HOW TO SHAPE HORIZONTALLY AND VERTICALLY

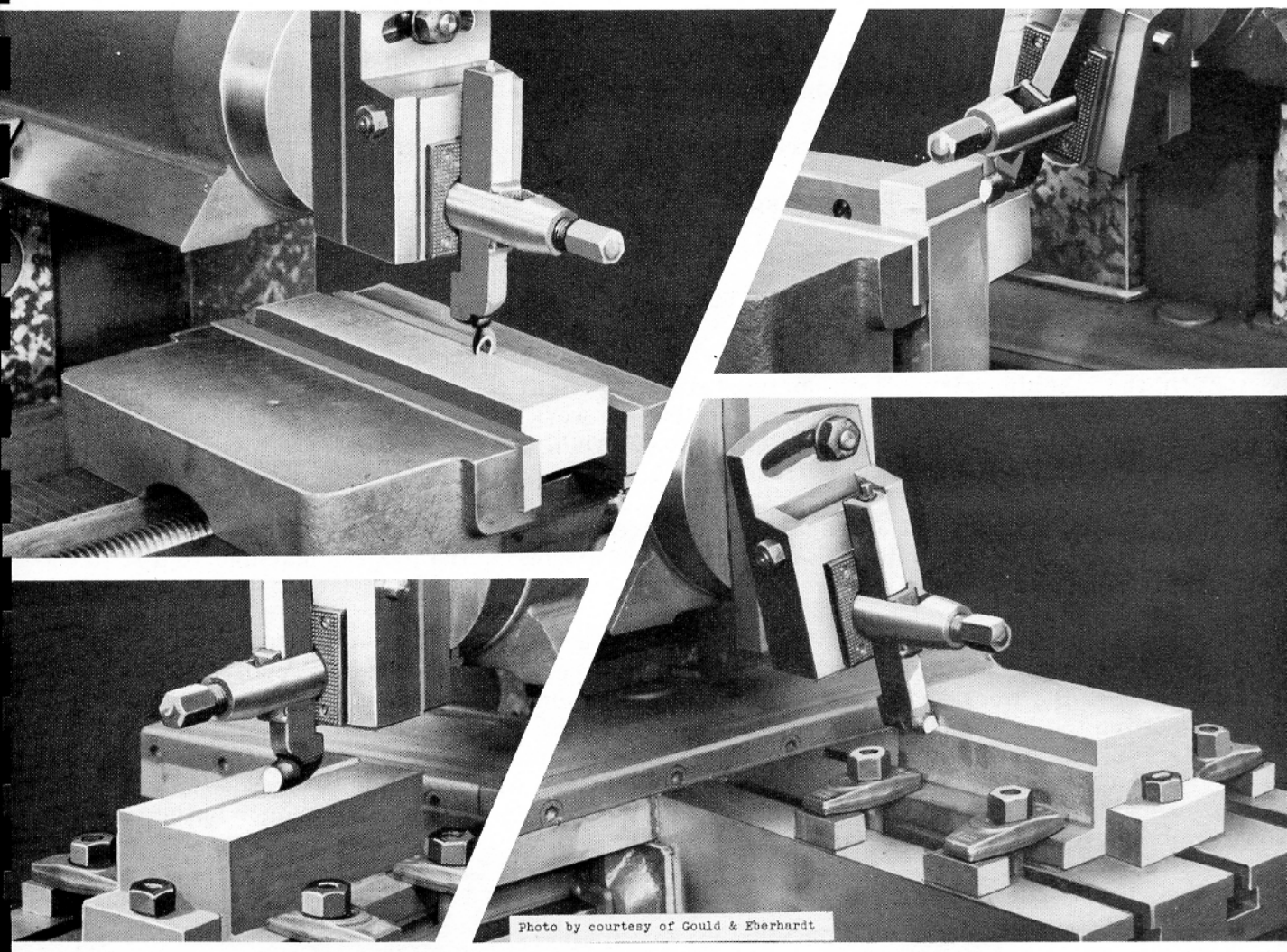


Photo by courtesy of Gould & Eberhardt

UNIT P 53 (A)

Parts I, II, III Pages 189 - 224

HOW TO SHAPE HORIZONTAL SURFACES

OBJECTIVES OF UNIT

1. To show how to set-up the shaper.
2. To tell how to shape a horizontal surface on work held in the vise.
3. To show how to take successive steps in shaping the four sides of a square or rectangular piece.
4. To describe how to shape a vertical surface.
5. To show how to square a shoulder.

INTRODUCTORY INFORMATION

The shaper is intended primarily for shaping flat surfaces on work usually held in the machine vise. Both horizontal and vertical cuts can be made with equal facility. The shaper is so constructed that the work can be fed under the reciprocating tool to produce a horizontal surface. Also, the tool can be fed down on the work to produce a vertical surface.

Considerable work of a preparatory nature is required before actual cutting is possible. This preliminary work consists of arranging the job, the machine, and the cutting tool and is referred to as "setting up the shaper".

Setting up includes proper placement of the work in the machine and adjustment of the various parts of the machine required to establish the proper relationship between the work and the tool. It also includes other adjustments necessary for setting the length of stroke, speed, and feed to meet job specifications. Finally, it includes the selection and placement of the cutting tool for the type of cut to be made and the material in the job. The entire set-up should be made with a view to having it as rigid as the construction of the shaper and the nature of the job make possible.

TOOLS AND EQUIPMENT

Crank or Hydraulic Shaper
Swivel Base Vise and Bolts
Lead or Soft-Faced Mallet
Micrometer
Outside Caliper
Tools and Holders
File
Brush
Chalk
Parallels
Cardboard
Oil Can
Tissue Paper
Wiping Cloth
Surface Gage
Steel Rod
Steel Rule
Steel Square

PROCEDURE

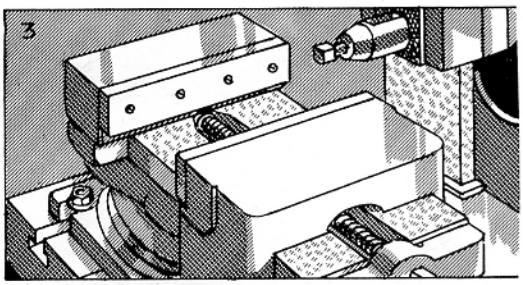
HOW TO MOUNT THE WORK IN THE SHAPER VISE

1. Mount the vise on the shaper, if it is not already in place. Note first, the type of base on the vise. Then, select the one which is appropriate for mounting a vise having this kind of base.

CAUTION The weight of the vise makes it imperative that assistance be sought when placing it on the shaper.

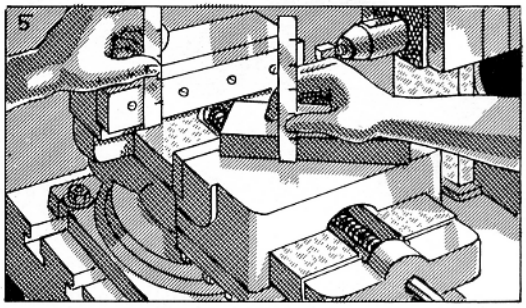
2. Swivel the vise on its base if necessary, placing the index line on the vise above the 90^{o} graduation on its base so as to set the jaws parallel with the stroke. For approximate settings, set the shaper vise with the aid of the graduations on the base. For accurate settings, set the vise parallel with the direction of the stroke with an indicator.

3. Open the vise jaws to receive the work (see Illustration 3).

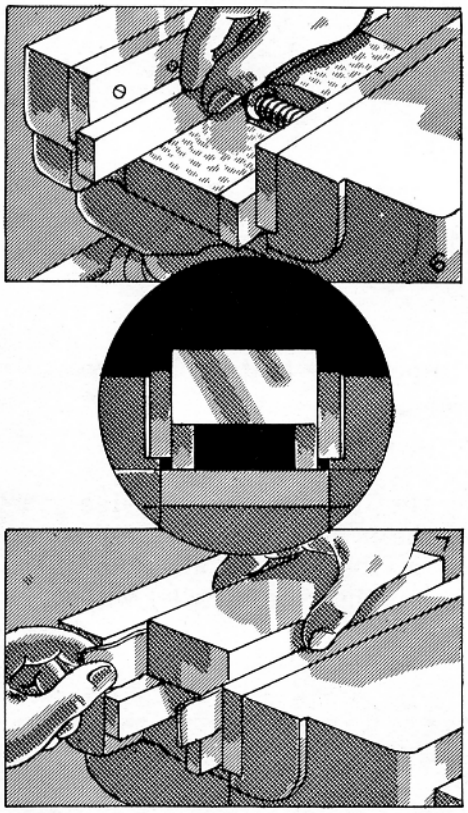


4. Brush chips and other foreign material from the vise jaws and from the bottom of the vise opening. Wipe these surfaces with a clean cloth. Remove any burrs which will interfere with the subsequent seating of the work.

NOTE: One of the important factors contributing to accurate machine work is cleanliness. To a machinist, cleanliness means not only freedom from chips and dirt, but freedom from burrs as well. Whenever a job is to be set in the shaper, the work holding device, and the parallels, if they are used, should be absolutely clean.



5. Measure the depth of the vise jaws. Then measure the thickness of the job to check whether or not the layout line indicating the depth of cut will extend above the vise about 1/8" when the job rests on the bottom of the vise opening. See Illustration 5.



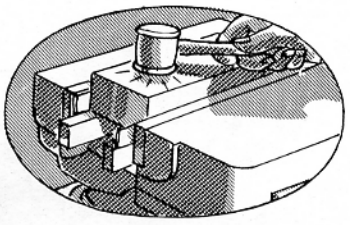
6. Place two identical parallels of correct height under the job, if the work is too low in the vise. Refer to Illustration 6. Space the parallels as widely as possible.

NOTE: Two narrow parallels are usually preferred to a single one of greater width. This is especially true in supporting castings as a casting seldom has a straight surface. The use of narrow parallels makes it easier to determine whether or not the work has been properly seated. The narrow parallels contact the work near its outer edges only and thus avoid contact with any high spots likely to be present in the center of the casting.

7. Place cardboard against the vise jaws if a casting is to be clamped (Illustration 7). It will absorb irregularities on the surface of the casting and protect the faces of the jaws. At the same time, the cardboard tends to distribute the pressure of the jaws evenly over the work.

8. Place the work on the parallels, approximately in the center of the vise. Then, tighten the vise. Exert enough pressure on the vise crank so that vise jaws hold the work securely during subsequent cuts.

NOTE: When the vise is tightened, the work sometimes lifts slightly and does not rest solidly on the parallels intended to support it during the cut. When the vise is tightened, the jaw advances until it grips the work. Then, as additional pressure is applied on the crank, the jaw, no longer able to advance in its original direction, lifts slightly and carries the work up with it. Lost play between the vise jaws and the body of the vise is responsible for this action. It cannot be eliminated entirely where parts must be free to move on one another.



9. Tap the work lightly to seat it on the parallels. Use a lead mallet or block for such materials as steel and cast iron, and a plastic or leather hammer for softer materials such as aluminum, so that the surfaces will not be marked.

NOTE: A light blow usually is sufficient to seat the work. If too hard a blow is struck, the work tends to rebound from the parallels. The intensity of the blow required can best be determined by slightly moving a parallel under the work while at the same time de-

livering light blows with the mallet. If the parallels are still loose, the intensity of the blow can be increased to the point where the work will be forced down and the parallels can no longer be moved (Fig. 283).

10. Test the parallels by trying to move them by hand to see whether or not they are tight under the job, if for any reason the vise requires additional tightening after the work once has been seated on the parallels. The work invariably lifts after each tightening of the vise. Therefore the seating procedure must be repeated each time the vise is tightened.

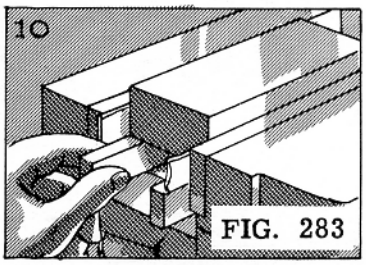


FIG. 283

Oil the shaper as previously directed in HOW TO OIL THE SHAPER.

