



The premier source of tooling, parts, and accessories for bench top machinists.



4660 HiTorque Micro Mill User's Guide

ER-16 Spindle
from LittleMachineShop.com

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Introduction

This user's guide covers operation and care of the LittleMachineShop.com HiTorque Micro Mill. Be sure to read and understand the safety guidelines presented in this book before using your HiTorque Micro Mill.

Specifications

End Milling Capacity	0.4" (10 mm)
Face Milling Capacity	0.6" (16 mm)
Drilling Capacity	0.4" (10 mm)
Table Size	15.7" × 5.7" (400 mm × 145 mm)
T-slots	3 slots 0.31" (8.0 mm) wide
X-Axis Travel	11.8" (300 mm)
Y-Axis Travel	5.9" (150 mm)
Z-Axis Travel	8.7" (220 mm)
Throat	5.5" (140 mm)
X- and Y-Axis Feed Screws	0.050" (1.27 mm) per rotation
Spindle Taper	ER-16
Spindle Motor	0.34 hp (250 Watts)
Spindle Speed	100-5000 RPM
Power Requirements	120 V 60 Hz 5 Amps
Machine Weight	106 lbs (48 kg)
Overall Dimensions (W × D × H)	20.5" × 19.3" × 28.7" (520 mm × 490 mm × 730 mm)

Safety Considerations

Always use common sense when using a power tool. Review the following safety instructions. Besides the general safety rules for any power tool, the following include specific considerations for the micro mill.

General Safety

- Use common sense. Think through the results of your actions before you act.
- Understand the operation of the machine. Do not operate the machine if you do not know what is going to happen.
- Learn, don't experiment. Study, understand, and do things where you have a clear expectation of the outcome. Don't "see what will happen."

- You are responsible for your own actions. We can't be held responsible for your actions when you use the machine.

Milling Machine Safety

- Your micro mill is called that for a reason: it's a small mill. Don't attempt jobs that are beyond its capacity.
- Check the workpiece after you secure it in the vise or other work holding device. Be sure it is secure before turning on the mill.
- Don't wear loose clothing or jewelry when operating the mill.
- Stop the spindle and make sure the machine is in a safe condition before:
 - Opening or removing safety shields
 - Reaching into work area
 - Changing or adjusting tools
 - Changing or adjusting workpieces
 - Changing speed ranges
 - Clearing chips or coolant
- Inspect cutting tools for sharpness, chips, and cracks before each use. Replace dull, chipped, or cracked cutting tools immediately.
- Handle cutting tools with care. Cutting edges are very sharp and can cause lacerations.
- Do not use unbalanced tools or fixtures in the spindle
- Remove all tools (wrenches, chuck keys, locking pins, and so on) from the spindle immediately after using them.

Electrical Safety

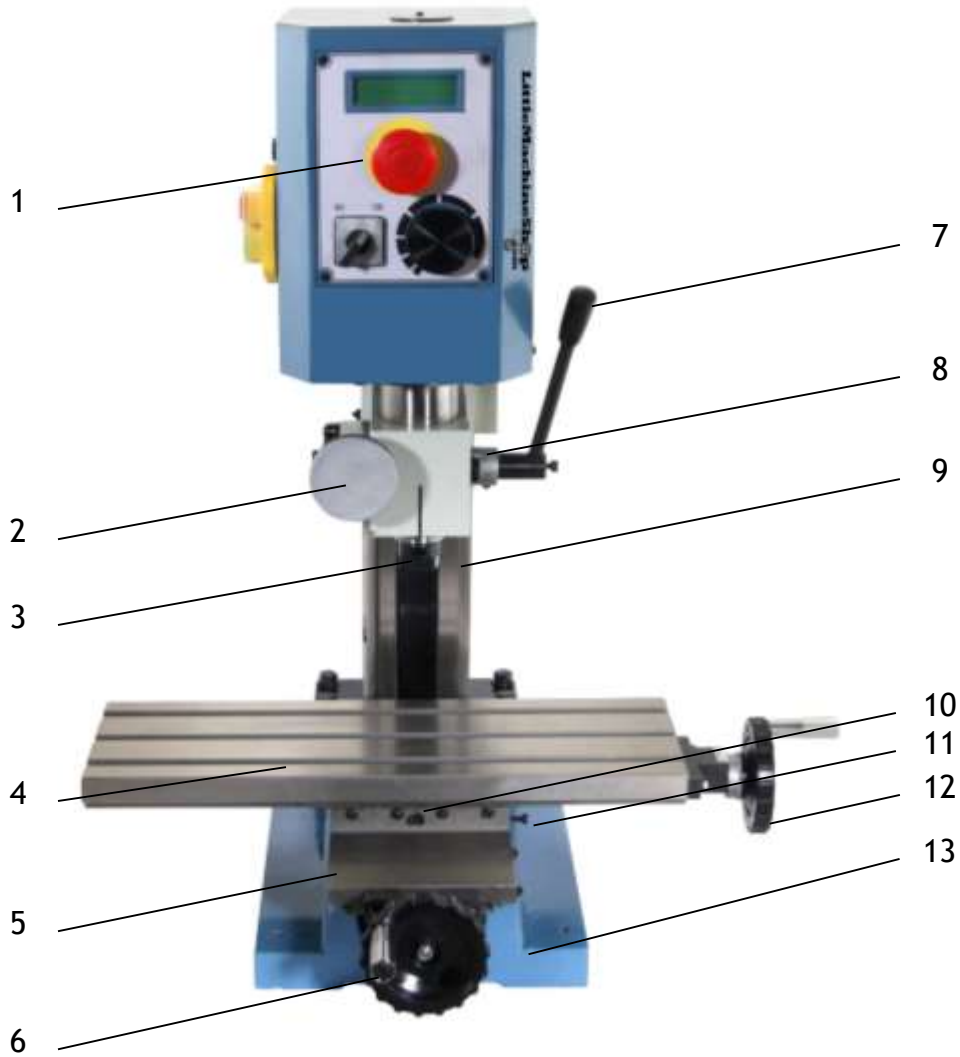
- Plug the machine into a grounded receptacle.
- Ensure that all components are properly grounded. The easiest way to ensure this is to plug your machines and devices into grounded outlets that you have tested.
- Use caution when using liquids and electricity. Ensure that coolants and lubricants are kept away from high voltage electrical components.
- Disconnect all components from the power receptacle before servicing.
- In the event of a power outage, turn off all components to ensure that the machine does not restart unexpectedly.

