Chapter

Machining Basics

How-to: Vertical Mill and Lathe Operation

The Mighty Bridgeport

What most of us call a "Bridgeport" is really a vertical mill. As Kurt Senescal from Creative Metalworks explains, "A lathe just spins things, so you can make them round. With a mill, you can make square parts or round parts, there are just so many more things you can do with a Bridgeport."

It's easy to understand how Bridgeport became the generic name that most of us associate with any vertical mill, as there seems to be a true Bridgeport in the vast majority of fabrication and repair shops where we hang out - shops dedicated

For a lot of motorheads, there is no such thing as a "vertical mill." But there is this terrific machine seen in all the shops and it's called a Bridgeport.

to the repair and construction of hot rods, of all types and flavors.

It was 1938 when the first Bridgeports, manufactured in Bridgeport, Connecticut, were introduced. To say they were successful is an understatement. Even after other manufacturers of machine tools began to offer similar features, Bridgeport remained the dominant brand for small and medium-sized machine shops.

Today, most true machine shops and manufacturing plants have switched to automated equipment, the ubiquitous CNC machines, which means that the original, manual Bridgeport machines can be found and had for anywhere from $500 to $2500. Like all used equipment, price differences between one machine and another are mostly due to condition, age and features. Among the available features offered through the years, by far the most popular is variable speed. To change the RPM of the tool in a manual machine, it's necessary to stop the machine, take the tension off the belt (see the nearby photos) and chose a different set of pulleys to either increase of decrease the speed of the tool. Variable-speed machines use an adjustable pulley, the diameter of which (and thus the RPM) can be changed on the fly while the machine is running.

Whether the Bridgeport in question uses the manual pulley system or the variable speed pulley, they all have a two-speed clutch hub. in either case, the RPM can be adjusted from 80 to over 2000 RPM (more on tool speed a little later).

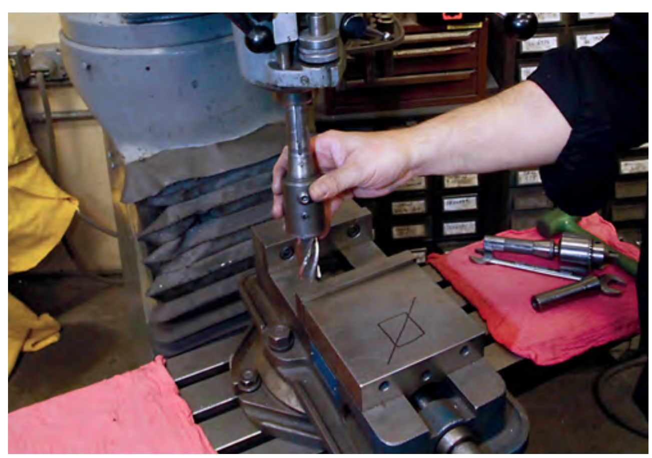
Unlike the variable speed option, all Bridgeport mills come with a head assembly that can be rotated through on the vertical axis, as well as rotated (angled) around a horizontal axis. The head assembly can also be angled back and forth, relative to the angle of the operator (see nearby photos).

The bed itself can also be moved in three axis, X, Y and Z (up and down); power feed options can be had for both the X and Y movement. In addition, there are a whole host of options, like rotary tables and DRO panels (digital read out).

A Bridgeport is simply one hell of a machine, with patience and a little creativity there aren't many machining tasks you can't tackle.

Changing the tooling on a Bridgeport starts by appling the brake then loosening the drawbar. The drawbar screws into the collet or tool holder (see pics below)...

... next, you need to tap on the top of the drawbar with a brass or rubber hammer - never, never use a steel hammer on a Bridgeport.



Now the collet and the tool itself will drop out.

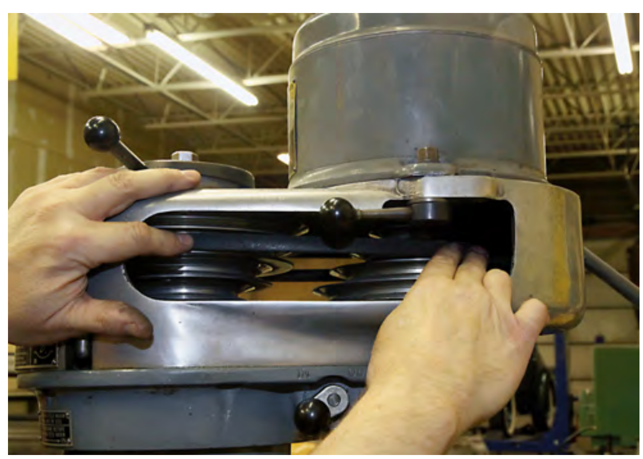
Once the collet is pulled out, the drawbar can be removed as shown - you do not normally need to pull the drawbar all the way out to remove a collet.

Reinstalling the drawbar starts by hand tightening the nut on top...

... then the final tightening can be done while holding the brake. Tightening the drawbar pulls the tapered collet up into the quill, forcing it to grip the tool.

The various belt pulleys, and an integral two-speed hub, make it possible to change the speed of the tool from 80 to over 2000 RPM.

To move the belt to a different set of pulleys, start by loosening the motor locknut handle, and moving the motor on it's pivot, which takes the tension off the belt .....

