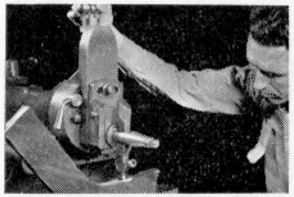
CHAPTER 7



Shaper and Planer
Setups and Operations

SHAPER CONSTRUCTION AND TYPES

Today's metal-working shaper is a versatile, handy machine. It offers speed and flexibility of setup in performing many kinds of work. The shaper is invaluable in the toolroom, in the die shop, and in small manufacturing operations. With it we can do work that is difficult or impractical to perform on other machines.

The shaper, Fig. 1, is a tool used to machine flat surfaces by performing successive reciprocating (alternating forward and backward) cuts over the workpiece. The horizontal shaper, Fig. 1, with ram movement in the horizontal plane, is the type most commonly used.

Shaper Parts

The parts of the horizontal shaper will be discussed as they might be brought together in assembling the machine. Main features and uses of the vertical shaper will be given in the discussion of shaper types.

Base. The base rests directly on the shop floor—or on the bench, if we speak of a bench-type machine. The base is a casting which serves as a foundation or platform for the machine.

Certain surfaces of the base are machined to fit parts that are fastened to the base. A rim on the base forms a trough to retain the excess oil that drips as machining operations are performed.

Column. The column, or frame, is mounted on the base. It is a hollow casting shaped like a box with openings at the top and bottom. It encloses the mechanism which drives the ram and houses the automatic feed. The ram *ways* at the top of the column form a guide for the ram.

The vertical face on the front of the column has been precision

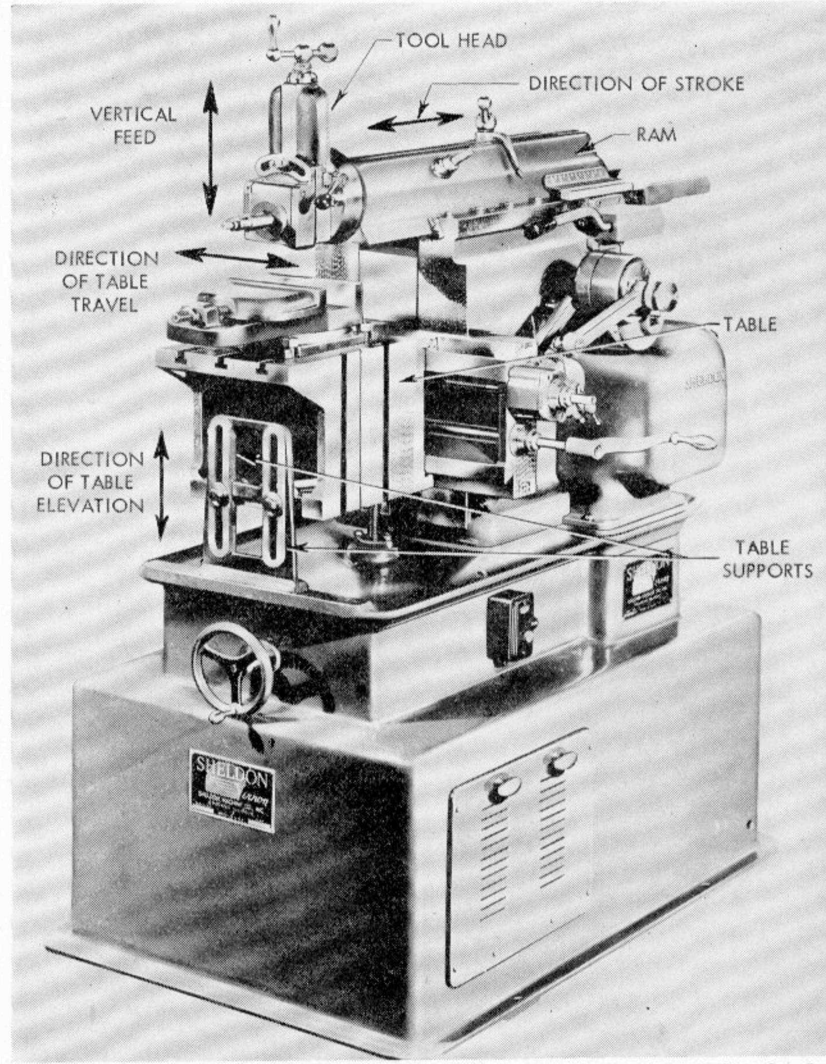


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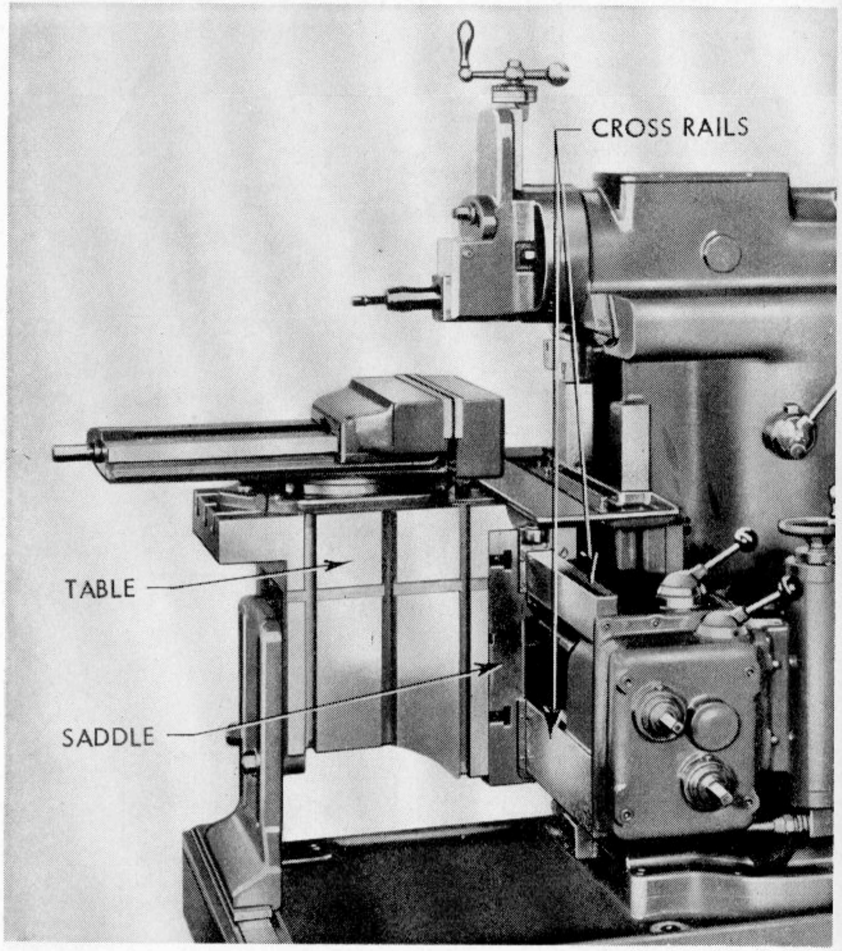
Fig. 1. Movements on the Horizontal Shaper

machined at right angles to the ram ways on the top of the column. The crossrail moves on this front face.

Crossrail. The crossrail, Fig. 2, is a long casting located across the front of the column. It allows vertical and horizontal movement of the table which slides upon it. An elevating screw controls the up-and-down (vertical) movement of the crossrail. A cross-feed screw, called a lead screw, is mounted horizontally in the crossrail. The lead screw controls sidewise movement of both the saddle and the table.



Rockford Machine Tool Co.

Fig. 2. The Saddle and Crossrails Mounted on the Column

Saddle. The saddle, or "apron," Fig. 2, is a flat casting located on the crossrail. This unit of the shaper supports the table.

Table and Table Support. The table is a boxlike casting, Fig. 2, with openings top and bottom. The rear face of the table is clamped to the front face of the saddle. The front face of the table, on many

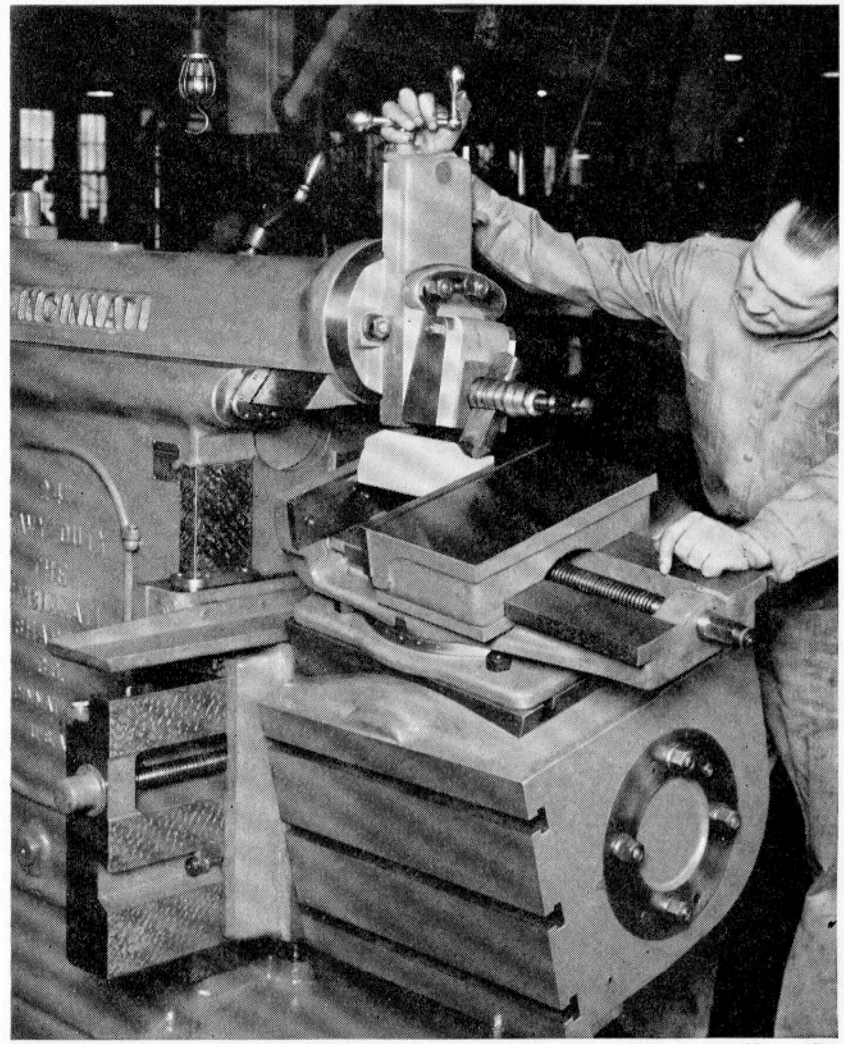


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Fig. 3. Work Being Shaped in the Vise on Table of a Universal Shaper

shapers, is used as a clamping surface for a table support. The top and two sides of the table are used to locate and hold the work directly, or to locate and hold a vise or fixture which in turn secures the workpiece. The surfaces on the top and two sides have T-slots to accommodate the bolts that clamp the work.

The table support, Fig. 1, if one is used, extends from the front face of the worktable to the base of the machine. It supports the outer end of the table, especially when a heavy cut is made.

Fig. 3 shows a universal shaper. This shaper differs from a standard shaper in that it has a table which can be tilted. This is an advantage when it is necessary to machine work surfaces to specified angles.

Ram. The ram, Fig. 4, another important part of the shaper, moves back and forth horizontally on the top of the column, carrying the

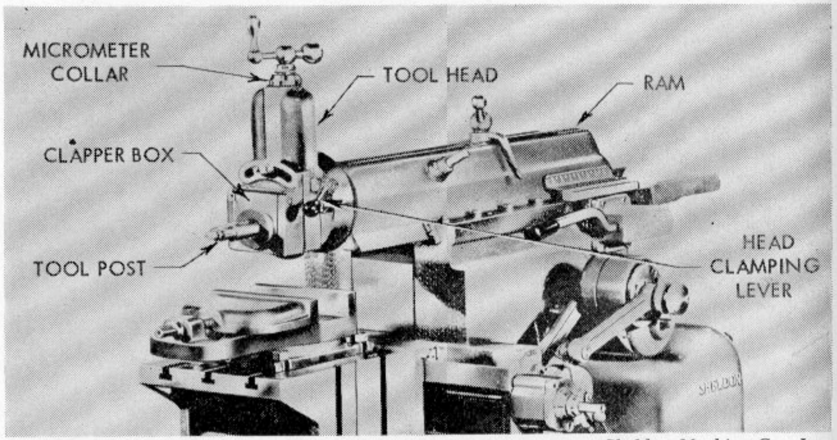

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Fig. 4. The Tool Head and Clapper Box

tool with it. It slides on carefully designed and precision machined *ways* cut in the top of the column. The stroke of the ram can be adjusted to any length up to the maximum stroke for the particular machine. The ram is propelled by either mechanical or hydraulic power.

Tool Head. The tool head, Fig. 4, is clamped to the forward end of the ram. It consists of the parts which hold the cutting tool and those parts which guide the tool vertically and adjust it for the desired cut. The head has a lead screw and a handle that permits feeding the clapper box and tool up and down by hand. An adjustable micrometer collar, graduated in thousandths of an inch, tells the distance the tool is raised or lowered when the down-feed screw is turned.