HOW TO ADJUST THE CUTTING TOOL AND THE TOOL HEAD

1. Review the description of the horizontal cut beginning on page 176.

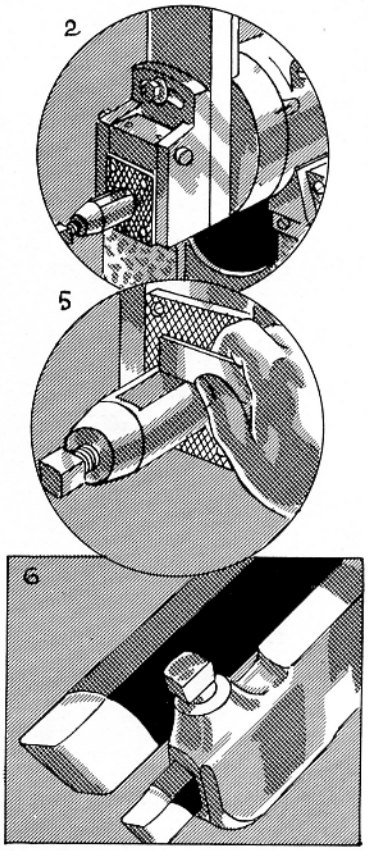
2. Set the tool head at right angles to the machine table (see Illustration 2). Place opposite the zero index line on the ram whichever of the graduations on the swivel block (either zero or 90°) that will square the head with the table.

3. Set the clapper box in a vertical position for light or medium cuts. For heavy cuts, swivel the upper end of the clapper box in the same direction as that in which the work is to feed.

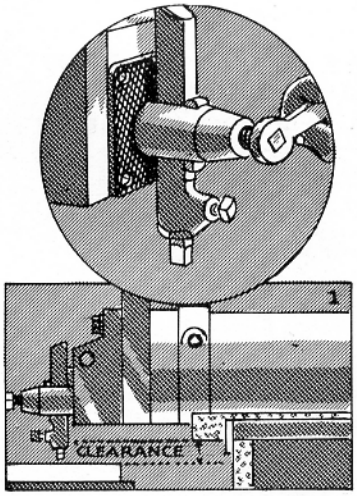
4. Run the tool slide up on the head so that it will not extend below the swivel block when the tool is later set to machine the work.

5. Measure the opening in the tool post so that either a forged tool or a tool holder of the correct size may be selected. Refer to Illustration (5).

6. Select a straight left-cut forged tool ground for taking a horizontal roughing cut on the kind of material in the job. If a straight tool holder is to be used instead, insert a tool bit ground to a similar shape as shown in Illustration (6).



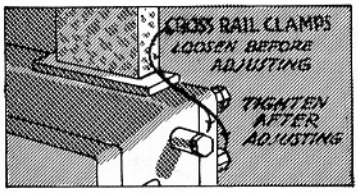
CAUTION Grip the tool bit in the holder as short as practicable for the cut being made.



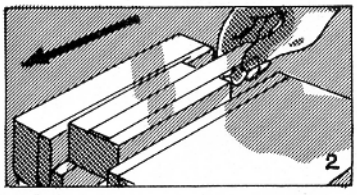
7. Clamp the tool or tool holder securely in the tool post in a vertical position. Ordinarily, allow it to extend no more than 1-1/2 inches beyond the tool block. If the cut is to be heavy, clamp the tool in a position slightly away from the work so if the tool moves, it will not dig into the work.

HOW TO ADJUST THE SHAPER PRIOR TO TAKING A CUT

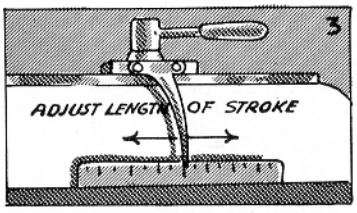
1. Adjust the cross rail on the column so that the surface to be planed is approximately two inches below the ram.



CAUTION Make certain that the bolts which clamp the cross rail to the column, as well as those which clamp the table support, have been loosened before attempting to raise or lower the cross rail. It is equally important that these bolts be tightened again, in the order previously described, after the rail has been relocated.



2. Measure the length of the surface to be planed. Add approximately one inch to this dimension in order to provide for clearance by the cutting tool at both ends of the stroke (refer to Illustration 2).



3. Adjust the ram stroke for this length (Illustration 3). To review the adjusting of the crank shaper, refer to HOW TO ADJUST THE STROKE on pages 79 and 80. For the hydraulic shaper, refer to HOW TO ADJUST THE STROKE AND THE POSITION OF THE RAM on page 92.

4. Adjust the position of the stroke so that the tool covers the entire surface which is to be planed.

5. Consult a table of ALLOWABLE CUTTING SPEEDS — FEET PER MINUTE to determine the cutting speed in feet per minute which is to be used. Base the cutting speed on the kind of material to be planed, the type of cut (whether roughing or finishing) and the material in the cutting tool.

NOTE: Most cone-driven shapers are not provided with charts such as appear on direct gear driven shapers.

6. Determine the number of strokes per minute which will result in a cutting speed in feet per minute approximately the same as that decided upon in Step 5.

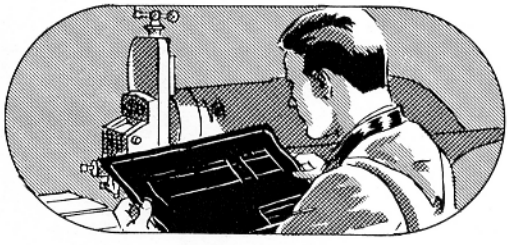
7. Select from the procedures given for setting the speed on various types of shapers, the one which is appropriate for the shaper being used. Adjust the shaper for the number of strokes per minute decided upon in Step 6. For setting the speed on a crank shaper, review HOW TO ADJUST THE SPEED OF THE RAM on page 82. For setting the speed on a hydraulic shaper, refer to HOW TO ADJUST THE SPEED OF THE RAM ON A HYDRAULIC SHAPER on page 94.

CAUTION Do not attempt to shift gears while the shaper is in operation as improper meshing may result in stripping the gear teeth.

8. Adjust the automatic or cross feed to a rate of feed commensurate with the depth of cut to be taken and the surface finish desired.

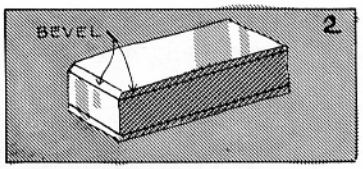
NOTE: The depth of cut and the resistance of the material being cut vary to such an extent on different jobs that it is impossible to recommend a feed which will function equally well under all conditions. It is best, therefore, to begin the cut with a light feed, and increase the feed just as soon as it becomes apparent this can be done to advantage.

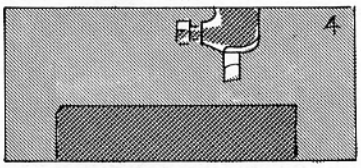
HOW TO TAKE THE ROUGHING CUT

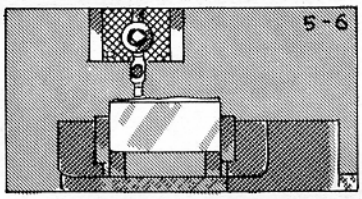


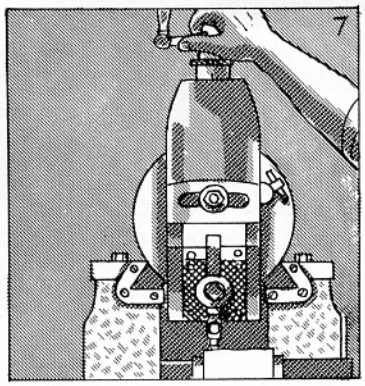
1. Consult the blueprint or job layout to determine the finished size of the job and how much material is to be removed.

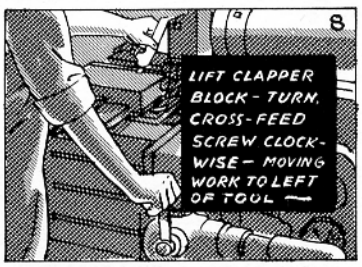
HOW TO SHAPE HORIZONTAL SURFACES











2. Plan to remove approximately half the excess material from the top surface and the other half from the opposite side when both surfaces are to be shaped.

3. Bevel the edges of the casting at the ends of the cut to prevent breakage of the corner below the finished surface (Refer to Illustration 2).

4. Make certain that the tool is higher than the surface of the work and the ram will also clear any projections which may extend from irregularly shaped work.

5. Move the work and table by means of the cross-feed screw to bring it into position with the cutting tool (Illustration 5-6).

6. Move the ram so that the tool is over the surface to be planed.

7. Bring the tool down (while the ram is not in motion) by turning the down-feed screw in a clockwise direction until the tool just barely touches the work. Then adjust the micrometer collar by placing the zero graduation opposite the index mark.

8. Lift the tool together with the tool block on the hinge pin to prevent interference with the work. Then, move the work to the left of the tool, as a left-cut tool has already been placed in the tool post.

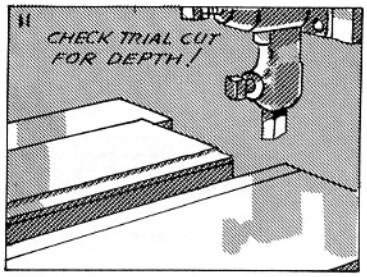
9. Set the tool, with the aid of the graduations on the micrometer dial, to the desired depth for the first roughing cut. Then, lock the tool slide in place. Remove at least 3/32" of metal in order to get under the scale on the casting, provided this amount of metal can be removed without cutting the work undersize.

HAVE ENTIRE SET-UP *CHECKED* BY YOUR INSTRUCTOR

10. Start the shaper. Feed the work to the tool BY HAND until the cut is just started and its depth can be determined.

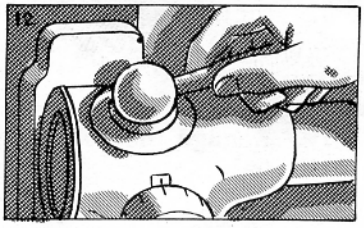
CAUTION Wear goggles as a protection from flying chips and keep the face and the eyes a safe distance from the work.

11. Stop the shaper and check the correctness of the tool setting. If further adjustment in the depth of the cut is necessary, make it only after the work has been moved from under the tool. See Illustration (11).



12. Start the shaper again. Then engage the automatic feed and complete the cut (Illustration 12).

13. Disengage the feed. Bring the table back to the position for starting the cut. Take additional roughing cuts if needed. Allow between .010" and .015" for the finishing cut.



HOW TO TAKE THE FINISHING CUT

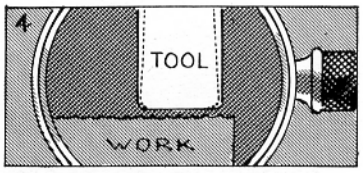
1. Stop the shaper. Replace the roughing tool with a finishing tool ground for cutting the kind of material in the job.

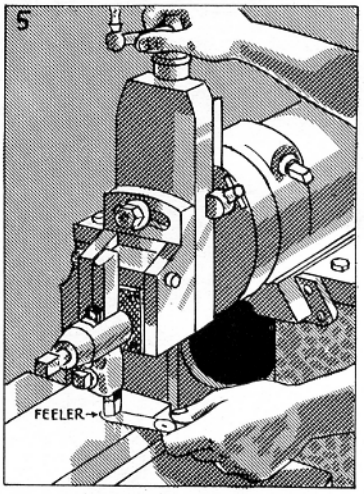
2. Bevel the edges of castings with a file to prevent the keen cutting edge of the finishing tool from coming in contact with sand and scale.

3. Position the work and ram so the tool is again over the machined surface. Set the cutting edge of the finishing tool parallel with the shaped work surface.

4. Clamp the tool holder lightly in the tool post with the cutting edge of the tool close to the work. Tap the tool holder until the cutting edge is exactly parallel with the surface to be finished. Then, tighten the tool-post screw to hold the tool securely.

5. Place a piece of paper or the blade of a thickness gage on the work and carefully lower the tool until it barely touches the feeler. This will aid in setting the finishing tool to the work preparatory to adjusting it for a cut of the desired thickness. See Illustration 5.





6. Set the graduated collar on the down-feed screw at zero. Move the work clear of the tool. Then, lower the tool the thickness of the feeler blade in thousandths plus the number of thousandths necessary to take a cut to the desired depth.

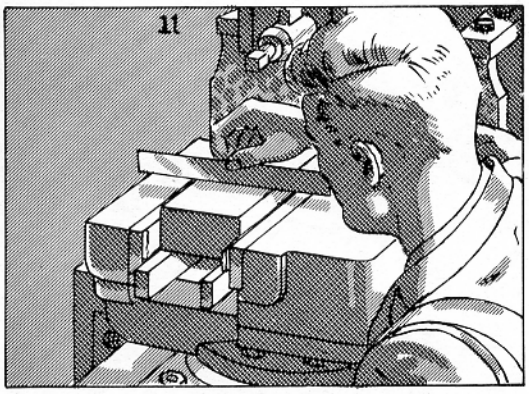
CAUTION When extreme accuracy and a good finish are required, plan to remove the metal allowed for finishing in two cuts instead of one. In this case, the first cut will serve as a trial cut only.