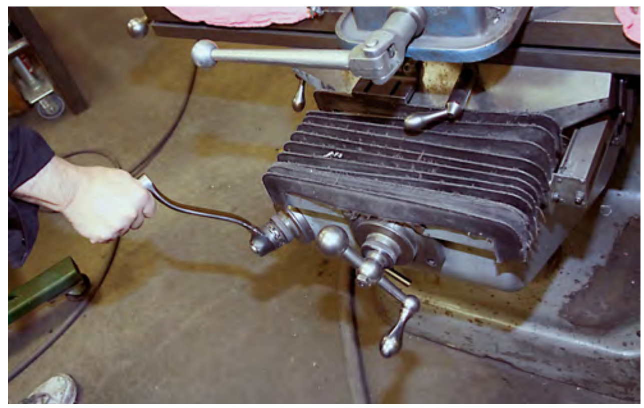


... then switch to the new belt position...

… put tension on the belt and lock the motor in place with the motor locknut handle.

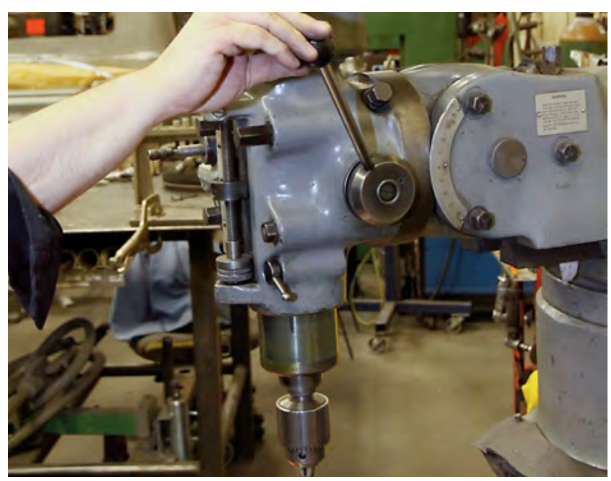
Moving the table along the y axis (closer or farther away from you) is done with the handle on the front of the machine.

Changing from hi to low range is done by moving the two levers shown here, together is low, apart is hi. When going to hi range it's necessary to spin the chuck so you know the gears are engaged.

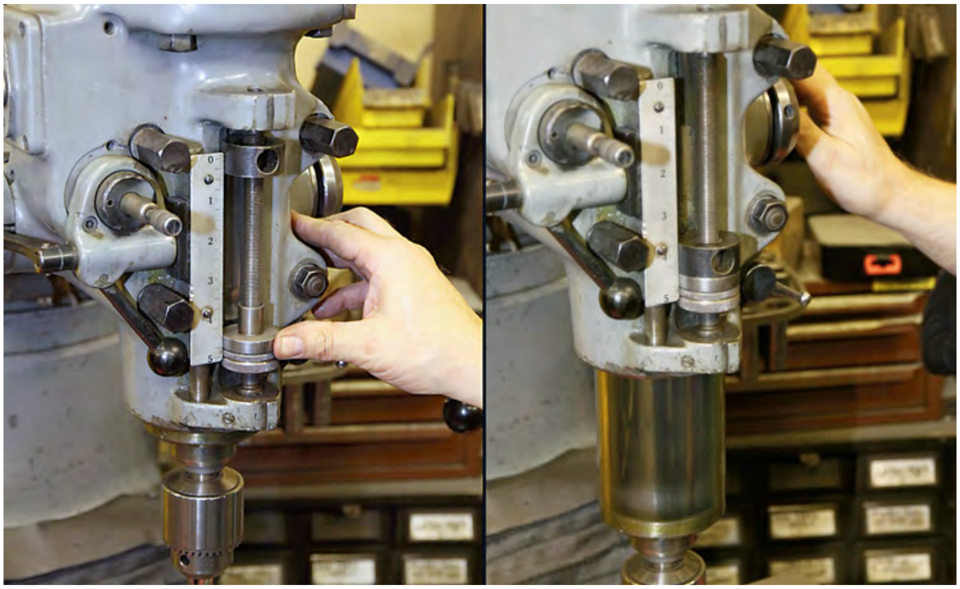


The third handle, shown here, moves the table along the z axis, (up and down).

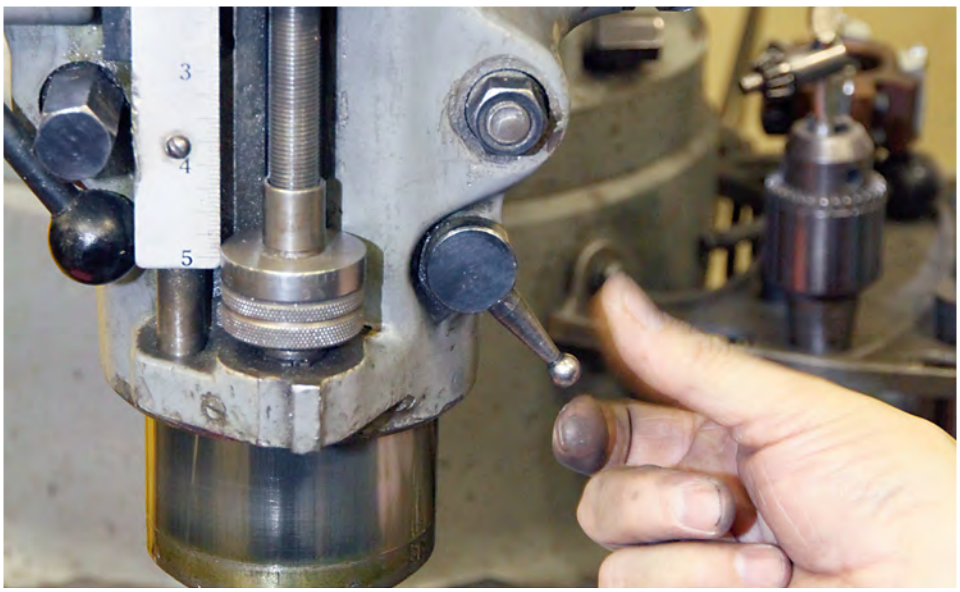
The table can be moved along the x axis (to the left and right) with the crank handle as shown.



