CHAPTER 8

VERTICAL TURRET LATHE AND HORIZONTAL BORING MILL

CHAPTER LEARNING OBJECTIVES

Upon completing this chapter, you should be able to do the following:

- *Describe and explain the use of a vertical turret lathe.*
- *Describe and explain the use of a horizontal boring mill.*

A vertical turret lathe works much like an engine lathe turned up on end. You can perform practically all of the typical lathe operations on a vertical turret lathe, including turning, facing, boring, machining tapers, and cutting internal and external threads.

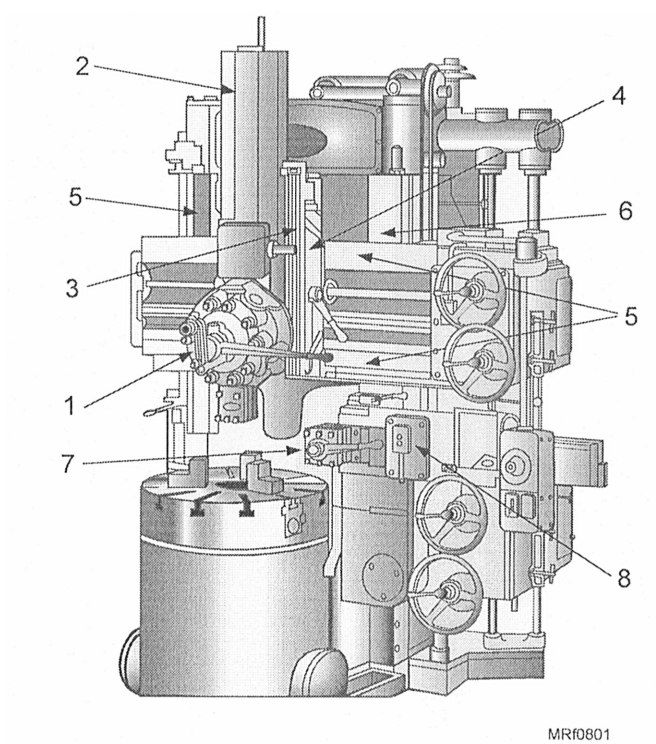
A horizontal boring mill can be used for many kinds of shopwork, such as facing, boring, drilling, and milling. In horizontal boring mill work, the setup of the work, as well as the setting of the tools, is similar to that found in lathe and milling machine work.

As with any shop equipment you must observe all posted safety precautions. Review your equipment operators manual for safety precautions and any chapters of *Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat*, OPNAV Instruction 5100.19B. that pertain to the equipment.

VERTICAL TURRET LATHE

The characteristic features of the vertical turret lathe are (1) a horizontal table or faceplate that holds the work and rotates about a vertical axis; (2) a side head that can be fed either horizontally or vertically; and (3) a turret slide, mounted on a crossrail that can feed nonrotating tools either vertically or horizontally.

Figures 8-1 and 8-2 show vertical turret lathes similar to those generally found in repair ships and shore repair facilities. The main advantage of the vertical turret lathe over the engine lathe is that heavy or awkward parts are easier to set up on the vertical turret lathe and, generally, the vertical turret lathe will handle much larger workpieces than the engine lathe. The size of the vertical turret lathe is designated by the diameter of the table. For instance, a 30-inch lathe has a table 30 inches in diameter. The capacity of a specific lathe is not necessarily limited to the size of the table. A 30-inch vertical lathe (fig. 8-1) can hold and machine a workpiece up to 34 inches in diameter by using both the main and side turrets. If you use



(1) Main turret head	**(5) Main rails**
(2) Turret slide	**(6) Upright bedways**
(3) Swivel plate	**(7) Side turret**
(4) Saddle	**(8) Side head**

Figure 8-1.—A 30-inch vertical turret lathe.