Clapper Box. The clapper box, or tool block, as it is sometimes called, Fig. 4, is an important part of the tool head. When the ram is moving forward on the cutting stroke, the tool block is forced back against the base of the clapper box. It is thus properly supported. The clapper or tool block is hinged to swing outward. This allows the tool

to lift slightly and swing clear of the work on the return stroke. In this manner the cutting edge of the tool does not drag (except for its own weight) over the surface of the work on the return stroke of the ram.

The clapper box is attached to the tool slide with a pivot screw and clamping nut. The clapper box may be swiveled through a small arc in either direction, clockwise or counterclockwise, Fig. 20, within the limits of the clamping nut slot. Proper adjustment of the clapper box will allow the tool to swing out from the work on the return stroke when machining vertical or angular surfaces. For horizontal cuts, the clapper box is usually set vertically.

The cutting tool, which is somewhat like a lathe tool in shape, is held in the tool post on the clapper box. On the forward or cutting stroke, the action of the cutting tool holds the clapper box securely against the ram head.

Shaper Size or Capacity

The size of a shaper is given by the maximum length in inches of the stroke of the ram. The maximum length of stroke may range from 6 inches on a small bench-type shaper to 36 inches on a heavy-duty machine. A 16-inch shaper, for example, can be adjusted for any stroke from 0 to 16 inches in length.

The dimension for the length of the stroke indicates, in addition to the size of the machine, the dimension of a cube that can be held and planed in the shaper. A 16-inch shaper has a traverse table feed that can be used to plane a surface 16 inches wide. The vertical distance between the tool head and the worktable, in its extreme lower position, is great enough to surface a 16-inch cube resting on the table. Thus, a cube measuring 16 x 16 x 16 inches can be shaped on a 16-inch machine.

Types of Shapers

Most manufacturers of horizontal shapers build the crank-operated push-cut type of shaper, the main parts of which have just been described.

Crank-Type Shaper. The crank-type shaper takes its name from the mechanism used to reciprocate the ram. Fig. 5 shows the crank drive. In construction, the crank-operated shaper employs a crank mechanism to change rotary motion to reciprocating (back and forth) motion. A large gear, called a "bull wheel," receives its rotary motion from the electric motor through belts and a speed-box drive shaft.

Hydraulic Shaper. The hydraulic shaper, Fig. 6, is similar in outer construction to the crank-operated shaper. The main difference consists in the method used to move the ram.

Hydraulic pressure, as a means to drive the ram, is of great prac-

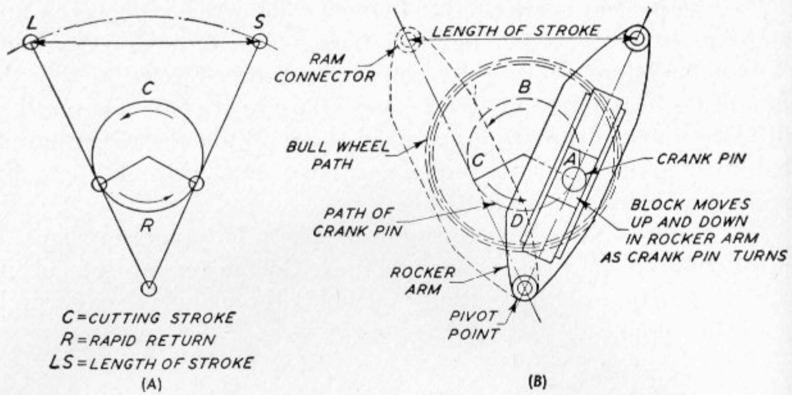
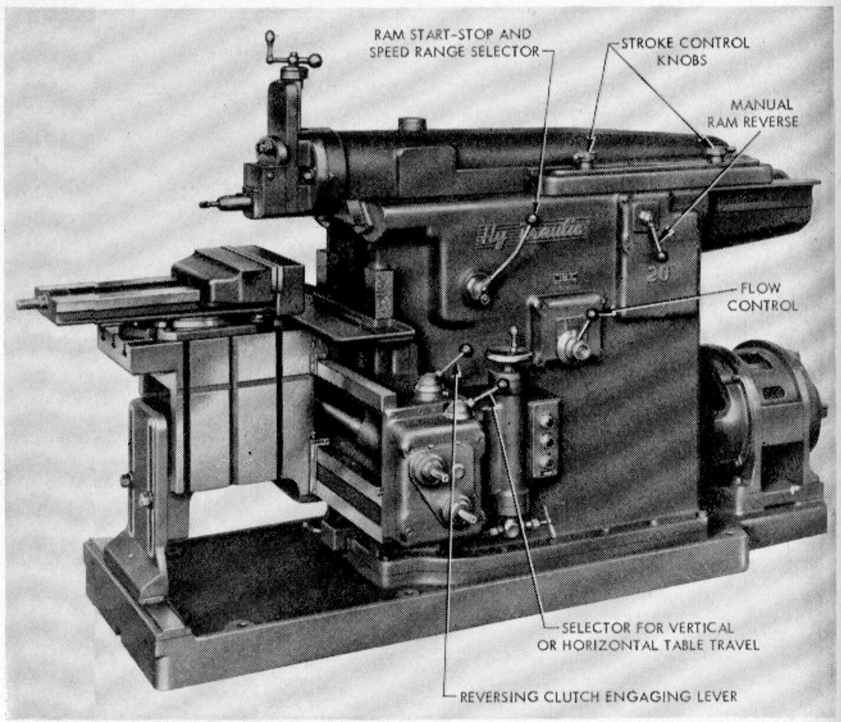


Fig. 5. The Crank Mechanism of the Crank-Type Shaper

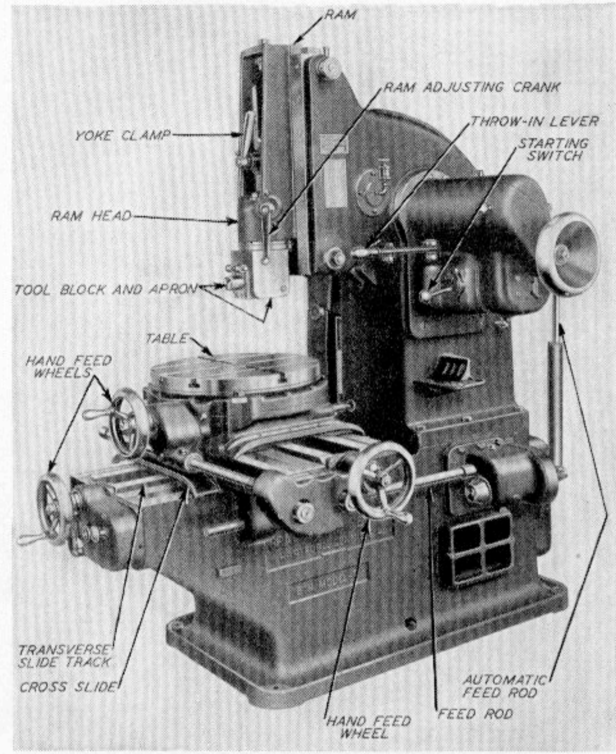


Rockford Machine Tool Co.

Fig. 6. The Hydraulic Shaper

tical value. The principle is based on Pascal's law, which states that a fluid enclosed in, say, a pipe, will transmit, when pressure is applied, equal pressure in all directions and to all surfaces it touches.

In the hydraulic shaper, the ram is moved back and forth by a piston moving in a cylinder under the ram. The flow of oil from a high-



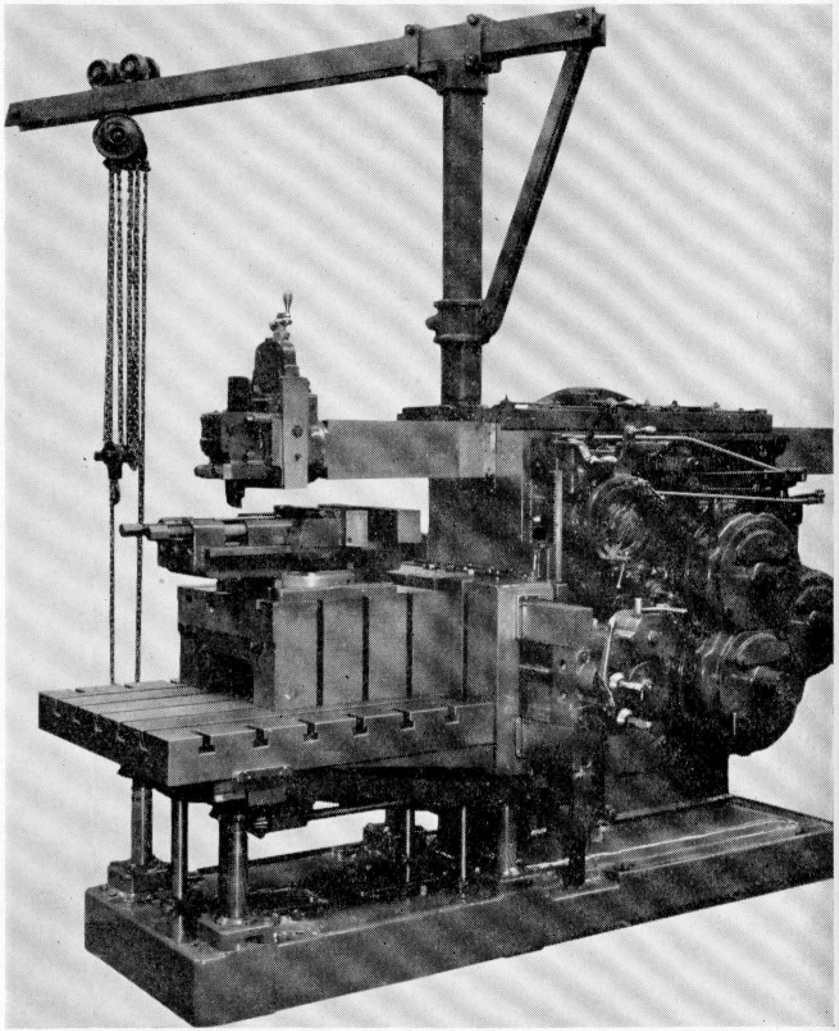
Pratt & Whitney, Div. of Niles-Bement-Pond Co.

Fig. 7. Vertical Shaper or Slotter

pressure pump acting against first one side of the piston and then the other moves the ram. This flow of oil gives a positive drive to the ram. There is no chance of backlash, as there is with a gear drive. A wider range of cutting speeds and feeds is possible with the hydraulic type of shaper than with the mechanical shaper.

Vertical Shaper. The vertical shaper, or slotter, Fig. 7, has an operating mechanism similar in principle to that used on crank shapers. The important difference between this machine and the horizontal shaper is the vertical ram. The construction of the table is quite different, too.

The vertical shaper is used in cutting internal slots and keyways of various shapes, and both external and internal gears. It is also used to cut intricate patterns in die work. The jobs that can be done on this



Morton Mfg. Co.

Fig. 8. Draw-Cut Shaper Arranged with Special Base, Interchangeable Bits and Cutter Holders

machine are like those done on the standard shaper, but the slotter will perform them in a number of different ways. Vertical shapers are built in three types: crank-driven, rack-driven, and screw-driven.

The rotary table on the vertical shaper can be fed in two directions as well as rotated. The flexibility of the rotary motion, together with the two-way horizontal feeding of the table, makes the vertical shaper a valuable tool for cutting keyways, slotting, and internal work. The ram may be tilted to give inside clearance for die work.

Shapers of Less Common Design. Among the less common designs is the traveling-head shaper. With this shaper, the ram and the tool move across the workpiece and the work remains stationary. The automatic feed moves the ram and tool.

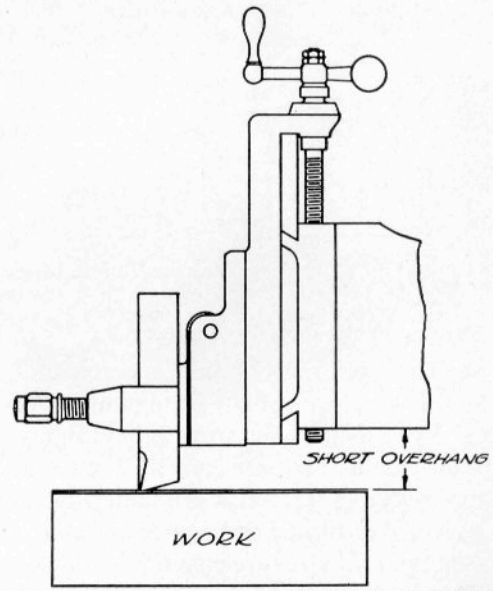
The draw-cut shaper, Fig. 8, is designed so the cutting is done on the return stroke of the ram instead of on the forward stroke.

Cutting Tools Used in Shaper

Interchangeable bits ground for different cutting operations may be quickly fastened in the toolholder or removed. The tool bit may be swung at different positions depending on the nature of the cut.

Whether an interchangeable bit and toolholder or a solid tool is used, clamping the tool properly is important. It is a good policy to keep the slide up and the grip on the tool short, as shown in Fig. 9, so as to have all the rigidity possible.

Grinding of Shaper Tools. Shaper tools are ground either by hand or by special grinding machines. The shapes and clearance angles for shaper tools are very important. The type of toolholder will determine the



Cincinnati Shaper Co.