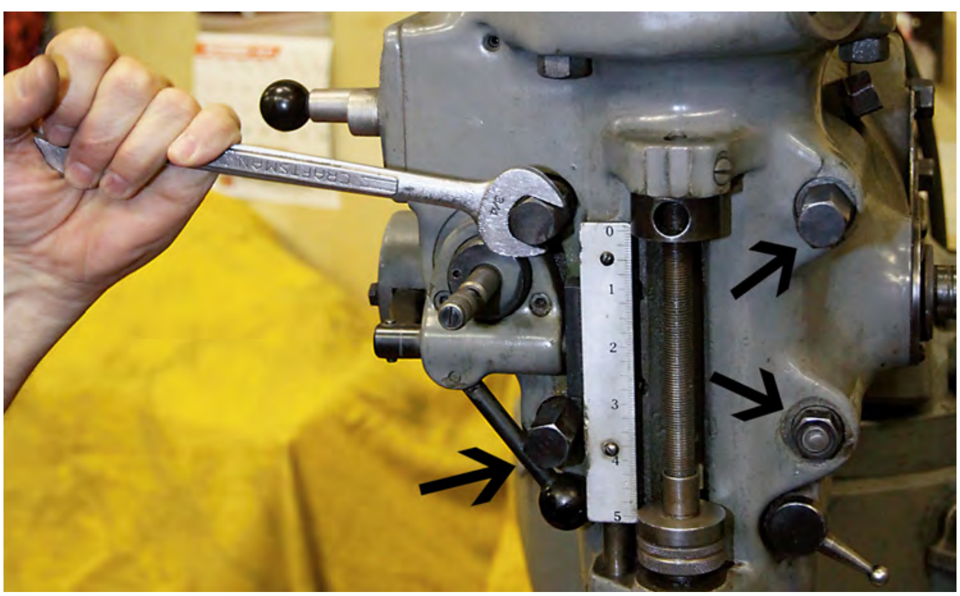
The mill can be used as a drill press by moving the quill up and down with the handle, or you can engage the power feed.



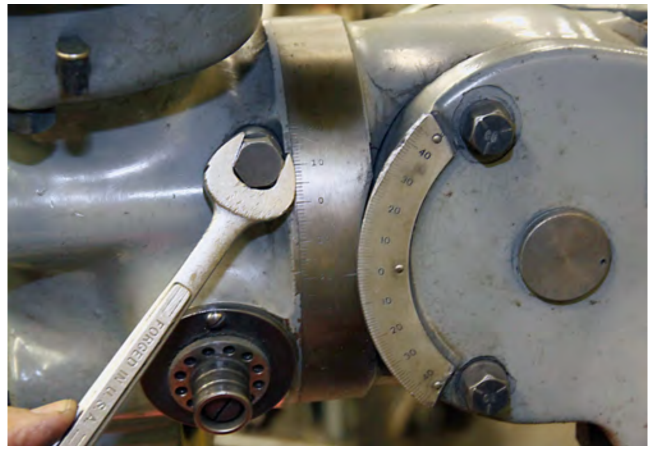
To stop the quill at a certain point, an adjustable stop can be set. In manual mode, the stop will physically stop the movement of the quill. In powered mode, the stop will kick the power feed out of gear.



If on the other hand, you don't want the quill to move at all the lock shown here can be engaged.

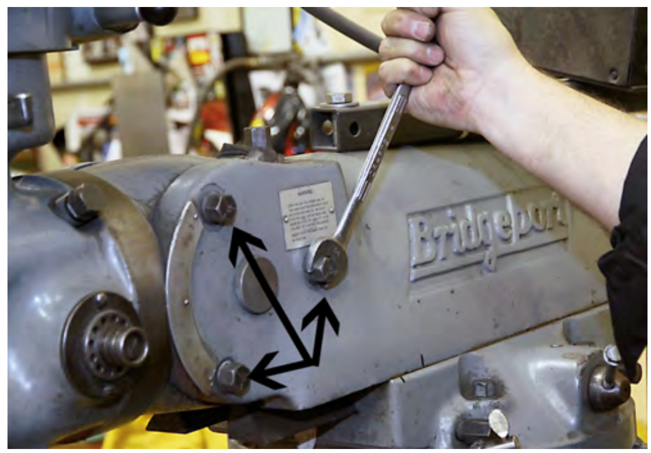


The Bridgeport was a big hit when first introduced partly because it is so very flexible. The four bolts shown here can be loosened...