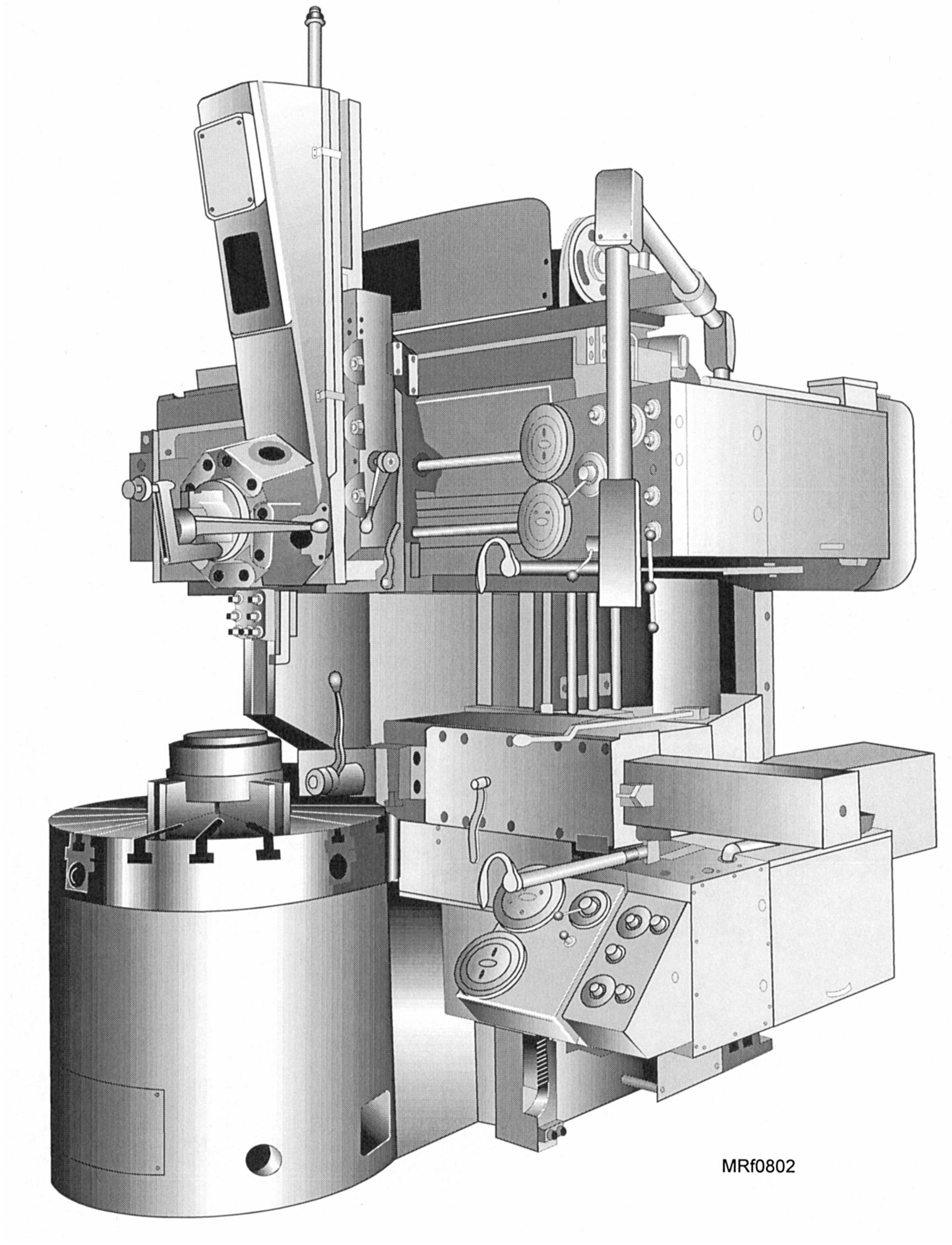


Figure 8-2.—A 36-inch vertical turret lathe.

only the main turret, you can machine a workpiece as large as 44 inches in diameter.

The main difference between the vertical turret lathe and the horizontal turret lathe is in the design and operating features of the main turret head. Refer to figure 8-1. Note that the turret slide (2) is mounted on a swivel plate (3) which is attached to the saddle (4). The swivel plate allows the turret slide to be swung up to 45° to the right or left of the vertical, depending on the machine model. The saddle is carried on, and can traverse, the main rails (5). The main rails are gibbed and geared to the upright bedways (6) for vertical movement. This arrangement allows you to feed main turret tools either vertically or horizontally, as compared to one direction on the horizontal turret lathe. Also, you can cut tapers by setting the turret slide at a suitable angle.

The side turret and side head of the vertical turret lathe correspond to the square turret and cross slide of the horizontal turret lathe. A typical vertical turret lathe has a system of feed trips and stops that functions similarly to those on a horizontal turret lathe. In addition, the machine has feed disengagement devices to prevent the heads from going beyond safe maximum limits and bumping into each other.

Vertical turret lathes have varying degrees of capabilities, including feed and speed ranges, angular turning limits, and special features such as threading.

You can expect to find a more coarse minimum feed on the earlier models of vertical turret lathes. Some models have a minimum of 0.008 inch per revolution of the table or chuck, while other models will go as low as 0.001 inch per revolution. The maximum feeds obtainable vary considerably also; however, this is usually less of a limiting factor in job setup and completion.

The speeds on any given vertical turret lathe tend to be much slower than those on a horizontal lathe. This reduction in speed is often required because of the large and oddly shaped sizes of work done on vertical turret lathes. A high speed can throw a workpiece out of the machine that may damage equipment and injure personnel.

One of the major differences between the lathes shown in figures 8-1 and 8-2 is in the method you will use to position the cutter to the work. On the lathe in figure 8-1, you will use a handwheel to position the work manually. On the lathe in figure 8-2, you will use an electric drive controlled by a lever. When you move the feed control lever to the creep position, the turret head moves in the direction selected in increments as low as 0.0001 inch per minute. This creep feed is independent of table revolution and can be made with the table stopped.

An attachment available on some machines permits threading of up to 32 threads per inch with a single-point tool. The gears, as specified by the lathe manufacturer, are positioned in the attachment to provide a given ratio between the revolutions per minute of the table and the rate of advance of the tool.

The same attachment also lets the operator turn or bore an angle of 1° to 45° in any quadrant by positioning certain gears in the gear train. You can then engage the correct feed lever to cut the angle. Later in this chapter, we'll explain in detail how you turn tapers on a vertical turret lathe without this attachment.

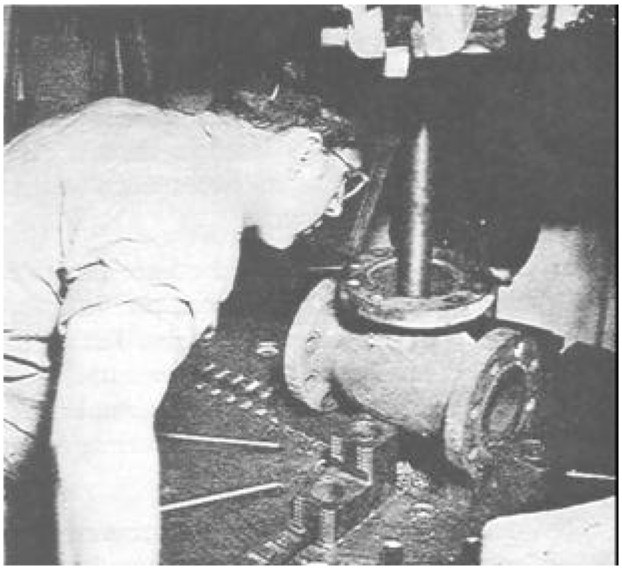
VERTICAL TURRET LATHE TOOLING

The principles used to operate a vertical turret lathe are not very different from those for a horizontal turret lathe. The only significant difference is in the main turret. We said earlier that the main head corresponds to the hexagonal turret of the horizontal machine. You can feed it vertically toward the headstock (down), horizontally, or at an angle. To do this, you can engage both the horizontal and vertical feeds, or you can set the turret slide at an angle from the vertical and use only the vertical feed.

