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FORESIGHT IS BETTER THAN NO SIGHT
READ INSTRUCTIONS BEFORE OPERATING

SHERLINE PRODUCTS
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CAUTION!
Read All Operating Instructions Carefully Before Attempting Any Machining Operations.

Vertical Milling Machine Operating Instructions

General Description

At first glance, a vertical mill looks similar to a drill press, but there are some important design differences; for example, the mill has a spindle that can take side loads as well as end loads and an accurate method of moving work in relation to the spindle on all three axes. It is wise to memorize these X-, Y-, and Z-axes, because, since the advent of complex electronically controlled milling machines, these terms have become common "shop talk," even outside engineering departments. Feed screws with calibrated handwheels control movements on these three axes. The handwheel calibrations are quite accurate and should be used whenever possible.

Angles can be machined by removing the headstock alignment key and rotating the milling head to the appropriate angle to the work or by holding the work at an angle to the spindle.

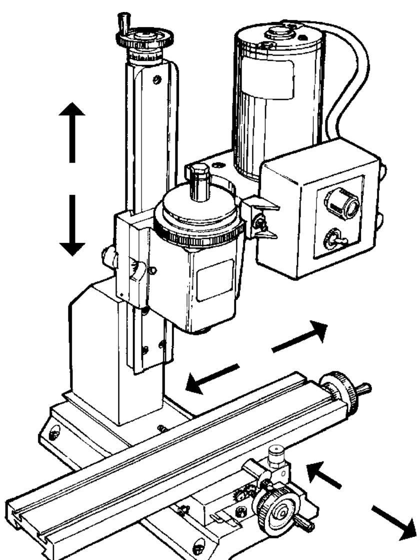


FIGURE 1—The axes of movement for milling on a standard 3-axis vertical milling machine.

(**NOTE:** Lighter than normal cuts should be taken when the alignment key is not in place.) The latter method must be used for drilling on 5000/5400-series mills to keep the drill movement parallel with the machine slide. Angle drilling can also be accomplished without removing the alignment key by using the optional rotary column attachment (P/N 3500). (The Model 2000 mill is also capable of angle drilling due to its multi-axis design.) All machine slides have an adjustable gib to compensate for any "play" that may develop. (See "adjusting gibs" on page 12 of the Assembly and Instruction Guide.)

It is assumed that anyone purchasing a vertical milling machine has had some experience working with metal cutting tools; therefore, these instructions are somewhat limited for a beginner. There is enough information, however, to enable a good craftsman to get started. Using a vertical mill correctly takes more skill and experience than is required for lathe operation because of the additional axis (vertical) and the more varied type of work that can be performed.

The machine must be well maintained, for it is subject to higher stresses than a lathe. This particular mill is one of the smallest being manufactured and is an extremely useful tool. However, it would be unreasonable to clamp a 3-pound piece of stainless steel to the work table and expect to make a 1-pound part from it. The key point is to work within the capabilities of the machine, and those limitations can only be determined by the operator.

Helpful Tips for Milling

- This is a small, light-duty mill and should not be used to remove large amounts of stock that could be easily removed with a hacksaw. For efficiency, select a piece of stock as close to finished size as possible.
- Stresses on a mill are quite high when cutting most materials; therefore, gib and backlash adjustments must be properly maintained.
- End mills must run true and be sharp. Holding end mills in a drill chuck is a poor practice. Use collets or an end mill holder instead. The 3/8" end mill holder (P/N 3079) allows you to use a large range of readily available 3/8" end mills with your machine. (Several other size inch and metric end mill holders are also available.)
- Fly cutting is an excellent way of removing stock from flat surfaces.
- Normal machine alignment is adequate for most work, but if the work is exceptionally large or requires extreme accuracy, shims may be employed to improve machine alignment.
- For accurate setups you should have and know how to use a dial indicator.

- Often, more time will be spent making fixtures to hold work than doing the actual machining.
- To help save time on many simple setups, a good mill vise is a must. A drill press vise is not designed for the forces involved in milling.
- Plan ahead. Always try to have one point from which to measure. Do not machine this point off part way through the job. This would leave you with no way of measuring the next operation.
- Remember the basic machining rule that says: "If the tool chatters, reduce speed and increase feed."
- It takes a long time to accumulate the knowledge, tools and fixtures required for many different types of milling operations. Do not become discouraged by starting with a job that is too complex or by using materials that are extremely difficult to machine.

CAUTION! Because the tool spins on a mill, hot chips can be thrown much farther than when using a lathe. Safety glasses and proper clothing are a must for all milling operations.

Securing the Workpiece

The first problem encountered will be holding the work and aligning it to the machine. It is important for reasons of safety and accuracy that the workpiece be solidly secured. This may be the most difficult task, since once the work is clamped in position, the method of doing the entire job has been established. Usually, a rectangular block can be easily held in a mill vise. Note that round stock may also be held in a "V" shaped vise slot. Mill vises are specially designed to pull the movable jaw downward as they tighten on it. (See Mill Vise P/N 3551 shown on page 36 and in the *Sherline Tools and Accessories Catalog*.)

Certain objects can be secured with a 4-jaw lathe chuck, which is, in turn, clamped to the machine. Some irregular shapes such as castings may present greater difficulties. Often they may be clamped directly to the table. Very small or irregular shapes can be secured by epoxying them to a second, more easily held piece of material. They are broken loose after machining. A mill tooling plate (P/N 3560) is a very useful fixture for holding parts. It has a number of holes predrilled for holding clamps, and additional holes can be drilled and tapped as needed. It also provides additional stiffness and protection for your mill table.

Locking the Axes

To keep the table from moving in a particular direction during an operation, there is a lock available on each axis. To lock the X-axis table from moving side-to-side there is a barrel lock on the front of the saddle. (See Figure 2.) The Saddle is locked by means of a thumbscrew on the left side that presses a nylon plug against the gib to pull the saddle tight against the dovetail. The Z-axis can be locked during milling operations by means of a brass lever that tightens against the saddle nut on the back of the column.