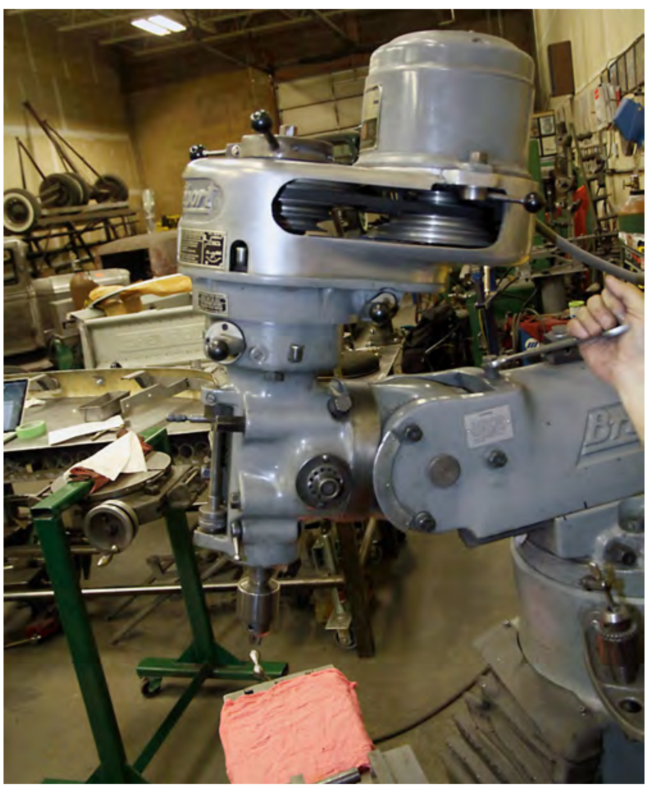


1) ... then the adjustment seen here can be used to pivot the head of the mill on the horizontal axis...

2).... as shown.



3) Or, you can loosed the three bolt heads on the side of the mill...



4) ... and use the adjustment (note Kurt's hand) to tilt the head as shown.

5) With the bolts shown here (there are a total of 4) you can slide the whole head assembly forward and back with the handle.

1) You can also turn the turret on the vertical axis by loosening the bolts shown (again, there are 4)...

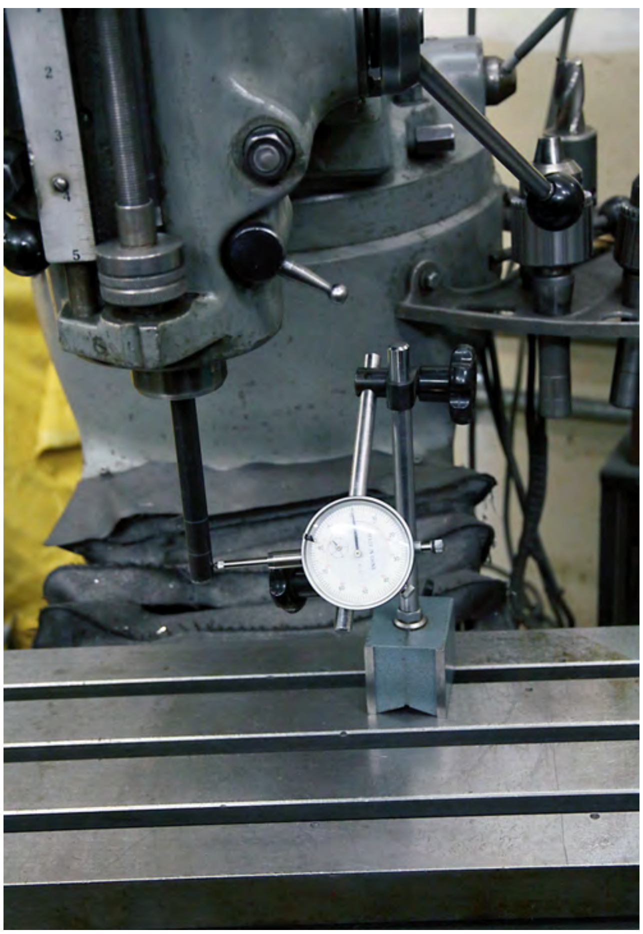
2) ... then swinging the turret manually.

3) All this swinging and jiving might leave you wondering if the head is really perpendicular to the table... in which case you need to "indicate the table," which is done with an indecol (the holding fixture) and a dial indicator...

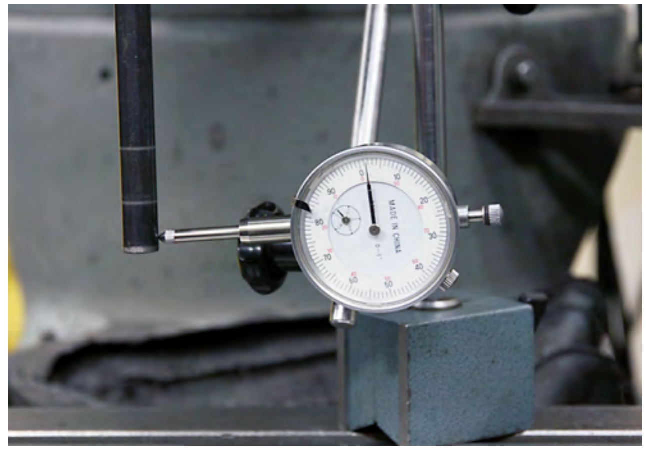
4) ... the indecol allows you to mount the dial indicator to the quill as shown.

5) You should be able to rotate the dial indicator through a 360 degree rotation, in 90 degree increments, and see no change in the reading. "This can be very time consuming," warns Kurt.

1) There is a simpler way to indicate the table. This Plan B, which starts with a piece of perfectly straight drill rod mounted in the collet...