Fig. 9. Slide Up and Grip on Tool Short for Rigidity

clearance of the heel of the tool. Some holders hold the tool bit in a vertical position. Others hold the tool bit at an angle approximately 20 degrees to the vertical. If the tool bit is extended downward vertically, 3 degrees of heel clearance is sufficient.

Shaper tools should always have proper clearance on the side of the tool as well as at the end of the tool. A side clearance of 2 degrees is commonly used. The cutting edges should be stoned after grinding. Stoning makes the cutting edge last longer. Fig. 10 shows various shapes of tool bits used in machining work on a shaper.

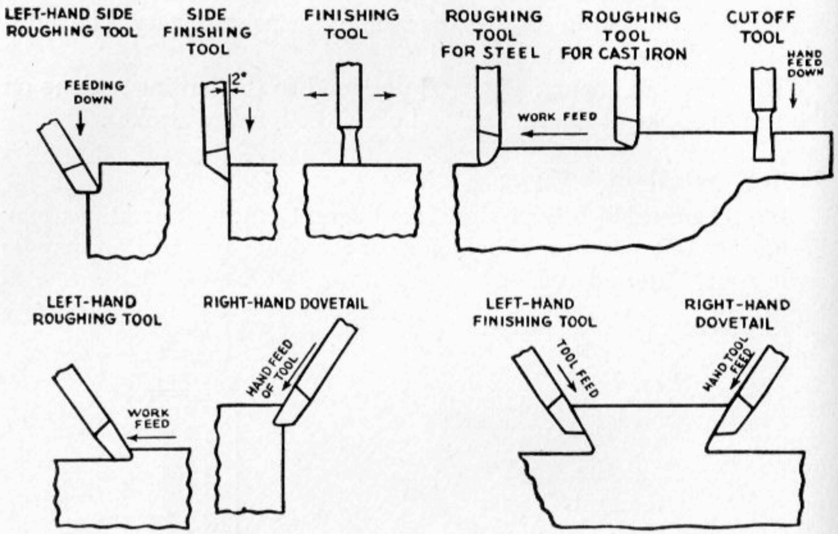


Fig. 10. Cutting Tools for Various Machining Operations on Shaper

Shaper Work-Holding Devices

The work must be held securely and solidly while it is machined in the shaper. It must not spring out of shape or "give" during the cut.

Vise. Usually the work is held in a vise bolted to the machine table with T-bolts. The vise consists of a fixed and a movable jaw. The standard vise, Fig. 11, has a graduated base on which the vise body can be swiveled or turned 360 degrees.

Standard vises are commonly the double-screw or single-screw type. The double-screw type can develop greater pressure and has a swivel jaw for taper work.

Parallels. Parallels, Fig. 12, are square or rectangular bars of steel

used in precision machining. They are placed beneath workpieces to provide a solid seat and to raise the work to a suitable height.

Bolts, Clamps, Jacks, and Toe Dogs. Common methods of holding

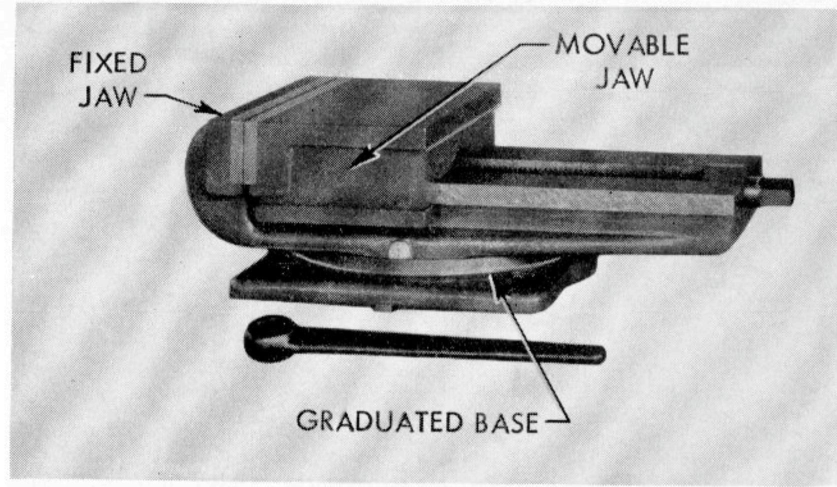


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Fig. 11. Standard Vise Used on Shaper

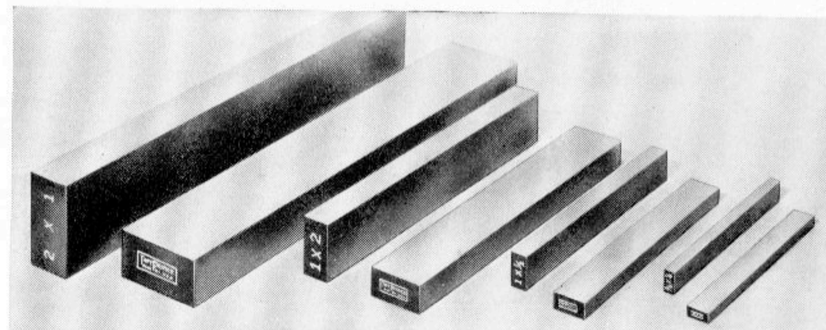

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Fig. 12. Parallels Used in Making Setups

work are shown in Fig. 13. Work properly mounted in a vise is shown at left in the illustration. The proper way of clamping a workpiece directly to the machine table is shown at right.

Fig. 14 shows the use of V-blocks to hold a round piece of work to the table. Fig. 15 shows the use of angle plates bolted in position on the table and the use of C-clamps.

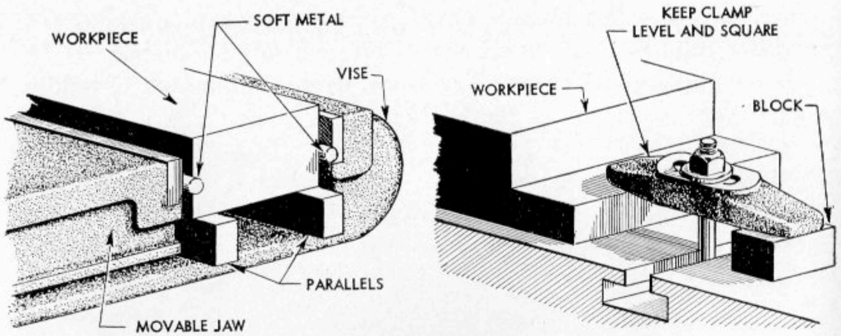
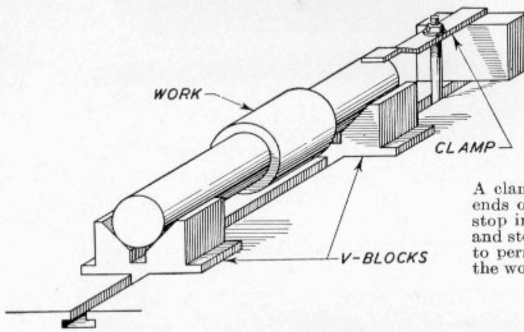


Fig. 13. Common Methods of Holding Work on Shaper



A clamp is used at both ends of the work, and a stop in front. The clamp and stop are omitted here to permit a clear view of the work in the V-blocks.

Fig. 14. Holding Thin Work by Means of V-Blocks

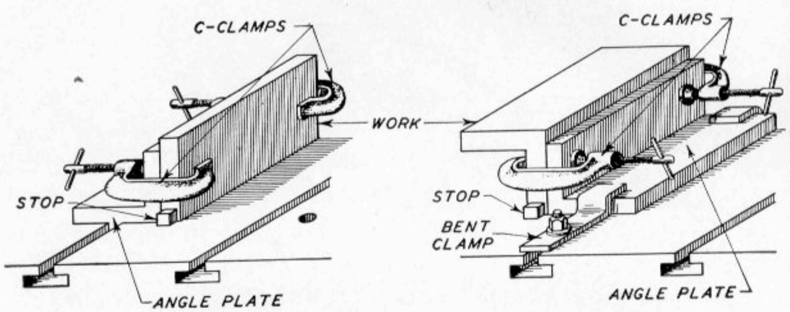


Fig. 15. Work Clamped to Angle Plates with C-Clamps

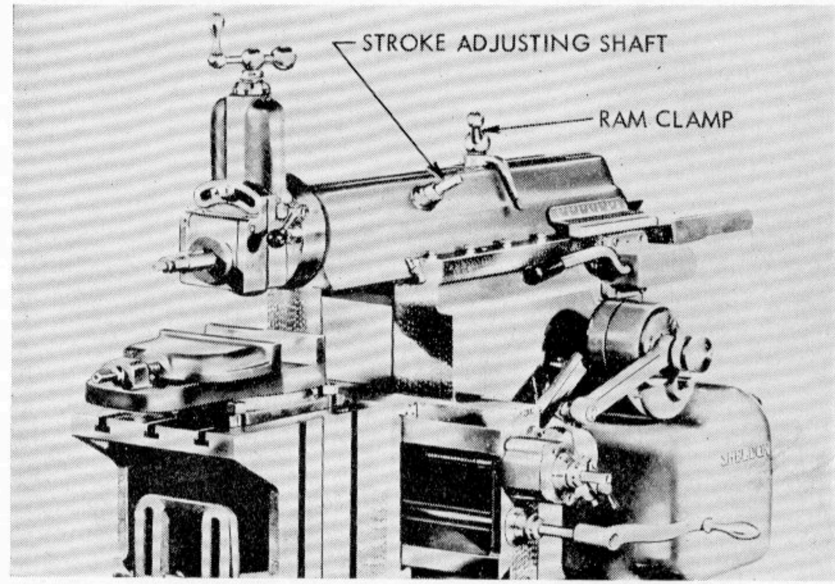
SHAPER SETUPS AND OPERATIONS

Up to this point in this chapter, the shaper parts, cutting tools, and work-holding devices have been discussed. Shaper operations will now be taken up one by one. Since it is always necessary to make a setup

for the operation, the necessary adjustments in making setups will be detailed here.

Adjustments Necessary in Making Setups

The shaper is a relatively simple machine to operate but, like other machines, it must be adjusted properly or it will not give satisfactory results. The purpose of this section is to instruct the operator in the mechanical adjustments necessary to get the shaper to function correctly during the various operations.



Sheldon Machine Co., Inc.

Fig. 16. Ram Adjustment Devices on the Shaper

Ram Adjustment. The following two adjustments are provided for the ram. *One,* the length of stroke is regulated by turning the stroke-adjusting shaft, Fig. 16, which is located at the operator's side of the machine. Turning this shaft in one direction lengthens the stroke; turning it in the opposite direction shortens the stroke. *Two,* if, after the length of the stroke has been set correctly, the travel of the tool does not cover the work, the position of the ram is changed to make it correct. To reposition the ram, the ram clamp, Fig. 16, is loosened. The ram-positioning shaft is turned until the ram stroke allows the tool

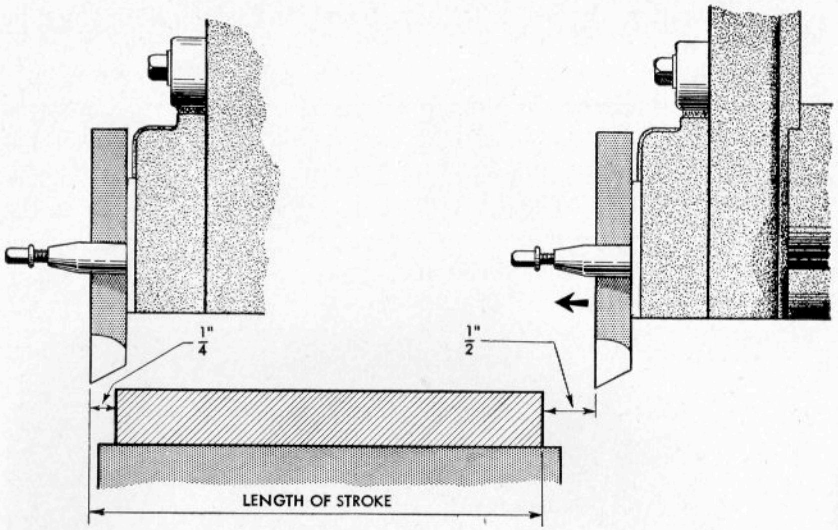


Fig. 17. Front and Back Positions of Ram in Relation to Size of Workpiece

to move ¼ inch beyond the workpiece on the forward or cutting stroke, and ½ inch behind the workpiece on the return stroke, Fig. 17. Then the ram clamp is tightened. Remember to make the adjustment for length of stroke before the adjustment for position over the workpiece.

