little more than

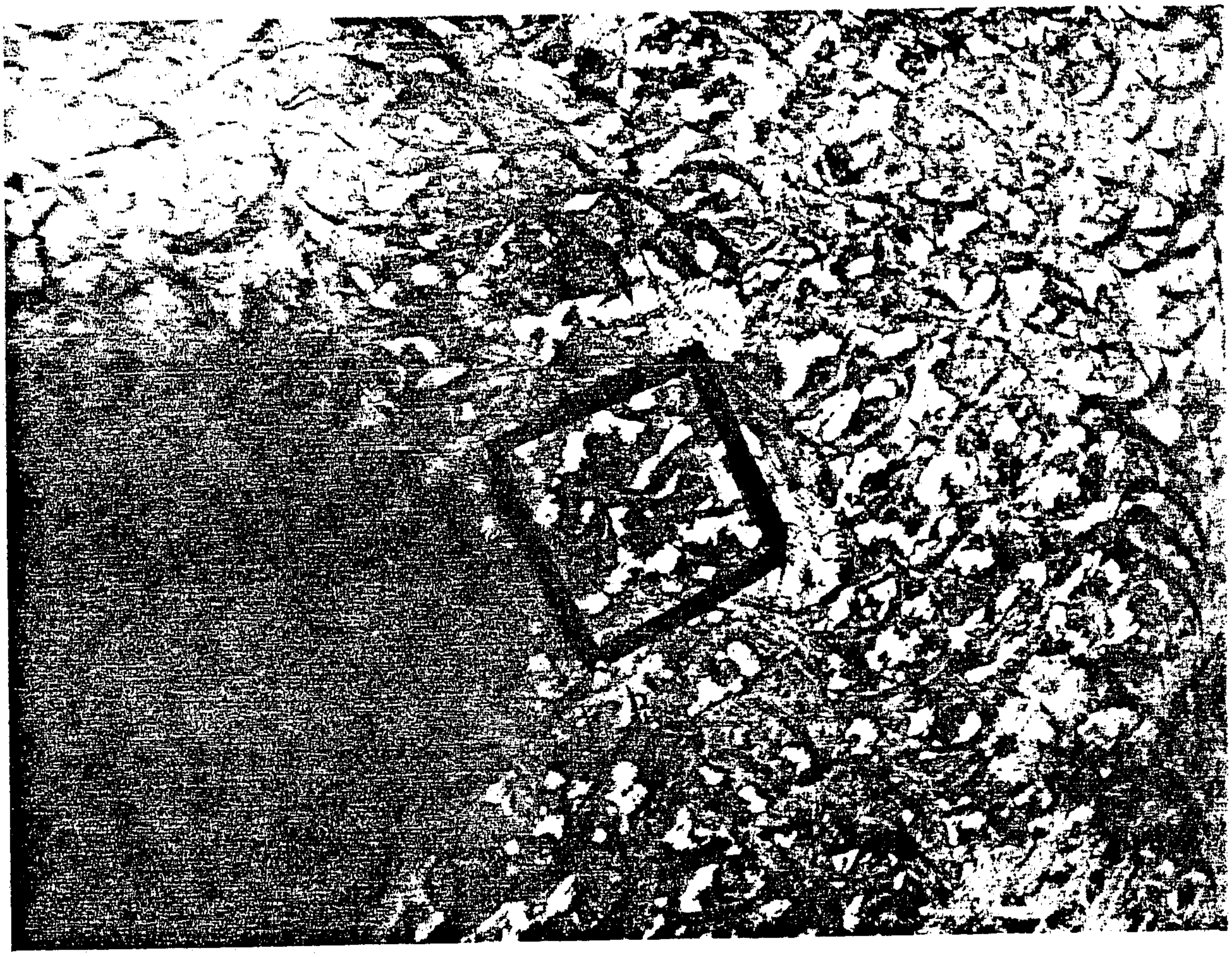

FIG. 13. Gaging a bearing.