Things to Consider Before You Start Cutting

The following steps should be considered before commencing any part:

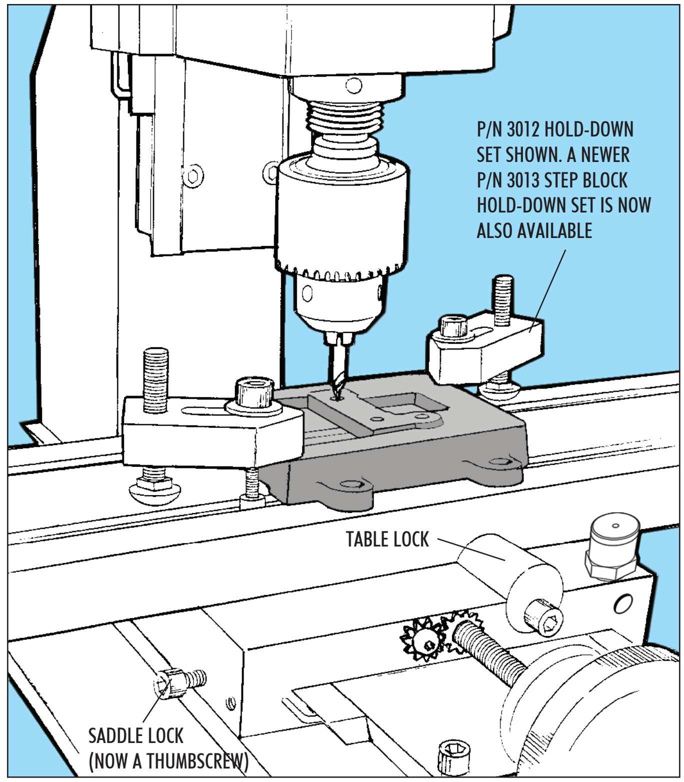


FIGURE 2—Large or odd shaped parts are usually clamped to the mill table as shown here. Smaller parts can be held in a milling vise. Here a center drill is used to accurately locate the holes to be drilled in a clamped part.

- Is the material about to be machined best suited for the job, and is it machinable with available cutting tools and equipment? Work with aluminum, brass, plastic or cast iron whenever possible. Too often a hobbyist will pick up the first correctly-sized piece of material he finds at his local salvage dealer thinking that, if it is rusty, it's steel, and that all steels are pretty much the same. Not so! Anyone who has ever tried to machine an old automobile axle can attest to this. If the part must be steel, grade 12L14, commonly called "lead-loy," is about the best material for machining. It was developed for screw-machine use and is available in round stock only. However, it works so well that many times it may be advisable to machine rectangular parts from it. It can also be case hardened. Your local screw-machine shop will usually have scrap pieces available and may be a good source for obtaining it.
- Avoid exotic materials, such as stainless steel, unless absolutely necessary because of machining difficulty and poor milling cutter life. (If each new mechanical engineer were given a block of stainless steel to mill, drill and tap upon his graduation, stainless steel sales would probably drop considerably!)
- Before beginning, carefully study the part to be machined. Select the best surface from which to work (usually the flattest).
- Decide if work should be "rough cut" to size. Some materials will warp while being machined. Close tolerance parts can be ruined by attempting heavy

machining at the end of the job rather than at the beginning.

- The method of holding the work is also determined by the type of machining to be performed. For instance, work that involves only small drilling jobs does not have to be held as securely as work to be milled.
- Lay the job out so that it can be machined with the minimum number of setups.
- Be sure to have all needed cutting tools available before beginning a job.
- Do not start off with a job so complex that the odds of success are limited. Making complex machined parts requires a great deal of intelligence, planning and skill. Skill is acquired only through experience.

In summary, you should be aware of the fact that milling is difficult, but not impossible. There are many more considerations than just moving the handwheels, and you should not start your first step until your last step has been determined.

Purchasing Materials in Small Quantities

Commercial metal suppliers are not set up to serve the home shop machinist. They usually have large minimum order quantities and high "cutting charge" fees that make it impractical to purchase small amounts from them. However, there are now a number of suppliers that cater to the hobby market. They have complete catalogs of the materials most commonly used by hobbyists, and you can order as much or as little as you need. The price per inch is somewhat higher than industrial rates, but the convenience and overall savings make it well worth it. There are several suppliers listed on Sherline's web site. Your local scrap yard can also be a good source for raw materials at good prices. Bring your own hacksaw, and be aware that the some yards are better than others at identifying and organizing the materials. If you are not sure exactly what kind of metal you are getting, you could be letting yourself in for a lot of trouble when you start cutting. See our **Raw Materials Online** page for a list of sources for obtaining raw material in small quantities.

Three Types of Work

There are three basic types of work that can be performed with a vertical milling machine: milling, drilling and boring. It would be extremely difficult to determine whether a vertical mill or a lathe would be the most valuable machine in a shop. Theoretically, most vertical mills are capable of reproducing themselves with standard milling accessories such as a rotary table and centers. This would be impossible on a lathe without exotic modifications and attachments. These instructions briefly describe standard vertical mill work. Several comprehensive books are available on this subject, and, although the machines they describe are much larger, the principles remain the same. A good starting point is a book we offer called *Tabletop Machining*. It is printed in full color and is available through Sherline as P/N 5301. Sherline tools are used throughout in all the setups and examples. (See ***Tabletop Machining*** online.)

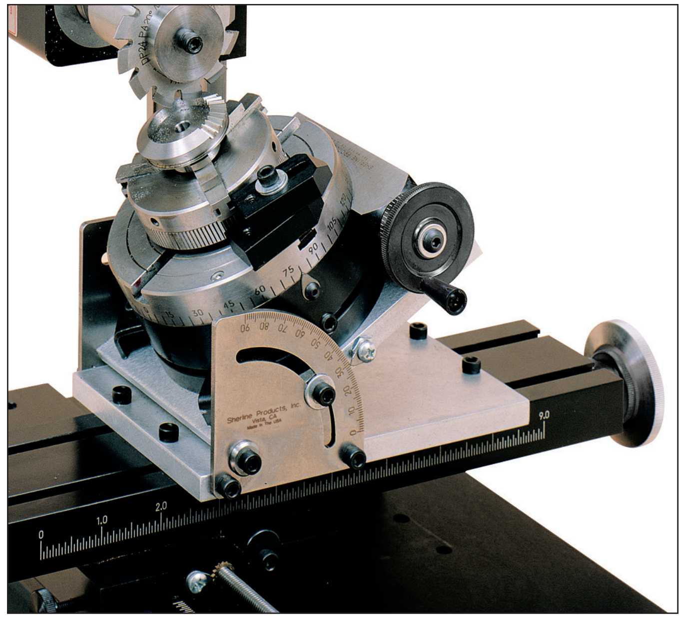


FIGURE 3—A complex setup shows a part held in a 3-jaw chuck, which is mounted to the rotary table, which is mounted to the tilting angle table, which is in turn mounted to the mill table. A mill arbor holds a geartooth cutter which is cutting teeth in a bevel gear. The horizontal milling conversion is used to mount the headstock in the horizontal position. With Sherline tools and accessories, the parts you machine are limited only by size, not by complexity.