Machine Safety

- Keep bystanders, children, and visitors a safe distance away while operating any power tool.
- Read the manual. Know the operation of every control before you attempt any operation of the machine.

- Make sure that all guards are in place and functioning before operating the machine.
- Check for damage and abnormal wear before operating the machine.
- Always wear safety glasses (side shields are recommended) that are ANSI Z87.1-2003 compliant.
- Wear hearing protection (ear plugs or ear muffs) when operating loud machines.
- Wear appropriate clothing; no rings, gloves, neckties, jewelry, or loose-fitting garments. Bind long hair or wear a hat.
- Do not use compressed air for cleaning machines. A shop vacuum works well and is much safer.
- Don't operate machinery while under the influence of drugs or alcohol.
- Ensure that your machines are well lit. Ensure that your shop is well lit, and have additional task lighting where appropriate.
- Maintain a clean and uncluttered work area.
- Avoid pinch points.
- Never leave a running machine unattended.
- Do not force or overload machinery.
- Use appropriate cutting tools with appropriate feeds and speed.
- Cutting tools get hot during use and can cause burns if handled inappropriately.
- Do not attempt to use workpieces that are too large or too heavy for the machine.
- Maintain your machines. Ensure that it is well-adjusted and in a safe state.
- Clear chips with a brush or other tool, never with your hands or with compressed air.
- Make sure the machine is on a flat, level surface that is capable of supporting the weight of the machine plus fixtures, vise, and workpiece.
- Clamp work securely. Cutting forces are significant and can turn workpieces that are not secured into projectiles.
- Be aware that chips and dust from some materials (magnesium, for example) are flammable. Understand the materials you are using.

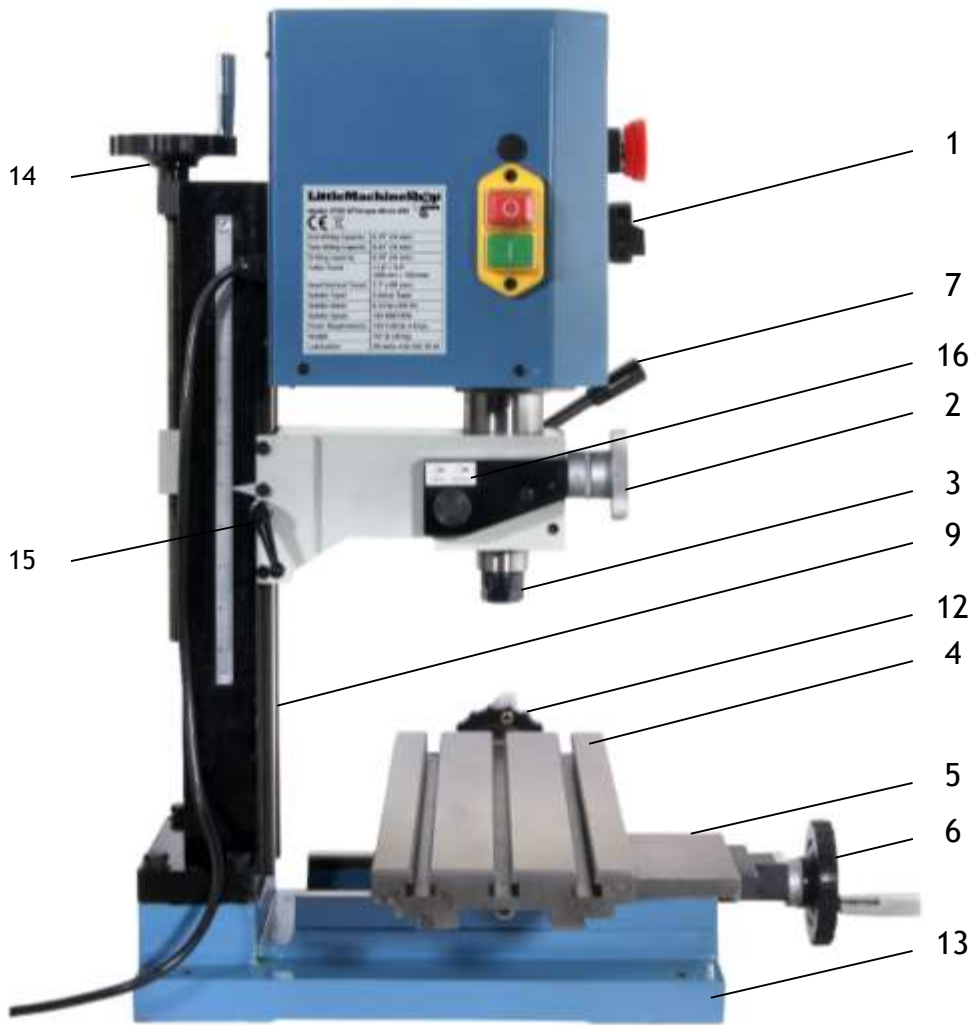
Features



1. Motor controls
2. Z-axis fine feed knob
3. Spindle
4. Table
5. Saddle
6. Y-axis hand wheel

7. Z-axis coarse feed handle
8. Z-axis depth stop
9. Column
10. X-axis lock screw
11. Y-axis lock screw
12. X-axis hand wheel

13. Base
14. Z-axis hand wheel
15. Z-axis lock lever
16. Z-axis fine feed engagement knob



Basic Accessories

The following accessories come with the HiTorque Micro Mill.

- 4 adjustable feet
- Spindle locking pin
- 3/8" drill chuck, arbor, and key
- 4 T-slot nuts
- Oil can
- Spanner wrench for spindle nut
- 3 Hex wrenches
- Open end wrenches 5.5/7, 8/10, 25 mm
- 3/8" ER-16 collet



Cleaning

Your mill will arrive coated with grease to protect it from corrosion during shipment. Follow this procedure to remove the grease:

1. Wipe most of the grease off with rags or paper towels.
2. Clean the surfaces with mineral spirits (paint thinner).
3. Coat the surfaces with oil.