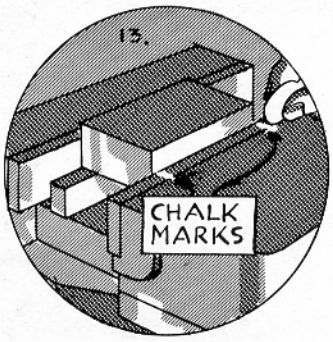
7. Reduce the speed somewhat whenever a finishing tool having a wide cutting edge is used. For round-nosed tools, however, use the speeds recommended in tables of ALLOWABLE CUTTING SPEEDS IN FEET PER MINUTE.

8. Start the shaper and note whether or not the stroke still clears the entire length of the work. A change in ram position may occur when the roughing tool is replaced with a spring-type finishing tool.

9. Increase the rate of feed so that the tool will move over approximately one-half the width of the flat cutting edge for cast iron. For steel, use a fairly fine feed per stroke.

10. Engage the automatic feed and take the finishing cut with the tool slide locked in place.





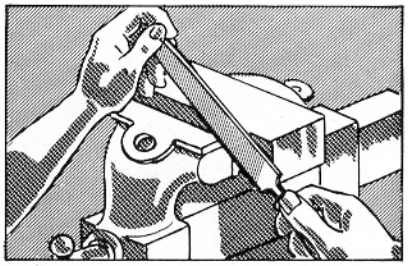
11. Stop the shaper with the ram in its rear position. Brush the chips from the work. Test the planed surface with a straight edge. Finally, take measurements to determine whether or not the work has been accurately machined (Illustration 11).

12. Bring the table back to position for starting a cut. Make further adjustments of the tool with the aid of the micrometer dial, if the work is still oversize.

13. Place a chalk mark when planing short work on the vise at each end of the work to place it in the vise in the same position for subsequent cuts. This prevents changing the position of the ram stroke each time the job is removed from the vise. (Illustration 13).

14. Remove the job from the vise and file from its edges the burrs produced by the tool. Be careful not to mar the finished surface.

15. Brush all chips from the machine and job when the work is finished. Return parallels and other accessories to their proper places in a clean condition.



HOW TO PLANE THE REMAINING SIDES OF A SQUARE OR RECTANGULAR JOB

NOTE: When several surfaces on a job are to be planed, it is considered good practice to rough out all these surfaces before finishing any one of them, in order to relieve internal strains which are likely to be present, especially in castings. The finishing cut will be taken immediately after the roughing cut on each side has been completed.

HOW TO CLAMP THE WORK AND TAKE THE CUT ON THE SECOND SIDE

1. Clean the vise and make certain that the finished surface on the work is absolutely clean too.

2. Set the work in the vise with the side just finished against the fixed jaw, and on parallels, if they are needed. The surface to be planed should be slightly above the vise jaws.

3. Place a round piece of steel horizontally between the movable vise jaw and the work as shown in Figure 284. Then draw the vise up tightly.

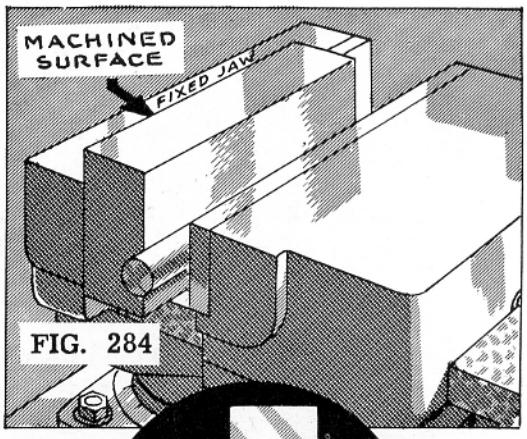


FIG. 284

NOTE: This steel rod should be placed about halfway upon the vise jaw. It makes only a line contact with the work and the vise and thus causes the finished surface of the work to be brought squarely against the fixed jaw of the vise. The fixed jaw should be square with the table.

When the rod is not used and the vise is tightened on the unmachined surface of the work instead (Fig. 285), the finished side of the work is quite likely to change its relationship with the fixed jaw as shown in Figure 285 at (A). As a result of this condition, the side and the top surfaces will not be cut square with each other.

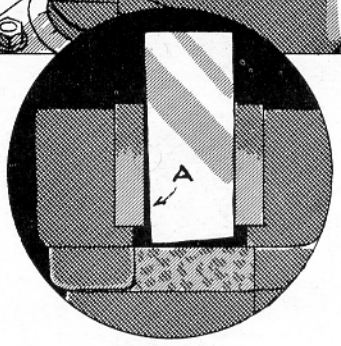
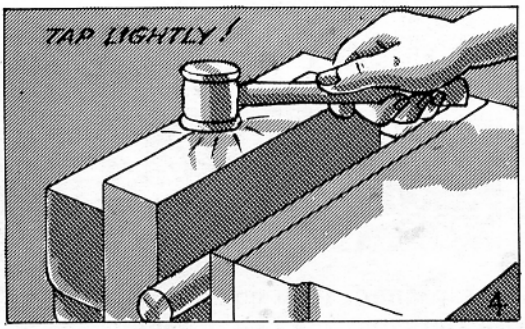


FIG. 285



4. Tap the work lightly with a lead mallet to seat it on the bottom of the vise or on the parallels, whichever means is used for supporting the work.

5. Remove the finishing tool and replace it with the roughing tool used for shaping the first surface.

6. Make certain that the position of the ram stroke is such that the tool will cover the entire surface of the work. Unless the work has been placed in the vise in the same lengthwise position as before, an adjustment of the ram position will be necessary.

7. Reduce the rate of feed to that used for the first roughing cut.

8. Take a roughing cut.

9. Take the finishing cut.

10. Use a fine file to remove from the corners of the work the burrs produced by the cutting tool. Then wipe the two machined surfaces clean.

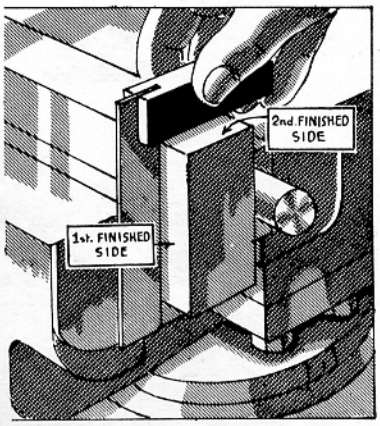


FIG. 286

11. Determine whether or not the finished surfaces are at right angles to each other. Hold the beam of a precision steel square against the surface just finished and the blade across the other finished surface (Fig. 286).

NOTE: If all light is excluded from under the square when its beam is held firmly against the surface just finished and its blade has been brought carefully to the other finished surface, these two sides of the work are at right angles to each other. The remaining sides of the work can then be machined with reasonable assurance that they too will be square with each other, provided the necessary precautions are observed when the work is clamped in the vise.

However, if light is visible under the blade, the work is not square. This condition may be corrected at this time by using one of the methods suggested on page 203.

12. Remove the work from the vise and prepare to plane the third side of the work.

HOW TO CLAMP THE WORK AND TAKE A CUT ON THE THIRD SIDE

1. Make certain that the vise opening and both finished surfaces on the work are absolutely clean and free from burrs.

2. Place the work in the vise. The surface that has just been finished should rest on the bottom of the vise opening, or on parallels if needed. The first side planed should rest against the fixed jaw (Fig. 287).

3. Place the rod between the movable jaw and the work as for the previous cut. Tighten the vise and seat the work.

NOTE: In order to check that work which does not require the use of parallels has been properly seated in the vise, a piece of tissue paper should be placed under each end of the work and allowed to extend so that it can be pulled with the fingers. (Fig. 287) The work has been properly seated when the paper is tight and cannot be withdrawn from under the work.

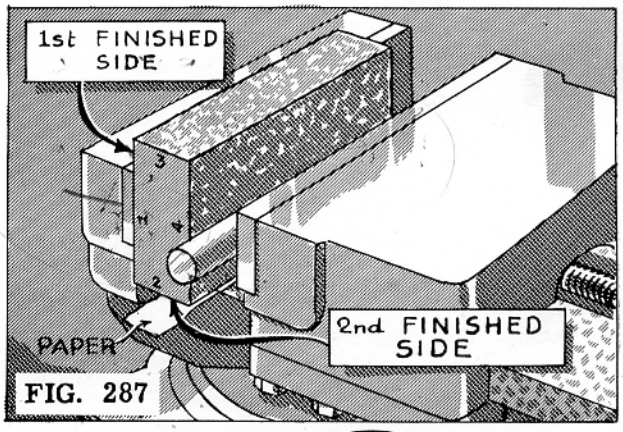


FIG. 287

4. Take a roughing cut as previously directed.

5. Remove burrs from the corners of the work with a file or abrasive stone. Clean the machined surface. Then check the work with a square as shown in Figure 286.

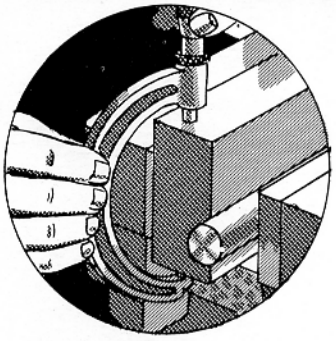


FIG. 288

6. Take a measurement with a micrometer at both ends of the work to determine whether or not the side just finished is parallel and to see how many thousandths must be removed to shape the work to size with the finishing tool (Fig. 288).

7. Take the finishing cut. Remove burrs and recheck with micrometer for size.

HOW TO CLAMP THE WORK AND TAKE THE CUT ON THE FOURTH SIDE

1. Make certain the vise opening is absolutely clean and that the three sides of the work which already have been machined are clean and free of burrs.

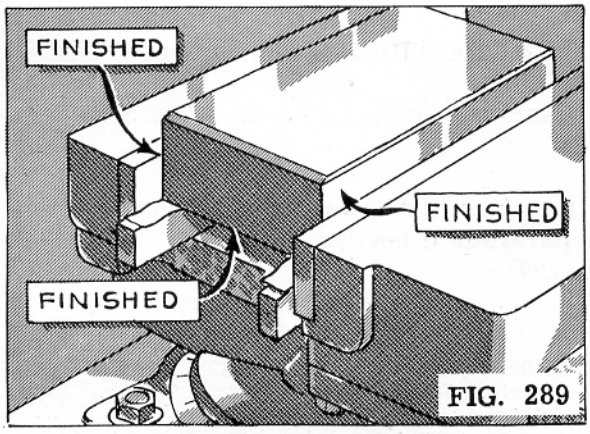
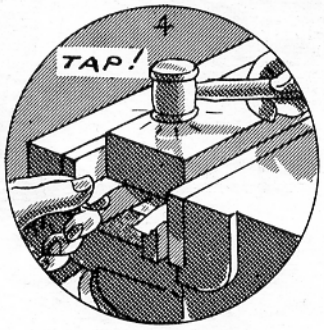


FIG. 289

2. Place the work in the vise with the first side machined resting on strips of tissue paper placed in the vise under both ends of the work. If the work is supported on parallels, place a strip of tissue paper under each corner of the work as shown in Figure 289.

3. Tighten the vise, leaving out the rod which was used before. Tap the work with a lead mallet to seat.

4. Pull lightly on the paper strips to check whether or not the work has been seated properly. (Illustration 4).



5. Take the roughing cut.

6. Take the finishing cut and check with micrometer for size.

7. Give the machine a thorough cleaning. Return all parallels and other accessories free from burrs to their proper places in a clean condition.

HOW TO SQUARE THE ENDS

The ends of short pieces may be planed square with their sides by following the directions below for clamping the work and taking a horizontal cut.

The ends of longer pieces are planed to best advantage by taking vertical cuts. The procedure for this kind of cut is explained later in How to Shape Vertical Surfaces.

1. Swivel the vise on its base so that the jaws are at right angles to the stroke.

2. Make sure that the work and the vise are clean and free from burrs.

3. Place the work in the approximate center of the vise with one end on the bottom surface of the vise or on parallels (Fig. 290).

4. Hold a steel square down firmly against the bottom of the vise. Then set the side of the work parallel with the blade of the square. Tighten the vise lightly.

5. Check the setting of the work with the square (Fig. 290). Move the square away from the work. Tap the work lightly. Then bring the square against the work to check for squareness.

