SHERLINE PRODUCTS
INCORPORATED 1974

SQUARING UP YOUR MILL

The following tips are taken from the Model 2000 mill instructions. Though the 8-direction mill is shown in the examples, the same procedures would be used for aligning the 5000-series mills, or any mill for that matter.

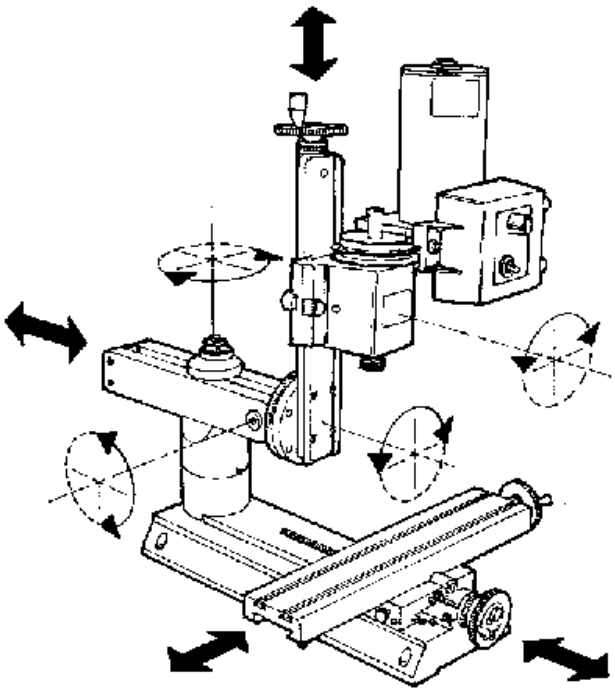

FIGURE 1-The axes of movement of a Sherline 8-direction mill. Table left/right movement is referred to as the X axis. Table in/out movement is the Y axis. Headstock up/down movement is referred to as the Z axis. The headstock can also be rotated on its saddle on all Sherline mills. The four additional movements available on the model 2000 mill are also shown above.

Determining the level of accuracy you really need

Squaring up a multi-direction mill can be a chore if you want "perfection". It is best to determine how accurate the setup must be before you start. The larger a close tolerance part is the better the setup required. An error of .001" (.025mm) per inch (25.4mm) would be a very small error on a part .4" (10mm) long. However, a part that is 5" long would have an error of .005". The type of machining that is going to be performed also has a bearing on the quality of the setup. As an example, a drilled hole doesn't usually require the quality of setup that would be used for a bored

hole, (assuming the hole is being bored for accuracy rather than for lack of a drill of the proper size). The amount of work that will be done with the setup should be considered too. If your setup is just to do one particular job you only have to set it up close enough to do that job. If the setup will accommodate future operations as well, it should be adjusted to the tolerances of the most critical job. For example, squaring up a mill and vise to work on a number of precise parts is worth more of your attention than setting up to drill one clearance hole in a non-critical part.

Limitations of the production process

Before starting you should realize that these mills are relatively inexpensive machine tools. They have accurately milled slides but the surfaces are not ground. To increase the accuracy of a Sherline tool only a percentage point would dramatically increase the price. We try to give a customer what we consider "the most bang for the buck".

Why aren't there alignment pins to square up the machine?

If you are a novice to machining, you probably believe a machine should be designed so that a couple of pins could be dropped into holes, squaring up the machine and eliminating this whole process. After all, that is the way they do it with woodworking machinery. The truth is the tolerances that work well for wood cutting tools simply aren't accurate enough for most metalworking tools. You just can't hold the tolerances required with "pins". When they fit tight enough to lock the head square to the table you can't remove them to do work that isn't square. They become more of a problem than the problem they were installed to eliminate. For example, an alignment or assembly error of .010" in a wooden kitchen table will never be noticed. Usually the floor it sits on is not even flat. It would be a waste of time and effort to make it more accurate than it has to be. On the other hand, a cylinder that has been bored out of square with the crankshaft in an automobile engine could wear the entire engine at an alarming rate. The piston goes up and down a million times in a normal day's use. The additional cost in fuel and shortened life demands accuracy. Your Sherline mill should be adjusted and aligned to the degree of accuracy demanded by the particular job you are attempting to do.