See the “Lubrication” section on page 17 for specific recommendations for lubricants.

Assembly

Follow these steps to assemble your mill:

Follow these steps to assemble your mill:

1. Clean the surfaces where the column mounts on the base.
2. Place the base on your workbench and then place the column atop the base. Have a friend hold it in place as you bolt it.
3. Place a flat washer, a lock washer, and a bolt (all furnished) over each of the four holes in the base of the column. Screw in the bolts using a 14 mm or 9/16" open end or socket wrench (not included), but do not tighten.
4. Insert an alignment pin (with the threaded end up) in the hole on each side of the column. Tap them in with a mallet until they're flush. Tighten the four bolts.
5. Loosen the set screw at the end of the Z-axis coarse feed shaft, install the handle, and tighten the set screw.
6. Install the handles on the X-, Y-, and Z-axis hand wheels. The handles should turn freely when installed.



Mounting Your Mill

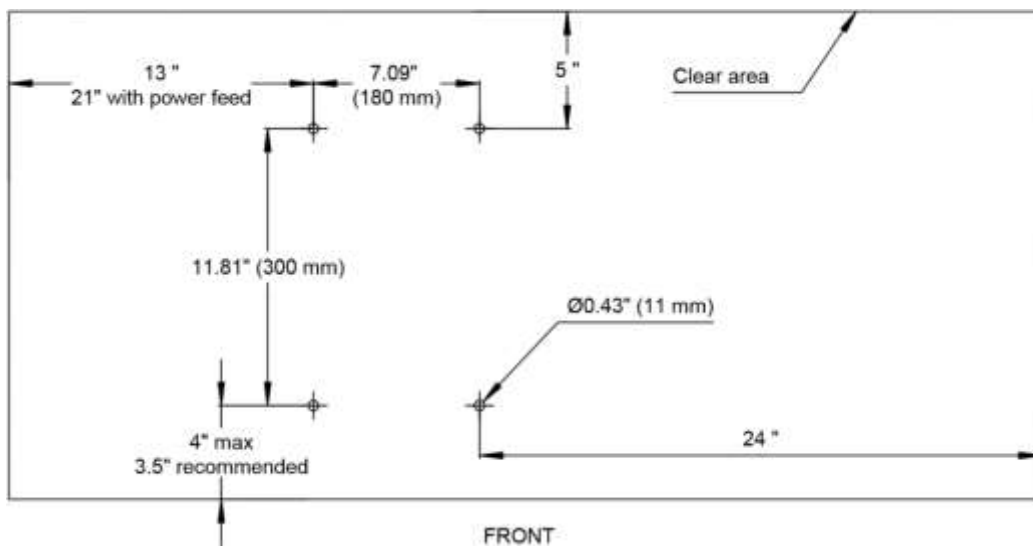
The micro mill comes with four adjustable feet. It is perfectly okay to install these feet in the threaded holes in the base and go to work.

If you prefer, you can bolt the micro mill to a workbench.

Before you mount your micro mill, plan the positioning carefully. If you simply bolt it to the middle of the workbench, it will be uncomfortable to turn the Y-axis hand wheel. Either mount the micro mill at the front edge of the bench so the Y-axis hand wheel hangs over the edge of the bench, or mount the micro mill on a riser about 1" thick to provide room to turn the Y-axis hand wheel. The mounting bolts must extend through the riser and bolt the mill to the bench to keep it from tipping.

Be sure that you have room on both sides of the mill for the X-axis travel. The table will move to the right so that the left end of the table is almost flush with the saddle. You need an additional 8" to the right so that you can remove the table off the right side of the mill. The table moves to the left so that the right end of the table is almost flush with the saddle.

The following diagram shows the holes required to mount the mill and the clear area around the bolt pattern to allow use and maintenance of the micro mill.



Mount the mill to the workbench with 5/16" or 8 mm bolts. The bolts should be about 1.5" (35 mm) longer than the thickness of the workbench. Use fender washers on the underside of wooden benches to prevent the nuts from pulling through.

Chris' Tip: If the bolts don't easily fit in the holes in the base, there might be some filler in the holes. Run a tap through the holes to clear them.

Operating Controls

There are several controls used to operate the mill. Become familiar with them before you use the mill.

Motor Controls



1. Power switch
2. Spindle speed readout
3. Emergency (E-Stop) switch
4. Speed control
5. Forward (FOR) and reverse (REV) switch.

The red E-stop switch latches in the off position when you press the red button. To turn the switch on, turn the actuator clockwise.

The power switch interrupts the input power to the speed control circuit board.

You control the motor speed by adjusting a potentiometer that provides the speed setting value to the speed control circuit board.

To power up the mill:

1. Turn the speed control to the minimum speed position.
2. Turn the FOR/REV switch to FOR (forward).
3. Turn on the power switch by pressing the green button.

Always turn the power off when you leave the mill. Leaving the power on can damage the speed control circuit board.

To power down the mill:

1. Turn the speed control to the minimum speed position.
2. Turn off the power by pushing the red button on the power switch.

To start the mill:

1. Ensure that the speed control is set to the minimum speed position.
2. Ensure that the FOR/REV switch is set to FOR (forward).
3. Advance the speed control to the desired speed.

To stop the mill:

- Turn the speed control to the minimum speed position.

X-Axis Hand Wheel

The X-axis hand wheel moves the table to the left or right, depending on which way it is turned. Use this hand wheel to position the table.

The dial on this handle indicates the relative position of the table. The graduated dial can be repositioned for convenience. Each division of the dial represents a movement of 0.001".

The HiTorque Micro Mill has 50 graduations on the dial. Each full turn of the hand wheel moves the table 0.050".

X-Axis Lock Screw

The X-axis lock screw is on the front of the saddle behind the Y-axis hand wheel. Use a 3 mm hex wrench and this cap screw to lock the X-axis so it does not move inadvertently.

Y-Axis Hand Wheel

The Y-axis hand wheel moves the table to the front or back, depending on which way it is turned. Use this hand wheel to position the table.