6. Tighten the work securely in the vise when it is square.

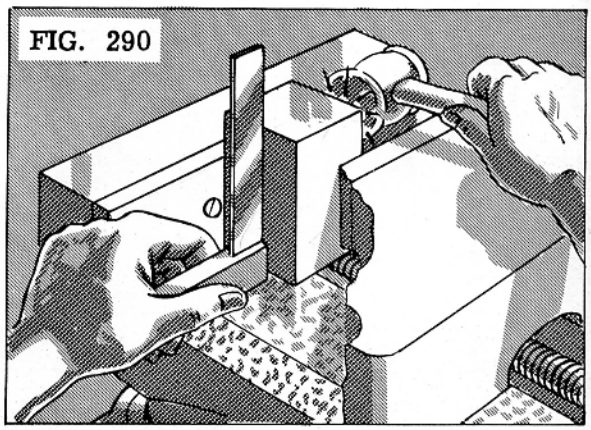
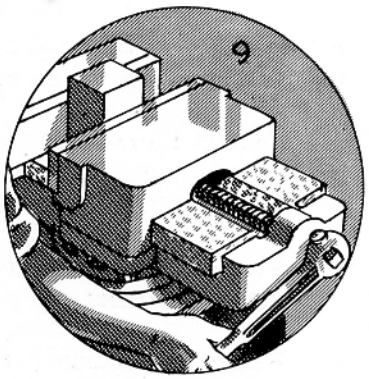


FIG. 290

7. Follow the same directions for taking a horizontal cut as previously described.

8. Check whether or not the end has been planed square with the sides with a steel square.

9. Square the opposite end by placing the work in the vise with the finished end down. Tap the work to seat it properly. Then take successive cuts to machine the work to size.

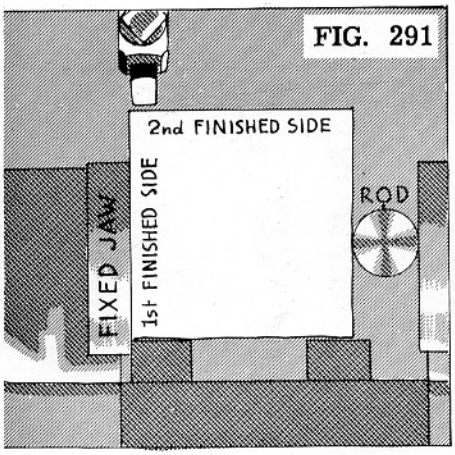


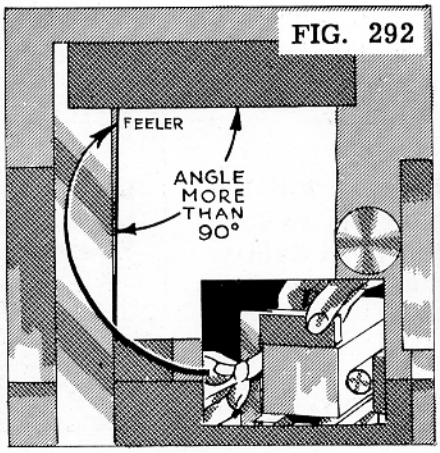
HOW TO CORRECT INACCURACIES BETWEEN RIGHT ANGLE SURFACES

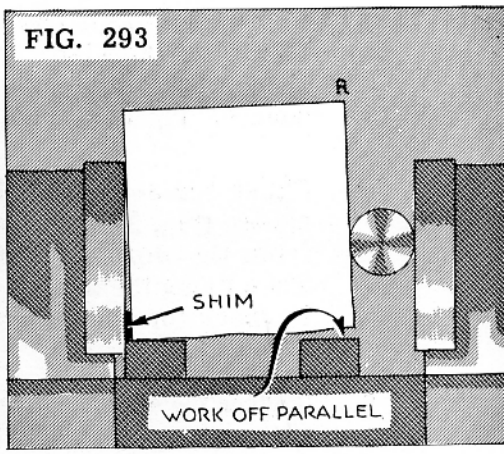
Even though the procedures for clamping the work and planing its sides have been followed conscientiously, subsequent testing with a precision steel square may show that these sides do not form perfect right angles.

This inaccuracy, evident by light visible under the blade of the square, may be the result of carelessness at the time the work was placed in the vise. On the other hand, it may reflect inaccuracies caused by wear on the vise jaw or wear in the machine. Regardless of the cause of the inaccuracy, steps (a), (b) and (c) which follow, should be taken first to eliminate errors resulting from carelessness before attempting to eliminate inaccuracies resulting other causes.

The logical time to make this correction is immediately after a true cut has been taken from the second side of the work.







A test with a steel square shows that the surface just planed is not square with the first surface which now rests against the fixed jaw of the vise (Fig. 292).

a. Inspect thoroughly the work, vise and parallels too (if they are used). Remove foreign material and recheck for burrs which may have been overlooked before and may have prevented the proper seating of the work in the vise.

b. Place the work in the vise again. Observe carefully all the precautions regarding cleanliness and proper clamping and seating. Then take a light cut.

c. Remove the burrs produced by the tool. Clean the surfaces of the work. Finally, check their squareness with a steel square by placing its beam on the surface just finished and bringing the blade to the adjacent side (Fig. 292).

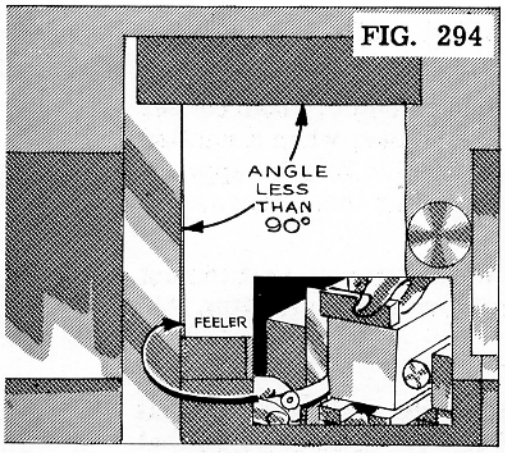
NOTE: If the adjacent side is still not square with the upper surface, proceed to correct this condition by retesting the fixed jaw for squareness with the aid of an indicator. The inaccuracy may also be corrected by using paper shims between the work and the vise jaw as directed below.

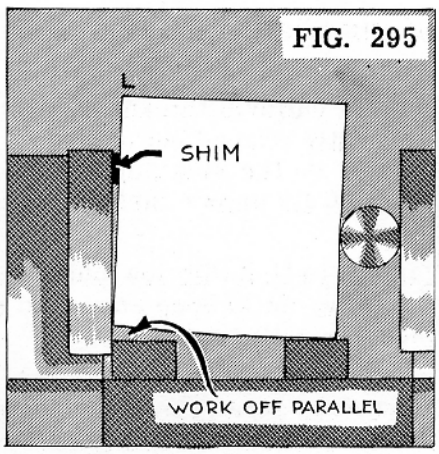
1. Place the work in the vise following the planing of the first side, and take a light cut on the second side (Fig. 291). Test the work with a steel square (Fig. 292).

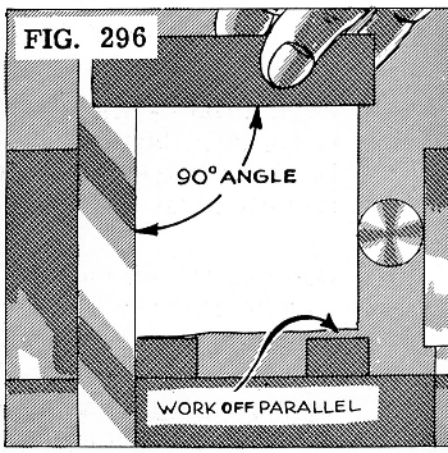
2. Measure the opening between the blade of the square and the side of the work. Use a paper feeler or the blade of a thickness gage in order to determine the approximate thickness of the shim required to correct the inaccurate condition in the work.

FOR ANGLES GREATER THAN 90° (FIG. 292).

3. Place along the bottom of the work a paper shim similar in thickness to that of the feeler used for measuring the opening between the square and the work (Fig. 293).







The shim will cause the work to tilt slightly in the vise, raising its right-hand edge. As a result, the cut will remove slightly more material at (R), Fig. 293, than at the other side of this surface.

FOR ANGLES LESS THAN 90° (FIG. 294)

4. Place the paper shim along the top (Fig. 295) to tilt the work slightly in a direction opposite to that in Figure 293. The tool will now remove slightly more material at (L) Fig. 295 than at the other end of this surface.

If the adjacent sides are not at right angles after inserting the shim and taking a trial cut, replace the shim with one which is thicker, if the opening still occurs in the same place as before taking the trial cut. This indicates that the work has not been tilted sufficiently. A thinner shim, of course, should be used when an opening shows along the square at the end opposite that at which it occurred before the shim was inserted and the trial cut taken.

NOTE: When a shim has been placed alongside the work in the vise, it will be impossible to seat the work so that both parallels are tight under the job. With the use of a shim, even though it is very thin, the work is tilted somewhat, with the result that the bottom of the work is now no longer parallel with the bottom of the vise surface (Fig. 295).

Work on which the bottom side is not at right angles with the side placed against the fixed jaw of the vise (Fig. 296) cannot be seated on both parallels. In this instance it is the work, and not a condition created by the insertion of a shim, which causes one edge of the bottom surface to be higher than the other edge.

HOW TO USE THE SURFACE GAGE ON SHAPER WORK

Even a flat casting is seldom of uniform thickness from end to end or from corner to corner. Castings are frequently warped out of shape. Therefore, when a casting has been placed on parallels or on the vise surface, its underside may be approximately level, but some point on its upper surface may be lower than others.

One use for the surface gage is to find this low point on the casting so that the cut may be set from this point. If the cut is deep enough to remove the scale from this place, the rest of the surface also will be "cleaned up."

Another setup for which the surface gage is frequently used on the shaper is one that requires the upper surface on a casting, instead of the lower one, to be level so that this surface can be planed by taking the smallest cut possible.

In addition, the surface gage is used for scribing lines parallel with the machine table to show the location of finished surfaces, and for setting up work according to layout lines on the job.

HOW TO FIND THE LOW CORNER ON A CASTING HELD IN THE MACHINE VISE

1. Wipe the upper surface of the movable jaw, or the top of the vise with a clean cloth. Then rub the palm of the hand over that portion of the surface on which the surface gage is to be used to check for burrs.

2. Rub chalk on the corners of the work so that the slightest touch of the scriber will be seen immediately.

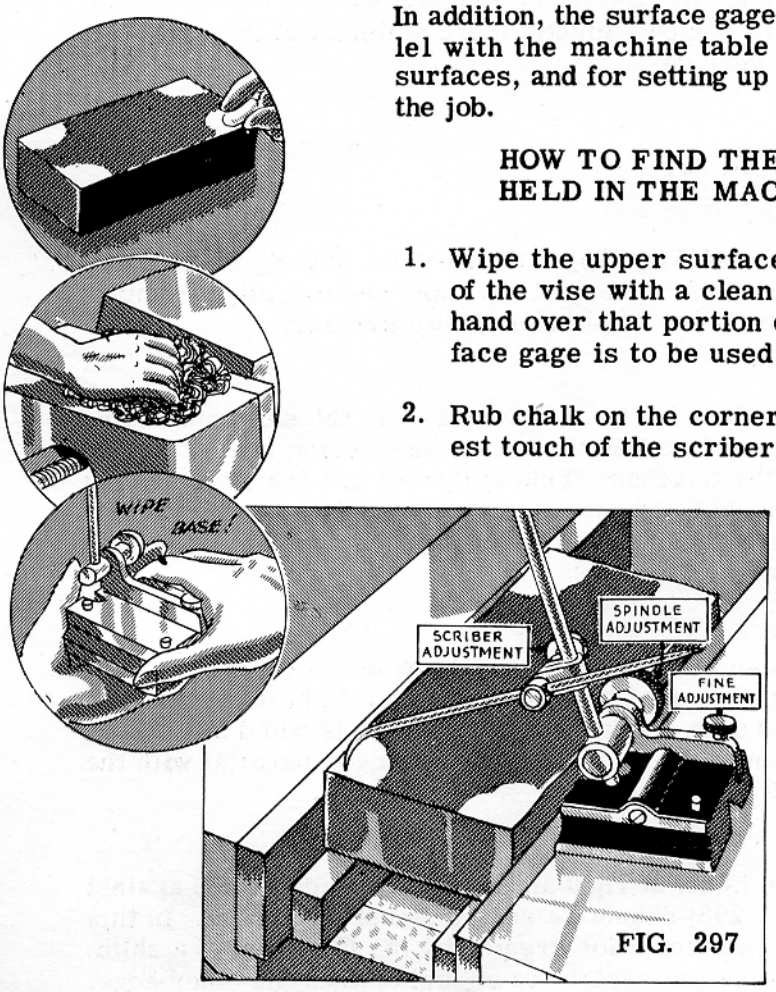


FIG. 297

3. Wipe the base of the surface gage clean. Draw it across the palm of the hand to remove any small particles of dirt which may not have been removed with the cloth and to check for burrs.

4. Place the gage on the movable vise jaw. Adjust the spindle and the scriber (Fig. 297) so that the four corners of the work can be reached with the bent end of the scriber.

5. Move the surface gage so that the scriber passes over one corner of the work. At the same time, turn the adjusting screw (Fig. 298) to bring the scriber to the work gradually. Obviously, the scriber touches the work when it scribes a light line on the chalked corner. It is also possible to "feel" when the scriber touches.