The tool angles used for the cutters of the vertical machine correspond to those on the horizontal turret lathe; they are an important factor in successful cutting. It is equally important to set cutters on center and maintain the clearance and rake angles in the process. Again, you must be sure the cutters are held rigidly.

In vertical turret lathe work, you must often use offset or bent-shank cutters, special sweep tools, and forming tools, particularly when you machine odd-shaped pieces. Many such cutting tools are designed to take advantage of the great flexibility of operation provided in the main head.

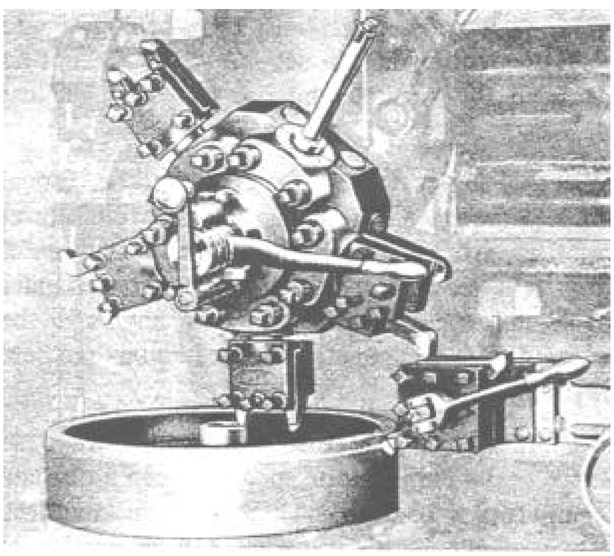
On a repair ship, you normally will use the vertical turret lathe for jobs other than straight



28.194

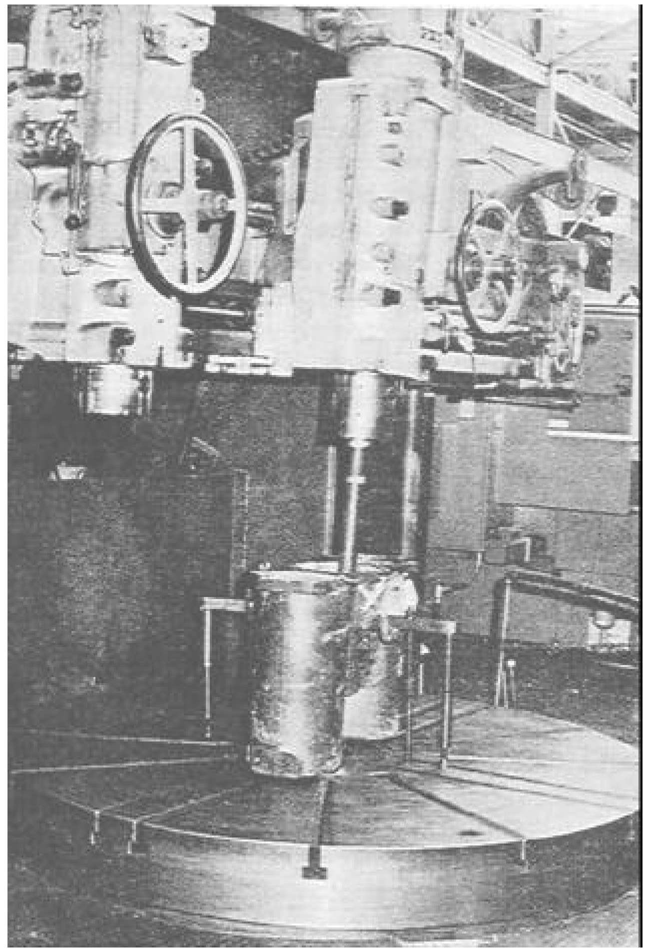
Figure 8-3.—Refacing a valve seat in a vertical turret lathe.

production work. For example, you can mount a large valve on the horizontal face of its worktable or chuck easier than on almost any other type of machine. For other examples, figure 8-3 shows a typical valve seat refacing job on a vertical turret lathe; figure 8-4 shows the double tooling principle applied to a machining operation, and figure 8-5 shows a straight boring bar used to bore a large saltwater strainer body.



28.195

Figure 8-4.—Double tooling.



28.461

Figure 8-5.—Straight boring bar being used to bore a large saltwater strainer.

TAPER TURNING

The following information is based on a Bullard vertical turret lathe. (See fig. 8-1.)

There are several ways to cut a taper on a vertical turret lathe. You can cut a 45° taper with either a main turret-held cutter or a side head-held cutter if you engage the vertical and horizontal feeds simultaneously. To cut a taper of less than 30° with a main turret-held tool, set the turret slide for the correct degree of taper and use only the vertical feed for the slide. If you did this operation on an engine lathe, you would use the compound rest and advance the cutter by manual feed. On a vertical lathe, you would USC the vertical power feed.