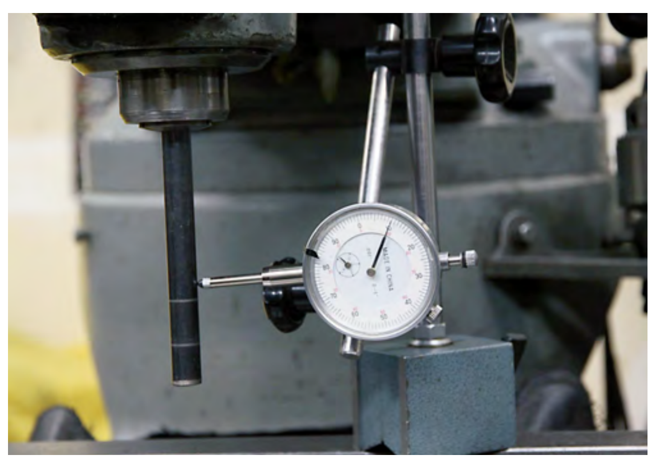


2) ... and the collet mounted in the mill, with the indecol and dial indicator set up as shown.

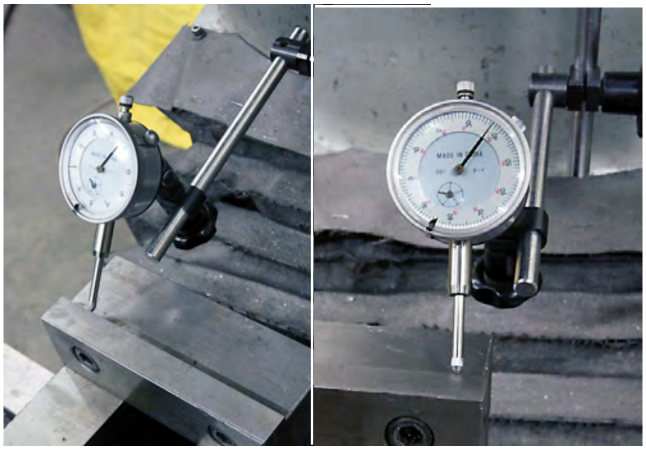


3) Start the process with the dial indicator at the very end of the drill rod.

4) Now, use the big crank handle on the front of the mill to move the table up (on the z axis).

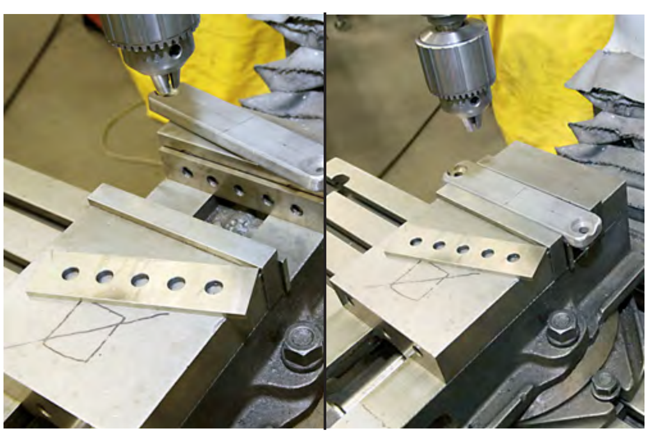


5) The reading on the dial indicator should remain constant as you raise the table. This Plan B method is much easier than the original Plan A.

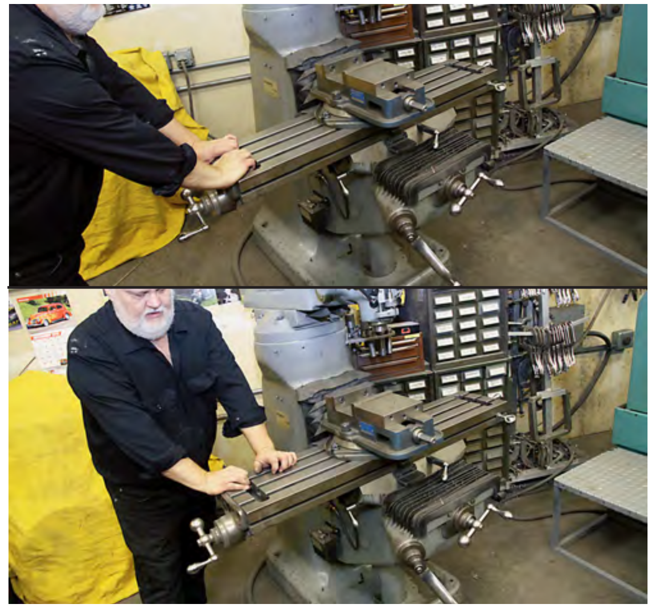


With the head indicated, you need to indicate the vise, which only needs to be done on the x axis - i.e. take a reading at one end of the vise, and move the table until you get a reading at the other end.

Half the job of milling is just mounting the material to be milled to the table. Luckily there are kits like the one shown, that make it relatively easy to securely mount odd shapes.



Parallels are often used to provide a machined shoulder for the work to sit on, squeezed securely by the jaws of the vise.

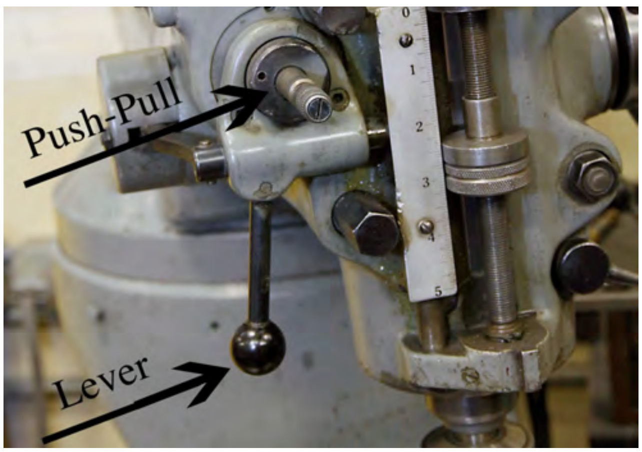


When checking the condition of a mill, be sure to check the amount of play in the table (when it's not locked in place). Some of the play can be adjusted out, but if it's too bad the sliding surfaces must be machined true.