6. Compare the height of the other corners with the one to which the scriber has been adjusted by sliding the gage on its base. Refer to illustration. In this way the scriber is brought to work from the side. Its setting will not be changed if a corner is higher as might be the case when the surface gage is lifted and the scriber is brought down on a higher corner.

7. Check to see which of the corners is the lowest so that the tool may be adjusted to this place for taking the cut.

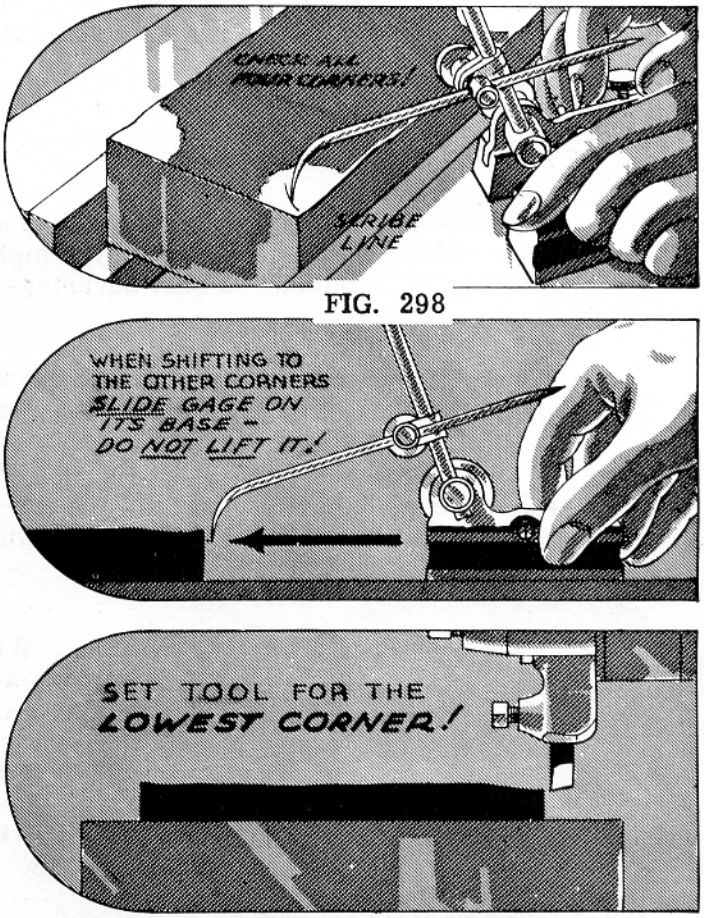


FIG. 298

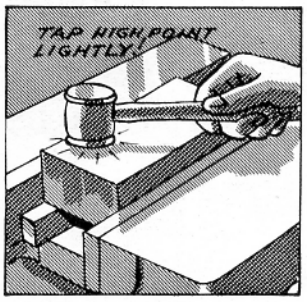
HOW TO LEVEL THE SURFACE ON A CASTING HELD IN THE VISE

1. Place the work in the vise with its upper surface as nearly level as possible. Tighten the vise temporarily by applying only enough pressure on the work to hold it in place while its surface is being leveled more accurately.

2. Clean the vise and gage and check for burrs. Adjust the scriber.

3. Bring the scriber to each corner of the work and note which one is the highest.

4. Tap the high corner down to the approximate level of the others with a lead mallet. Then check all the corners again with the surface gage.



5. Continue to tap the high corner down after each check is made with the gage until the four corners are as nearly the same height as the condition of the casting will permit.

SETTING WARPED CASTINGS

6. Set those corners level which are diagonally opposite each other. In this way there will be a balance between the high and the low corners, and the casting can then be machined to best advantage.

7. Tighten the vise sufficiently to hold the work during the cut. Recheck the work after tightening to make certain that its position in the vise has not changed.

8. Place shims under the parts of the job that do not rest on parallels or on the vise if the work is likely to move down in the vise as a result of the cutting pressure (Fig. 299).

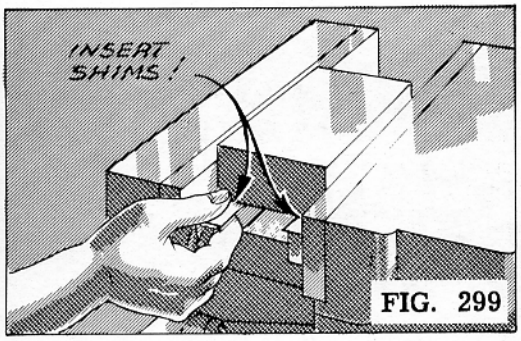


FIG. 299

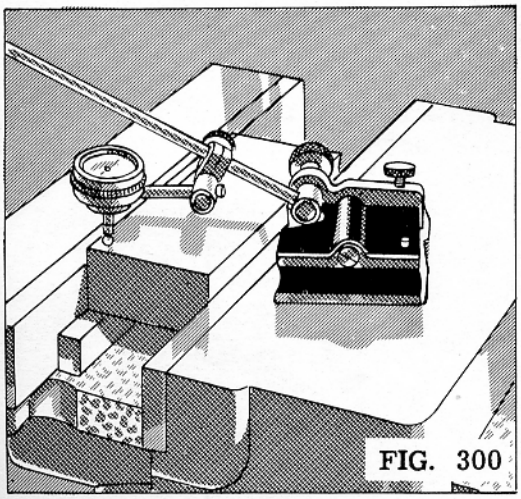


FIG. 300

NOTE: When it is necessary to level a finished surface accurately, instead of leveling a rough surface approximately, a dial indicator can be used on the surface gage in place of a scriber as shown in Figure 300.

HOW TO SCRIBE LAYOUT LINES ON WORK HELD IN THE VISE

1. Rub chalk on the ends and on the sides of the work.

2. Clean the surface gage and check for burrs.

3. Hold a scale in a vertical position with one end on a parallel which supports the work, or on the bottom of the vise if the work is seated on it. (Fig. 301).

4. Set the point of the scriber to the dimension on the steel rule which coincides with the thickness of the finished work. (Fig. 301).

5. Scribe a line on the side of the casting from which the cut is to be started. Draw the base of the surface gage across the top of the vise jaw. At the same time, keep the scriber in contact with the side of the work (Fig. 302).

NOTE: If a line must be scribed on another face of the work which is inaccessible to the surface gage in its present adjustment and location, transfer the gage to another true surface and readjust the scriber point to the first line scribed.

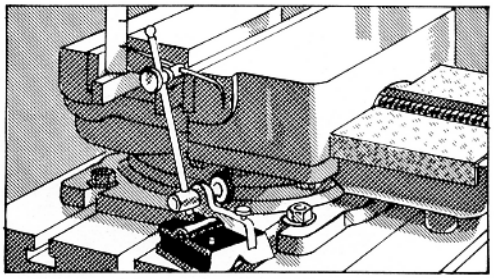


FIG. 301

HOW TO SET UP WORK ACCORDING TO A LAYOUT

1. Clamp the work in the vise temporarily with the layout line which indicates the finished surface as nearly level as it is possible to set it by eye (Fig. 303).

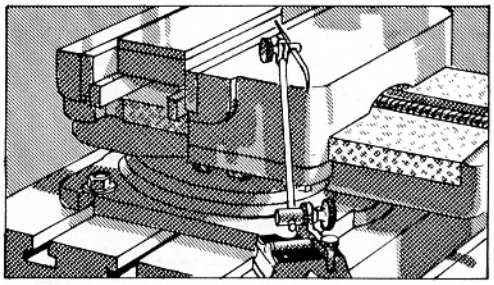


FIG. 302

2. Clean the vise jaw and surface gage and check for burrs.

3. Place the surface gage on the surface which has been prepared for its use. Adjust the point of the scriber to one end of the layout line (Fig. 303).

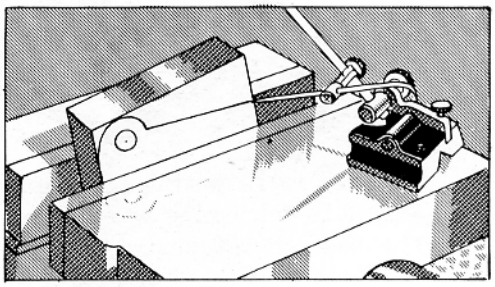


FIG. 303

4. Slide the surface gage to the opposite end of the layout line and note any variation between the height of the line and the scriber. (Fig. 304).

5. Tap the work as required to bring the layout line level with the scriber point.

6. Continue to check and adjust the work in the same way until there is no apparent deviation in the height of the line from end to end.

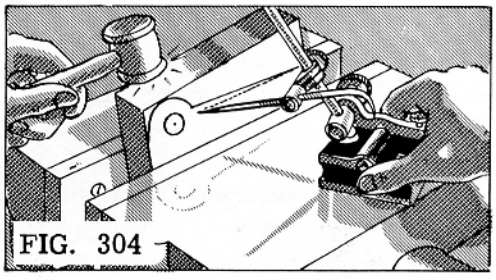


FIG. 304

7. Tighten the work securely in the vise. As a precaution, check again after tightening in order to detect any shifting of the work which may have occurred.

HOW TO SHAPE VERTICAL SURFACES

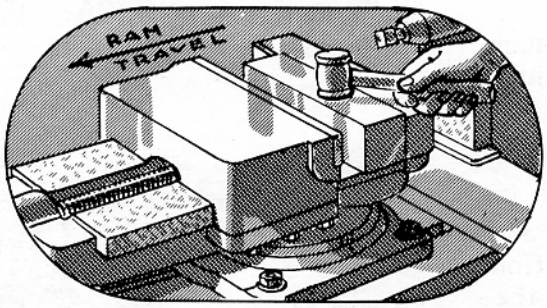
PROCEDURE

HOW TO MOUNT THE WORK IN THE VISE FOR A VERTICAL CUT

1. Bolt the vise to the table. If the vise is not already mounted, select from the several methods given in How to Mount the Shaper Vise (page 119) the one which is appropriate for mounting a vise of the type selected.

2. Swivel the vise on its base, if necessary, so that the jaws are at right angles to the stroke, or as expressed in another way, so that the jaws are parallel with the face of the column.

3. Place the index line on the vise over the zero graduation on the base. When a more accurate setting is desired, set the vise at 90° to the direction of the stroke with an indicator.



4. Place the work in the vise -- on parallels if it must be raised -- so that the end which is to be squared extends approximately one-half inch beyond the right side of the vise. At the same time, place a strip of paper under each end of the work if it rests on the vise, or under each corner of the work if it rests on parallels.

5. Tap the work with a lead mallet to seat in the vise. Pull lightly on the paper strips to determine whether or not it has been properly seated. In order to have the ends planed square with its sides, the work must be placed parallel with the table as well as at the right angles to the stroke of the ram.

6. Bevel the edges of the work at the end of the cut, almost to the depth of the cut.

HOW TO MOUNT THE WORK ON THE TABLE FOR A VERTICAL CUT

1. Remove the vise from the table.

CAUTION For heavy machine vises, secure help in removing from table.

2. Clean the table thoroughly. Then remove any burrs or high spots with a smooth file or abrasive stone.

3. Clean the surfaces of the work. At the same time, inspect these surfaces for burrs which must be removed before placing the job on the machine table.

4. Place a single thickness of thin paper on the shaper table for the purpose of increasing the amount of friction between the work and the table and reducing the likelihood of the job shifting during the cut (Fig. 305).

5. Place the work on the table with one of its sides as nearly parallel with the face of the column as it is possible to set by eye. At the same time, allow one end to extend about one-half inch beyond the right side of the table.

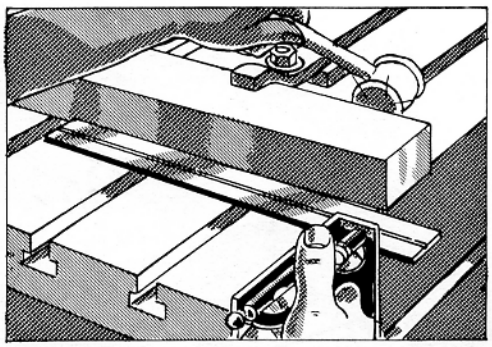


FIG. 305

6. Clamp the work to the table lightly. Use straps and the shortest bolts possible which will still provide a full thread for the nut. If gooseneck clamps are available, use these. Their construction makes it possible for the bolt and nut to be below the clamp itself. This feature of having the top of the bolt no higher than the strap is important, especially when vertical cuts are taken. Any extension of the bolt above the work adds to the distance the tool slide must be extended from the head during the cut.

7. Recheck the side of the table which is to be used for squaring the work to see that it is free from burrs and clean.

8. Place the head of a combination square (or the blade of a steel square) against the side of the table. Extend the blade long enough to permit the work to be squared. (See Figures 305 and 306.)