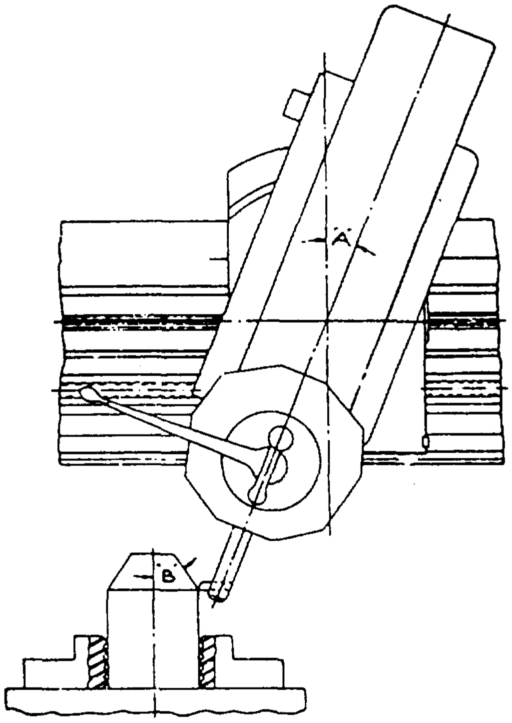


Figure 8-6.—Head setting for 30° to 45° angles.

If you swivel the main turret head on a vertical turret lathe, you can cut 30° to 60° angles without special attachments. To machine angles greater than 30° and less than 60° from the vertical, engage both the horizontal feed and the vertical feed simultaneously and swivel the head. Determine the angle to which you swivel the head in the following manner. For angles between 30° and 45°, swivel the head in the direction opposite to the taper angle you are turning, as shown in figure 8-6. The formula to determine the proper angle is $A = 90° - 2B°$. A sample problem from figure 8-6 follows:

Formula: $A = 90° - 2B°$

Example: $B = 35°$

Therefore, $A = 90° - (2 \times 35°)$

$A = 90° - 70°$

Angle: $A = 20°$

For angles between 45° to 60°. swivel the head in the same direction as the taper angle you are turning as shown in figure 8-7. The formula to determine the proper angle is $A = 2B° - 90°$. A sample problem from figure 8-7 follows:

Formula: $A = 2B° - 90°$

Example: $B = 56°$

Therefore, $A = (2 \times 56°) - 90°$

$A = 112° - 90°$

Angle: $A = 22°$

When you use the swivel method to turn a taper, use great care to set the slide in a true vertical position after you complete the taper work and before you use the main head for straight cuts. A very small departure from the true vertical will produce a relatively large taper on straight work. You may cut a dimension undersize before you are aware of the error.

Another way to cut tapers with either a main head-held or side head-held tool is to use a sweep-type cutter ground. Set it to the desired angle and feed it straight to the work to produce the desired tapered shape. This, of course, is feasible only for short taper cuts.

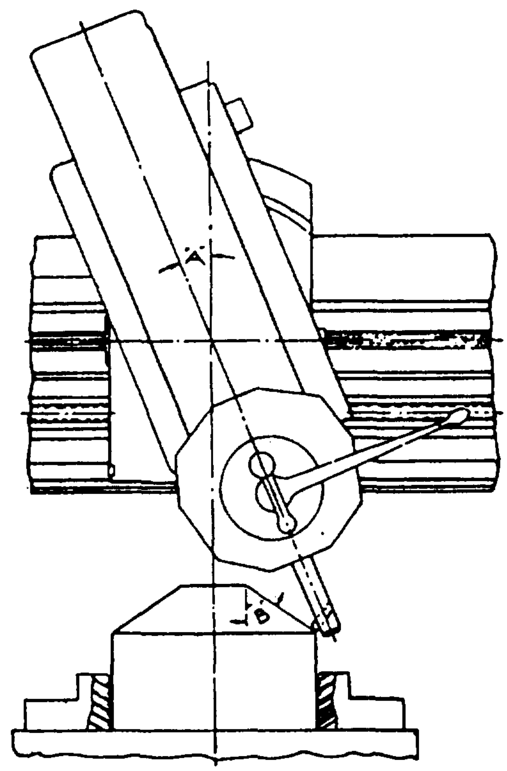


Figure 8-7.—Head setting for 45° to 60° angles.

HORIZONTAL BORING MILL

The horizontal boring mill (fig, 8-8) consists of the four major elements dscribed in the next paragraphs.

1. BASE and COLUMN: The base contains all the drive mechanisms for the machine and provides a platform that has precision ways machined lengthwise for the saddle. The column provides support for the head and has two rails machined the height of the column for full vertical travel of the head.

2. HEAD: The head contains the horizontal and auxiliary spindle and the mechanism to control them. The head also provides a station on which you can mount various attachments. The spindle feed and hand feed controls are contained in the head, along with the quick traverse turnstile and the spindle feed engagement lever.

3. SADDLE and TABLE: A large rectangular slotted table is mounted on a saddle that can be traversed the length of the ways. T-slots are machined the entire length of the table. They are used to hold down work and various attachments, such as rotary table angle plates.

4. BACKREST or END SUPPORT: The backrest is mounted on the back end of the ways. It supports arbors and boring bars as they rotate and travel lengthwise through the work, such as the in-line boring of a pump casing or large bearing. The backrest blocks have an antifriction bearing; the boring bar passes through and rotates within this bearing. The backrest blocks travel vertically with the head.

Navy machine shops and shore repair activities usually have two types of horizontal boring mills: The table type is used for small work, and the floor type for large work. The floor type is the most common of the two. This machine is well suited for repair work where you often machine large, irregular parts.