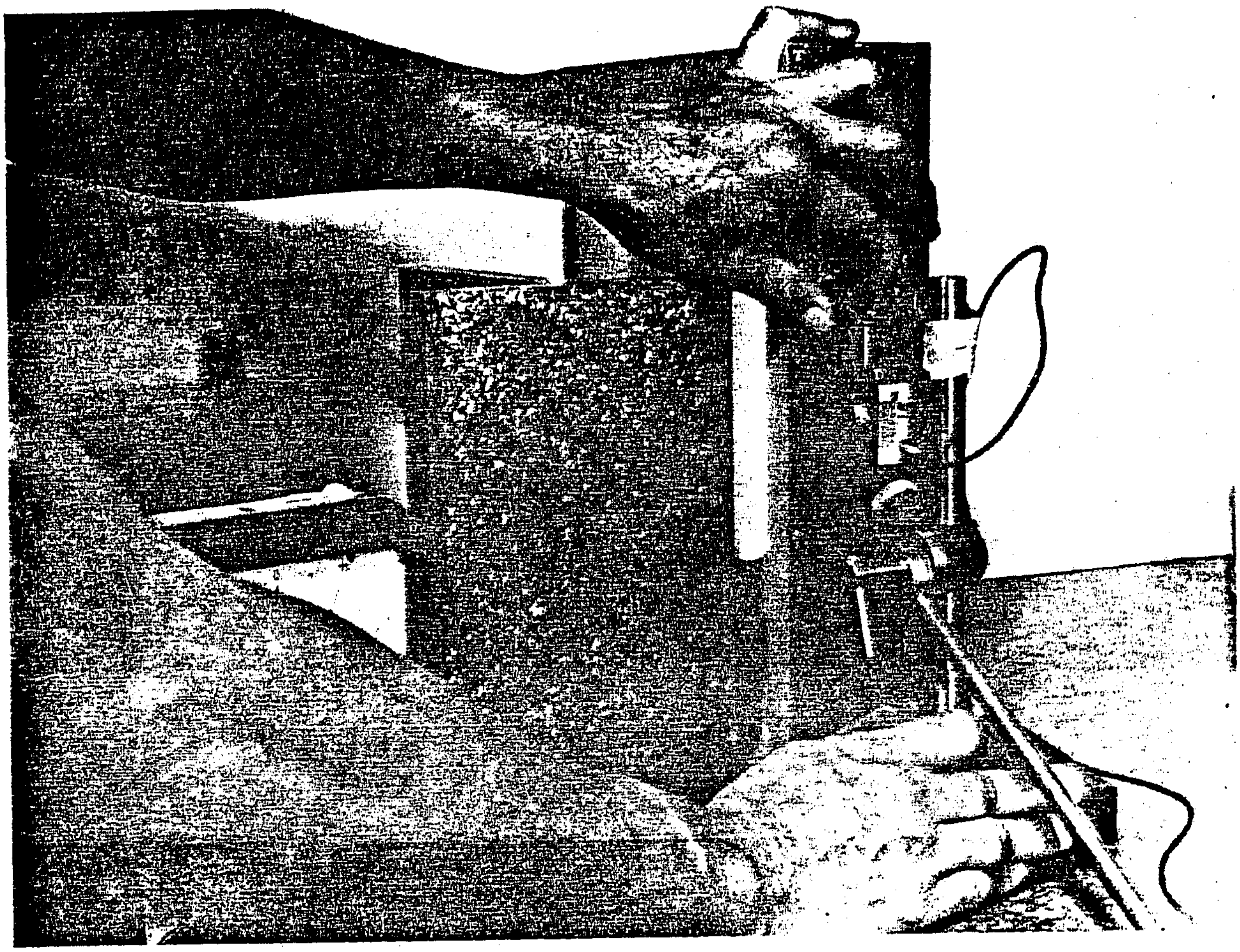

FIG. 14. Setting the surface gage to the master square.