Types of Milling Cutters

Milling on a vertical mill is usually accomplished with end mills. These cutters are designed to cut with both their side and end. (See Figure 11, Page 6.) Drilling is accomplished by raising and lowering the entire milling head with the Z-axis feed screw. Center drills must be used before drilling to achieve any degree of accuracy. (See Figure 2.) Note that subsequent holes may be accurately "dialed in" from the first hole by using the calibrated handwheels. Each revolution of the wheel will yield .050" of travel or 1mm for the metric machines. There is no need to start with the handwheel at "zero," although this can be easily accomplished with the optional resettable "zero" handwheels to make calculations easier.

Boring is a method of making accurate holes by rotating a tool with a single cutting edge, usually in an adjustable holder called a "boring head." It is used to open up drilled holes or tubing to a desired diameter. (See Figure 4.)

Another type of milling is performed with an adjustable fly cutter, which may be used for surfacing. For maximum safety and rigidity, the cutting bit should project from the holder no further than necessary. A 1-1/2" diameter circle of cut is quite efficient, and multiple passes over a surface should overlap about 1/3 of the circle size. For machining aluminum, use a speed of 2000 RPM and remove about .010" (0.25 mm) per pass.

Standard Milling Versus Climb Milling

It is important to understand that the cutting action of a milling cutter varies depending upon the direction of feed.

Study the relationship of cutting edges to the material being cut as shown in Figure 4. Note that in one case the tool will tend to climb onto the work, whereas in the other case the tool will tend to move away from the cut. The result is that climb milling should normally be avoided except for very light finishing cuts.

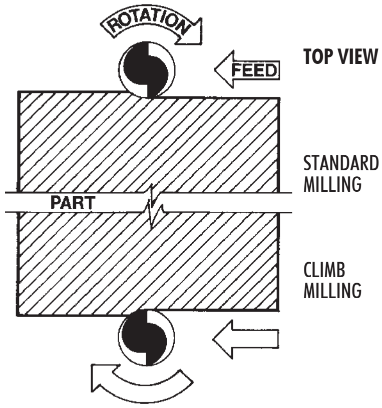


FIGURE 4—Standard vs. climb milling. For clarity, imagine the cutter is moving rather than the part.

Climb Milling Advantages and Drawbacks

Though you will almost always use conventional milling, climb milling can create a better finish in two ways. First, the lightest part of the cut is at the end of the cut. Second, the chips are tossed from the cutting area and do not affect the finish.

The major problem with machining in this direction is that the cutter may actually do just that—climb up on the part and break. Also, when a climb cut is first started, the work has to be pushed into the cutter. Then the cutting action pulls the backlash out of the table leadscrew, and a heavier cut is taken than planned. If you understand and compensate for these drawbacks, climb milling can be used. However, for those new to milling, it is best to try and plan your cuts so that the end mill is cutting in the conventional manner.

Working to Scribed Layout Lines

A common practice when working with a mill is to lay out the hole centers and other key locations using a height gauge and a surface plate. A coloring (usually deep blue) called layout fluid or "Dykem" is brushed or sprayed on a clean surface of the part. A thin layer is best because it dries quicker and won't chip when a line is scribed. The purpose of this fluid is to highlight the scribed line and make it easier to see.

Don't prick-punch the scribed, crossed lines representing a hole center. Using a center drill in the mill spindle and a magnifying glass, bring the headstock down until the center drill just barely touches the scribed cross. Examine the mark left with a magnifying glass and make any corrections needed to get it perfectly on center. You should be able to locate the spindle within .002" (.05 mm) of the center using this method.

Once the first hole is located in this manner, the additional holes can be located using the handwheels. (This is where the optional resettable "zero" handwheels are useful.) Now the scribe marks are used as a double check and the handwheels take care of the accuracy. Don't forget the rules of backlash—always turn the handwheels in the same direction as you go from one point to the next.

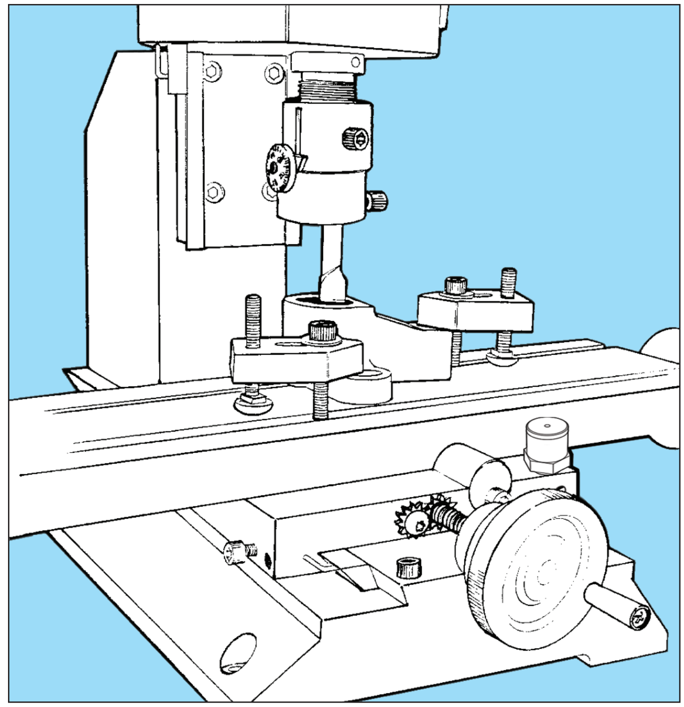


FIGURE 5— Boring the inside of a hole to exact size with a boring tool held in a boring head.