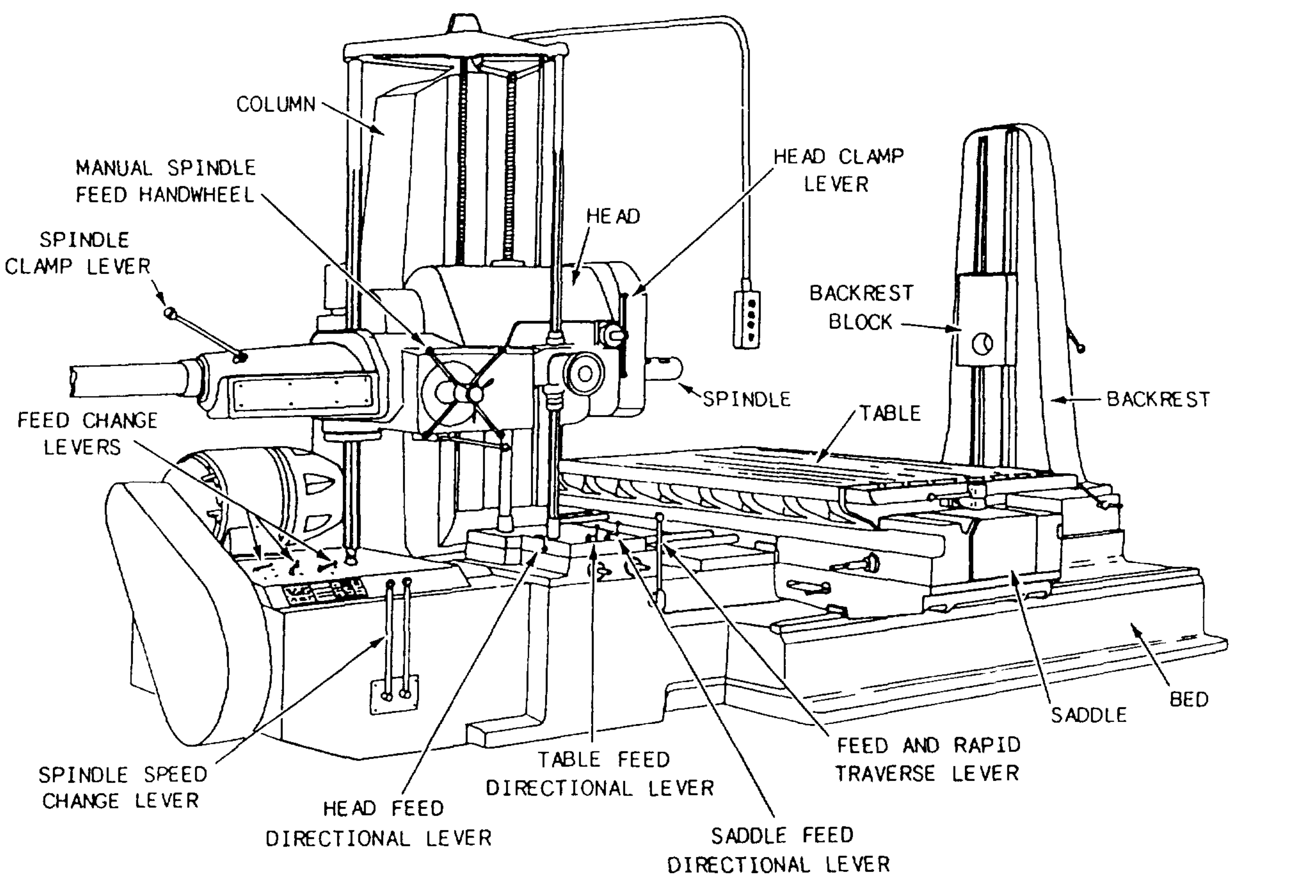


Figure 8-8.—Horizontal boring mill.

The reference to the size of horizontal boring mills differs with the manufacturer. Some use spindle size. For example, Giddings and Lewis model 300T has a 3-inch spindle. Others use the largest boring bar the machine will accept. In planning a job, consider both of these factors along with the table size and the height the spindle can be raised. Always refer to the technical manual for your machine.

It is most important that you set up the work correctly. Mistakes cost man-hours and material. Often you will find it's better to set up a casting to the layout lines than to a rough surface since the layout lines will always be used as a reference.

Be sure the holding clamps used to secure a piece of work are tight. If you use braces, place them so they can't come loose. Fasten blocks, stops, and shims securely. If a workpiece is not properly secured, you could ruin the material or the machine and injure personnel.

Different jobs may require different types of attachments. These attachments include angular milling heads, combination boring and facing heads, thread lead arrangements, and so forth. Boring heads are available in a variety of diameters. These boring heads are particularly useful to bore large diameter holes and face large castings. You also can use locally made collars, and you can use stub arbors to increase diameters.

COMBINATION BORING AND FACING HEAD

The boring and facing head (fig. 8-9) is used to face and bore large diameters. It is mounted and bolted directly to the spindle sleeve, and it has a slide with automatic feed that holds the boring or facing tools. (This attachment can be fed automatically or positioned manually.) There are various sizes, but each is made and used similarly. The heads are balanced to permit high-speed operation with the tool slide centered. Whenever you use tools off center, be sure you counterbalance the head, or use it at lower speeds.

Generally, the boring and facing head will come equipped with several toolholders for single-point tools, a right-angle arm, a boring bar, and a boring bar holder that mounts on the slide. Use the following instructions to set up and operate the boring and facing head:

1. Retract the spindle of the machine into the sleeve. Engage the spindle ram clamp lever.

2. Disengage the overrunning spindle feed clutch to prevent accidental engagement of the spindle power feed while you mount the combination head on the machine. If the slide is centered and locked, you may run the spindle through it for use in other operations without removing the attachment, but be sure you disengage the spindle overrunning clutch again before you resume use of the slide.