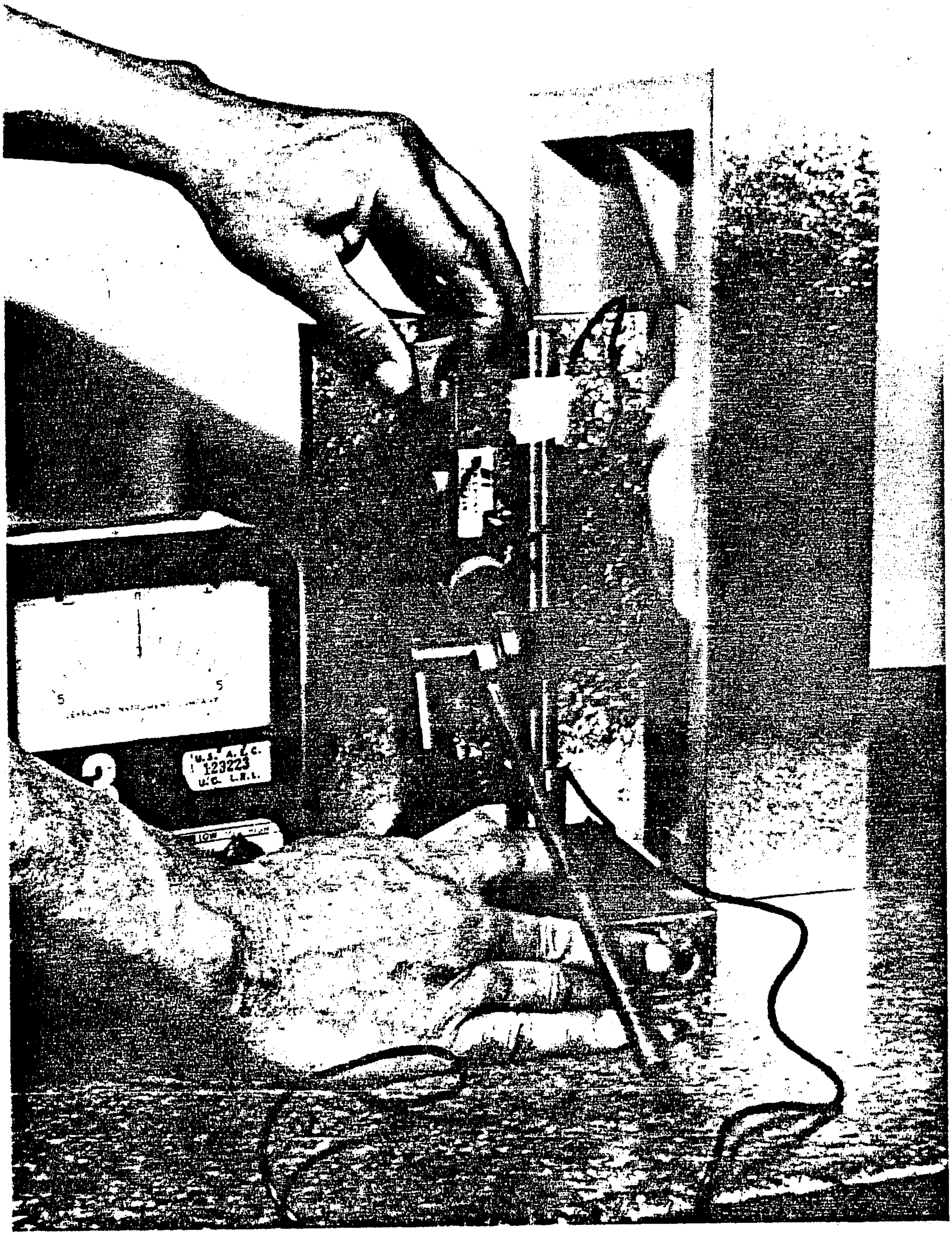

FIG. 15. Taking a squareness reading on the angle plate.