Using a Dial Indicator

(**NOTE:** For more on use of a dial indicator to square up your mill, see pages 14-17.)

The basis of most accurate machining involves the use of a "universal dial test indicator"; a small, inexpensive indicator which is calibrated in .001" or .01 mm divisions. An indicator with a large face or one that reads in finer divisions is not necessary for use with this mill. Three major tasks that can be accomplished with an indicator are:

1. Checking the squareness of a setup.
2. Finding the center of a hole.
3. Aligning the work with the machine.

A vise can be mounted or a part can be clamped down exactly parallel with the machine slides by holding the test indicator stationary and moving the slide with which you wish to align the part. When "indicating in" a vise, always take the reading on the fixed jaw. To start with, use approximately .005" indicator deflection from neutral. Remember that excessive pressure can cause inaccurate readings. Also, try to keep the indicator finger at a reasonable angle to the indicated part or surface. When the part is properly aligned, there will not be any deflection on the indicator. If you wish to locate the spindle over an existing hole, place the indicator in the spindle and read the inside surface. Move the X- and Y-axes until there is no deflection when the spindle is rotated. At this point, the spindle is in perfect alignment with the hole's center.

When aligning the spindle to used bearing holes, remember that the hole may be worn out-of-round, and it may be impossible to attain zero indicator deflection reading. Boring out a worn bearing hole to a larger diameter and sleeving it

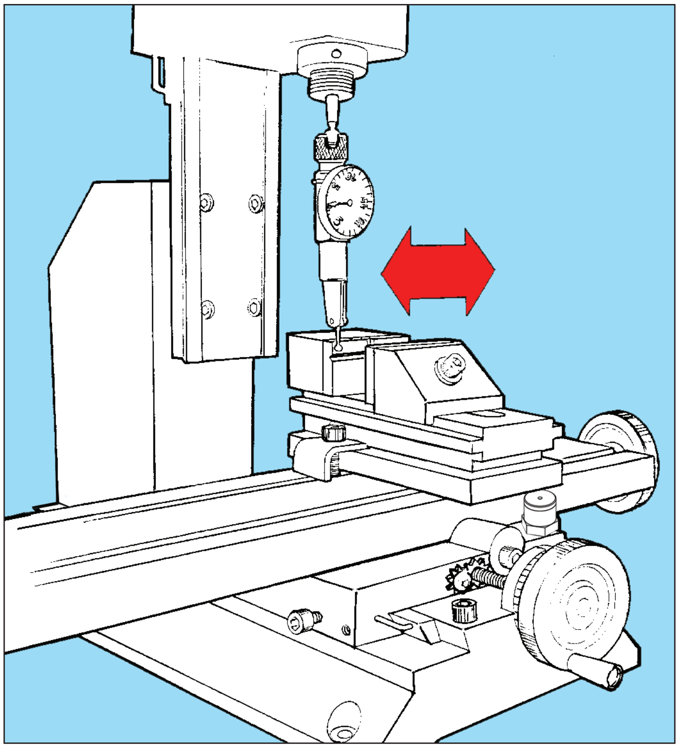


FIGURE 6—Indicating in the jaws of a vise. Shown is a Starrett "Last Word" Indicator. Starrett gauges are available in numerous sizes and types. They are manufactured in Athol, Massachusetts and can be purchased from most industrial dealers.

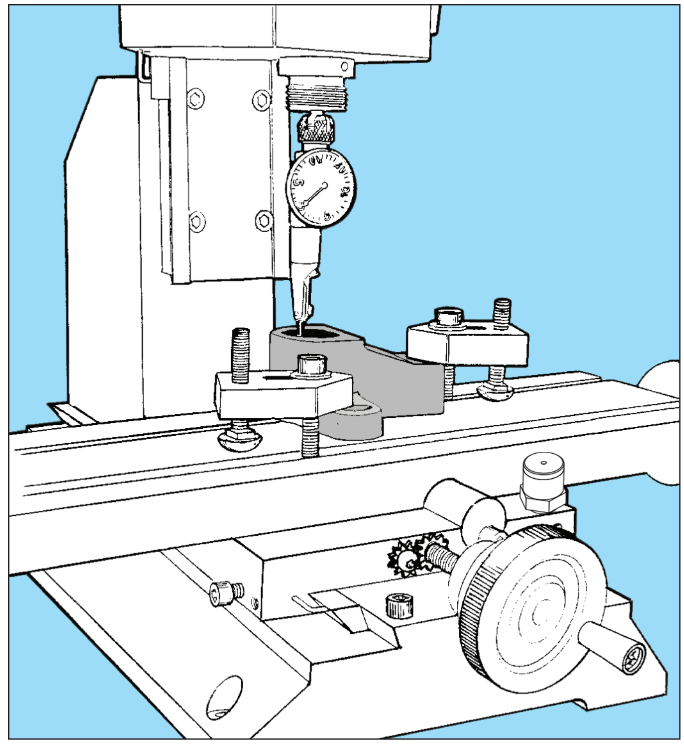


FIGURE 7—Indicating in the center of a hole.

with a simple bushing made on a lathe is a fairly common machining operation. With the new bushing pressed in, the bearing will be like new.

The squareness of your machine may also be checked with an indicator. For instance, alignment of the head can be checked by offsetting the indicator in the spindle so the tip will move on about a 3" to 5" diameter circle. The amount of reading relative to the table is the amount of error. Don't be discouraged to find a few thousandths of an inch error in your machine. This machine has been designed to have the most accuracy commensurate with reasonable cost. In machine tool manufacturing, accuracy and cost run hand-in-hand. To increase accuracy only a few percentage points could double the selling price, because entirely different manufacturing processes would be required. However, you can personally improve the accuracy of your machine with a few shims, if needed, by employing your dial indicator.

The column bed is aligned with the column block at the factory. If you remove it, it will have to be realigned by mounting a known "square" on the mill table and adjusting placement of the bed by running an indicator on the square as the headstock is raised and lowered. The same method can be used to check alignment of the column bed to ensure it is square with the Y-axis. To correct any error (which should be small), place a shim between the column block and the mill base.