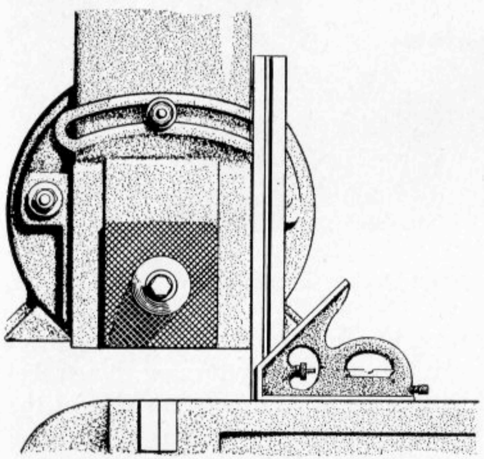
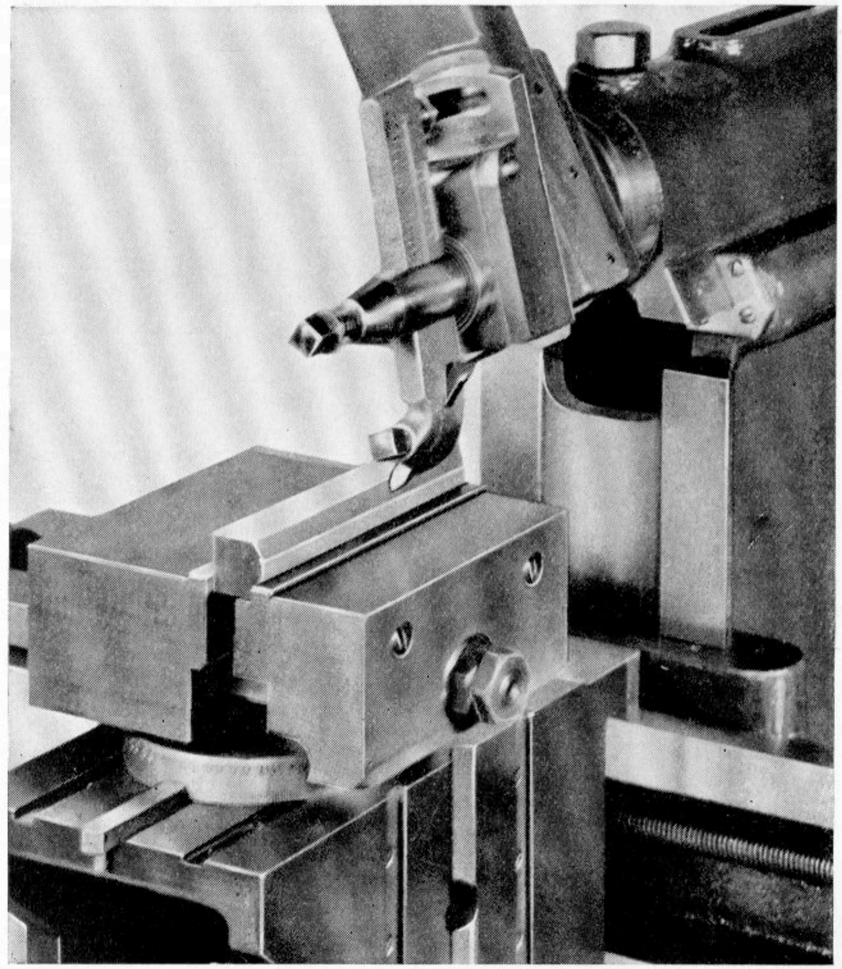


Fig. 18. Squaring Head with the Aid of Combination Square

Head Adjustment. Movement of the tool slide and the cutting tool is controlled by the handle at the top of the head. This handle is attached to the down-feed screw inside the slide, Fig. 4. Turning the handle clockwise lowers the slide. For convenience in making accurate adjustments of the slide and tool, the feed screw has a micrometer dial graduated in thousandths of an inch.

To make accurate adjustments of the tool, all "back lash" must be taken out of the down-feed screw before the dial is set to a definite figure. This back lash is the lost motion between the threads of the screw and the threads in the nut which the screw travels through.

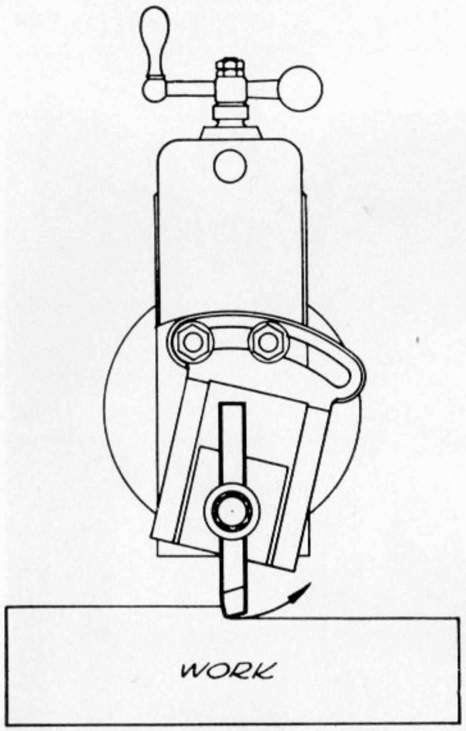
To feed the head vertically, the head must first be squared by lining up the zero mark on the head with the zero mark on the ram. To check further on squareness, use a combination square, as shown in Fig. 18.



Delta Power Tool, Div. of Rockwell Mfg. Co.

Fig. 19. Shaping an Angle with Slide and Clapper Box Set at Angle

In the setup for shaping a dovetail and in certain other setups, it is necessary to position the tool head at an angle as shown in Fig. 19. Be sure not to run the ram back into the column with the slide set at an extreme angle, as the slide will strike against the column when the ram moves back on the return stroke.



Cincinnati Shaper Co.

Fig. 20. Clapper Box Turned with Top Away from Tool's Cutting Edge, Permitting Tool To Swing Away from Work on Return Stroke

Adjusting the Clapper Box. Usually the clapper box is set so the top slants slightly away from the cutting edge of the tool. This permits the tool to swing away from the work on the back stroke of the ram, protecting the cutting edge of the tool, Fig. 20.

Table Adjustment. The table is raised or lowered by the hand crank. The supporting clamp and saddle-clamping screws must first be loosened.

The table may be moved back and forth (transversely) on the saddle by means of the lead screw, either by a hand crank or by mechanical power. The power drive is through a ratchet-feed mechanism.

Testing the workseat of a vise for parallelism to the stroke of the ram should precede any setup. This is done using a dial indicator clamped in the tool post. The workseat in the vise should be cleaned carefully, and accurately sized parallels should be used, Fig. 21.

Adjusting Vise to Ram. On most jobs it is necessary to adjust the solid jaw of the vise either parallel or at right angles to the stroke of the ram.

To test the vise jaws for being at right angles to the stroke of the ram, a dial indicator is clamped in the shaper tool post. The indicator button is brought to bear on the solid jaw of the vice as shown in Fig. 22. The table is moved at right angles to the ram, using the hand cross-feed. When the vise is set so that there is no movement of the needle on the indicator, this test is complete.

To test the vise jaws for being parallel to the ram

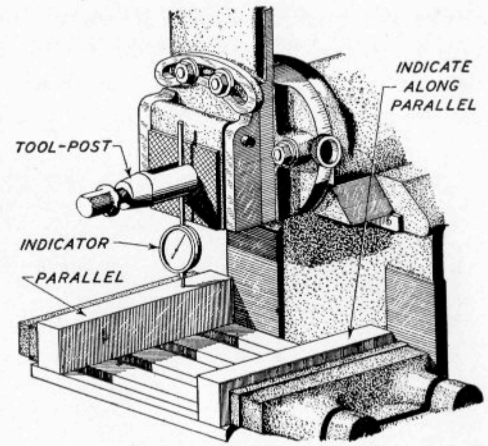


Fig. 21. Testing the Work Seat for Parallelism

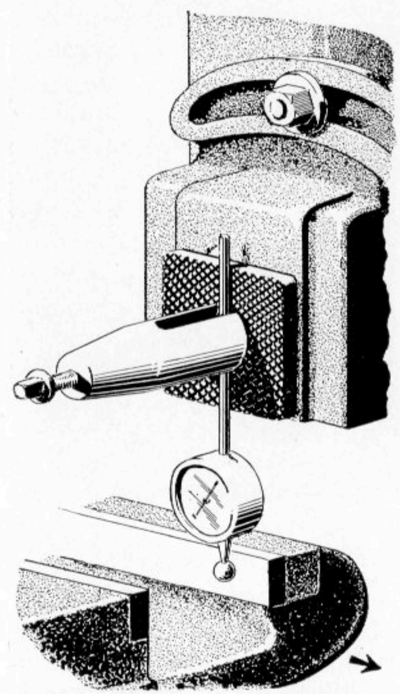


Fig. 22. Testing Solid Jaw of Vise for Right-Angle Position to Ram Stroke, Using Dial Indicator

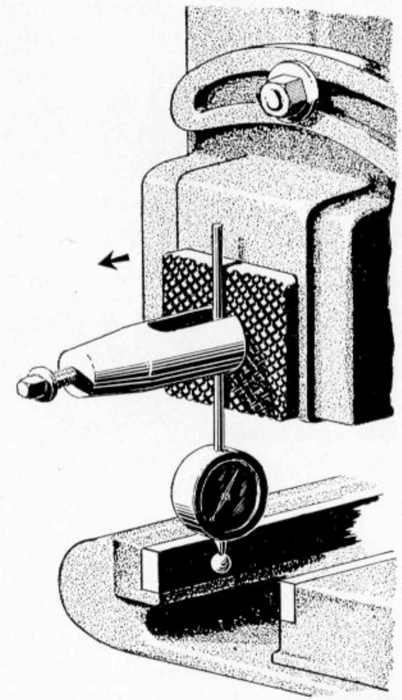


Fig. 23. Testing Solid Jaw of Vise for Position Parallel to Ram Stroke, Using Dial Indicator

stroke, the indicator button is brought to bear on the solid jaw of the vise as shown in Fig. 23. The ram is moved forward and back to determine any movement of the indicator needle. If there is none, it can be assumed that the vise jaw is parallel with the ram stroke.

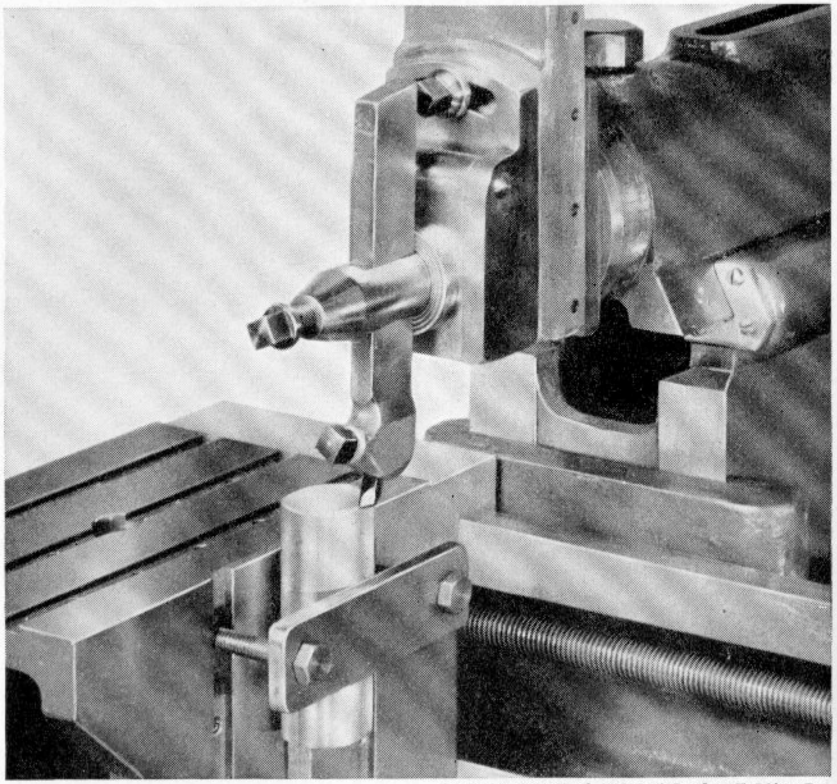


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Fig. 24. A Conventional Setup for Shaping End of Round Shaft

Variety of Shaper Operations

The versatility of the shaper should again be emphasized, as there are a great many operations that can be done on it. Fig. 24 shows a setup used in shaping the end of a round shaft.

Another shaper operation and setup is shown in Fig. 25. An internal keyway is being cut, using an extension toolholder.

Fig. 26 shows a setup used to hold a workpiece when shaping

splines in a groove or shaft. The indexing centers make it possible to space the splines accurately around the cylindrical workpiece.

Other operations which can be readily performed on the shaper are serrating, dovetail cutting, and contour cutting.