3. Set the spindle for the speed to be used.

4. When the combination head is mounted on the sleeve, follow these steps: Before you shift the spindle back-gear to neutral, or make any spindle back-gear change, rotate the sleeve by jogging it until the heavy end of the head is down. Any spindle back-gear change requires a momentary shift to neutral which allows the sleeve to turn freely. The sleeve may rotate unexpectedly until the heavy end of the facing head is down, hitting you or the work.

5. Lift the head into position on the machine at the sleeve by inserting an eyebolt into the tapped hole in the top of the head.

6. To line up the bolt holes in the sleeve with those in the head, jog the spindle into position.

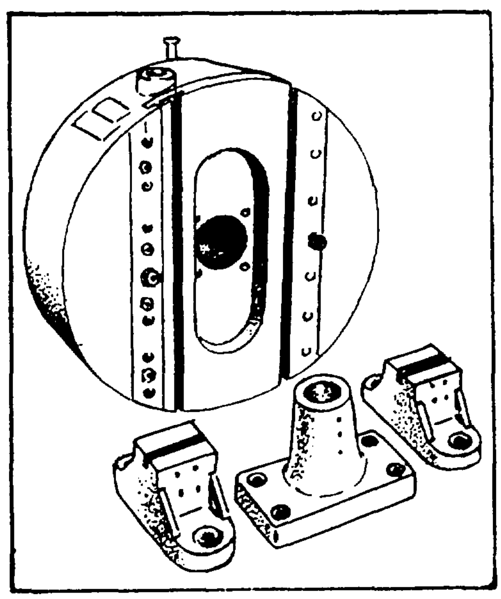


Figure 8-9.—Combination boring and facing head.

7. After you have tightened the mounting bolts, rotate the feed adjusting arm on the backing plate until the arm points directly toward the front.

8. Mount the restraining block on the head.

9. Set the slide manually; insert the tee-handled wrench into the slot in the slide adjusting dial and turn the wrench until the slide is positioned. The dial is graduated in thousandths of an inch and one complete turn equals a 0.125-inch movement of the slide.

After the slide is clamped in place, a spring-loaded safety clutch prevents movement of the slide or damage to the feed mechanism if the feed is inadvertently engaged. This is not provided to allow continuous operation of the head when the slide is clamped and the feed is engaged—it is a jamming protection only. A distinct and continuous ratcheting of the safety clutch warns you to unlock the slide or to disengage the feed. Do not confuse this warning with the intermittent ratcheting of the feed driving clutches as the head rotates. The same safety clutch stops the feed at the end of travel of the slide that prevents jamming of the slide or the mechanism through overtravel.

The slide directional lever is located on the backing plate beneath the feed adjusting arm. The arrows on the face of the selector show which way it should be turned to feed the slide in either direction. There are also two positions of the selector to disengage the slide feed. The direction of the spindle rotation has no effect on the direction of the slide feed.

The slide feed rate adjusting arm scale is graduated in 0.010-inch increments from 0.000 to 0.050 inch, but the first two increments are each 0.005 inch. Set the feed rate by turning the knurled adjusting arm to the desired feed in thousandths per revolution.

When you mount the single-point toolholders, be sure the tool point is on center or slightly below center so the cutting edge has proper clearance at the small diameters. You may damage the feed mechanism if you operate the head with the tool above center.

After you mount the facing head, perform the machining operation using the instructions in the operator's manual for your boring machine.

RIGHT-ANGLE MILLING ATTACHMENT

The right-angle milling attachment is mounted over the spindle sleeve and bolted directly to the face of the head. It is driven by a drive dog inserted between the attachment and the spindle sleeve. This attachment lets you perform milling operations at any angle setting through a full 360°. You can perform boring operations at right angles to the spindle axis using either the head or the table feed depending on the position of the hole to be bored. You may use standard milling machine tooling held in the spindle by a drawbolt that extends through the spindle. Figure 8-10 shows a right-angle milling attachment.

BORING MILL OPERATIONS

You can use the boring mills for drilling, reaming, and boring operations. You also can use it to face valve flanges, and bore split bearings and pump cylindrical liners. We will explain these in the next paragraphs.

Drilling, Reaming, and Boring

Drilling and reaming operations are done the same way with both a horizontal boring mill and a radial drill. The major difference is the way the tool is held in the machine. It's horizontal in the horizontal boring mill (fig. 8-11) and vertical in the radial drill.

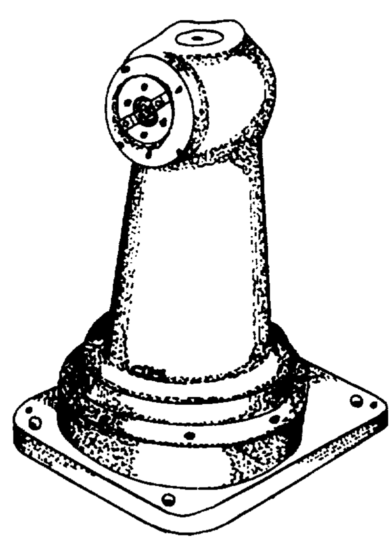
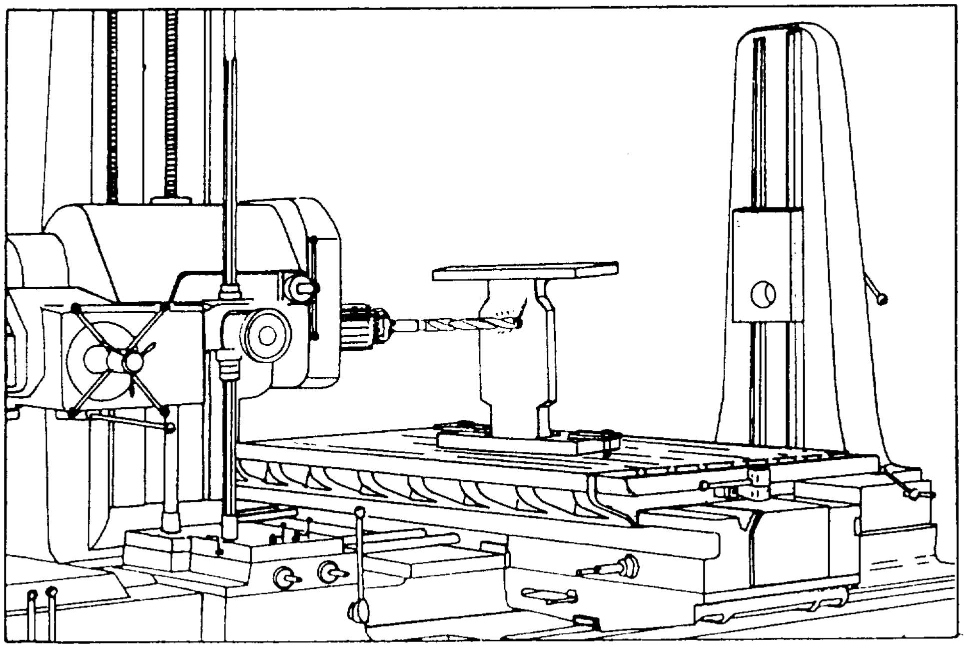