Locating the Edge of a Part in Relation to the Spindle

There are two quick methods of "picking up an edge" of a part on a mill. The first is to put a shaft of known diameter in the spindle and see that it runs perfectly true. Using a depth micrometer against the edge of the part, measure the distance to the outside diameter of the shaft. To that dimension add half the known shaft diameter. You now have the distance from the edge of the part to the centerline of the spindle. Rotate the handwheel on the axis being set exactly this distance and you will have the centerline of the spindle lined up with the edge of the part from which you measured.

The second method is much easier. It involves the use of a clever tool called an "edge finder." These devices have been around for years and have two lapped surfaces held together by a spring. One surface is on the end of a shaft that fits in a 3/8" end mill holder and is held in the spindle. The other is a .200" diameter shaft held to the larger shaft with a spring so it is free to slide around. With the spindle running at approximately 2000 RPM, the shorter shaft will be running way off center. As this shaft is brought into contact with the edge you are trying to locate in relation to the spindle, the .200" shaft will be tapped to the center as the spindle rotates. This keeps making the .200" shaft run continually truer. When the shaft runs perfectly true it makes contact with the part 100% of the time. This creates a drag on the surface of the shaft that will "kick" it off center. (See Figure 8.) At this point you know the part is exactly .100" (half the diameter) from the centerline of

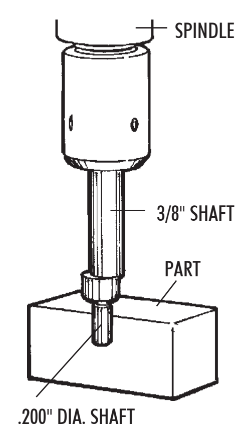


FIGURE 8—Using an "edge finder" to accurately locate the edge of a part.

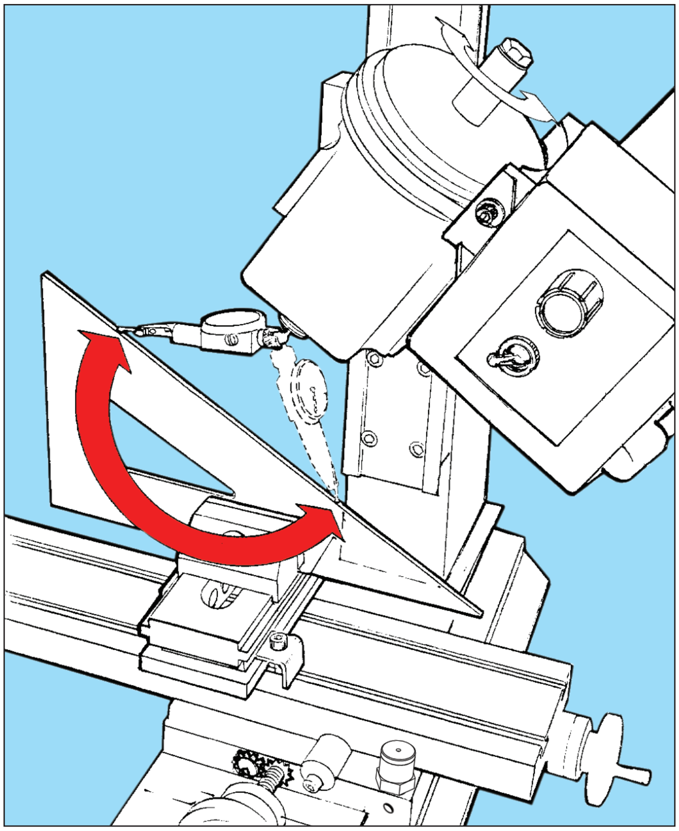


FIGURE 9—Indicating in a 30° head tilt using a mill vise and draftsman's triangle

the spindle. Advancing the handwheel on a Sherline mill two revolutions (.050" per revolution) will bring the edge of the part into alignment with the spindle.

It is important to use a high quality edge finder such as the Starrett 827A shown in the drawing. It must have a 3/8" shaft to fit the end mill holder on the Sherline mill. Metric sized edge finders are also available which work in the same manner.

For those who like to own the newest gadgets, electronic edge finders are now available. Import models are available for less than $100.00.

Determining the Depth of Cut

There are no firm rules other than common sense for determining depth of cut. A .030" cut depth with a 3/16" end mill in aluminum could be considered light, but .003" cut depth in steel with a 1/32" diameter end mill would break the cutter. Start with very light cuts and gradually increase the depth until satisfactory results are achieved. Try to develop the skill of knowing how much of a cut is satisfactory without breaking the cutter or damaging the work.

Note that regular end mills should not be used for drilling; however, they may be employed to enlarge an existing hole. The cutting edges deserve more respect than those of drills even though similar in appearance; they are designed to cut with their sides. Handle and store them with care.

Work Accurately

It should be remembered that a good machinist is capable of making a part to much closer tolerances than those of the machine with which he is working. The accuracy of the parts you make is limited only by your skill as a craftsman and the quality of your measurement equipment. Accuracy should be the ultimate goal of every machinist!

Cutting Speeds for Milling

Speed Adjustment Chart

$$\text{SPINDLE RPM} = \frac{3.82 \times \text{S.F.M.}}{D}$$

S.F.M. =	The rated Surface Feet per Minute for milling. For drilling, use 60% of the rated surface feet.
RPM =	The rated spindle speed in Revolutions Per Minute
D =	The Diameter of work in inches

FIGURE 10—Formula for adjusting spindle speed for cutting a given diameter.

NOTE: To estimate RPM, remember that the speed range of your vertical mill is from 0 to 2800 RPM. (The lowest usable speed is about 70 RPM, so we use that in our specifications. To obtain much more torque at the lower speed ranges, the drive belt can be switched to the smaller diameter positions on the spindle and drive pulleys.) Therefore, in the normal belt position, half speed is approximately 1450 RPM and so on. You can estimate these speeds by a combination of the setting on the speed control knob and the sound of the motor itself. When using the optional digital readout (P/N 8100), the exact RPM is displayed constantly on the LCD screen.