1 to 1. The error is not amplified very much, so you can say that you have close to 0.001 in. of material to remove.

To alter the geometry of a part by removing more material from one end than the other, it would be wise to step-cut the part. To step-cut the angle plate, use the following procedure. Red lead a margin of about 1/2 in. on the edge you will not cut, in this case the edge next to the finished face. Divide the remainder of the surface into three equal parts by marking with a grease pencil, or use a line drawn with red lead. It is wise to mark the edge of the part also where it won't be cut, so you can keep track of the step line. Red lead the first step farthest from the margin or the end that requires the most material removal. Take a scaling cut or a random cut over the red leaded portion; when approaching the step line ease up on the pressure and take a few cuts over the step line. This will help in tapering the cut at the step line (Fig. 16). For the second cut, red lead the first step and also the second step. Again take a scaling cut over the red leaded surface. This time taper off the cut at the second step line. You have now cut the first step twice and the second step once. Proceed with the third step by red leading all three steps. Scale off the entire surface, but make sure not to touch the 1/2 in. margin. You have now taken a tapered cut across all of the surface, but not the pivot point, without taking a blue reading. With even scaling the rough bearing should still be close, but a minor touch-up may be necessary. After the rough bearing is touched up, go back and check the geometry with the indicator. If the error is still large enough to require another step cut, the second step cut should be staggered from the first step cut. Generally the first cut is an odd number of steps and the second is even numbered, so the step line of one cut will fall somewhat in the center of the previous step. This tends to keep the surface flat and also prevents exaggerating the steps.

The step cutting procedure is a rapid way to alter the geometry of a part and is applicable in all scraping, but will vary by the length of the parts. Some long machine tool ways may require six or seven steps, but the same rules apply.

The geometry of the angle plate is now within 100 μin., so you may proceed to pick a bearing on the surface. As the number of spots are increased, keep track of the geometry with the indicator and make slight adjustments as necessary.

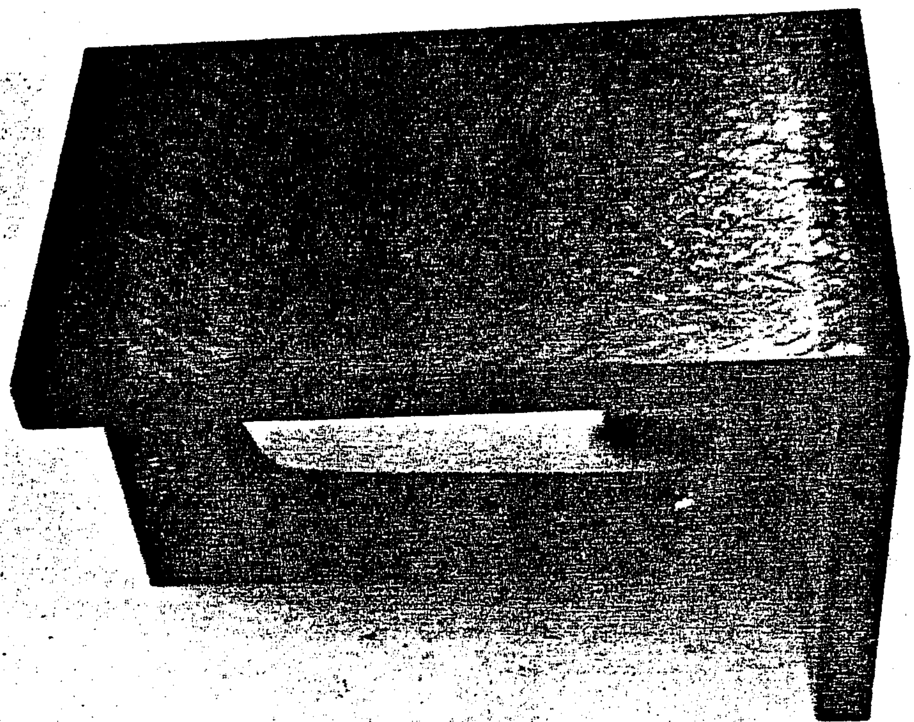

FIG. 16. Step cutting.