The dial on this handle indicates the relative position of the table. The graduated dial can be repositioned for convenience. Each division of the dial represents a movement of 0.001".

The HiTorque Micro Mill has 50 graduations on the dial. Each full turn of the hand wheel moves the table 0.050".

Y-Axis Lock Screw

The Y-axis lock screw is on the right side of the saddle behind the X-axis hand wheel. Use a 3 mm hex wrench and this cap screw to lock the X-axis so it does not move inadvertently.

Z-Axis Lock Lever

The Z-axis lock lever is on the left side of the head assembly. Use this lever to lock the mill head so it does not move inadvertently.

Pulling out on the lever and simultaneously turning it can change the locked position of this lever. Pulling out disengages the lever from the locking screw and allows it to move to a different position. You might need to adjust the screw in the base of the lever to make this adjustment.

Z-Axis Hand Wheel

The Z-axis hand wheel is on the top of the column. Use this hand wheel to raise or lower the mill head.

To move the mill head using the Z-axis hand wheel, you must first loosen the Z-axis lock lever.

Z-Axis Coarse Feed Handle

The Z-axis coarse feed handle is on the right side of the spindle housing. The long handle allows you to quickly lower and raise the head. Use it for drilling.

Z-Axis Depth Stop

There is a collar on the shaft that is rotated by the Z-axis coarse feed handle. This collar can be set to restrict the travel of the quill. Rotate the collar and tighten the set screw to drill a series of holes to the same depth.



Z-Axis Fine Feed Knob

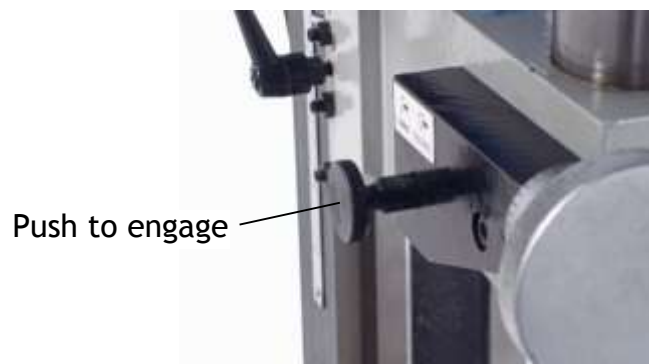
The Z-axis fine feed knob is located on the left front corner of the spindle housing. Use this knob to make fine adjustments to the position of the quill. There are 40 divisions on the dial. Each full turn of the knob moves the head assembly 0.080". Each division of the dial represents a movement of 0.002".

To engage the Z-axis fine feed:

- Press the smaller knob behind the Z-axis fine feed knob in to engage the fine feed. It's easier if you turn the Z-axis fine feed knob while pressing.

To disengage the Z-axis fine feed:

- Pull the smaller knob behind the Z-axis fine feed knob out to disengage the fine feed. It's easier if you turn the Z-axis fine feed knob while pulling.



Adjustments

Keeping your micro mill in adjustment is an ongoing process. You should check all the following adjustments when you set up your mill and then periodically as you use your mill.

X-Axis Gib

A gib is a strip of metal placed between the bearing surface of two machine parts to ensure a precision fit and provide adjustment for wear. The micro mill has gibs in several places, including between the saddle and the table.

The X-axis gib provides adjustment for the mating dovetails on the saddle and the table that provide the X-axis (crosswise) motion.

To adjust the X-axis gib:

1. Loosen the four lock nuts on the front of the saddle.
2. Slightly loosen all four setscrews on the front of the saddle.
3. Snug each setscrew equally. This will lock the table in position.
4. Loosen each setscrew 1/8 turn to allow the table to move.
5. While holding the setscrews from turning, tighten the lock nuts.
6. Test by turning the hand wheel. Loosen or tighten all the setscrews the same amount until the table moves freely, but without play in the dovetail.



X-axis gib adjusting screws

Y-Axis Gib

The Y-axis gib provides adjustment for the mating dovetails on the base and the saddle that provide the Y-axis (in and out) motion.

To adjust the Y-axis gib:

1. Loosen the four lock nuts on the right side of the saddle.
2. Slightly loosen both setscrews on the right side of the saddle.
3. Snug each setscrew equally. This will lock the saddle in position.
4. Loosen each setscrew 1/8 turn to allow the saddle to move.
5. While holding the setscrews from turning, tighten the lock nuts.

6. Test by turning the hand wheel. Loosen or tighten both setscrews the same amount until the saddle moves freely, but without play in the dovetail.

Z-Axis Gib

The Z-axis gib provides adjustment for the mating dovetails on the column and the head assembly that provide the Z-axis (vertical) motion.

To adjust the Z-axis gib:

1. Loosen the four lock nuts on the left side of the head assembly.
2. Slightly loosen all four setscrews on the left side of the head assembly.
3. Snug each setscrew equally. This will lock the head assembly in position.
4. Loosen each setscrew 1/8 turn to allow the head assembly to move.
5. While holding the setscrews from turning, tighten the lock nuts.
6. Test by moving the Z-axis coarse feed handle. Loosen or tighten all the setscrews the same amount until the head assembly moves freely, but without play in the dovetail.

Tramming the Mill

Tramming is the process of squaring the column with the table on a mill. It involves placing shims under the corners of the base of the column where it bolts to the base.

Tramming the mill requires the use of a dial indicator, or better, a dial test indicator. The indicator is mounted so that it rotates with the spindle and reads against the table at the farthest distance possible from the spindle.

The indicator can be mounted with a test indicator holder, or with a simple shop-made holder.