Checking for play in the quill is a simple matter of extending it all the way and then moving it back and forth.

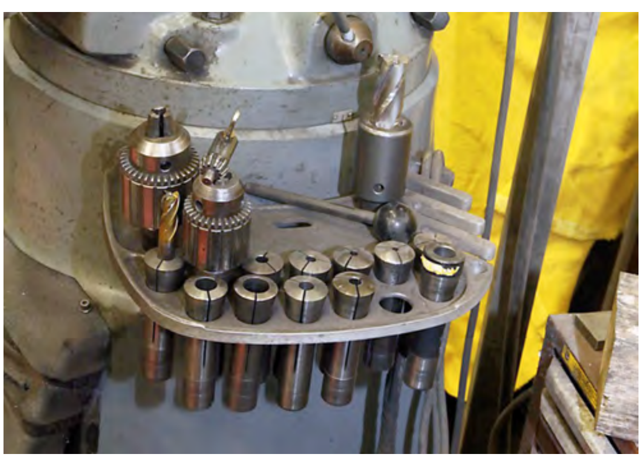
The speed of the quill power feed is variable, adjusted by the crank seen here.

For drilling a chuck can be mounted to a collet and then inserted into the mill.



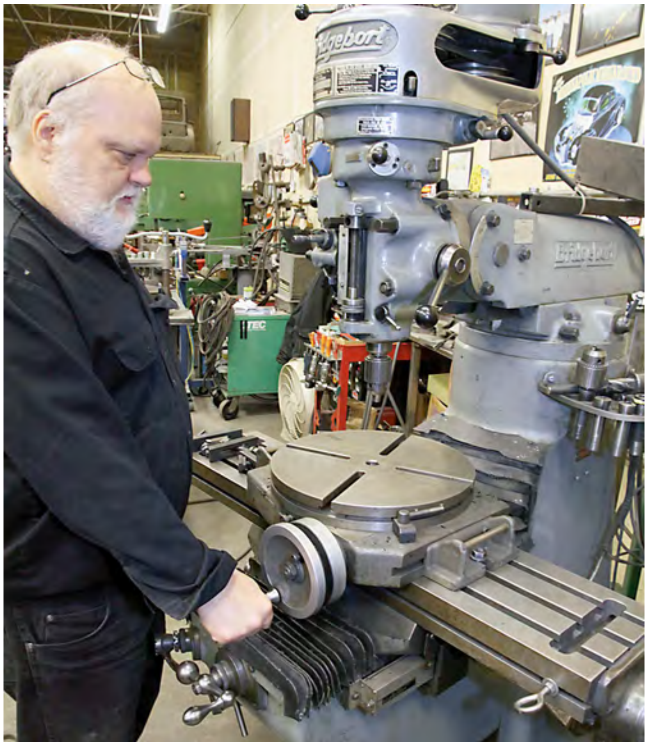
The lower lever is used to engage the power feed for the quill, while the upper push-pull control is used to change the direction of feed.

Some common tools include (top left to bottom right) a ball-end mill, a roughing or hogging mill, a 2-flute mill, a collet and a 4-flute mill.



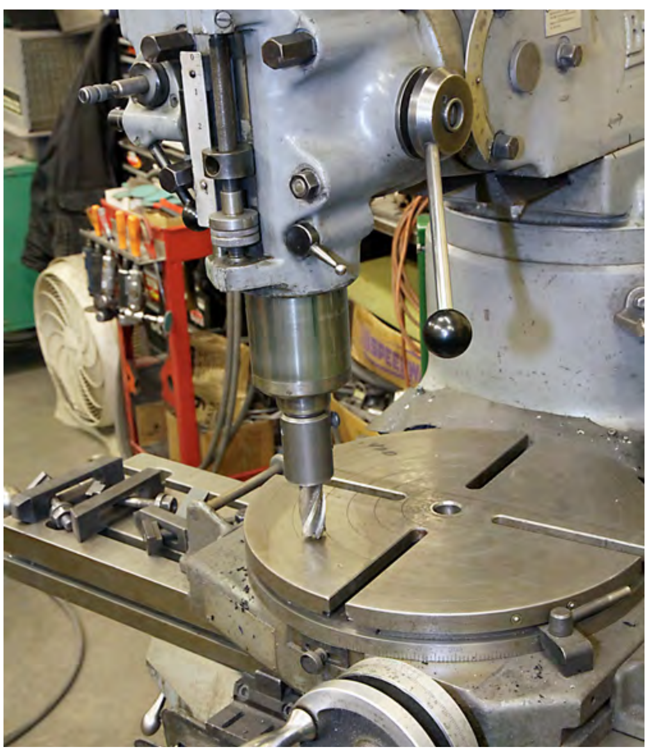
A variety of collets are needed for a variety of tools. Each ID matches the shaft OD of a particular tool.

Close up shows a collet holding a 4-flute end mill. The taper matches the female taper of the quill, pulling the collet up into position with the drawbar tightens the collet's grip on the tool.



A rotary table adds considerably to the already long list of things you can make and shape with a Bridgeport.

Center the table under the quill, add one end mill and you can make a step in the work, as shown, just by rotating the table as the end mill spins.