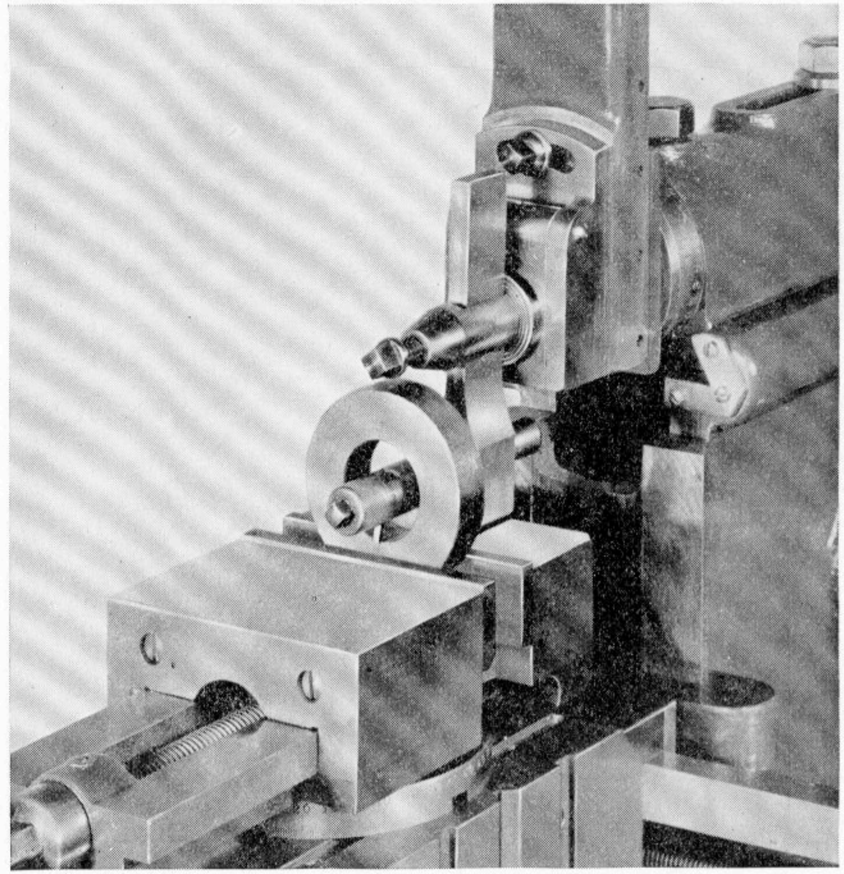

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Fig. 25. Cutting an Internal Keyway on Work Held in Shaper Vise

Shaping Horizontal Surface

Much of the work done on the shaper is shaping flat surfaces on pieces held in one or another of the holding devices. The horizontal or vertical surface produced is the result of a series of cuts made with a single-point cutting tool.

Fig. 27 shows a conventional shaper setup. This type of job probably accounts for 50 per cent of the work done on a shaper. The setup shows a piece of steel clamped in a single-screw vise. For horizontal cuts intended to remove excess metal regardless of finish, a roughing

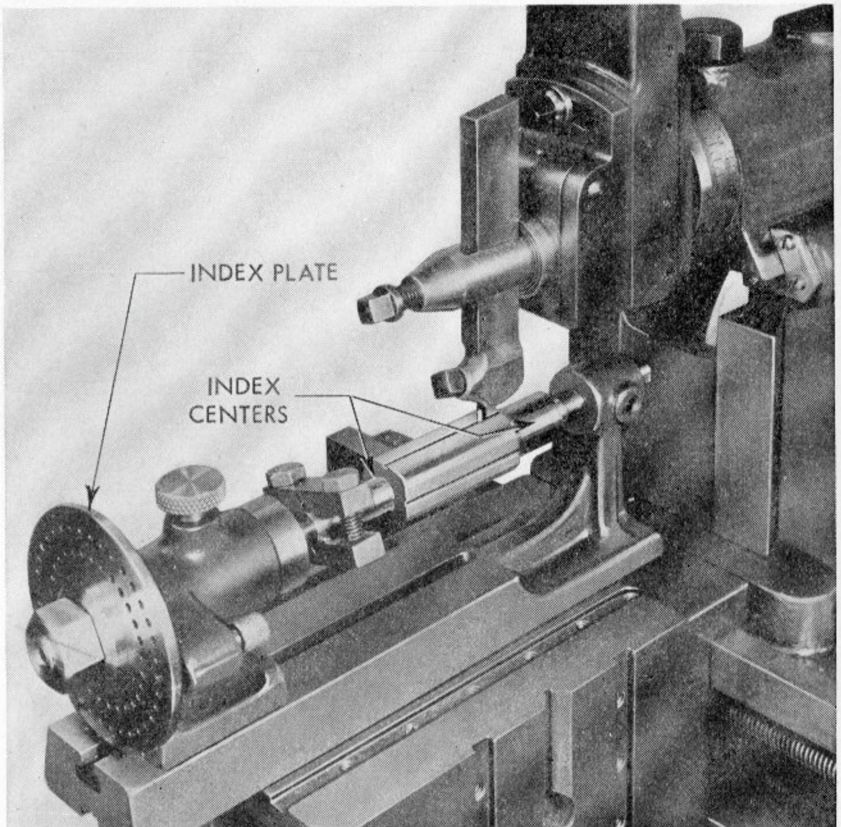

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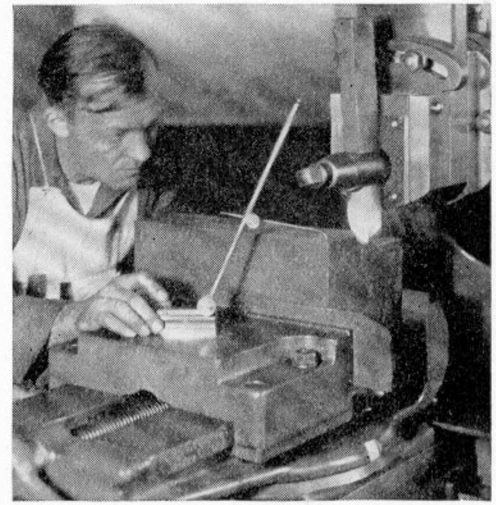
Fig. 26. Setup for Shaping Splines in Shaft

tool is used. The cutting tool should be clamped securely in the tool post in a vertical position square with the surface to be shaped.

Suggestions on How To Shape a Horizontal Surface. During the operation, the operator stands at the right and in front of the machine where the controls are within reach. The cut is started at the right end of the horizontal surface (nearest the operator). The first cut taken

from a casting should be deep enough to get under the scale. Roughing cuts remove excess material. A finishing cut is then made to bring the work to size and produce a smooth finish. By setting the cross-feed about one-half the width of the cutting edge of the tool, each cut will overlap the last cut and a smooth surface will be obtained.



Lufkin Tool Co.

Fig. 27. Surface Gage Being Used To Check Surface of Work Held in Shaper Vise

Shaping Vertical Surface

The work is mounted in the vise or directly to the table. The surface to be cut must be carefully lined up with the ram. An indicator can be fastened to the ram and the ram fed across the workpiece by hand to test trueness.

Either a straight or offset toolholder can be used for vertical cuts if the tool is properly ground. The toolholder must be so adjusted that it will not strike the vertical surface. The slide and toolholder, when in the lower cutting position, should not extend any more than absolutely necessary. The cutting edge of the tool should be set in an approximately horizontal plane.

For vertical cuts, the clapper box must be set at an angle from its vertical position, Fig. 28. This prevents the tool from dragging and scoring the planed surface during the return stroke. It should be emphasized again that the tool slide, the tool, and the clapper box must be carefully set for vertical cutting.

Suggestions on How To Shape a Vertical Surface. In making the cut, the tool is fed down carefully by hand about .010 inch at the end of each return stroke of the tool.

The finishing cut is made with a finishing tool properly ground for the material of the workpiece. It is adjusted in the tool post so its cutting edge, Fig. 28, is in alignment with the vertical surface. When the workpiece is cast iron, the edge of the casting is slightly beveled with a file to prevent the sand and scale on the casting from dulling the finishing tool. To prevent chipping the edge of the work at the end of the cutting stroke, it is wise to bevel the workpiece with a file to the depth of the cut.

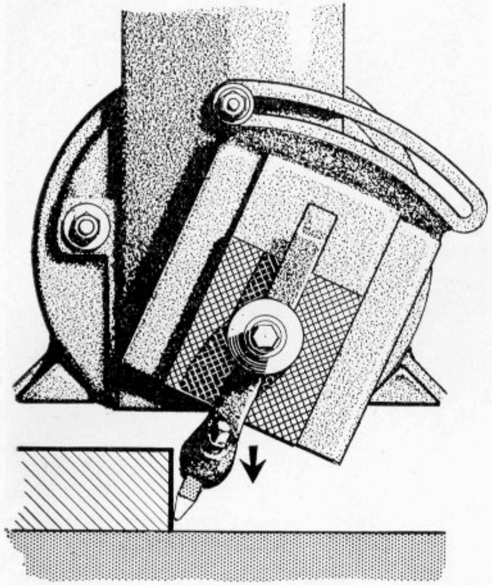


Fig. 28. Clapper Box Turned for Vertical Cut

Setup for Angular Shaping

When cuts are made at any angle other than a right angle to the horizontal or the vertical, they are called *angular cuts.*

Angular cuts are usually made on the shaper by swiveling the head to the desired angle either to the right or left of the vertical position. As the tool slide is lowered, the tool is fed along the surface to be cut, Fig. 29.

It is not always necessary, however, to swivel the head to machine one surface at an angle to another. The work may be set on tapered parallels in the vise in such a position that the layout line, representing the angular surface, is in a horizontal position, Fig. 30. The angular surface is then machined by horizontal shaping. If tapered parallels are not available or if the angle is an odd one, the work can be mounted in the vise with the aid of a surface gage, Fig. 31. If parallels are not used to support the work, care must be used that the work does not move under pressure of the tool, or the proper angle will not be cut.

Another method of shaping angular surfaces is to tip the table if the shaper is equipped with a universal table. The work is placed horizontally in the vise. Then the table is set at the desired angle and a horizontal cut is taken as in horizontal shaping.

For cutting chamfers, the side cutting tool is appropriate, Fig. 10. Fig. 32 shows the machining of a 55-degree dovetail on an iron casting. On jobs of this kind, the head is swiveled to the desired angle—in this case 55 degrees. Then the tool is fed downward either by hand or by

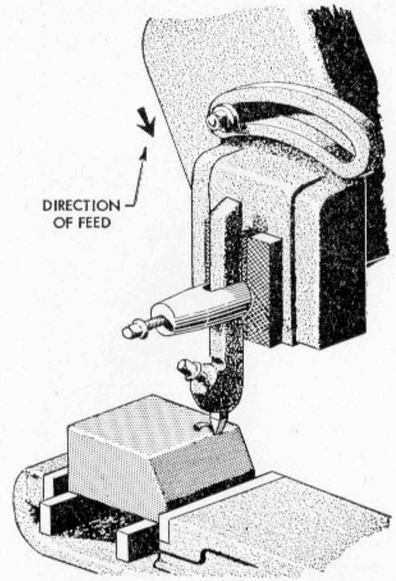


Fig. 29. Head Swiveled into Position So Tool Is Fed Downward by the Tool Slide

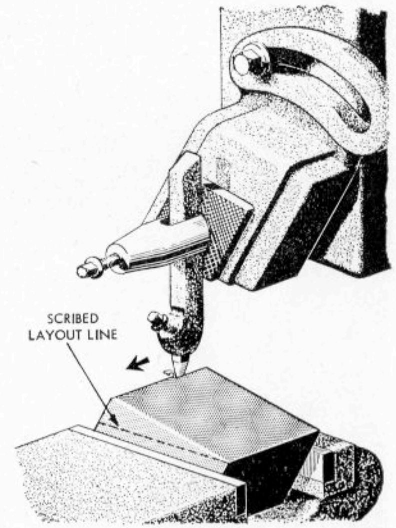


Fig. 30. Machining Angular Surface by Horizontal Shaping

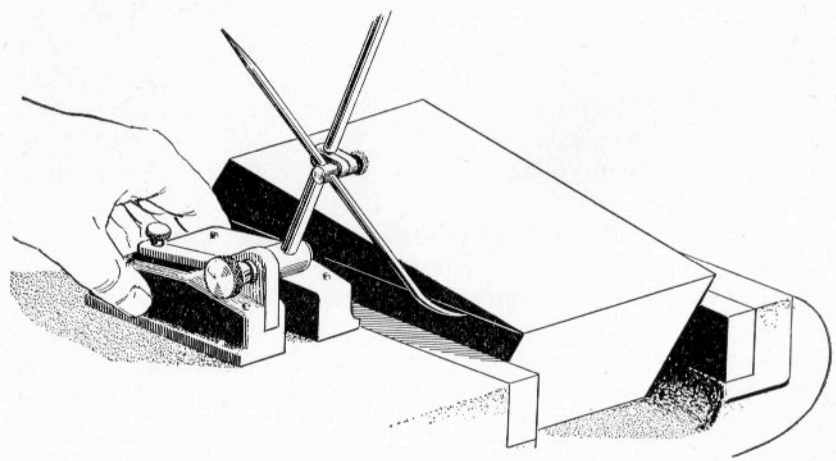
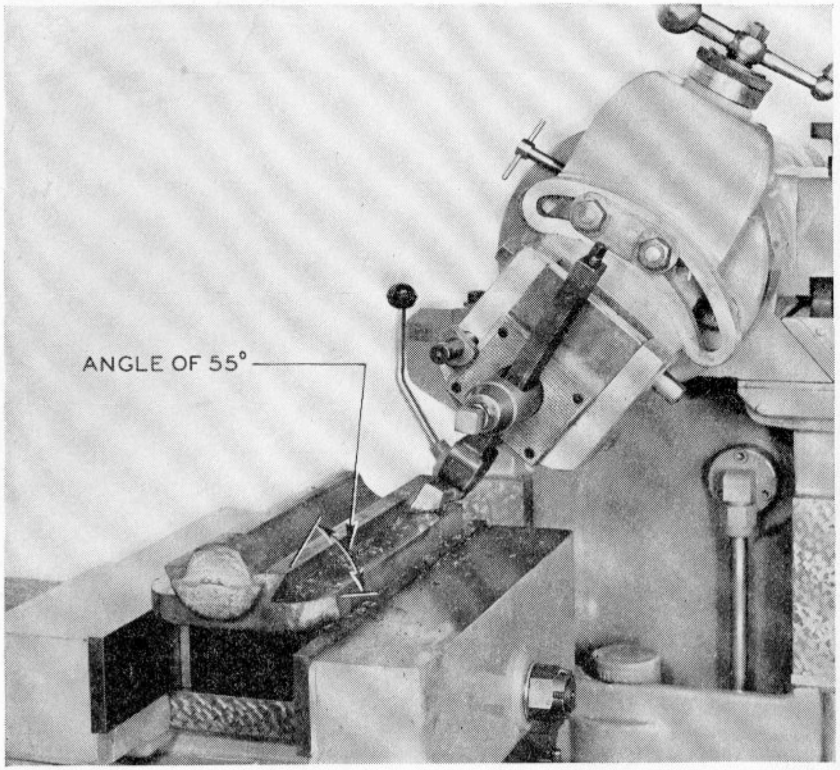


Fig. 31. Adjusting Work in Vise Before Doing Horizontal Shaping To Give Angular Surface

power. The proper shape of tool is of course necessary to secure the desired corner and finish. The work is held in the vise on parallels. The tool used here is the replaceable bit.