End Mills

End mills are the standard cutting tools used on a vertical mill. We recommend 3/8" shank end mills held in the 3/8"end mill holder (P/N 3079). One of the benefits of 3/8" end mills is that they are available in a large range of sizes. The end mill is held with a set screw on its flat surface, and it can be easily changed. They are also lower in price than miniature cutters because of their popularity.

FIGURE 11— 4- and 2-flute double-ended end mill sets.

You can also use miniature series end mills having 3/16" or 1/4" shank sizes which should be held in collets or end mill holders sized for those tools. Many "Dremel®" type cutting tools come with a 1/8" shank. End mills held in collets must be single-ended, while end mill holders are capable of holding single- or double-ended end mills. We recommend using 2-flute, high-speed steel (HSS) end mills for aluminum because the flutes are less prone to clog with chips. Use 4-flute cutters for cutting steels with lower RPM. The solid carbide tools are not suggested since they are very expensive and the cutting edges will chip unless used with heavy-duty production equipment.

As a convenience to our customers, Sherline keeps in inventory many of the popular sizes of end mills that are appropriate for use on our machines. See our "Cutting Tools Price List" for selection. End mills may also be purchased on-line or from your local industrial machine shop supply outlet. Do a search for or see the yellow pages under "Machine Shop Supplies."

END MILLS (Slot and side milling)

Material	Cut Speed S.F.M.	1/8" (3mm) Diameter	1/4" (6mm) Diameter	3/8" (10mm) Diameter
Stainless Steel, 303	40	1200 RPM	600 RPM	400 RPM
Stainless Steel, 304	36	1100	500	350
Stainless Steel, 316	30	900	450	300
Steel, 12L14	67	2000	1000	650
Steel, 1018	34	1000	500	350
Steel, 4130	27	800	400	250
Gray Cast Iron	34	1000	500	350
Aluminum, 7075	300	2800	2500	2000
Aluminum, 6061	280	2800	2500	2000
Aluminum, 2024	200	2800	2500	2000
Aluminum, Cast	134	2800	2000	1300
Brass	400	2800	2800	2800

DRILLS

MATERIAL	CUT SPEED (S.F.M.)	1/16" (1.5mm) Diameter	1/4" (6mm) Diameter
Carbon Steel	36	2000 RPM	550 RPM
Cast Iron, Soft	30	1800	450
Stainless Steel	24	1400	360
Copper	72	2000	1100
Aluminum, Bar	240	2000	2000

FIGURE 65—Drill and milling cutter speed chart.

Because small diameter cutters (less than 1/8") are quite fragile, the largest diameter cutter possible for the job requirements should be employed. Be certain that the RPM is appropriate before attempting to remove any metal. An end mill can be instantly damaged if a cut is attempted at excessive RPM. Like all cutting tools, end mills will have a short life span when used for machining steel or other exotic materials. Save new cutters for finish work. Because of excessive cutter deflection (bending), do not use small diameter end mills with long flutes unless absolutely necessary.

Resharpening End Mills

End mills can be resharpened by your local tool and cutter grinding shop. End mills lose their cutting edge clearance after a couple of sharpenings and should no longer be reused.

Using the Mill Column Saddle Lock

The saddle locking lever is located on the back side of the mill column just above the saddle nut. This lever tightens against the saddle nut on the column leadscrew to keep it from moving during milling operations.

With the lever released, adjust the Z-axis handwheel to the desired setting. Rotate the lever counter-clockwise to lock the saddle. This will eliminate any backlash in the leadscrew. Friction on the gib can still cause a little backlash to be present between the handwheel and the leadscrew thrust. To eliminate this, push down on the saddle to make sure the handwheel is fully seated against the thrust. Double check your height adjustment. Now, when milling, the saddle cannot move any further down.

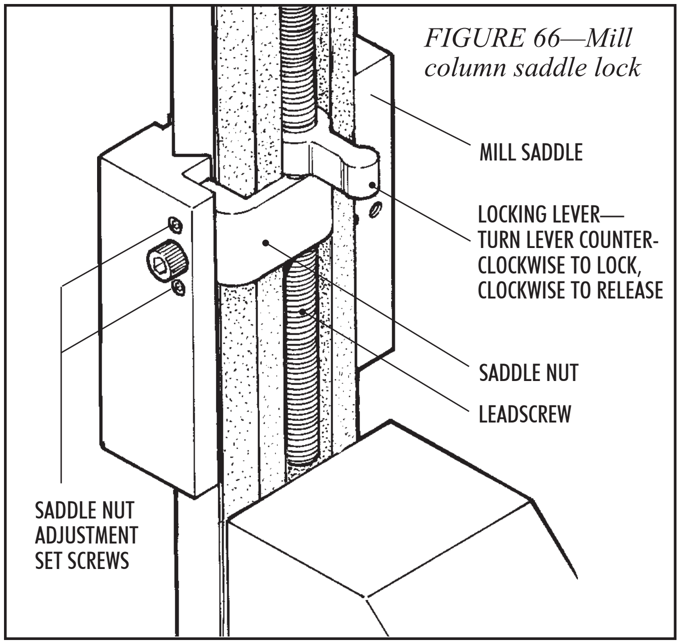


FIGURE 66—Mill column saddle lock

To release the saddle, rotate the lever clockwise. A spring-loaded ball in the saddle fits in a detent on the lever to keep it from locking accidentally when the Z-axis is adjusted. (See Figure 66.)

An adjustable saddle lock is available that allows adjustment of backlash on the Z-axis. This is particularly useful in CNC applications but can be used on manual machines as well. It is standard on new CNC machines and available as an upgrade for manual machines as P/N 4017Z/4117Z.

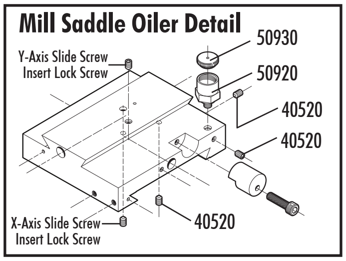
Machining Tip

Use of a tooling plate (P/N 3560) is an inexpensive way to protect the surface of your mill table while providing a flat, versatile clamping surface with a predrilled pattern of tapped holes for mounting parts and fixtures. The additional thickness also adds rigidity to the mill table. A round tooling plate is also available for the rotary table (P/N 3725).