Locate the rotary table mounted off-center relative to the centerline of the quill, and the possibilities are almost endless.

The line drawn on the aluminum plate shows the path the end mill will follow as the table (and the work) rotate.

The Lathe

While the vertical mill is a somewhat modern tool, the lathe is at least 3000 years old - some of the very first examples were powered by one person pulling a rope wrapped around the piece of work while the second person shaped the wood with a sharp tool. Eventually the power-person was replaced by belts driven by a water wheel or horses, and later, steam.

Though it might be true that lathes are only good for making things round, there are actually three operations commonly performed on a lathe: turning, facing and boring.

Your basic metal-cutting lathe with headstock, tailstock and tool support or carriage.

Compared to a Bridgeport, lathes are fairly simple machines. On one end you have the headstock, the heart and soul of a lathe. The headstock contains the engine or drive mechanism that rotates the spindle. Whether through belts or gears or a variable-speed motor, the headstock has provisions to change the speed of the spindle, the device that holds the work.

Most spindles use a three-jaw chuck to secure and center the work, though four jaw spindles are a nice option for mounting items that have a rectangular or irregular shape. When the work is mounted in the lathe with a chuck, it's a good idea to do as many operations as possible without removing the work from the machine. Because anytime you take a shaft or object out of the jaws, and then put it back in later, there will be some shift in the position, and you will have to indicate the work again before you go back to cutting.

The tailstock, as the name suggests, is located at the other end of the bed from the headstock, and is generally used as a place to mount a center and thus help to support the work at the other end. For metal work, a live center with a high quality bearings is often used in the tailstock to support the work (note the photos).

The tool support can be moved manually with the lowest/largest wheel, or the power drive. The cross slide can likewise be moved manually or by power drive.

Things to Keep in Mind when Operating a Lathe or Mill

1. If it's moving don't touch it.
2. Be sure to pick the right speed. Go too quick and you will burn up the tool or the project. Too slow and you will break stuff.
3. Beware loose shirttails, ponytails etc. You can easily be pulled right into the machine.
4. Wear safety glasses always, for those times when the machine shoots out shrapnel.
5. Cutting tools must be sharp.
6. The tool must be held securely.
7. The work must be held securely.
8. You need to listen to what the machine is doing. As Kurt says, "I can tell from my office if someone is running the machine too slow or too fast. I can tell by the sound if the tool is sharp or dull. And you have to look too, visual checks are important. But once you have a little experience, you can tell from across the shop if something isn't right or someone is doing something stupid."

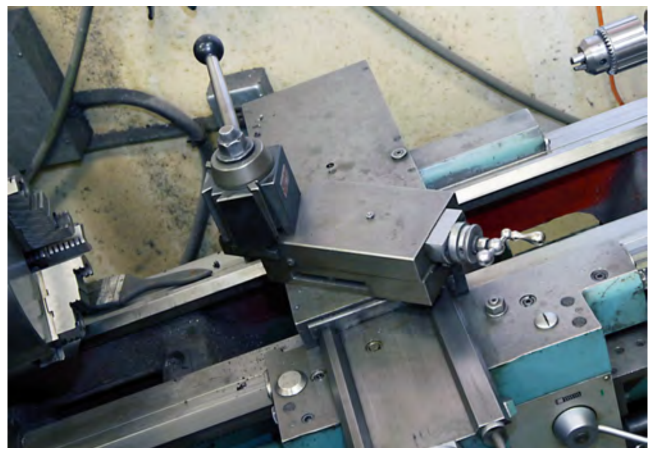
Between the headstock and the tailstock is the bed, with precision slots that allow both the carriage and tailstock to move parallel to the centerline of the headstock. The carriage is gear driven by the long screw gear seen on most lathes that moves the tool parallel to the work, or axially. There is also a cross slide mechanism in the carriage that allows the tool holder to be moved radially, closer to or farther away from the work. Both these movements can be done manually with the wheels seen on the front of the tool support, or with a variable speed power feed.

Shown in the nearby photos is an Aloris tool holder with its quick release feature so the part of the toolholder that actually clamps the tool can be quickly pulled off the lathe and another clamped in its place.

Operation

With the lathe, the important thing to keep in mind is not just the RPM of the spindle, but the surface speed of the work. If the work is a small

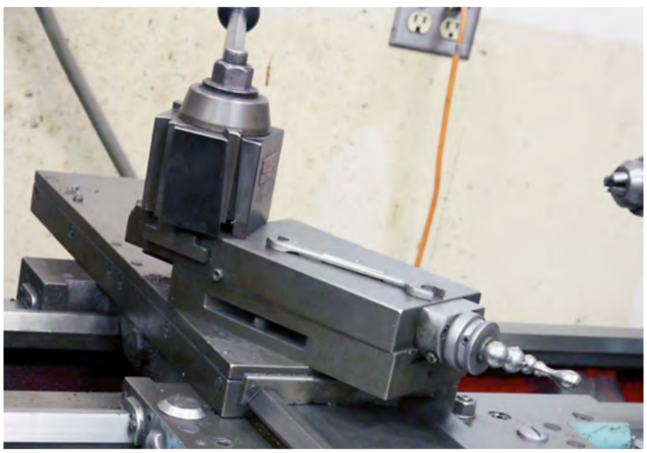
The tailstock can be equipped with a chuck for a drill bit as seen here, or more often, a shaft with a tapered end used as a support for the work.



The tool holder in this case is from Aloris, which makes for fast tool changes.

Not all lathes are the same, this Harris lathe uses the levers seen here to change the speed of the spindle.