Figure 8-10.—Angular milling head.

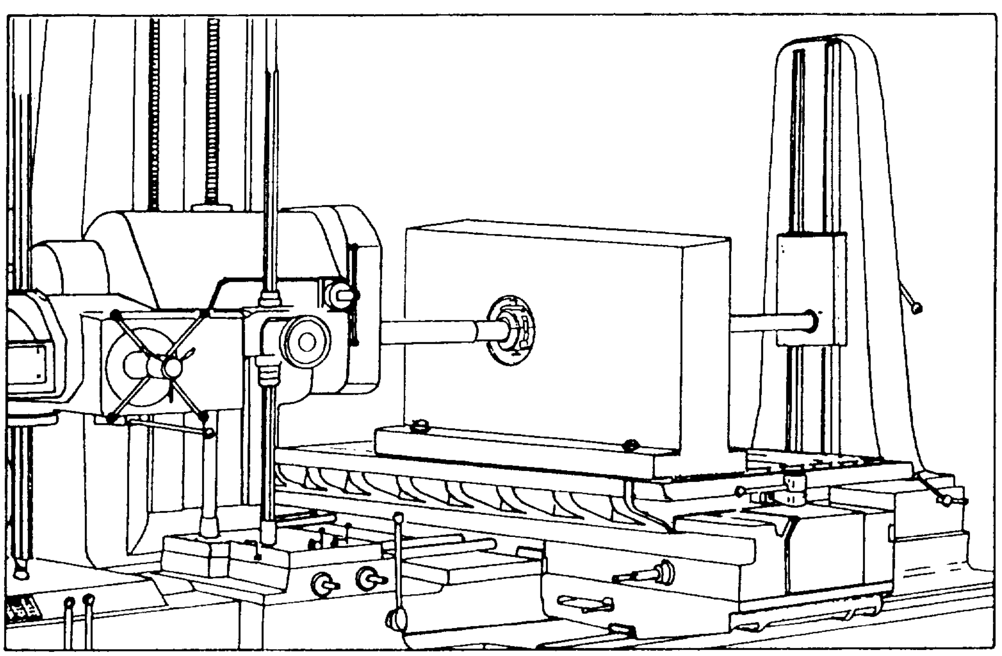


126.30

Figure 8-11.—Drilling in the horizontal boring mill.

In-Line Boring

To set the horizontal boring machine for a line boring operation, insert a boring bar into the spindle and pass it through the work. The boring bar is supported on the foot end by the backrest assembly. Depending on the size of the bore, you can use either standard or locally manufactured tooling. The head provides the rotary motion for the tools mounted in the boring bar. Align the work with the axis of the boring bar and bolt and/or clamp it to the table. In the cutting operation, the spindle usually moves while the work is held stationary. However, there may be times when you need to hold the bar in a fixed position and move the table lengthwise to complete the operation. (See fig. 8-12.)



28.280

Figure 8-12.—Boring bar driven by the spindle and supported in the backrest block.

The table can be power driven to provide travel perpendicular to the spindle. This makes it possible to bore, elongate, and slot when you use the table in conjunction with vertical movement of the head.

You can use a horizontal boring mill to line bore a split casing pump. You can use a standard boring bar, but it is preferable to manufacture dummy bearings and install them in the pump's bearing housings. After you have installed the dummy bearings, you will manufacture a boring bar to fit the bearings. You will then modify a tapered shank that fits the boring machine spindle so you can have a universal joint welded to it. The other end of the universal joint will be modified to accept the boring bar. By using a universal joint, the tapered shank will drive the boring bar without the pump being in perfect alignment. This is a long and complicated job, and it is best to consult with someone that has done it before you attempt it.

Reconditioning Split-Sleeve Bearings

Practically all of the high-speed bearings the Navy uses on turbines are the babbitt-lined split-sleeve type. Once a bearing of this type has wiped, it must be reconditioned at the first opportunity. *Wiped* means the bearing has been damaged by an abnormal condition, such as insufficient lubrication. If it has wiped only slightly, it can probably be scraped to a good bearing surface and restored to service. If it is badly wiped, it will have to be rebabbitted and rebored, or possibly replaced. When you receive a wiped bearing for repair, use the following procedure and follow it as closely as possible:

1. Check the extent of damage and wear marks.
2. Take photos of the bearing to show the actual condition of the bearing and for future reference during machining and reassembly.
3. Check the shell halves for markings. A letter or number should be on each half for proper identification and assembly. (If the shell halves are not marked, mark them before you disassemble the bearing.)
4. Inspect the outer shell for burrs, worn ends, and the condition of alignment pins and holes.
5. Check the blueprint and job order to be sure the required information has been provided to you.
6. Be sure the actual shaft size has not been modified from the blueprint.