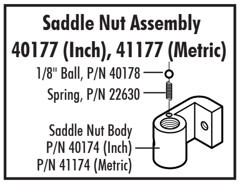
Learning About Other Accessories for Your Mill

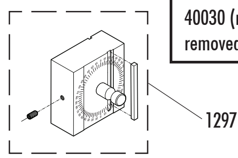
The addition of accessories can greatly enhance the utility of your mill. The best place to learn about Sherline accessories is on our website. Instructions for their use are posted there. A complete list of accessories with links to instructions for each can be found on our website at Accessory Instructions. If you do not have an Internet connection, Sherline offers a collection of printed instructions called the *Sherline Accessories Shop Guide*, P/N 5327. A color catalog featuring the tools and accessories may be requested by calling (800) 541-0735 or (760) 727-5857.

NOTE: Where different, Inch part number is given first, followed by Metric part number.

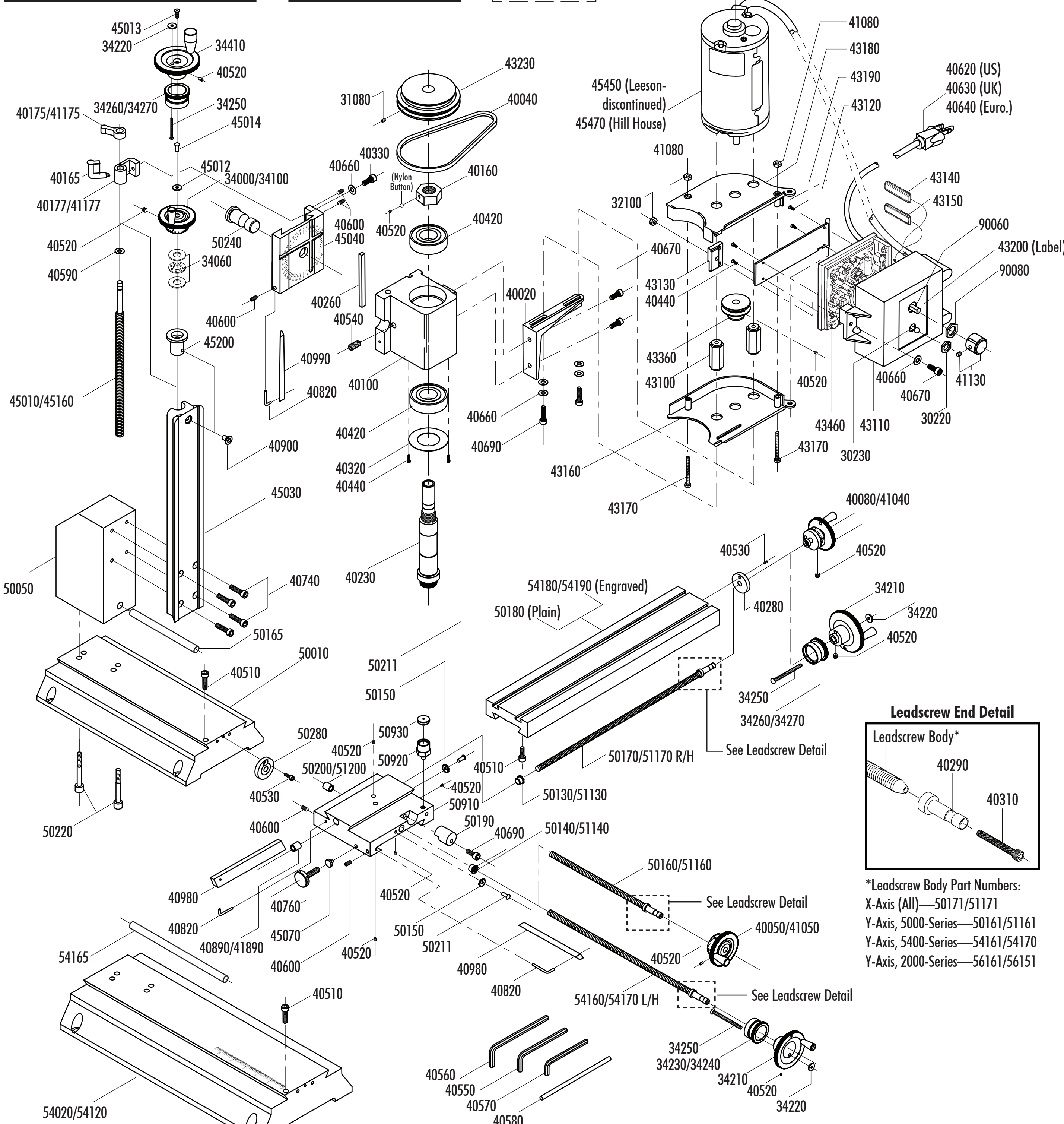


Exploded View and Part Numbers





NOTE: Some factory assembled machines may have a 0.005" shim washer P/N 40030 (not shown) placed between the handwheel and thrust to adjust backlash. If removed when servicing the machine they should be replaced in the same position.



*Leadscrew Body Part Numbers:
X-Axis (All)—50171/51171
Y-Axis, 5000-Series—50161/51161
Y-Axis, 5400-Series—54161/54170
Y-Axis, 2000-Series—56161/56151

SHERLINE Lathes and Mills
KEY TO MATERIALS: A=Aluminum, B=Brass, C=Composite, DC=Die Cast, P=Plastic, U=Urethane, S=Steel