The lower levers control the speed and direction of the power feed.



The Aloris tool holder does more than just hold the tool. Loosen two nuts and the mechanism rotates.

The part of the tool holder that actually holds the tool or can be popped off quickly by just...

diameter rod the effective surface speed is much faster than that of a larger diameter piece running at the same spindle RPM.

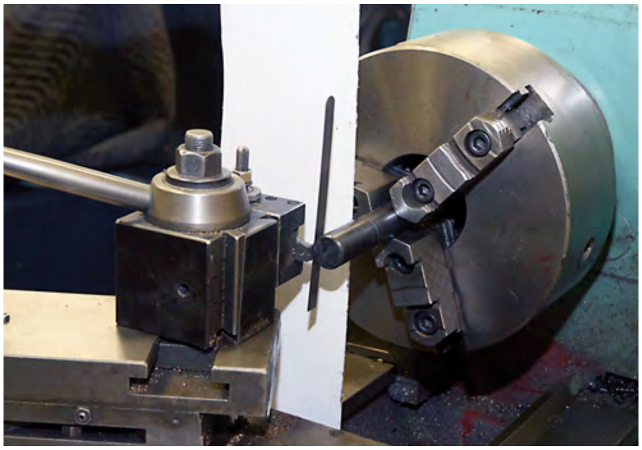
Tools

Most fab shops, including Creative Metalworks, buy lathe bit blanks, and shape them as needed for a particular job. "The cutting bit needs to be higher at the tip," explains Kurt, "that's all. We sharpen and shape them for each particular job."

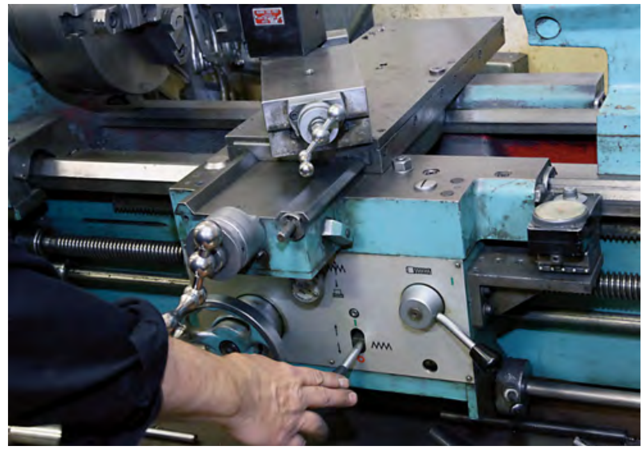
Cutting fluid

Whether you're working on the mill or the lathe, there are plenty of times when the operation will require cutting oil. Cutting oil is more a coolant than an aid to the actual cutting. With aluminum Kurt just blows compressed air at the tool to provide cooling and help clear the chips away from the work.

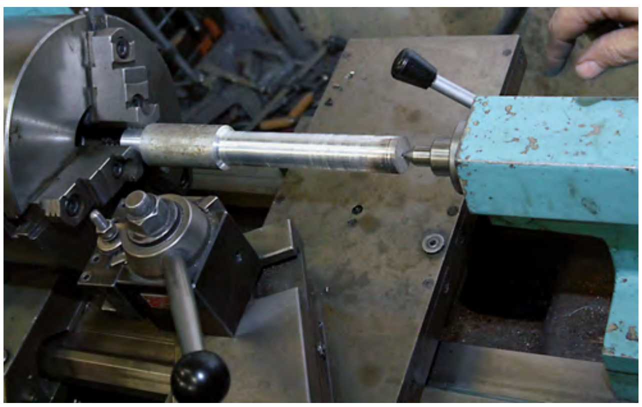
... twisting the handle shown here in a counter-clockwise direction. The nice thing about this is you have 5 or 6 different bits ready to drop on at a moment's notice.



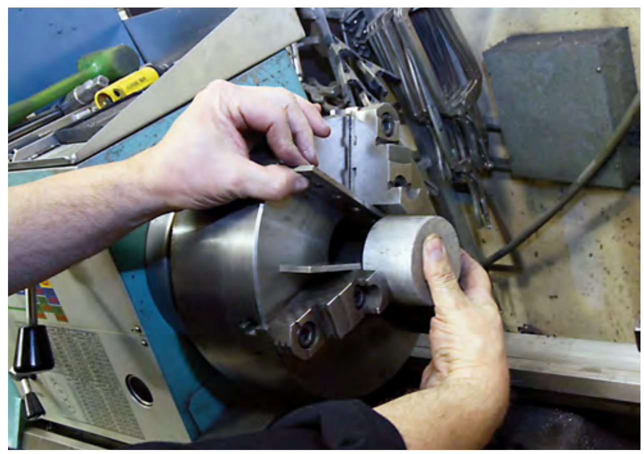
A good way to ensure the cutting edge will contact the work on the horizontal centerline - a thin piece of metal should be vertical when held against the work by the edge of the tool bit.



Shown is the control for the horizontal feed. Just above that is the feed control at 90 degrees to the lathe's axis.



A center is simply a support with a pointed end that supports the "other end" of the work. A live center like this one is equipped with a bearing.



For mounting round objects like that shown, a set of parallels are often used to keep the work square.

If a piece of work is taken out of the lathe, then reinstalled, it needs to be indicated with the dial indicator as shown. Sometimes a tap from a soft hammer is all that's required to bring it in line.

At Creative Metalworks, and most fabrication shops, tool blanks are shaped to fit the job at hand, these are just a few examples.