9. Press the head of the square firmly against the side of the table and carefully slide it toward the work. Note which end of the blade comes in contact with the work.

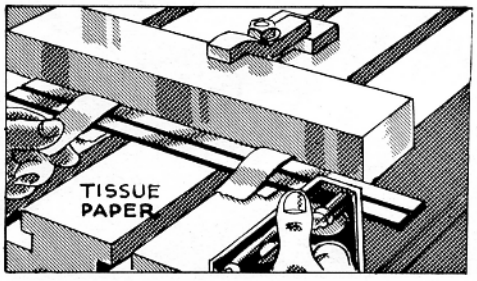


FIG. 306

10. Move the square back. Then tap the end of the work which did not touch the blade until the opening between the work and the square disappears and the work is parallel with the blade. This indicates that the work is now at right angles to the ram.

11. Recheck the alignment of the work more accurately with the square. Place a piece of tissue paper between the work and each end of the blade. With the blade removed tap the work and continue to test until the same amount of "drag" is felt on both pieces of paper when they are withdrawn from between the blade of the square and the work (Fig. 306).

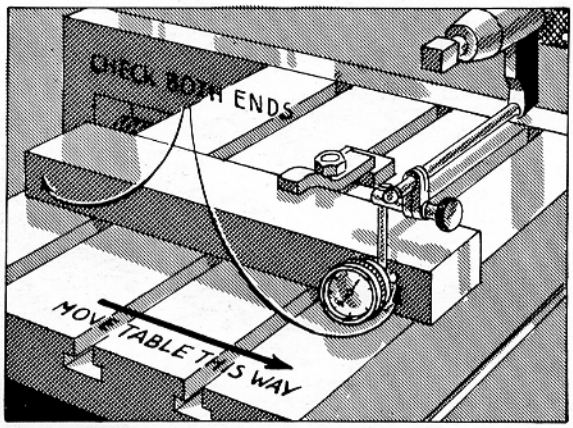


FIG. 307

12. Align very accurate work with a dial indicator instead of a square. Clamp the indicator in the tool post with its contact point against the front face of the work. Move the work crosswise by means of the crossfeed screw to determine the amount the work is out of alignment. Adjust the work in the same manner as before, until the indicator reading does not change during the movement of the table and work (Fig. 307).

13. Tighten the work securely. As a precaution, check its alignment again to see whether or not its position changed when the bolts were drawn down tightly.

14. Place a suitable stop in front of the work at the right and another in the rear of the work at the left (Fig. 308) as an additional precaution against shifting of the work during the cut.

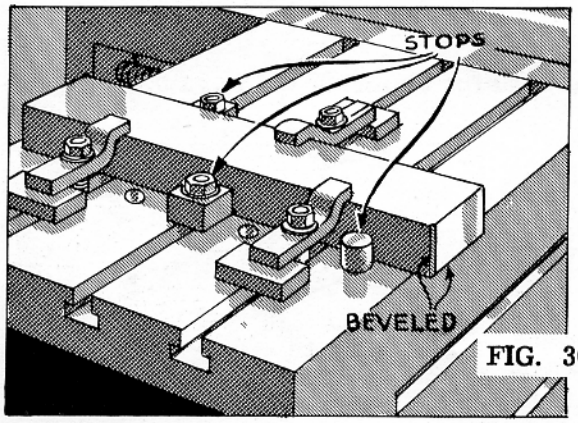


FIG. 308

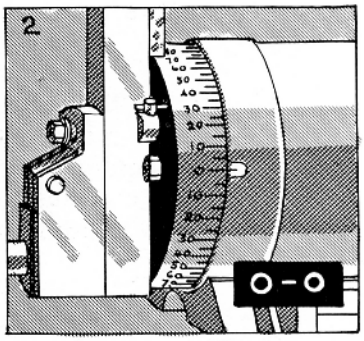
CAUTION If stops having screws are selected, be careful not to force the screws against the job so hard that the work is shifted out of alignment. Recheck alignment with indicator after all straps and clamps are secured.

15. Bevel the edge at the front of the work with a file, almost to the depth of the cut.

OIL Oil the shaper before starting a cut.

HOW TO ADJUST THE CUTTING TOOL AND THE TOOL HEAD

1. Set the tool head at right angles to the machine table by placing opposite the index line on the ram whichever of graduations — zero or 90° — will cause the head to be positioned square with the table (Illustration 2).



2. Tighten the clamping bolts just enough to hold the tool head in this position.

3. Check the accuracy of this setting with a square (Fig. 309). Hold the head of the square down firmly against the finished surface on the table or vise. Carefully slide the square against the side of the tool slide and note whether or not it is parallel with the blade of the square.

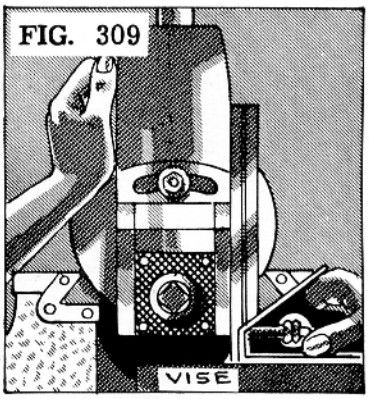
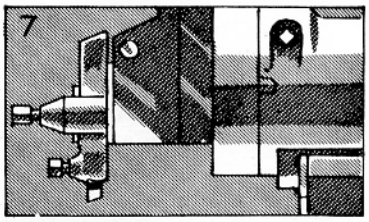


FIG. 309

4. Move the square away. Then tap the tool head with the palm of the hand or with a soft hammer until no light is visible between the square and either end of the tool slide (Fig. 309).

5. Tighten the clamping bolts on the head securely when the head is square.

6. Loosen the binder bolt on the clapper box and swivel its upper end to the right to the limit of the elongated slot. Then tighten the bolt again.



7. Note the height of the vertical surface which is to be shaped. Run the tool slide up far enough at the start of the cut so that when the cut has been completed and the tool has reached the lower edge of the vertical cut (Fig. 310), the slide will not extend much below the swivel block.

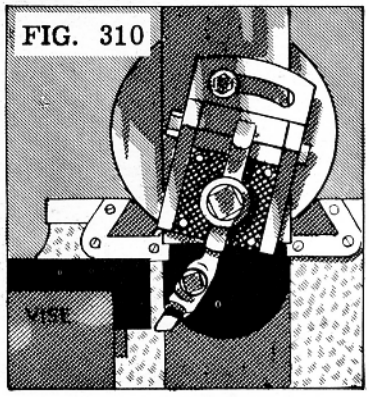


FIG. 310

8. Measure the opening in the tool post so that either a forged tool or a tool holder of the correct size may be selected.

9. Determine whether a straight or an offset tool holder can be used to better advantage on this cut. Then select a tool bit that has been ground especially for taking a vertical cut on the right-hand end of the job and for

cutting the kind of material in the work. If a forged tool is selected instead of a tool holder and a tool bit, its selection too should be based on these same factors.

10. Clamp the tool holder in the tool post in such a position that the vertical cut can be made without interference between the holder and the job. Extend the tool holder beyond the tool block the shortest distance possible for making the cut. In no instance should this distance be less than the height of the vertical cut, if rubbing of the tool slide on the work is to be avoided (Fig. 310).

HOW TO ADJUST THE SHAPER PRIOR TO TAKING A VERTICAL CUT

1. Adjust the position of the cross rail on the column up or down so that a space of approximately one inch is apparent between the ram and the top of the work, or between the ram and the straps and bolts, whichever is higher.

CAUTION Before raising or lowering the table, loosen the bolts for clamping the cross rail and those for clamping the table support. Tighten them again immediately after the rail has been moved to its new position on the column.

2. Measure the length of the surface which is to be planed; add approximately one inch to this dimension in order to provide for clearance of the work by the cutting tool at both ends of the stroke.

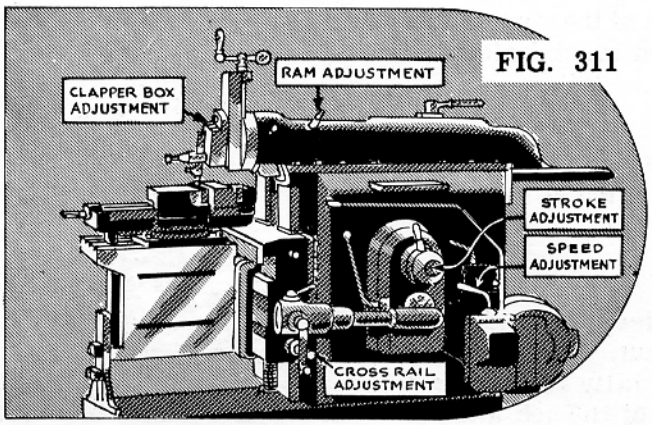


FIG. 311

3. Adjust the ram stroke for length.

4. Adjust the position of the stroke so that the tool covers the entire surface which is to be planed.

5. Consult a table of Allowable Cutting Speeds in Feet Per Minute. A typical

table is given on page 308. From this table, determine the cutting speed in feet per minute which is to be used. Base the decision on the kind of material to be planed, the type of cut (whether roughing or finishing) and the material from which the cutting tool is made.

NOTE: Most cone-driven shapers are not provided with charts such as appear on direct-driven shapers.

6. Determine the number of strokes per minute which will result in a cutting speed in feet per minute approximately the same as that decided upon in step 5.

7. Adjust the shaper for the number of strokes per minute decided upon in step 6.

CAUTION Shift gears only when the shaper is not in motion.

8. Check whether or not the cut can be made without any part of the ram striking the work by feeding the tool down for the length of the cut while the ram is not in motion. Then carefully move the ram through one complete stroke by hand.

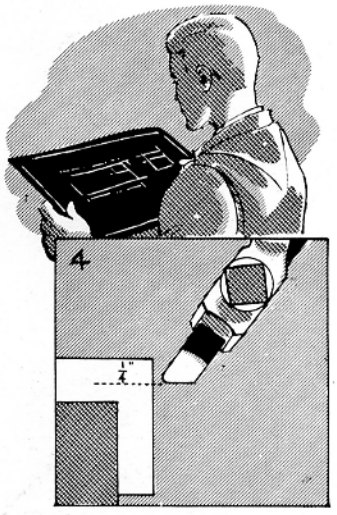
HOW TO TAKE THE ROUGHING CUT (VERTICAL)

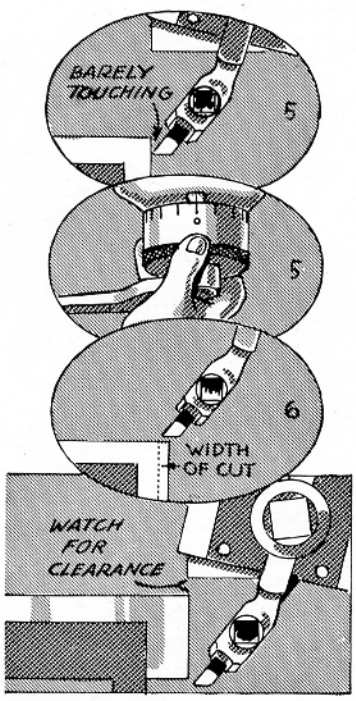
1. Consult the blueprint or the job layout to determine how much material is to be removed by the tool.

2. Plan to remove approximately one half the excess material from each end when both ends must be squared and the job must be planed to a definite length at the same time.

3. Bevel the vertical edges at the ends of the cut to prevent breakage of the corner below the finished surface.

4. Set the tool for a cut of the desired thickness by moving the work to the left of the tool. Then, by means of the down-feed screw, move the tool down about 1/4" from the top of the vertical surface (Illustration 4).





5. Move the work toward the tool carefully by means of the cross-feed screw until they just barely touch. Set the micrometer dial on the cross-feed screw to zero (Illustration 5).

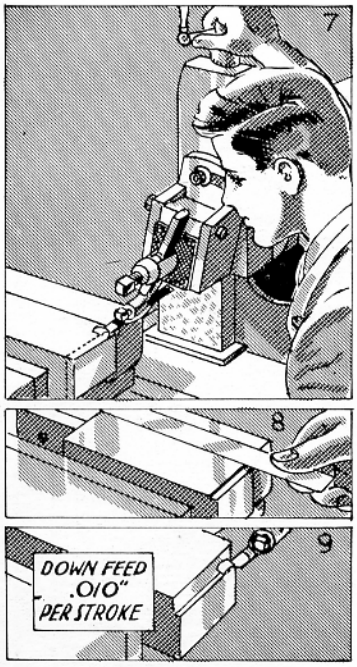
6. Raise the tool so that it just clears the top of the job. Move the work to the tool for the desired cut, measuring its thickness by means of the graduations on the dial on the cross-feed screw.