Start by getting the column close to square with the table

The first place to start is to get the column approximately square with the table using the pointers and laser engraved scales on the machine. The first time you set it up you will have to use a machinist's square on the side-to-side column rotary adjustment as the pointer will not have been "zeroed in" yet. None of these adjustments must be extremely precise at this point because a finger type dial indicator will be used to make the final adjustments later. Remove the headstock/motor/speed control unit from the saddle. Place a machinist's square on the table and line up the front of the saddle to get the column approximately square front to back. Then line up on the right side of the saddle to get the column approximately square side to side. Reinstall the headstock assembly.

Check for any built-in error in your machine

ALL SHERLINE MILLS...(See Figure 2.) To check the built-in error of the machine use a dial indicator mounted in the spindle. Move the table under spindle with the Y-axis handwheel and note the error. This error will usually be around .001" to .002" (.05mm) in 3" (76mm). (Remember the components are not precision ground, they are precision milled.) When squaring the head this error should be accounted for. Remember you are squaring the head and spindle to the base of the machine where the saddle travels, not the surface of the table itself. The head doesn't have to be square for this operation as long as you don't rotate the spindle since you are only checking for square in one direction.

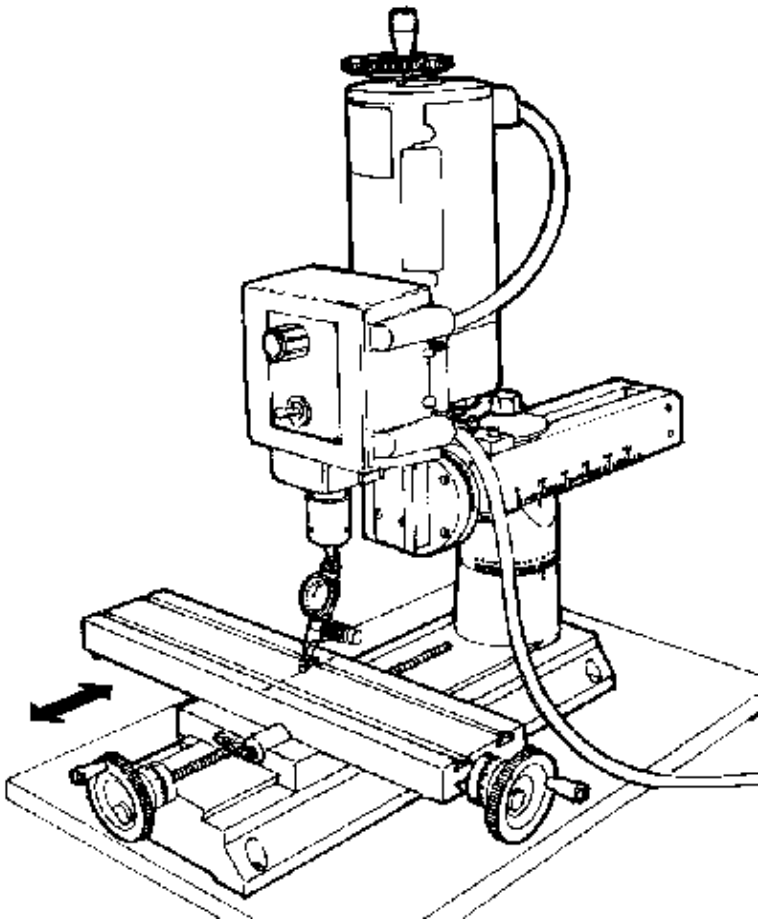

FIGURE 2-Checking for built in error in the table travel along the Y-axis

Squaring up the column

MODEL 2000 MILLS...(See Figure 3.) The next decision to make is where the spindle is to be located. With all the adjustments that can be made with the 8-direction mill you'll probably start with the spindle located near the middle of the X/Y table movements. Something that isn't too obvious should be considered now. If the ram (the two-bar slide that allows you to move the head in or out and left or right) isn't square with the X-axis, the rotating column calibrations will

have an error. To square up the ram, mount a dial indicator to the worktable and move the X-axis back and forth while reading the left and right surfaces of the column bed near the bottom. This only has to be done if you will be rotating the column and want to be able to rely on the angle graduation readings. Once set, lock the ram in place with the flange nut.