To tram the mill:

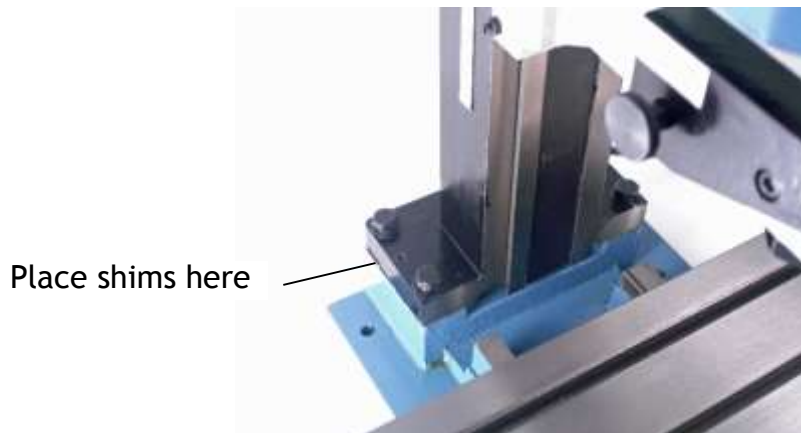
1. Mount the dial indicator or dial test indicator so that it will rest on the front left and front right corners of the table.



2. Take readings on the left front and right front corners of the table. Calculate the difference to see how much and which way to move the column.

Chris' Tip: The factory specification is about 0.0005" per inch, or almost 0.010" over the width of the table. You may want to try to do better than this.

3. Place shims under the appropriate side of the base of the column. Place the shim or shims on the side that gave you the highest reading.



4. Take additional readings, adding or removing shims. Repeat until the readings are the same to within 0.002".
5. Now mount the dial indicator or dial test indicator so that it will rest on the front center and back center of the table.
6. Take readings on the front and back of the table. Calculate the difference to see how much and which way to move the column.
7. Place shims under the front or back of the base of the column. Place the shim or shims on the side that gave you the highest reading.
8. Take additional readings, adding or removing shims. Repeat until the readings are the same to within 0.002".

Lubrication

We recommend the use of two lubricants on your mill.

- Where oil is required, we recommend Lubriplate 3V Machine Tool Oil. Lubriplate 3V is a 20 weight oil especially designed for machine tool way lubrication and bearing lubrication.

Chris' Tip: Lubriplate 3V Machine Oil is available from LittleMachineShop.com. If you prefer to purchase locally, get Mobil 1 synthetic motor oil, any viscosity, available at most auto parts stores.

- Where grease is required, we recommend Lubriplate 630-AA Lithium-Based Grease. Lubriplate 630-AA is an NLGI No. 1 lubricant. Lithium grease is a plastic-friendly general use grease that is easy to find and easy to use.

Chris' Tip: Lubriplate 630-AA grease is available from LittleMachineShop.com, but you might have trouble finding it locally. Don't worry about the brand name. Get white lithium grease. Every auto parts store and most hardware stores have it.

The following points on your micro mill require lubrication.

Location	Lubricant	Frequency	Notes
Column dovetail and rack	Lubriplate 3V Machine Tool Oil	Daily	
Table and other machined surfaces	Lubriplate 3V Machine Tool Oil	Daily	Oil lubricates and prevents corrosion
Table dovetails	Lubriplate 630-AA Lithium-Based Grease	Yearly	
Table feed screws and nuts	Lubriplate 630-AA Lithium-Based Grease	Yearly	
X-axis thrust bushings	Lubriplate 630-AA Lithium-Based Grease	Yearly	

The spindle bearings are deep groove ball bearings that are shielded and do not require additional lubrication.

Maintenance

Maintenance of the micro mill is simple, but important. Regular maintenance will keep your micro mill working like new for many years.

Cleaning

The maintenance you perform most often is cleaning. Keeping swarf off of wearing surfaces is the most important thing you can do to prolong the life of your micro mill.

- Use a 1" paintbrush to remove swarf from the machine as you work.
- Clean swarf from the mill, from top down after each use.

Changing Spindle Tools

The tools you work with are centered in the micro mill spindle by the ER-16 collet.

To remove a tool from the spindle:

1. Insert the spindle lock pin the hole in the side of the spindle.
2. Use the 25 mm end wrench to remove the ER-16 collet nut. The collet and tool will come out with the nut.



To install a tool into the spindle:

1. Put the tool into the appropriate ER-16 collet.
2. Snap the ER-16 collet into the collet nut. Tip the collet to that it engages the eccentric ridge inside the collet nut. Straighten the collet to snap it in place.



3. Put the tool, collet and nut up into the spindle and thread the nut onto the spindle.
4. Insert the spindle lock pin the hole in the side of the spindle.
5. Use the 25 mm end wrench to tighten the ER-16 collet nut.

Squaring a Vise

When you mount a vise on the mill table, it is important that it be mounted square to the table. If your vise is not square to the table, you will not be able to produce accurate work.

The vise is usually mounted with the long axis of the vise perpendicular to the long axis of the table. Thus the jaws are parallel to the X-axis of the mill.

To square a vise on the table:

1. Mount the vise on the table and snug, but don't tighten, the mounting bolts.
2. Open the vise jaws at least 1".
3. Put the 3/8" diameter post on the top dovetail of a dial test indicator.
4. Put the dial test indicator post in a drill chuck, end mill holder, or collet in the mill's spindle with the dial facing front.
5. Move the X-, Y-, and Z-axis controls so the point of the dial test indicator is between the vise jaws and about 1/8" below the top of the vise jaws.
6. Move the X-axis so the dial test indicator's point is about 1/16" inside of one end of the vise jaws.



7. Move the Y-axis so that the dial test indicator's point contacts the fixed jaw of the vise. Continue moving the Y-axis to zero the dial test indicator.
8. Move the X-axis so that the dial test indicator's point wipes across the width of the fixed jaw of the vise.
9. Take a reading when the point of the dial test indicator reaches the far end of the vise jaw.
10. Move the Z-axis to raise the dial test indicator so that the point is above the vise jaws.
11. Tap the vise with a dead-blow hammer to rotate it in the appropriate direction to reduce the reading on the dial test indicator.

12. Repeat steps 5 through 11 until the reading on the dial test indicator is acceptable to you. You should be able to reduce the reading to 0.001" or less.
13. Tighten the vise mounting bolts.

Using Parallels

Precision parallels are used to raise the workpiece off the bed of the vise to a position where you can mill the top surface. Parallels come in sets of graduated heights. Choose a pair of parallels that position the top surface of the work above the top of the vise jaws, while keeping enough material between the jaws of the vise for effective clamping.