NOTE: During the vertical cut, the tool is frequently extended farther from the tool post than usual so that the cut can be made to the bottom of the work without interference between the tool slide and the job. For this reason both the rate of feed and the width of the cut should be somewhat less than they are for horizontal shaping.

HAVE ENTIRE SET-UP *CHECKED* BY YOUR INSTRUCTOR

OIL Oil the shaper before operating.

7. Start the shaper. Feed the tool down carefully by hand until the cut is started and the width can be seen (Illustration 7).



CAUTION Wear goggles as a protection from flying chips and keep the face and the eyes a safe distance from the work.

8. Stop the shaper to measure the work and make certain that the work in its present position will not be cut undersize because too heavy a cut is removed.

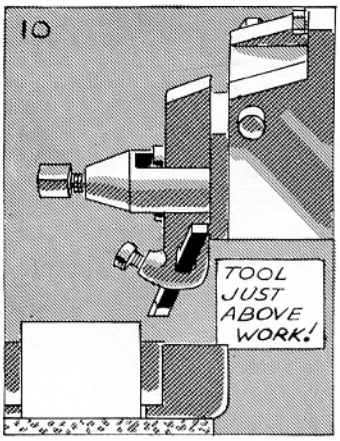
9. Start the shaper again. Feed the tool down about .010" at the end of each return stroke of the tool (Illustration 9). Continue the feeding until the entire vertical surface has been shaped.

NOTE: Inasmuch as both the size of the cut and the quality of the finish desired may vary considerably, it is impossible to specify a rate of feed suitable for

every combination. The recommended procedure, therefore, is to feed the tool to the work slowly at first. Then increase the rate when the action of the tool makes it apparent this can be done with safety.

CAUTION Keep the fingers and hands away from the cutting tool while the shaper is in operation. It is extremely dangerous to place the hands directly behind the vise, or the work, at any time while the shaper is in operation.

10. Stop the ram in its backward position when the cut has been completed and raise the tool to the top of the work for starting the cut.



11. File the burrs from the edges of the work preparatory to testing it with a square. Wipe the upper surface and the end in order to remove the filings and any other foreign material which may be present.

12. Test the work with a steel square as shown in Figure 312 to see if the end has been planed square (at right angles) to the upper surface.

NOTE: When the surface of the work is unusually rough and irregular before it is machined, this condition is very likely to be reflected on the finished surface as a result of spring in the tool. A second, light cut, made for the purpose of removing these irregularities, is advisable for correcting this condition. Then a true surface will be produced which indicates the actual position of the head in relation to the upper surface of the work.

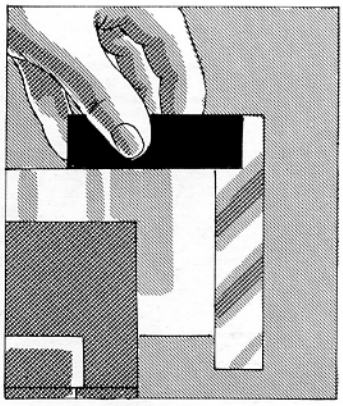


FIG. 312

13. Test the work with a square by pressing its beam down firmly against the upper surface of the work. Carefully move the blade toward the end just machined. Then note whether or not the vertical surface is parallel with the blade.

NOTE: If the work and the tool head have been set up correctly, the end should be machined square with the top of the work. If this is the case, the blade of the square will touch the end from top to bottom and neither an opening nor light will be visible between the work and the blade of the square.

The work is not square when light is visible between the square and the end of the work. To correct this condition, the tool head must be swiveled slightly in one direction or the other depending upon whether the light is visible at the upper or the lower end of the blade.

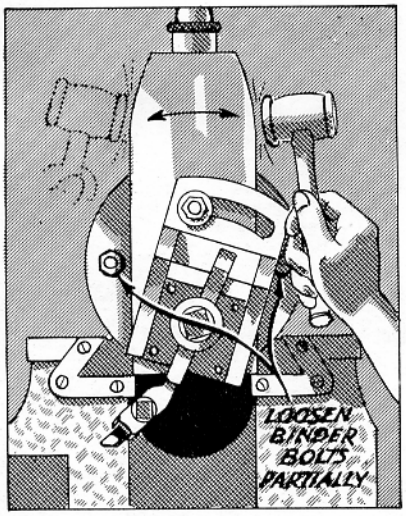


FIG. 313

14. When the position of the tool head is to be changed only a small amount for correcting a slight inaccuracy in the cut, partially loosen the binder bolts holding the swivel block to the ram.

Swivel the head in the direction desired by tapping it lightly with a block of wood or lead, to the left when the opening occurs at the lower end of the square; to the right when the opening occurs at the upper end (Fig. 313). The number of adjustments required to make the work square will depend upon the operator's ability to estimate the amount of swiveling needed on the head to produce the desired correction in the cut.

15. Reset cutting edge of the tool with the work after each adjustment of the head. Their relationship changes each time the head is swiveled. Take another light cut and check the result with a square as before.

CAUTION When taking several trial cuts to square the work, be careful not to cut the work undersize.

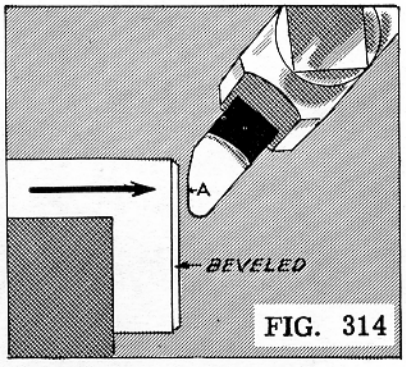


FIG. 314

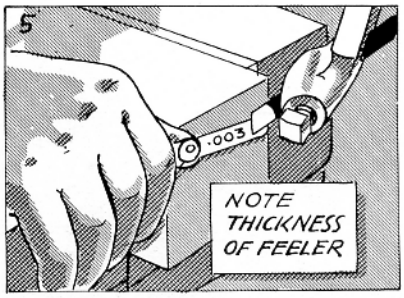
HOW TO TAKE THE FINISHING CUT (VERTICAL)

1. Replace the roughing tool with a left-side finishing tool ground for cutting the kind of material in the job. Locate the tool in the tool post and position in relation to the cut.

2. File a small bevel on the edges of castings to prevent the sand and scale on their surfaces from dulling the keen cutting edge of the finishing tool. (Fig. 314).

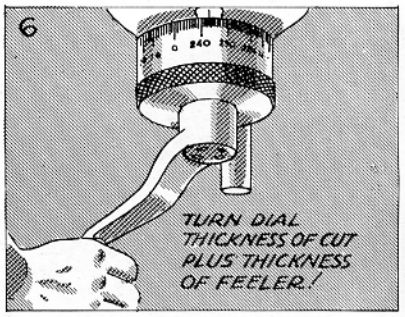
3. Move the ram to position the tool opposite the vertical surface. By means of the down-feed screw, lower the tool so that it extends alongside this surface. Then, using the cross-feed screw, move the work over until it almost touches the tool.

4. Adjust the tool in the tool post so that its cutting edge at (A) in Figure 314 is parallel with the vertical surface. Tighten the tool-post screw.



5. Place a feeler blade against the end of the tool. Continue to move the work carefully toward the tool until a slight "drag" is required to withdraw the feeler from between the work and the tool (Illustration 5). Set the graduated collar on the cross-feed screw to zero.

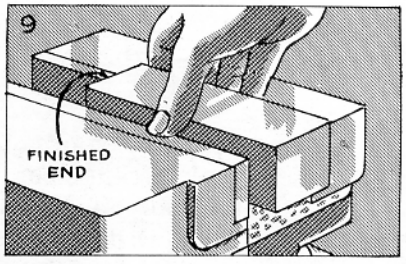
6. Raise the tool so that it clears the job. Move the work to the right a distance equivalent to the thickness of the cut desired and the feeler. Use the micrometer collar to measure the distance. (Illustration 6).



7. Start the shaper. Feed the tool down at the end of each return stroke of the ram. Use a fine feed when finishing steel and a coarser feed for cast iron.

8. File the burrs from the edges. Wipe the surfaces clean. Test the work with a square.

9. Square the opposite end of the work by reversing its position in the shaper.



NOTE: If the work is long enough to project beyond the vise jaws or table, the second end may be shaped to length by swiveling the tool holder and clapper box in the opposite direction using a cutting tool ground for taking a cut on the left side of the job.

10. Replace the finishing tool with the roughing tool.

11. Take the roughing cut allowing .010" to .015" on the overall length of the work for the finishing cut.

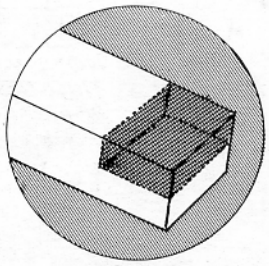
12. Replace the roughing tool with the finishing tool used for the opposite end and proceed to take a finishing cut the same as on the first end.

13. Measure the overall length of the work. If the job is oversize, take additional cuts. Use the micrometer dial on the cross-feed screw to determine the amount of metal to be removed.

14. Brush all chips from the machine, and return the parallels and other accessories to their proper places in a clean condition at the completion of the job.

HOW TO SHAPE COMBINED HORIZONTAL and VERTICAL SURFACES

PROCEDURE



Squaring a shoulder is usually preceded by horizontal and vertical cuts. As a rule, the shoulder is squared immediately after these cuts have been made and before the work is removed from the shaper. Therefore, directions for mounting the work will not be given in this unit.

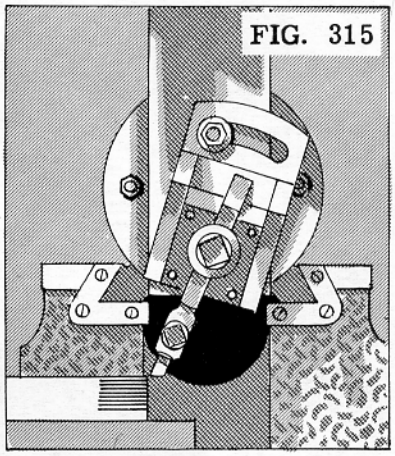


FIG. 315

1. Set the tool head at right angles to the table.

2. Swivel the clapper box to the right as for a vertical cut.

3. Select a round-nosed roughing tool suitably ground for taking a horizontal cut on the material in the job. The tool should have its cutting edge on the left side and a relatively small radius on the corner.

4. Mount the tool holder in the tool post. Allow it to extend just far enough for the tool to reach the lower horizontal surface without having the tool slide strike the job. At the same time, place the tool holder in a position (slightly angular) which will enable the tool to cut to the corner without having its holder rub on the vertical surface (Fig. 315).

5. Make certain that the length of the stroke, its position relative to the cut, and also the speed of the shaper have been adjusted to suit the job.

CAUTION Carefully move the ram through one complete stroke to make certain that the above adjustments have been made correctly.

6. Take a series of horizontal cuts and rough out the work to within 1/64" of the final dimensions on both the horizontal and the vertical surfaces.

7. Remove the roughing tool and replace it with one ground especially for squaring the corner. Surfaces (A) and (B) on this tool (Fig. 316) form an angle slightly less than 90^{o}.

8. Adjust this tool to the work so that a slight opening appears at (B) when the point just barely touches the horizontal surface. A similar opening must appear at (A) when the point touches a vertical surface such as the end of a scale placed against the side of the tool as shown in Figure 316.

NOTE: Although it is intended primarily for squaring right-angle corners, a tool ground like the one shown in Figure 316 functions equally well as a finishing tool for both the horizontal and the vertical surfaces which form a shoulder. The procedure for its use in this manner has been explained here. The practices to be followed when a tool of this kind is used only for squaring the shoulder will be covered later (page 223).

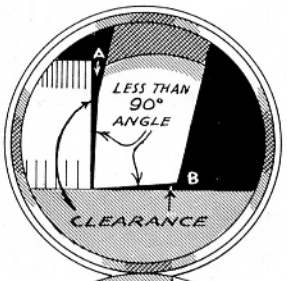
9. Set the tool so that it just barely touches a feeler placed on the upper surface of the work when the height of the shoulder must be accurately maintained. Then set the micrometer collar on the down-feed screw to zero.

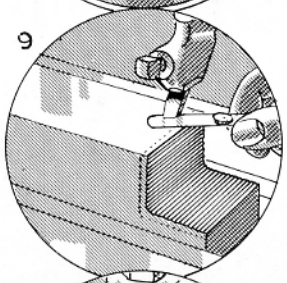
10. Move the work to the left so that it is no longer under the tool. Then use the micrometer dial and feed the tool down a distance equivalent to the height of the shoulder and the thickness of the feeler (Illustration 10).