After you have completed these steps, send the bearing to the foundry to be rebabbitted. When you receive the rebabbitted bearing from the foundry, rough machine the bearing on a shaper to remove the excess babbitt extending above the horizontal flanges. Be extremely careful that you do not damage the base metal of the horizontal flanges during this operation. After rough machining, blue the remaining excess babbitt and scrape it until no more excess babbitt extends above the horizontal flanges.

Next, assemble the two half-shells and set them up on the horizontal boring mill. Check the spherical diameter of the bearing to ensure that it is not distorted beyond blueprint specifications. Generally, the words "BORE TRUE TO THIS SURFACE" are inscribed on the front face of the bearing shell. When you dial in the bearing, be sure to dial in on this surface.

When you have aligned the bearing in the boring mill, you can complete practically all the other operations without changing the setup. Bore the bearing to the finished diameter and machine the oil grooves as required by blueprint specifications. Figure 8-13 shows a line shaft bearing that has had the "cheeks" or oil reservoir grooves cut into it

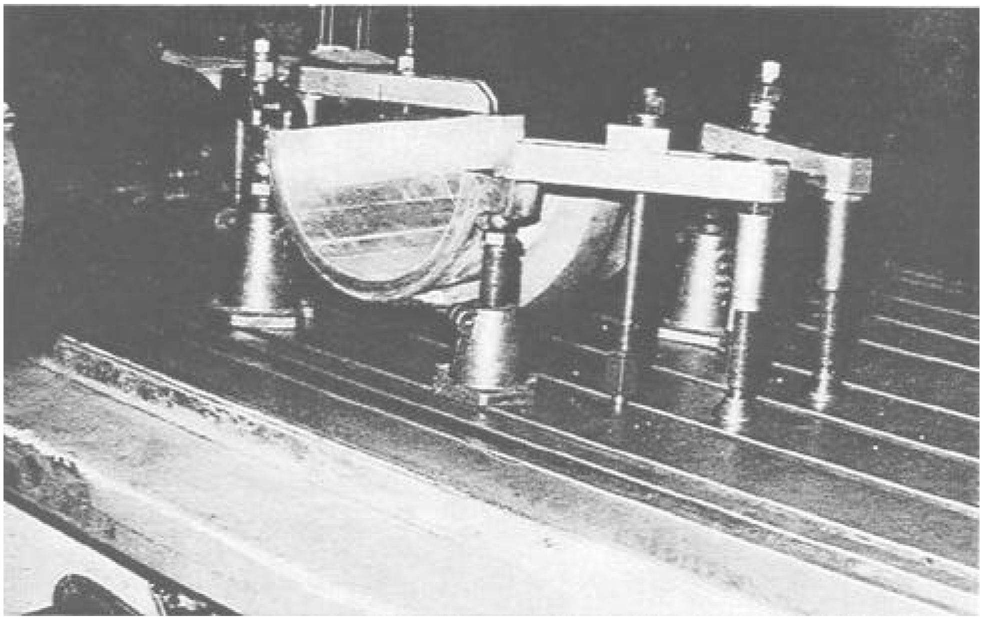
Oil is distributed through the bearing by oil grooves. These grooves may be of several forms; the two simplest are axial and circumferential. Sometimes circumferential grooves are placed at the ends of the bearings as a controlling device to prevent side leakage, but this type of grooving does not affect the distribution of lubricant.

When you machine grooves into a bearing, you must be careful in beveling the groove out into the bearing leads to prevent excess babbitt from clogging the oil passage. The type of grooves used in a bearing will not be changed from the original design.

When all machining is complete, both the repair activity and the ship's force determine that the bearing meets blueprint specifications and has a good bond between the shell and the babbitt metal.

Threading

You can cut threads on horizontal boring mills that have a thread lead arrangement. On some machines, a thread lead arrangement is available with



28.462

Figure 8-13.—Line shaft bearing that has had the "cheeks" or oil reservoir grooves cut into it.

as many as 23 different threads, both standard and metric.

To cut threads with these machines, use a system of change gear combinations to obtain the different leads. Secure a single-point tool in a suitable toolholder and mount the toolholder in the spindle of the machine. While you cut threads, keep the spindle locked in place. The saddle, carrying the workpiece, advances at a rate determined by the change gear combination, Feeding, in conjunction with the spindle rotation in the low back gear range, produces the threads.

Cut the thread a little at a time in successive passes. The thread profile depends on how the cutting tool is ground. When you have completed the first pass, back the cutting tool off a few thousandths of an inch to avoid touching the workpiece on the return movement. Then, reverse the spindle driving motor. This causes the saddle direction to reverse while the direction selection lever position remains unchanged. Allow the machine to run in this direction until the cutting tool has returned to its starting point. Advance the cutter to cut the thread a little deeper, set the spindle motor to run in forward, then make another cutting pass. Follow this procedure until the thread is completed. A boring bar with a micro-adjustable tool bit or a small precision head is ideal for this operation. It allows fast, easy adjustment of the tool depth and accuracy and control of the depth setting.

When you set up to cut threads, remove the thread lead access covers and set up the correct gear train combination as prescribed by the manufacturer's technical manual. After you have set up the gear train, tighten the nuts on the arm clamp to lock the sliding arm. Be sure to replace the retaining washers on all the studs and lock them with the screws provided with the machine. Refer to the manufacturer's technical manual for the machine you are using for the correct gear arrangement.