Clamping with a Clamping Kit

The clamping kit is the “Erector Set” of the milling machine. Use it to clamp large workpieces, fixtures, and even vises to the mill table.

Use 1-2-3 blocks as part of your “Erector Set.” They can be used to hold workpieces up off the table so you won’t drill into the table. They can be used to mount workpieces, and they can be used to set work up perpendicular to the mill table.



When clamping with step blocks and clamp bars, the end of the clamp bar on the step block should be just a little higher than the end on the workpiece. This ensures that the end of the clamp bar makes contact with the workpiece. The stud should be located as close to the workpiece as possible so that the majority of the clamping force is exerted on the workpiece and not the step block.

Finding the Edge of a Workpiece

Once your work is secured on the table, the next step is to locate the edge of the work so you can zero the X- and Y-axis dials.

Most engineering drawings show dimensions from two perpendicular edges of the workpiece. These are the two edges that you should “find,” or locate, as you zero the X- and Y-axis dials.

The goal is to set the X- and Y-axis dials to zero with the centerline of the spindle directly over the respective edge of the workpiece. Then all movements of the workpiece relative to the spindle are referenced to these two edges.



To find the left edge of a workpiece:

1. Put the solid body of an edge finder in a collet or drill chuck in the mill's spindle.
2. Offset the movable end of the edge finder so that it is not concentric with the body.
3. Move the edge finder so that it is clear of the workpiece beyond the left edge.
4. Lower the mill's head so that the smaller diameter section of the movable end of the edge finder is next to the workpiece.
5. Turn the mill on and adjust the speed control to about one third of full speed.

With the edge finder spinning, it is obvious that the movable end of the edge finder is not concentric with the body.

6. Slowly turn the X-axis hand wheel clockwise to move the table to the left. As the workpiece approaches the edge finder it first forces the movable end to become more concentric with the body.
7. When the movable end of the edge finder is almost perfectly concentric with the body it will all of a sudden jump to one side and stay there.

The point at which the movable end of the edge finder jumps to one side is the point you are looking for. Stop turning the X-axis hand wheel at this point.

8. Turn the motor off.
9. Raise the mill's head so that the edge finder is completely above the workpiece.
10. Set the X-axis dial to zero.
11. Turn the X-axis hand wheel clockwise 0.100". Because your dial has 50 divisions, you turn two full turns.
The movable end of the edge finder is 0.200" in diameter, so you are moving the distance from the center of the edge finder to the edge of the workpiece.
12. Zero the X-axis dial.
This is the zero point for your X-axis movements.

Drilling

There are several ways to locate the position at which you want to drill a hole. You can use your layout tools to scribe crossed lines at the hole location, and then use a wiggler to align the mill's spindle over the intersection of the scribed lines.

You can use an edge finder to locate two edges of the workpiece, and then use the X- and Y-axis hand wheels and dials to locate the correct location.

Once you find the location, start the hole with a center drill or spotting drill. These specialized drills have relatively large diameter shanks to prevent bending or wobble as you start the hole. This ensures that the hole is located directly below the center of the spindle.

Next, drill a pilot hole about 1/8" in diameter (but not larger than the final size you need).

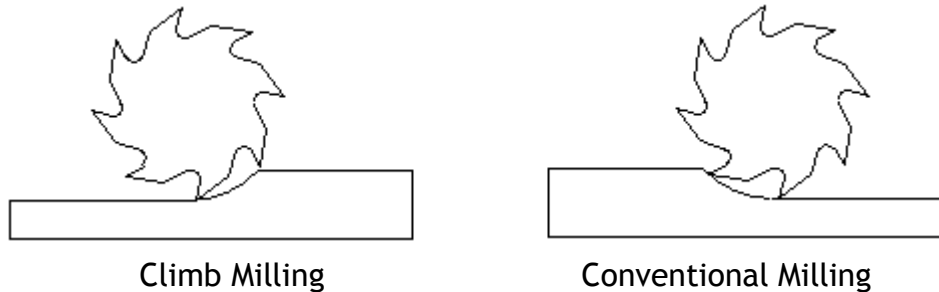
Finally, drill to the final drill size you need. You can drill the final hole size as long as two conditions are met. First, the web of the drill bit (the short straight section at the very tip of the drill) must fit into the pilot hole. Second, the drill must not be too large for the micro mill to drive. If power is an issue, use smaller drills to reach the final diameter in steps.

Milling

You use ER-16 to hold end mills in the mill's spindle.

End mills are called that because they cut on the end, as well as on the periphery. Earlier milling cutters used in horizontal milling machines only cut on the periphery. This makes end mills versatile. You can mill the sides of a workpiece, the top surface of a workpiece, and even cut slots and holes in a workpiece.

Conventional Milling Versus Climb Milling



Depending on the direction in which you move the workpiece against the end mill you are either climb milling or conventional milling. As shown in the illustration above, you are climb milling when the end mill turns as to climb the slope made by cutting.

Climb milling has several advantages, and is often recommended for modern milling machines. The flutes dig in to material with a climbing action, and the workpiece and rotation of the cutter are going in the same direction. With this forward stroke the tooth starts with a full chip and pushes the workpiece down against the table or holding device. This requires less machine power, the cutter does not dull as soon, and a better surface finish is produced.

However, climb milling requires a very rigid milling machine with virtually no backlash. Because the workpiece and the milling cutter are moving in the same direction, the milling cutter tends to pull the workpiece away from the driving device if there is any backlash. This can overload the cutter and stall the machine. Or it can simply leave a poor surface finish.

On light mills like the micro mill, use conventional milling for all but the lightest cuts. Then, take your final cut of one or two thousandths of an inch using climb milling for the best surface finish.

Plunge Milling

Plunge milling is the same action as drilling, but using a center cutting end mill instead of a drill bit. This is how you start a slot that does not extend to the edge of the workpiece.

Some end mills are center cutting. This means that one of the cutting edges on the end of the end mill extends across the center of the end mill so that there is a cutting edge for the full diameter of the end of the end mill.