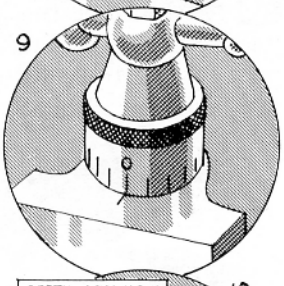
11. Lock the tool head in place (Illustration 11). Reset the micrometer dial at zero and start the shaper.

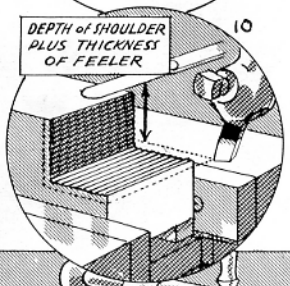
12. Adjust a rate of feed which will produce the kind of surface finish desired. Engage the automatic feed. Then take a finish cut on the horizontal surface (Illustration 12).

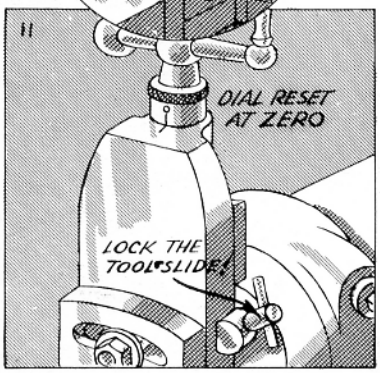
FIG. 316

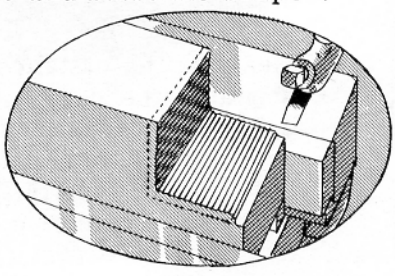












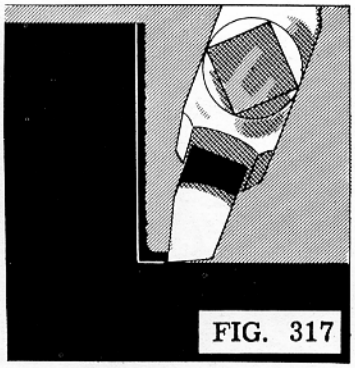


FIG. 317

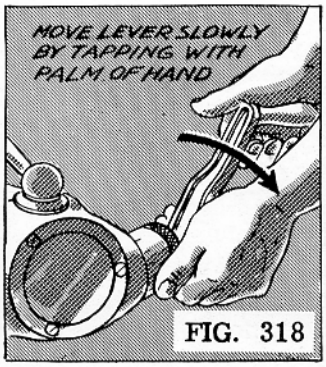


FIG. 318

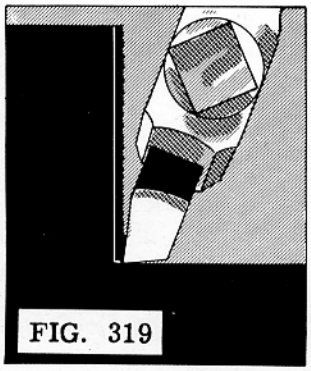


FIG. 319

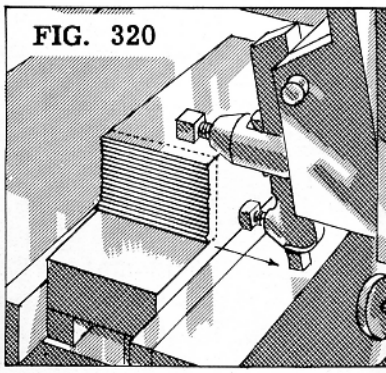


FIG. 320

13. Disengage the automatic feed just before the tool reaches the corner (Fig. 317). Use the hand feed and move the work toward the tool slowly. Tap the handcrank lightly with the palm of the hand to control to best advantage the amount of feed per stroke (Fig. 318).

14. Continue the hand feeding until the metal left in the corner by the round point on the roughing tool has been removed and the tool has cut almost to the layout line indicating the location of the shoulder (Fig. 319). Then stop the shaper at the end of its backward stroke (Fig. 320).

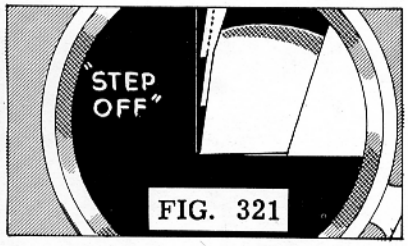
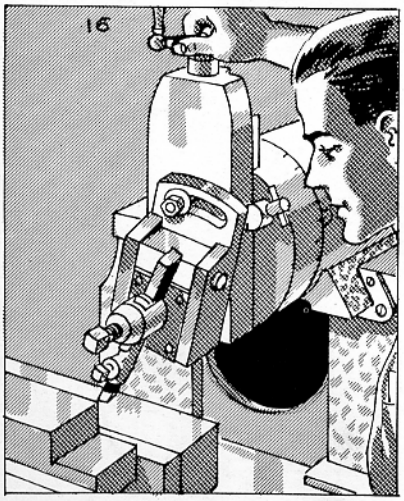


FIG. 321

NOTE: If a large fillet has been left in the corner, it may be necessary to "step it off". That is, it may be desirable to remove the fillet by taking several light cuts rather than by taking a single heavy one (Fig. 321).



15. Raise the tool to a position slightly above the vertical surface. Adjust the work to the tool preparatory to taking the vertical cut.

16. Start the shaper. Feed the tool down carefully until the cut is just started. Make further adjustments of the work, if necessary, so that the final setting will result in a cut which splits the vertically scribed line.

17. Measure the distance from the end of the work to the shoulder whenever it must be maintained accurately by using the graduations on the micrometer collar of the cross-feed screw. Move the end of the work against the left side of the tool (Fig. 322), using a feeler between them. Set the micrometer collar to zero (Fig. 323). Raise the tool above the vertical surface (Fig. 324). Move the

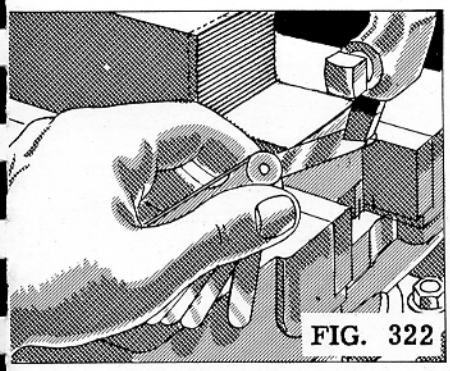


FIG. 322

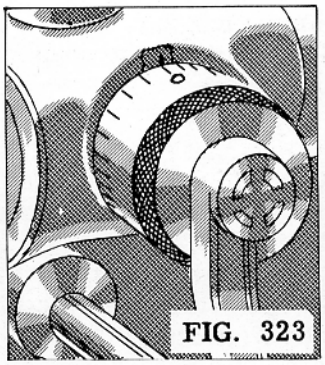


FIG. 323

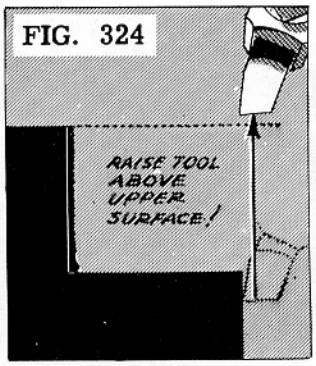


FIG. 324

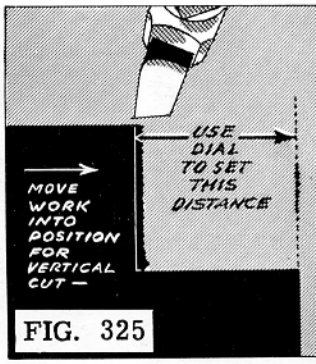


FIG. 325

work over the number of thousandths required to locate it in position for taking the finishing cut on the vertical surface (Fig. 325). Include the thickness of the feeler in moving the work to this dimension.

18. Decide upon the rate of feed to be used. Feed the tool down this distance at the end of each return stroke.

19. Continue to feed the tool down steadily until it reaches the horizontal surface and the zero on the graduated dial on the down-feed screw is again opposite the index line. In other words, the tool should be fed down until it is again in the identical vertical position it occupied when the finishing cut was made on the horizontal surface.

20. Feed the work slowly away from the tool by hand so that the surface in the corner merges with the horizontal surface. When the tool is fed down, the slight angle at which the lower surface of the tool has been set is duplicated on the horizontal surface in the corner (Fig. 326). Consequently, point (A) is slightly higher than the remainder of the horizontal surface. It is for the purpose of removing this point that the work is fed away from the tool slowly after the tool has reached the horizontal surface (Fig. 327).

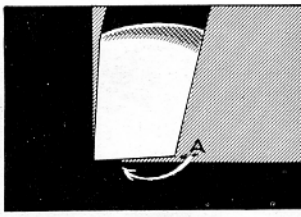


FIG. 326

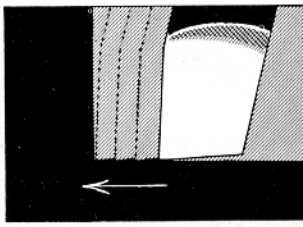
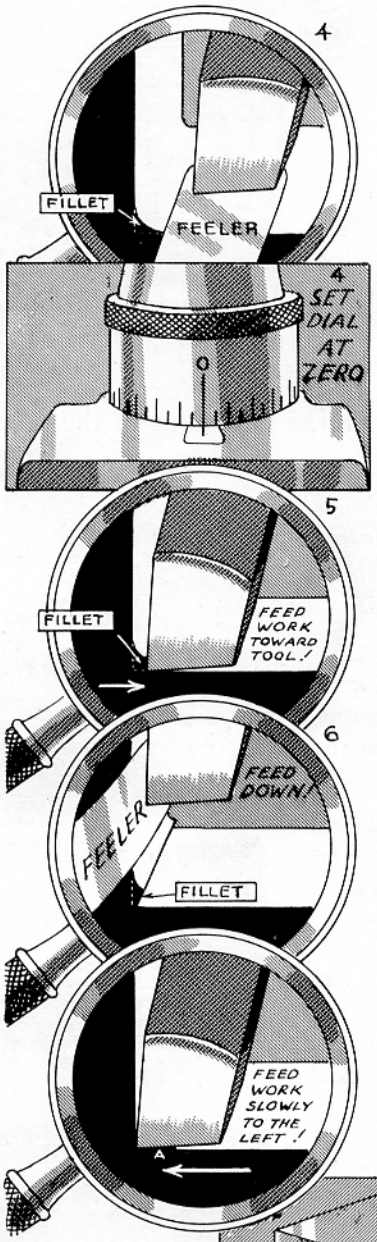


FIG. 327

NOTE: When finishing cuts have been taken on both the vertical and the horizontal surfaces with a round-nosed tool, leaving a fillet in the corner, the shoulder can be squared as follows:

1. Select a tool similar to the one used for squaring a corner.

2. Set the tool in relation to the work so it will not rub for either the vertical or horizontal surface.



3. Make certain the length of stroke, its position relative to the cut and the speed of the shaper have been adjusted to suit the job.

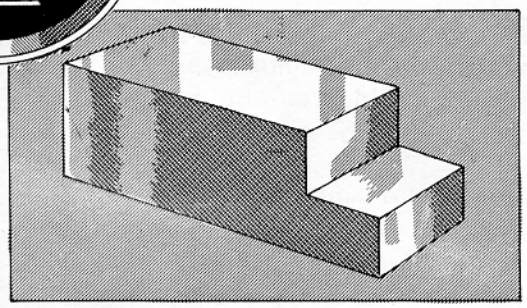
4. Place a feeler of known thickness (in thousandths of an inch) on the horizontal surface under the tool (Illustration 4). Move the tool down carefully (with the ram stationary) until a slight drag is felt when the feeler is withdrawn. Set the micrometer collar on the down-feed screw at zero (Illustration 4).

5. Start the shaper. Feed the work toward the tool by hand until the side of the tool is almost in line with the vertical surface.

6. Raise the tool so that its point is above the fillet. Then carefully move the work toward the tool. Tap the crank on the cross-feed screw lightly by hand until the tool just barely scrapes the shoulder.

NOTE: This adjustment can also be made by placing a feeler between the work and the tool while the ram is stationary. Then move the work toward the tool a distance in thousandths equal to the thickness of the feeler. This distance can be measured by means of the micrometer dial on the cross-feed screw.

7. Feed the tool down carefully until it reaches the horizontal surface and until the zero on the micrometer dial on the down-feed screw has been turned beyond its index line a distance in thousandths equal to the thickness of the feeler used under the tool when it was adjusted for the horizontal cut.



8. Turn the handcrank on the cross-feed screw in to feed the work slowly to the left so that the tool will remove the slight projection at (A) and cause the surface in the corner to merge with the horizontal surface.