This example of scraping "in" the angle plate is a very precise scraping example and should be learned and practiced so you will be able to maintain the gages used in machine tool rebuilding. You will also have the basic knowledge in the art of hand scraping.

In the course of scraping, particularly machine tool ways, it will be necessary to use hand-held master straightedges. These straightedges come in various sizes and shapes. Sizes pertain to width and length and the shape pertains to angles of various degrees or just flat. The angled straightedges are for scraping dovetails (Fig. 17). It is necessary to learn the techniques of handling these straightedges to scrape machine tools.

Selecting the proper straightedge for the job will help make the reading more accurate. The first and most important of the criteria is that the master must be longer than the surface being scraped. It is wise to select a length that will give two or three inches of overhang at each end to allow for sliding the straightedge. Balance is the next consideration. Select a straightedge that most closely fits the width of the surface being scraped, bearing in mind that the width of the surface to be scraped must be covered by the master at all times. Balance becomes more difficult in the case of dovetail-shaped ways. The dovetail can restrict the position of the straightedge, creating a great deal of width overhang and consequently requiring counterbalancing with your hands.

When reading dovetails, the angle of the straightedge is used entirely by hand balancing. It requires a great deal of skill to handle the straightedge while performing the rock test on dovetails.

Using the straightedge on a flat surface is very much the same as using a surface plate, except that the master is on top and moving instead of moving the surface being scraped. A situation can develop where the center of the surface, with respect to width, will become high and the straightedge will roll over the high center, thus generating a false reading. This situation can be detected by the feel of the straightedge--when sliding, it will feel light. Also, scraping the bearing on the edges will not respond as predicted. This condition is best corrected by scraping the center only, until the bearing appears light. This will ensure that the center is not high and will only be one or two cuts low.

If the width of the straightedge is considerably wider on one edge than the surface being scraped, it will be out of balance and require