PART NO.	DESCRIPTION	MATERIAL
12970	Headstock Spacer Block (Deluxe Mill)	A/S
30220	Toggle Switch Retaining Ring	S
30230	Toggle Switch	--
31080	10-32 x 3/8″ Flat Pt. Set Screw	S
34000 (34100)	Oversize Handwheel, Inch (Metric)	A
34060	Thrust Bearing Washer Set	Ball
34200 (34300)	2″ Zero Adjust. Hndwhl. Asby., Inch (Metric)	A/S
34210	2″ handwheel Body	A
34220	Handwheel ocking Nut	S
34230 (34240)	Y Axis/Crosslide Collar, Inch (Metric)	A
34250	6-32 x 7/8″ Pan Hd. Screw	S
34260 (34270)	X, Z Axis and Leadscrew Collar, Inch (Metric)	A
34400 (34500)	2-1/2″ Zero Adjust. Hndwhl. Asby., Inch (Metric)	A/S
34410	2-1/2″ Handwheel Body	A
40010	15″ Lathe Bed	DC
40020	Motor Bracket	DC
40040	Drive Belt	U
40050 (41050)	1-5/8″ Handwheel, Y Axis/Crosslide, Inch (Metric)	A
40070	Faceplate	DC
40080 (41040)	1-5/8″ Handwheel, X Axis/Leadscrew, Inch (Metric)	A
40090	Drive Dog	DC
40100	Headstock Casing	A
40120	15″ Lathe Bed	S
40160	Preload Nut	S
40170 (41170)	Saddle Nut, Inch (Metric)	B
40180	Tool Post	A
40200 (41200)	Leadscrew, Inch (Metric)	S
40220 (41220)	Feed Screw, Inch (Metric)	S
40230	Headstock Spindle	S
40240	Headstock Pivot Pin, Lathe	S
40250	Tool Post Tee Nut	S
40260	Head Key	S
40270 (41270)	Tailstock Spindle, Inch (Metric)	S
40280	Thrust Collar	S
40300	Leadscrew Thrust	S
40320	Bearing Washer	S
40330	10-32 x 5/8″ Skt. Hd. Cap Screw	S
40340	110-32 x 1″ Skt. Hd. Cap Screw	S
40370	Leadscrew Support	S
40380	#1 Morse Center	S
40390	#0 Morse Center	S
40400	Plug Button	P
40420	Headstock Bearing	Ball
40440	Self Tapping Screw	S
40500	10-24 x 7/8″ Skt. hd. Cap Screw	S
40510	10-32 x 3/8″ Skt. Hd. Cap Screw	S
40520	10-32 x 3/16″ Cup Pt. Set Screw	S
40530	5-40 x 3/8″ Skt. Hd. Cap Screw	S
40540	5/16-18 x 3/4″ Cone Pt. Set Screw	S
40550	5/32″ Hex Key	S
40560	3/16″ Hex Key	S
40570	3/32″ Hex Key	S
40580	Spindle Bar	S
40590	1/4″ I.D. Washer	S
40600	10-32 x 1/4″ Flat Pt. Set Screw	S
40620	Power Cord, USA	--
40630	Power Cord, UK	--
40640	Power Cord, Europe	--
40660	3/16″ I.D. Washer	S
40670	10-32 x 1/2″ Skt. Hd. Cap Screw	S
40690	10-32 x 3/4″ Skt. Hd. Cap Scrw	S
40760	10-32 x 5/8″ Thumbscrew	S
40820	Gib Lock	S
40860	Tailstock Locking Screw Grommet	P
40870	Tailstock Spindle Locking Screw	S
40890 (41890)	Slide Screw Insert, Inch (Metric)	B
40900	10-32 x 3/8″ Flat Hd. Skt. Screw	S
40910	Saddle	A
40980	Crosslide Gib	C
40990	Saddle Gib	C
41080	6-32 Hex Nut	S
41110	Tailstock Casing	A
41130	DC Speed Control Knob and Set Screw	P/S
43100	DC Motor Standoff	A
43110	DC Speed Control Case	P
43120	DC Speed Control Hinge Plate	P
43130	DC Speed Control Cover Mounting Plate	P

PART NO.	DESCRIPTION	MATERIAL
43140	DC Speed Control Tab, Small	P
43150	DC Speed Control Tab, Large	P
43160	Belt Guard, Outer	P
43170	6-32 x 1-3/8" Pan Hd. Screw	S
43180	Belt Guard, Inner	P
43190	#2 x 1/4" Flat Hd. Sheet Metal Screw	S
43200	DC Speed Control Foil Label	Foil
43230	Stepped Main Spindle Pulley	A
43360	Stepped Motor Pulley	A
43460	DC Speed Control Electronics	--
44010	24" Lathe Base	DC
44120	24" Lathe Bed	S
44200 (44230)	24" Leadscrew, Inch (Metric)	S
44210 (44220)	Slide Screw, Inch (Metric)	S
44880	Crosslide	A
45010 (45160)	Leadscrew, Z Axis, Inch (Metric)	S
45030	Column Bed	S
45040	Saddle, Z Axis	A
45070	Lock, Teflon	P
45170	Column Saddle Lock	P
45180	3/16" Ball Bearing	S
45190	#10 Type B Washer	S
45200	Leadscrew Thrust, Bored	S
45450 or 45460	45450=DC Motor with externally replaceable brushes (Leeson) 45460=DC Motor with externally replaceable brushes (Hill House) (**NOTE:** We purchase motors from two different manufacturers to keep pricing competitive. Specifications on both are the same, but replacement motors should be ordered with the same part number as the original. Part number is printed on motor.)	Motor
50010	10" Mill Base	A
50050	Column Base	A
50120	Backlash Lock	S
50130 (51130)	Backlash Nut, X Axis, Inch (Metric)	S
50140 (51140)	Backlash Nut, Y Axis, Inch (Metric)	S
50160 (51160)	Leadscrew, Y Axis, Inch (Metric)	S
50170 (51170)	Leadscrew, X Axis, Inch (Metric)	S
50180	Mill Table	A
50190	X Axis Lock	S
50200 (51200)	Nut, Y Axis, Inch (Metric)	B
50210	8-32 x 1/4" Pan Hd. Screw	S

PART NO.	DESCRIPTION	MATERIAL
50220	1/4-20 x 1-3/4" Skt. Hd. Cap Screw	S
50240	Headstock Pivot Pin, Mill	S
50280	Thrust Collar, Mill	S
50910	Saddle	A
50980	Gib, X Axis	C
50990	Gib, Y Axis	C
54020 (54120)	12" Mill Base, Deluxe Engraved, Inch (Metric)	A
54160 (54170)	Leadscrew, Y Axis, Deluxe Mill, Inch (Metric)	S
54180 (54190)	Mill Table, Deluxe Engraved, Inch (Metric)	A
90060	DC Speed Control 5K Potentiometer	--
90080	3/8-32 Hex Nut	S