Rockford Machine Tool Co.

Fig. 32. Machining a 55° Dovetail

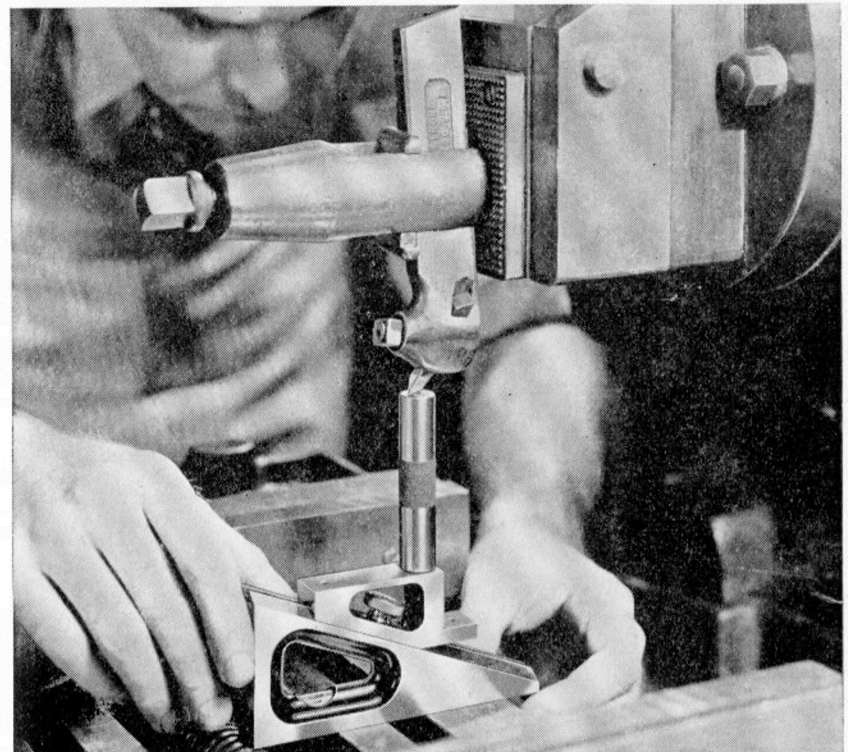
Shaping One Horizontal Surface at a Given Distance from Another

Often in shaping work, one surface must be shaped at a given distance from another surface, as in cutting a stepped surface on a step-block. This requires great care in adjusting the position of the cutting tool for height, especially on the finish cut.

Several methods are in use for gaging the setting of the tool bit and the location of the finished surface. Fig. 27 shows the surface gage being used to check the horizontal surface shaped by the cutter.

The planer gage, Fig. 33, is a very useful gage not only for setting

the planer tool, from which it got its name, but also for setting the shaping tool. This gage has come to be used more and more. The planer gage is actually an adjustable size block and adjustable parallel combined.



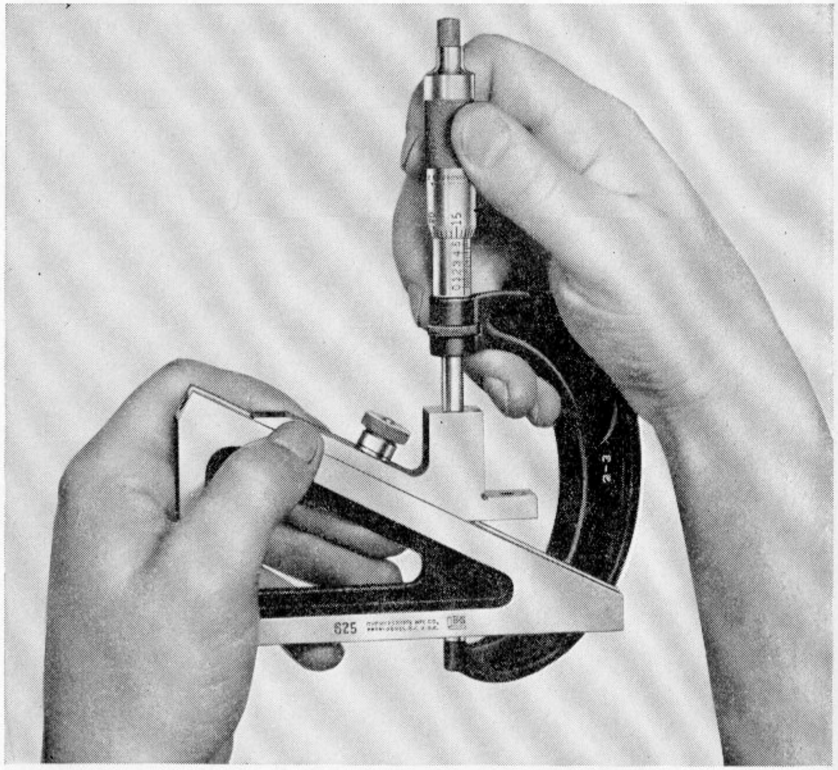
L. S. Starrett Co.

Fig. 33. Planer Gage Being Used To Set Cutting Tool for Proper Height

The gage may be set with a height gage, with indicator, with gage blocks, or with a micrometer, Fig. 34. With the gage at the required height, it is then used to set the vertical-feed micrometer collar so the operator knows when he has fed the tool into the desired lower position.

Serrating

Serrating gives a surface uniform roughness to increase its holding power.



Brown & Sharpe Mfg. Co.

Fig. 34. Setting Planer Gage Block to Micrometer Size

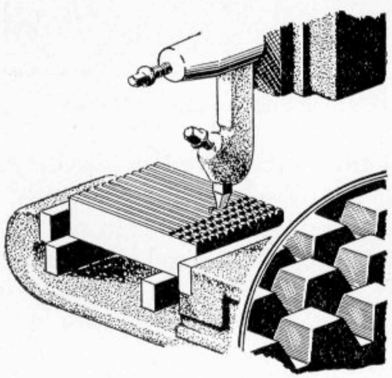
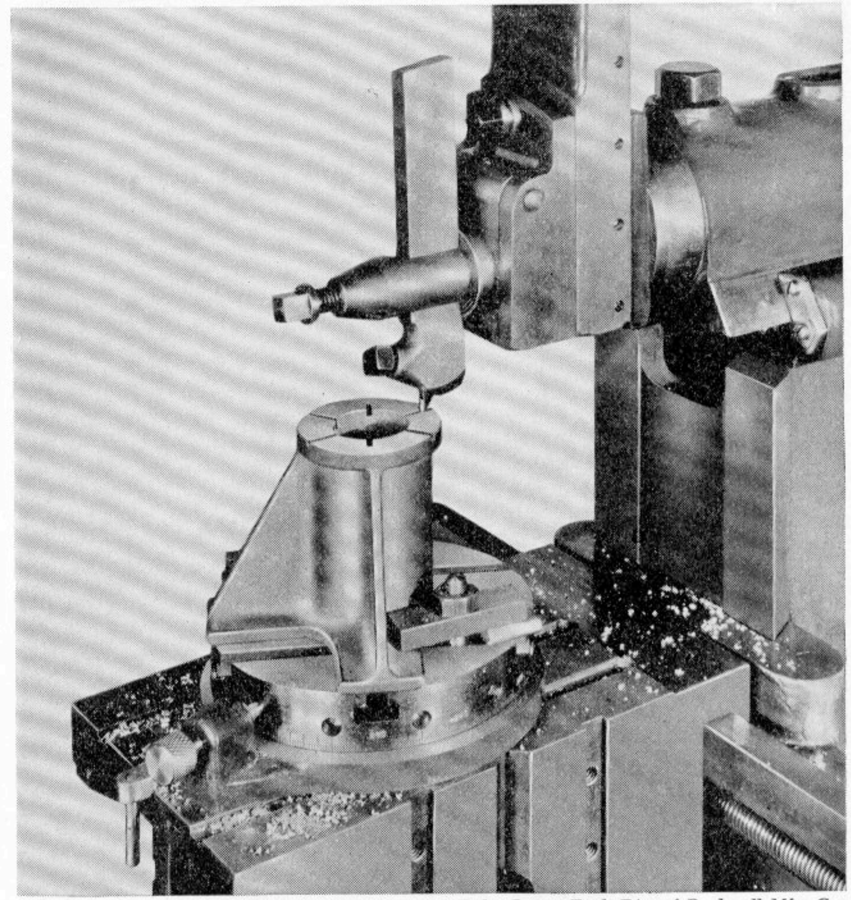


Fig. 35. Serrating Work on the Shaper

The operation of serrating involves cutting a series of equally spaced grooves in the surface of a workpiece, Fig. 35. Two sets of grooves are machined across each other, leaving small, regularly shaped areas between the grooves. The grooves may cross each other at right angles or at less than a right angle. The grooves may also be cut parallel with the sides of the work or at an angle. They may be V-shaped or rounded at the bot-

tom. The serrations are cut with the procedures used for horizontal shaping. The tool used is ground to conform to the serration desired.



Delta Power Tool, Div. of Rockwell Mfg. Co.

Fig. 36. Slotting Operation

Slotting and Grooving

Slotting, Fig. 36, is the operation of cutting a slot or groove in a workpiece. The sides may be straight or angular. Slots cut to a standard width and depth to receive standard size blocks or keys are called keyways.

A groove is a shallow slot. These slots are cut in work surfaces to act as reservoirs and channels for oiling.

If the slot is the same width as the tool, it can be cut in one operation. If the slot is wider than the tool, several cuts will have to be taken. The slot can be checked for depth with a scale, a depth gage, or a micrometer depth gage, as explained in the chapter on measuring tools.

Internal Shaping

A good example of internal shaping is the cutting of internal keyways. Internal shaping involves a variety of different jobs such as machining internal surfaces and cutting internal gears. Internal shaping can be done on both horizontal and vertical shapers.

Cutting keyways and slots is commonly done on the vertical shaper and slotter. The horizontal shaper, however, can also be used for this purpose, Fig. 25.

The success of internal shaping depends on proper tooling. The clapper is locked in the clapper box to keep the tool from lifting out of the cut. The application of a small amount of cutting compound will preserve the cutting edge of the bit even though it drags on the return stroke. At the same time, the compound will give a better finish to the work. It is necessary to lock the clapper when positioning the cutting bit upward to prevent digging into the work on the return stroke.

Shaping Contours

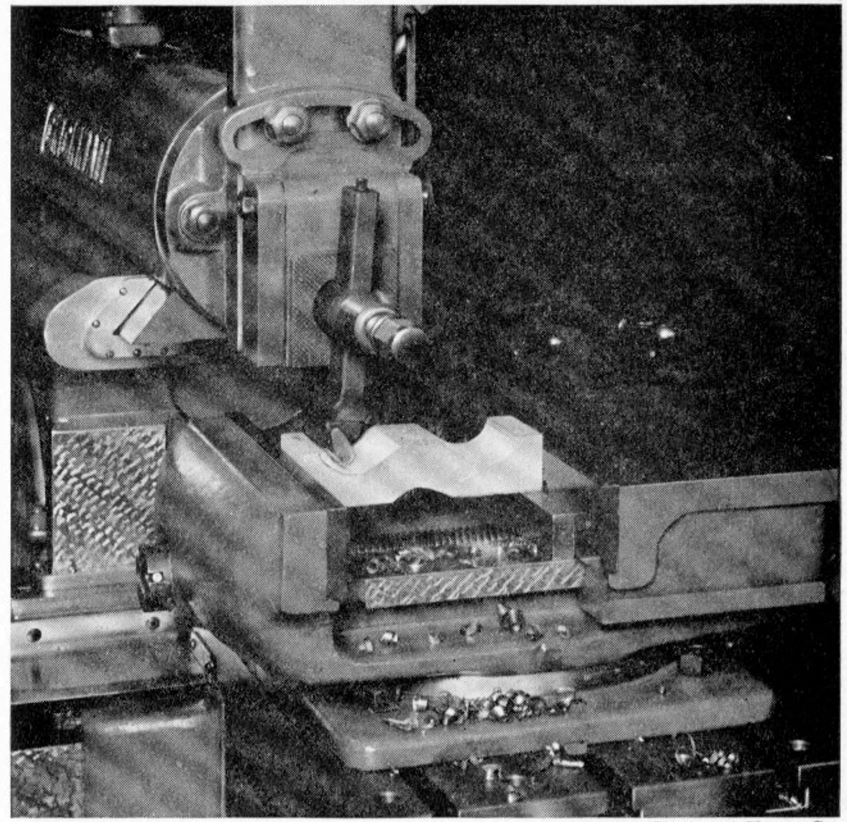
Another function of the shaper is the operation of contouring, Fig. 37. Contouring is sometimes done on an irregularly shaped piece cast in the foundry. Enough material is left to machine the part to finish size and shape. Frequently, however, the required part must be shaped from a solid piece of metal.