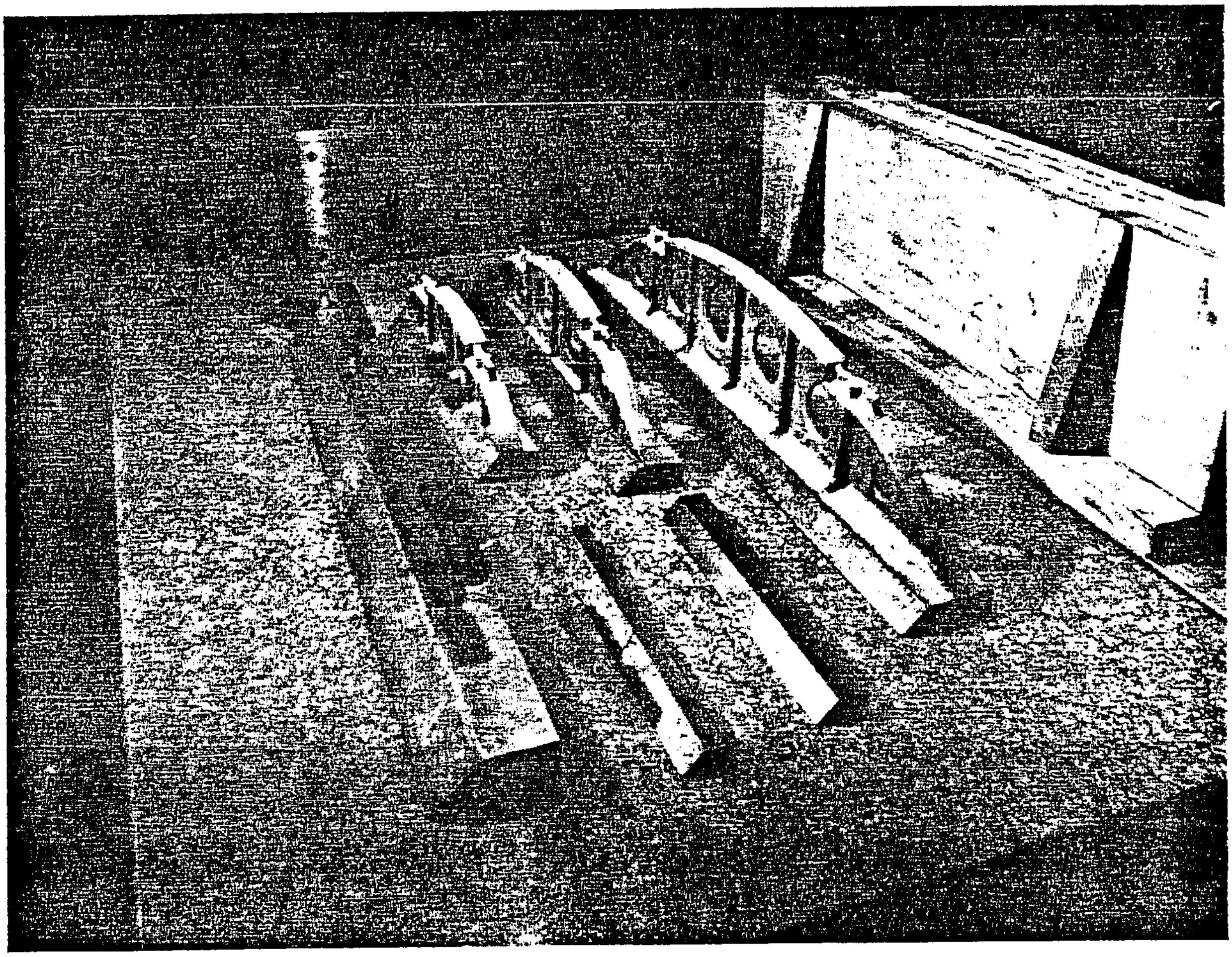

FIG. 17. Various straightedges.

counterbalancing to get a true reading. This is accomplished in the following manner. Carefully set the straightedge on the surface, being careful not to slide it. Hold the straightedge at its ends with the palms of your hands. Slowly lift the heavy or unbalanced edge of the straightedge until it rests on the light edge. Carefully lower the high edge until it contacts the surface; at that point feel the weight of the straightedge on your hands. This will be the counterbalance weight necessary to keep the straightedge flat on the surface. When performing the rock test under these conditions, be careful not to change the counterbalance weight from hand to hand and influence the rock test. It is also very easy to generate a high center in terms of the width, so be careful (Fig. 18).

Scraping dovetails involves the use of the angle of the straightedge, so counterbalancing is always necessary. Follow the procedures as previously outlined. An added problem when scraping dovetails is that the straightedge will slide into the corner of the flat surface and the dovetail; this makes it necessary not only to counterbalance, but also to hold the straightedge out of the corner (Fig. 19). With practice you will become proficient in handling straightedges.

FLAT SCRAPING

Flat scraping is a variation of hook scraping and is used when a bearing surface will be lapped for smoothness in the final form. An example of this usage is the roller ways used in machines. The scraped ways are hand lapped to prevent roller bounce in the slide. The difference in hook scraping and flat scraping is the angle at which the blade is held when scraping. When flat scraping, it is important that the entire scraping procedure be done with the scraper very flat. This will make the hooks wide and shallow, which produces a relatively smooth scraped surface that will require a minimum of lapping. All of the procedures used in hook scraping apply for flat scraping. The major difference is the spots of the bearing. In hook scraping, a large number of small spots is required, whereas flat scraping produces a few large spots. It is wise to use as wide a scraper as possible with a minimum of curve on the blade.