Non-center cutting end mills have cutting edges on the end, but they do not extend to the center. These end mills will cut on the end and can be used for slotting and surfacing, but you cannot plunge a non-center cutting end mill straight down into the workpiece.

Milling Slots

Milling slots is the signature operation for a vertical milling machine. For example, to make a belt-adjustment slot, you plunge mill through the

workpiece at one end of the slot, mill the length of the slot and raise the end mill at the other end.

But of course, life is not as simple as this. You may or may not be able to remove all the material in one pass. If the workpiece is thick you might need to make multiple passes along the length of the slot, lowering the end mill between passes.

And, if you use an end mill where the diameter of the end mill is the same as the width of the slot, you are conventional milling on one side of the slot, and climb milling on the other. You will see markedly different surface finishes on the two sides of the slot. But since slots usually need to provide some clearance for the bolt that will go through them, the solution is easy. Use an end mill the same size as the bolt, then take a few cleanup passes to widen the slot slightly wider than the end mill diameter. Your final passes should be climb-milling passes on each side of the slot.

Surfacing

Surfacing is used to square a workpiece and to provide a good-looking surface as well as to change the size of a workpiece.

If you are trying to make a good-looking surface, use as large a diameter cutter as is practical. While a fly cutter can surface a large area in one pass, we do not recommend its use on the micro mill. It is prudent to use a smaller diameter cutter, such as an indexable end mill for surfacing.

Common Accessories

You will soon find that the purchase of a mill is just an initial step. There are many tools and accessories that you will need to get full use from your mill. Following are some common accessories used with the micro mill.

End Mills

Conventional wisdom is that 2-flute end mills are used on aluminum, while 4-flute end mills are used on steel and brass. Take a look at why before you make a choice.



Two flute end mills



Four flute end mills

Two-flute end mills are used on aluminum because aluminum is easy to machine and you can take big cuts. Two-flute end mills provide a lot of room

between the flutes for the big chips produced when making heavy cuts. But on a micro mill, you are probably not as concerned about maximizing production, and thus you are not taking the same big cuts that a production shop might. Four-flute end mills can produce a slightly better finish at the same cutting speeds because there are twice as many cutting edges, each taking off half as much material. But again, if you are not trying to maximize production, you can simply slow the feed rate with a 2-flute end mill for the same effect. End mills are also classed as “center cutting” or “non-center cutting.” With a center cutting end mill, you can plunge the end mill into the work as you would a drill. This is important if you are cutting a slot that does not extend to the edge of the part. Center cutting end mills are easy to identify. If the flutes meet in the middle of the end of the end mill, it is a center cutting end mill. In some cases, one of the flutes will be longer, reaching right to the center. If the flutes stop short of the center, leaving a space with no flutes in the center, it is a non-center cutting end mill. Virtually all 2-flute end mills are center cutting end mills. Currently, most 4-flute end mills are center cutting. All the end mills that LittleMachineShop.com sells are center cutting end mills. The 6-piece end mill sets we sell are economical starter sets. Because all the end mills in the set have 3/8" shanks, you only need one end mill holder or collet to use the entire set.

Work Holding

There are two main ways to hold work on a mill's table: with a vise or by clamping the workpiece to the table. In our experience, most work can be held in a vise. But from time to time there is a large or odd-shaped workpiece that must be clamped to the table.

Vises

There is a range of different types of vises that you can use on a micro mill.



Choose a vise that will handle the work you do. You don't need a 3" vise if the parts you make are a half inch long. While you can usually put small parts in a large vise, it is more convenient to use an appropriate-size vise.

Vise jaws are often too deep for the work. In general, you want the top of the workpiece to extend above the top of the vise jaws. To fill the gap from the bottom of the workpiece to the “ways” of the vise, you use parallels. Parallels

are strips of metal that have been carefully ground so that the top and bottom edges are parallel with very tight tolerances. They usually come in matched pairs. Place one parallel adjacent to each jaw in the vise and place the workpiece so it rests on the parallels.

Clamping Kits and Accessories

Clamping kits and their accessories, including 1-2-3 blocks, are the “Erector Sets” of work holding. Use the various pieces of the clamping kit as you see fit to hold a workpiece to the micro mill's table.



In many cases, you need to lift the workpiece off the table, either because the mill spindle won't reach it or because of a projection on the bottom of the workpiece. 1-2-3 blocks are precision ground to be flat and parallel. Use them as spacers to lift the workpiece. You can also use them as an angle plate by bolting a workpiece to the side of the 1-2-3 block and then clamping the 1-2-3 block to the mill table.