The contouring operation can be performed in two ways. First, the automatic table feed can be used to control the movement of the work horizontally, while the hand feed is used on the vertical feed. Second, both the cross feed and the down feed can be controlled by hand.

If the material is a solid block, it can be partly roughed out by taking several horizontal cuts with the power feed, Fig. 38*A*.

The distance the work must be moved sideways and the distance the tool must be moved downward will depend on the slope of the curve.

A series of cuts is taken. The tool and the work are manipulated until the metal is cut to within 1/16 inch of the layout line, Fig. 38*B*.



Cincinnati Shaper Co.

Fig. 37. Machining a Contoured Surface on the Shaper

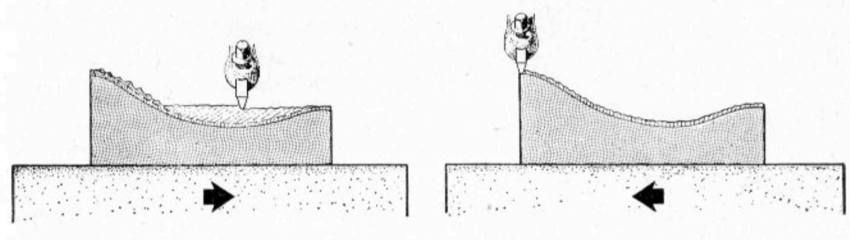


Fig. 38. Successive Steps in Machining a Contour

These roughing cuts may leave the surface rough and irregular. Two finishing cuts of 1/32 inch each take off the remaining material. A round-nose tool is used for the finishing cut.

Special Jobs

The special jobs developed by operators of shapers in industry are surprising. These unusual jobs often demand special fixtures and even special shapers. Form tools with fixtures are often used in manufacturing. Splined shafts, and even emergency gears, are occasionally produced on a shaper with a set of index centers.

Care of Shaper

1. The shaper must be kept well oiled at all times, especially all bearing surfaces.

2. All work surfaces should be kept clean and free from nicks and burrs. Accurate work is not possible if the table and vise are rough and untrue.

3. All cutting tools should be kept sharp. Cutting will be more efficient with less strain on the machine. Avoid deep cuts which cause the machine to overwork and vibrate unnecessarily.

4. The table should always be at such a height that the tool head will not need to be lowered much beyond the end of its guides. Undue overhang will cause the tool to chatter and may result in breakage to the head.

5. It is, of course, necessary to see that the work is properly and securely held in place. It is not uncommon for the tool to dig in and dump the work on the floor, and the operator may be injured. Position the work so that the ram will not strike it. When the tool head is swung at an angle, the ram must be positioned so the tool head does not strike the ram ways on the backward stroke. Accidents may cause gear damage or springing of some part of the machine.

Shaper Speeds and Feeds

The term *speed,* as used in connection with the shaper, has two distinct meanings.

Machine Speed. The speed of a machine-crank shaper is the number of cutting strokes made by the ram during one minute of operation. This is governed by the speed of the main driving gear or bull wheel.

The speed of the shaper—that is, the number of strokes made by the ram in one minute—remains constant for a given speed of the driving gear whether the stroke is long or short. Cutting speeds are changed by changing the rate and the amount of rocker-arm movement.

Cutting Speed. The cutting speed, or speed of the cutting tool, is the average rate of speed the tool attains when the shaper has been adjusted to make a given number of cutting and return strokes of a given length in one minute.

The rate of speed, then, is determined from two factors: time and distance. The time is figured as that fractional part of a minute for the cutting stroke. The distance is the total length in feet of the cutting stroke.

The cutting speed is determined by the total distance the tool travels during the cutting strokes made in a minute, and by the ratio of cutting-stroke time to return-stroke time. This can be more clearly stated by taking an actual case. In most shapers, it takes about 1½ times as long to make the cutting stroke as it does to make the return stroke. This is a ratio of 2:3. The sum of these figures is 5. Thus, the return stroke requires 2/5 of the cycle time, and the cutting stroke requires 3/5 of the cycle time. A complete cycle (5/5) consists of one cutting stroke and one return stroke.

Formula To Be Used. If the length of stroke in inches and the number of strokes per minute are given, their product gives the number of inches cut during one minute of the machine's operation. Since cutting speed is expressed in feet, this must be multiplied by 12 to reduce to inches.

The actual time of cutting is 3/5 of the total time. Therefore, since distance divided by time equals rate, divide the distance (in feet) by 3/5, that is, multiply by 5/3, and the result will be the cutting speed. Rather than multiply in every problem first by 12 and then by 5/3, it will be quicker to multiply by .14 which amounts to the same thing. The formula then becomes:

$$\text{Cutting speed} = .14 \times N \times L$$

Where

N = strokes per minute
L = length of stroke

PROBLEM: What is the cutting speed of the tool when the shaper makes 60 strokes per minute, and the stroke is 12 inches long?

SOLUTION:

$$\text{Cutting speed} = .14 \times N \times L$$
$$\text{Cutting speed} = .14 \times 60 \times 12$$
$$\text{Cutting speed} = 100 \text{ feet per minute}$$

Strokes per Minute. The number of strokes per minute at which the shaper should be run, knowing the cutting speed of a given metal, is figured in the following way.

TABLE I. SHAPER CUTTING SPEEDS (FEET PER MINUTE)

MATERIALS	CUTTING SPEED* (ft. per min.)		LUBRICANT	
	H.S.† Tools	C.S.†† Tools	Roughing	Finishing
Cast Iron (Soft & Medium)	60	30	Dry	Dry
Cast Iron (hard)	35	20	Dry	Strong soda water
Soft Steel	Highest possible	35	Cutting compound Soda water, soap water	Soda water Soap water
Hard Steel	35	15	Mineral lard oil Cutting compound	Mineral lard oil
Brass	Highest possible	35	Dry	Dry
Phosphor Bronze	50	20	Dry	Dry
Monel Metal	50	20	Mineral lard oil	Mineral lard oil
Aluminum	125	50	Dry	Kerosene
Copper	80	40	Dry	Dry
Babbitt	Highest possible	50	Kerosene, plain or mixed with lard oil	Kerosene and lard oil

* Cutting speeds are approximate only. In special cases the proper lubricants must be determined by experiment. Many mechanics do not use lubricants on shaper work, except in special situations.

† High speed.

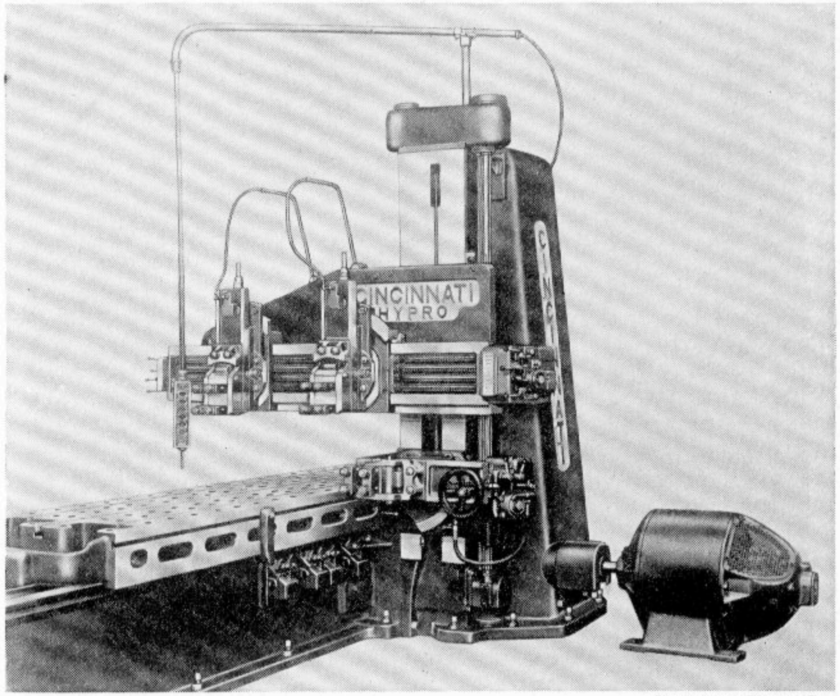
†† Carbon steel.

PROBLEM: Assume we wish to find the number of strokes per minute at which a shaper should be run to machine a piece of steel whose cutting speed is 80 feet per minute, and the stroke is adjusted for 6 inches.

SOLUTION:

$$\text{Strokes per minute} = \frac{\text{cutting speed}}{.14 \times \text{length of stroke}}$$
$$\text{Strokes per minute} = \frac{80}{.14 \times 6 \text{ inches}} = \frac{80}{.84}$$
$$\text{Strokes per minute} = 95 \text{ strokes per minute}$$

Generally the shaper is operated too slowly. Hence it is well for the beginner to determine the speed at which the machine should be operated, and to work as near that speed as possible.



Cincinnati Planer Co.

Fig. 39. Open-Side Planer with Two Rail Heads and One Side Head

Table I gives the cutting speeds recommended for shaping various materials. The length of the stroke can be read from the setting on the machine.

Safety Precautions—Shaper

The two most common causes of injury around the shaper are (1) flying chips and (2) getting caught between the work-piece and the tool. Remember that it is dangerous to allow fingers near moving parts. If the tool is throwing off chips, the operator should keep his eyes out of the line of stroke of the ram. Injuries may happen if the operator tries to take measurements when the ram is in motion. On some machines, injury can result if removable handles are left in place while the machine is running.

Observe the following precautions:

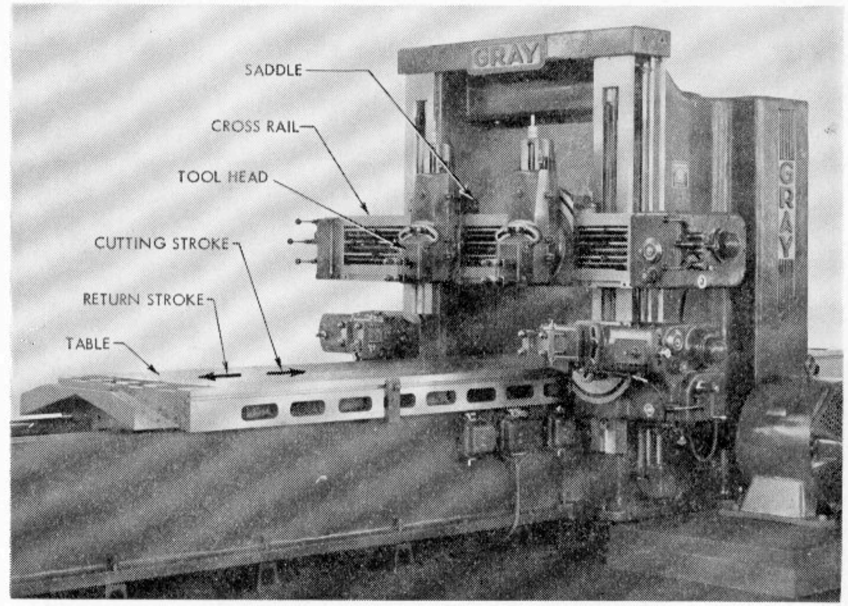
1. When belts and pulleys are used to drive a shaper, they should be enclosed in standard guards of angle iron and wire mesh, or angle iron and expanded or sheet metal.
2. When the shaper is so located that the rear of the ram at the extreme limit of its possible travel comes within 18 inches of a wall, post, or other obstruction, or such travel projects into an aisle or walkway, the space between the end of the ram travel and the obstruction or aisle or walkway should be enclosed by standard iron pipe railings or their equivalent.
3. Men operating shapers should be provided with and required to wear goggles unless the machine is provided with a chip guard.
4. Shaper operators should not wear gloves, loose or torn clothing.
5. When clamping the work in place on the machine table, the clamps should be so placed and blocked that they will have full purchase on the work and not spring out of shape.
6. When clamps are used, the bolts and nuts should be tightened only with wrenches which fit properly, as otherwise the wrench may slip off and the operator may be injured.
7. When a vise is used to hold the work, the operator should make sure that the bolts holding the vise in position and place are securely tightened.
8. Stop the machine before making adjustments to the machine or work, or before reaching across the table.

Courtesy of the National Safety Council

Feed. In horizontal shaping, the feed is defined as the distance the work is moved toward the cutting tool for each forward stroke of the ram. The feeding may be either by hand or by an automatic feeding mechanism. The amount of feed used is an important factor in determining the time required to complete the work with a given finish. The kind of metal and the type of job must be considered in selecting the feed.