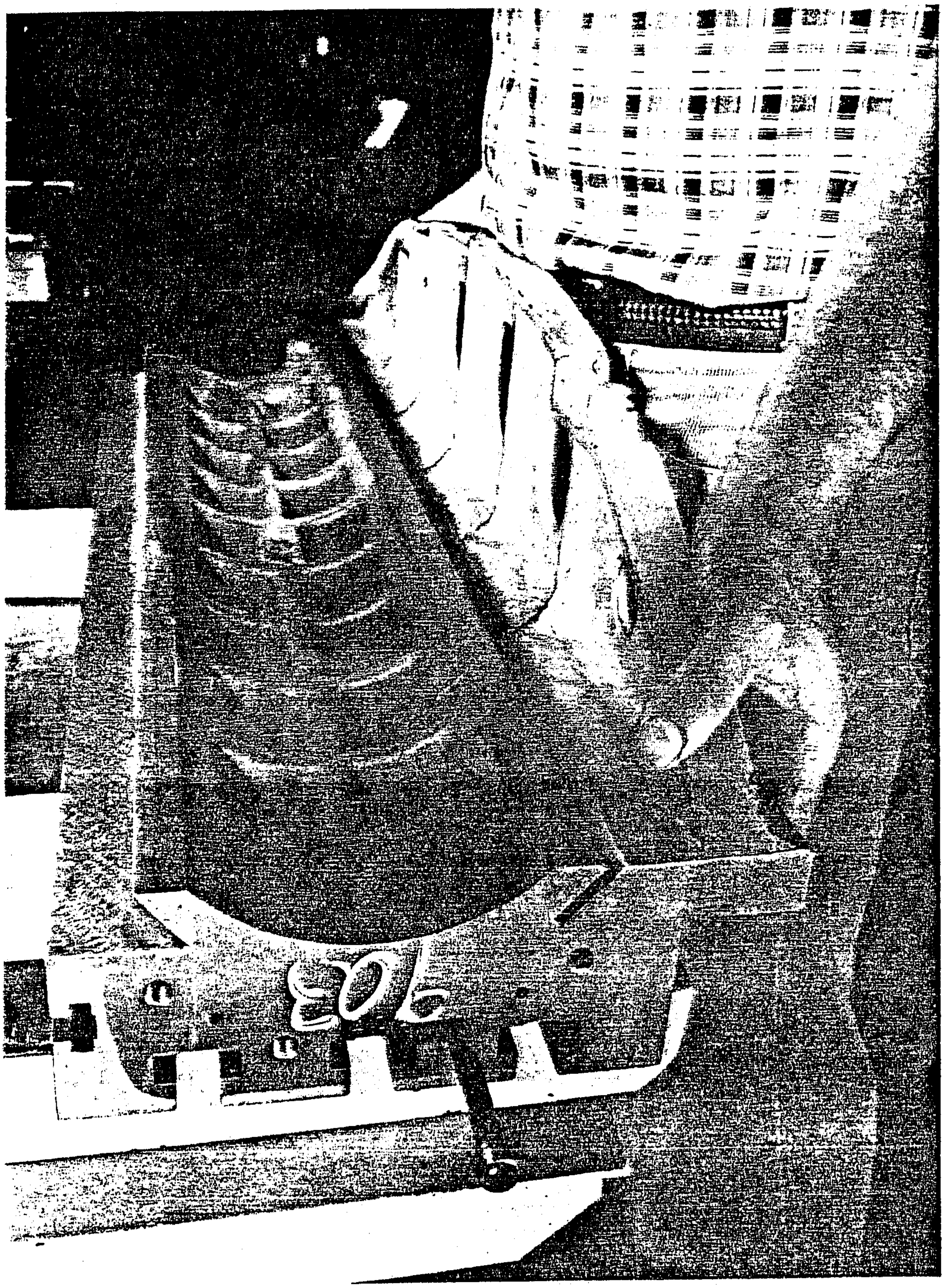

FIG. 18. Counterbalancing a straightedge.

FIG. 19. Reading a dovetail.