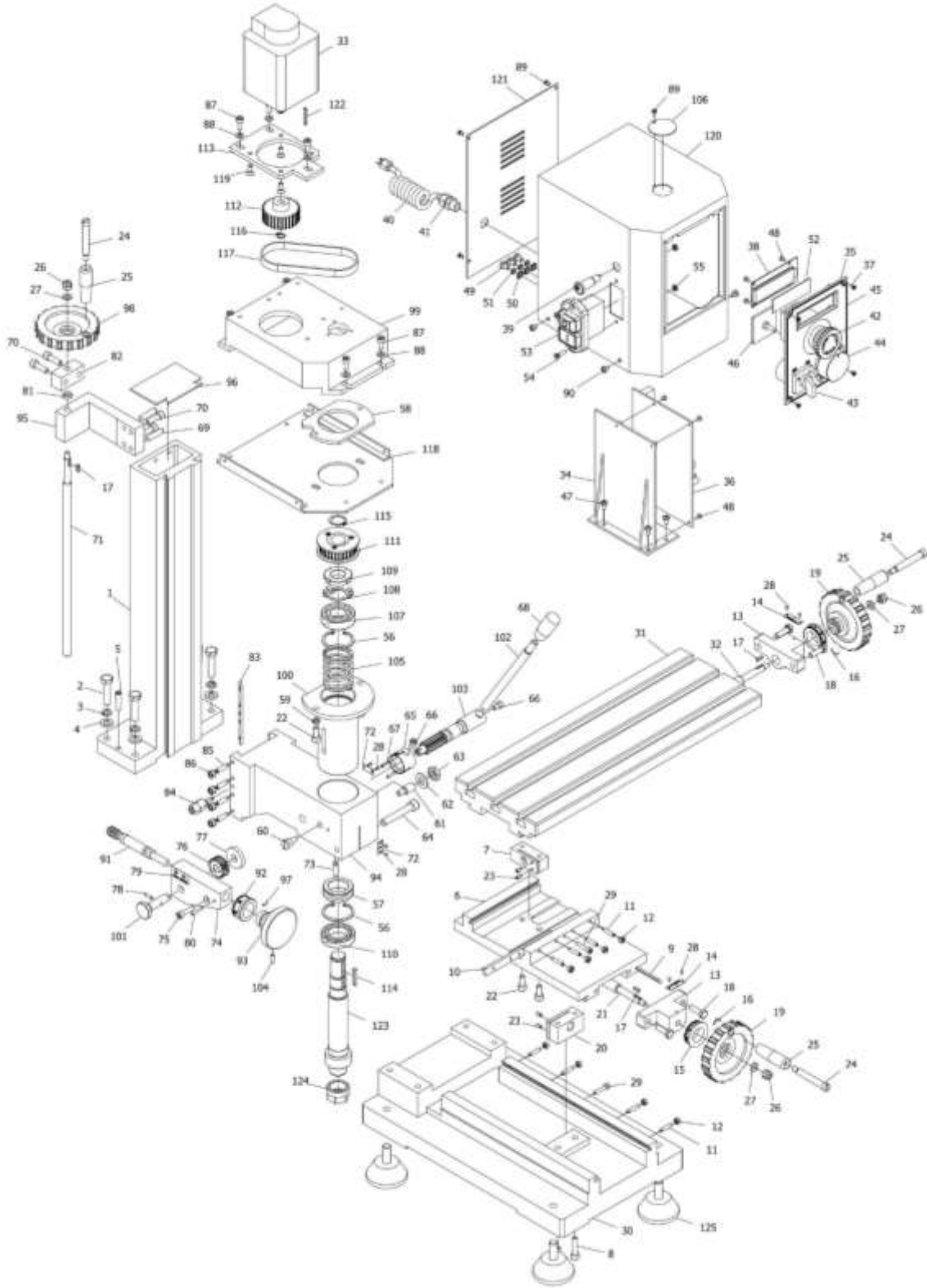
Setup Tools

Once you have your workpiece mounted on the micro mill, you are ready to start cutting metal. Except for one thing; you don't know where the cutting tool is in relation to the workpiece. Edge finders and center finders help you determine the relationship between the cutting tool and the workpiece.



Edge finders locate the edge of the workpiece. Center finders locate the center of existing holes. Wigglers locate the intersection of scribed lines on the workpiece.

Parts Diagram



Parts List

Item	Description	Qty
1	Column rail	1
2	Screw M8×35	4
3	Spring washer M8	4
4	Washer	4
5	Pin 6×26	2
6	Bed	1
7	Screw nut	1
8	Screw M6×25	2
9	Cross wedge	1
10	Wedge	1
11	Headless set screw M4×20	8
12	Nut M4	8
13	Screw base	2
14	Label	2
15	Dial	2
16	Damp spring	2
17	Key 3×10	3
18	Screw M6×20	4
19	Hand wheel	2
20	Screw Nut	1
21	Cross screw	1
22	Screw M6×14	4
23	Headless set screw	4
24	Handle bolt	3
25	Handle sleeve	3
26	Top nut M6	3
27	Washer	3
28	Rivet	8
29	Screw M4×20	2
30	Base	1
31	Worktable	1
32	Lengthways screw	1
33	Brushless Motor	1
34	Support for PC Board	1
35	Switch panel	1
36	PC Board	1
37	Sunk screw	4
38	LCD	1
39	Fuse holder	1
40	Power line	1
41	Cable joint	1
42	Scram button HY57B	1
43	Change-over switch ZH-A	1

Item	Description	Qty
44	Potentiometer knob	1
45	Electricity label	1
46	X-1 small plate	1
47	Small Phillips head screw	4
48	Tapping screw	8
49	Small Phillips head screw	3
50	Lock washer	3
51	Spring washer	3
52	Baffle	1
53	Electromagnetic switch	1
54	Sunk screw	2
55	Nut M4	2
56	Circlip	2
57	Spring seat ring	1
58	Sleeve support plate	1
59	Spring washer	2
60	Joint screw	1
61	Adjust screw	1
62	Washer	1
63	Nut M10	1
64	Screw M8×50	1
65	Mark show sleeve	1
66	Screw M5×8	2
67	Spring pin 3×12	2
68	Long handle sleeve	1
69	Pin 6×26	2
70	Screw M6×20	4
71	Lifting screw	1
72	Label	2
73	Headless set screw	1
74	Worm base	1
75	Screw M5×20	1
76	Helical gear	1
77	Spacing ring	1
78	Pin B 3×12	1
79	Joint label	1
80	Pin B 3×18	1
81	Washer	1
82	Screw support	1
83	Wedge	1
84	Handle	1
85	Headless set screw	4

Item	Description	Qty
86	Nut M5	4
87	Screw M5×12	7
88	Washer	7
89	Small Phillips head screw	5
90	Small Phillips head screw	4
91	Worm shaft	1
92	Vernier scale ring	1
93	Hand wheel	1
94	Spindle seat	1
95	Nut block	1
96	Cover board	1
97	Damp spring	1
98	Hand wheel	1
99	Support	1
100	Spindle sleeve	1
101	Joint shaft	1
102	Handle shaft	1
103	Gear shaft	1
104	Socket set screw	1
105	Compression spring	1
106	Dust cover	1
107	Ball-bearing	1
108	Lock washer	1
109	Round nut M20×1.5	1
110	Ball-bearing	1
111	Spindle belt wheel assembly	1
112	Motor pulley	1
113	Motor connecting plate	1
114	Key 4×8	1
115	Circlip	1
116	Circlip	1
117	Timing belt	1
118	Baseplate	1
119	Sunk screw	4
120	Shield	1
121	Back shroud	1
122	Key 3×25	1
123	ER16 spindle	1
124	ER16 nut	1
125	Footing	4

Wiring Diagram