PLANER CONSTRUCTION AND TYPES

The planer, Fig. 39, is a machine used principally for machining flat or plane surfaces which may be horizontal, vertical, or angular. It



G. A. Gray Co.

Fig. 40. Modern Double-Housing Planer

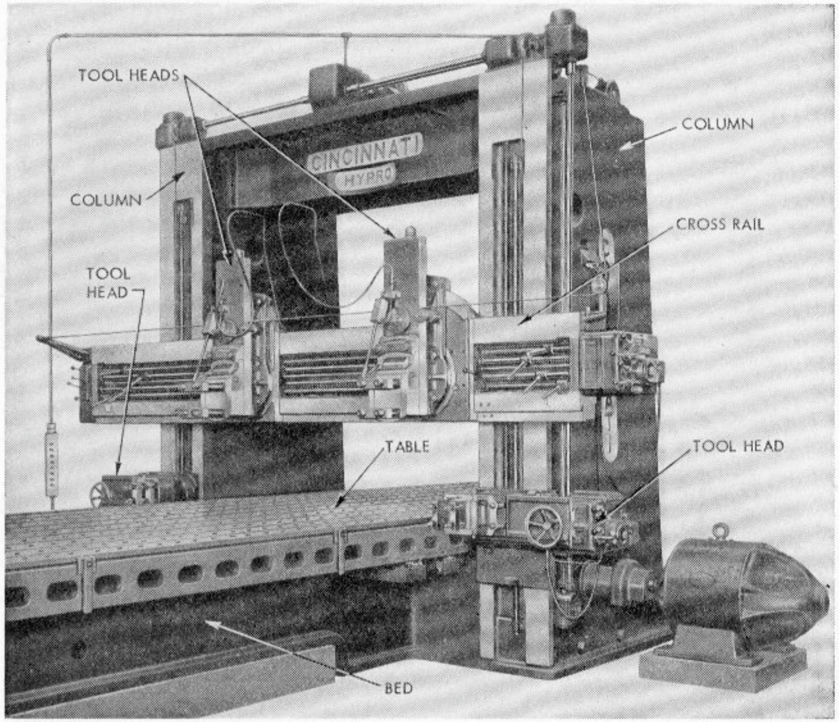
is also used for forming irregular or curved surfaces. Typical examples of planer work are: planing column supports, machine bases, machine covers; surfacing cuts on built-up structural sections or bases and bearing supports; roughing out special shapes from billets or bars.

On the planer, the cutting tools are securely clamped in their movable tool heads. The work is clamped on the table which moves horizontally to the cutting tools, Fig. 40.

Double-Housing Planer

One of the more common types of planers is the standard or double-housing (double-column) planer, Fig. 41. It has the following major parts.

Bed. The bed is of sturdy construction and provides the foundation for the machine. The upper part of the bed has precision-machined



Cincinnati Planer Co.

Fig. 41. Large-Size Double-Housing Planer

surfaces called V-ways or flat ways to guide the table in a straight line while the tool is cutting. The ways prevent the side thrust of the tool from forcing the table to one side as it moves along the bed.

Table. The table or platen is a precision-machined plate which travels on the ways of the base. The table is driven by a rack and gear, by helical gear, or by hydraulic power.

Column. Two columns (housings) rise vertically at the sides of the

machine on the double-housing planer. These columns support the crossrail and house the elevating screws and controls for the machine.

Crossrail. A crossrail is mounted on the columns. It may be raised or lowered on the columns to accommodate different sizes of work on the table and to allow for tool adjustment.

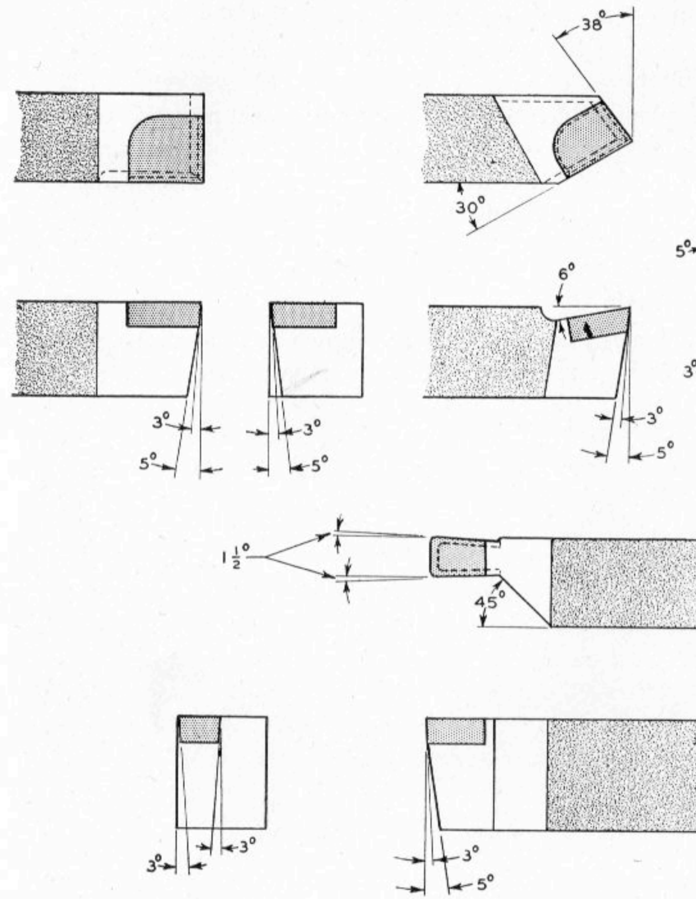


Fig. 42. Cutting Tool Angles for Tipped Tools Used on the Planer

Tool Head. The tool head, Fig. 41, is supported by the crossrail and travels on it. Small planers have but one head for holding a tool. Larger planers have two heads on the crossrail so that two tools may be cutting at the same time, thus doubling the work done by the machine.

Size or Capacity of Double-Housing Planers. The specified width of the planer refers to the maximum width of the work which can be planed. This width is slightly less than the distance between the housings. The height of the machine is the maximum height of the work which can be planed under the tools on the crossrail. The length of the planer refers to the maximum length of a piece of work which can be planed on the moving table.

Open-Side Planer

Open-side planers have only one housing to support the crossrail and tool heads, Fig. 39. Work of irregular shape may be accommodated with the work extending out over the side of the table. The working parts of this machine are essentially the same as on the double-housing planer.

Planer Cutting Tools

Cutting tools used in the planer are shown in Fig. 42. These tools may be made of high-speed steel, or they may consist of a mild steel

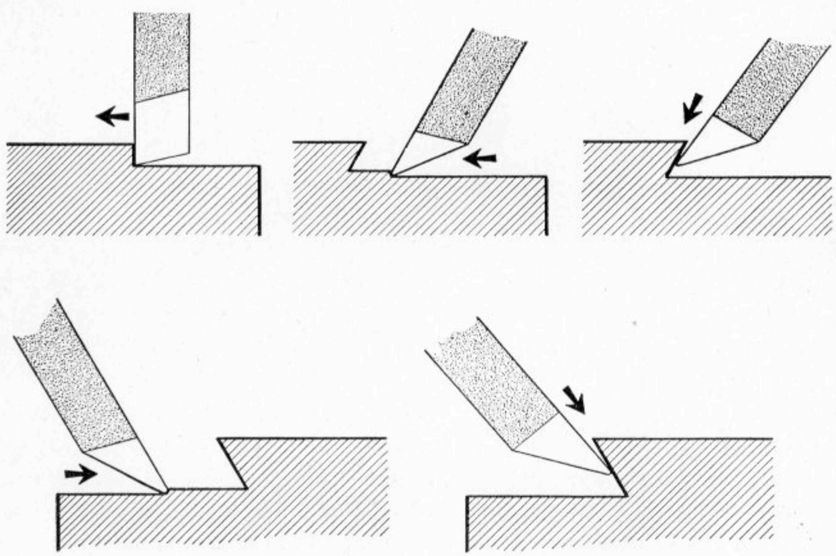


Fig. 43. Various-Shaped Tools Shown in Use in Common Planer Operations

shank with an insert of high-speed steel brazed on the end. The cutting edge is formed on the end.

Grinding Cutting Tool. Planer tools are ground somewhat like lathe and shaper tools. Because a planer tool is usually set perpendicular to the work, not as much front clearance is necessary as for lathe tools. Some side rake should be ground to give a shearing action for a smoother finish. Side clearance is ground on the tool to avoid rubbing along the work back of the cutting edge. Fig. 43 shows how tools are set for planing various surfaces on castings.

Work-Holding Devices

The various holding devices used on the planer are similar to those used on the shaper. By use of these clamps, bolts, stop pins, etc. the work is clamped to the table.

PLANER SETUPS AND OPERATIONS

To set up a planer job efficiently, certain steps must be taken to prepare the machine and to secure the work on the table. The following procedure is suggested for most jobs.

1. Run the table forward on the bed so it is free of rail and head.
2. Clean table and T-slots.
3. Place work on table.
4. Arrange stops and move work into position.
5. Level and square work.
6. Adjust clamping equipment.
7. Check setup.
8. Select and mount the proper tool for cut and material.
9. Select and adjust proper feeds and speed.

In making the setup, set the travel of the table several inches longer than the work to allow the feed to take place before the cutting action begins. Since planer heads have setscrews to tighten them to the rail when in cutting position, these setscrews must be loose before the head is moved. If the rail must be lowered, always lower it below the desired height. Then raise it to correct height to take up lost motion in the screws, called backlash.

Oil and lubrication of moving parts should be included in the setup. Follow the manufacturer's recommendation. Avoid dropping tools and parts on the table and ways of the machine.

Setup for Planing Horizontal Surface

Similarity of typical setup involving the use of bolts, clamps, and stops is found in the discussion of the shaper.

Tool Setting. Remember to avoid excessive overhang of the tool. A short hold offers better support to the tool bit. See that the crossrail is no higher than necessary for the work to pass under it. If work is not being planed evenly across, check the rail by measuring the distance from the table to the crossrail at each side.

Planing Vertical Surface

When making this setup, adjust the head square with the table. Use a machinist's (combination) square and indicator. Place the square on the planer table. As the indicator button follows the blade of the square up and down, any difference shows up on the indicator.

Planing Angular Surface

To plane an angular surface requires the tool slide to be set to the desired angle. This can be accomplished by loosening the two lock nuts which are used for locking the tool slide in any fixed position. The round end or base of the tool slide is graduated in degrees. While

TABLE II. PLANER CUTTING SPEEDS (FEET PER MINUTE)[1]

MATERIAL TO BE PLANED	HIGH-SPEED STEEL TOOLS				CAST ALLOY TOOLS				CARBIDE TIPPED TOOLS			
	Depth of Cut											
	1/8	1/4	1/2	1	1/8	1/4	1/2	1	1/16	3/16	3/8	3/4
	Feed											
	1/32	1/16	3/32	1/8	1/32	1/16	3/32	1/8	1/32	1/32	1/16	1/16
Cast iron, soft	95	75	60	50	160	135	110	95	255	205	165	140
Cast iron, medium	70	55	45	35	125	105	90	75	205	165	135	110
Cast iron, hard	45	35	25	...	95	80	65	...	140	110	90	...
Steel, free-cutting	90	70	55	40	140	105	85	65	315	245	190	140
Steel, average	70	55	40	30	105	80	60	45	270	205	160	120
Steel, low-machinability.....	40	30	25	...	65	50	40	...	195	145	115	...
Bronze	150	150	125	...	Maximum table speed							
Aluminum	200	200	150	...	Maximum table speed							

[1] Source: G. A. Gray Co.

noting these graduations, the tool slide is moved to the degree of graduation desired; then the tool slide lock nuts are tightened.

Another method often used for determining the angular setting of the tool slide is the use of a bevel protractor and a dial indicator. The protractor is set to the desired angle and then clamped lightly to the planer table. The dial indicator is clamped lightly in the tool post of the planer slide. The planer slide is then set to the approximate angle, which is determined by running the slide up and down by hand. The indicator pointer contacts the blade of the protractor as the slide is moved. The correct setting of the slide is determined by the indicator hand. If there is no deflection of the indicator hand as the slide is moved from top to bottom of its travel, the slide is correctly positioned to machine the desired angle.

Speeds and Feeds

Recommended speeds and feeds for planing various metals are given in Table II.

Safety Precautions—Planer

Stop the machine for all adjustments. In close observation of the action of the cutting tool, wear goggles to avoid eye injury from flying chips. Keep the fingers away from the cutting tool. Avoid pinching fingers under heavy work when mounting work to the table. Keep the floor around the machine free from oil and objects that would cause the operator to fall.

Observe the following precautions:

1. If the housings of the planer are of the open type, the openings should be covered with sheet metal or other substantial guards to prevent the operator reaching through the openings.
2. Safety dogs should be placed at each end of the planer table to prevent it from running off the gear rack.
3. The floor about the planer should be maintained in good repair.
4. If a chip guard is not provided, the operator should be provided with and required to wear goggles with strength-tested lenses.

(continued on page 268)

Safety Precautions (*continued*)

5. Before attempting to raise or lower the crossrail, the operator should make certain that the crossrail clamps have been loosened. When the crossrail has been set to the desired height, the clamps should be securely tightened.

6. The planer operator should make sure that the cutting tools are set in such a position that if they shift away from the cut, they will raise away from the cut and not dig into the work.

7. When the planer is in motion, the operator should not attempt to shift the safety dogs, tighten down work or tool, make any adjustment to the planer or the work, sit on the planer table, or oil the planer.

8. Chips should not be removed by hand or wiping rag. A suitable brush should be used for this purpose.

Courtesy of the National Safety Council