MODEL 5000-SERIES MILLS...Though the column ram does not rotate on the 5000-series mills, its squareness can still be checked in the same manner if desired. The factory alignment of the holes is quite accurate, but a small amount of adjustment is available by loosening the two screws that hold the column base to the bed and pressing the base to one side or the other while retightening.

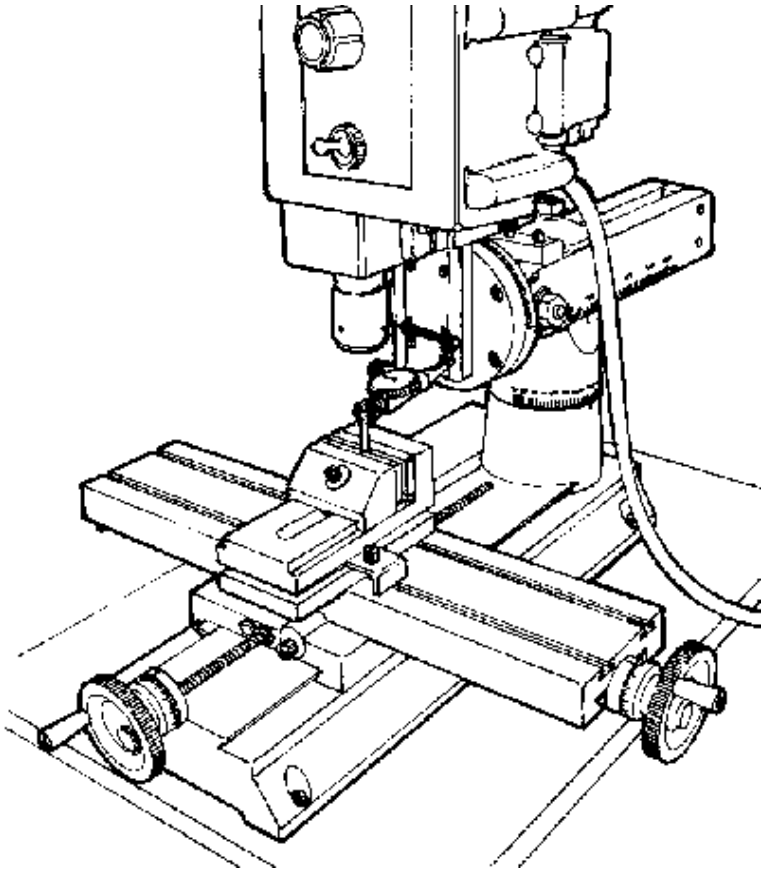

FIGURE 3-Squaring up the ram parallel to the Y-axis on the 2000-series mill. The indicator can be held with a chuck on the table or a mill vise as shown here. When square, tighten the nut on top of the column. 5000/5400-series mills can be adjusted slightly by loosening the two bolts that hold the column base in place, twisting the column slightly and retightening the bolts.

Squaring the column with the X-axis

MODEL 2000 MILL OR MODEL 5000-SERIS MILL WITH OPTIONAL ROTARY COLUMN ATTACHMENT...(See Figure 4.) The column should next be squared with the X-axis. This is

accomplished with an indicator mounted in the spindle. Have the four socket head cap screws used to clamp the column rotation tight enough to keep the column from rotating, but not so tight that you can't move it with a light tap from a plastic mallet to the column bed. Because the axis that allows you to tilt the column in and out hasn't been squared yet you should only read the indicator at the same Y-axis location on the worktable that you used before. Offset the indicator at an angle in the spindle so that when the spindle is rotated it describes about a 2" to 3" circle on the table. Take readings at the extreme left and right positions. Adjust the column with light taps until there is little difference in the readings at either extreme. I wouldn't try to get it perfect yet, just close enough so there isn't a gross error.

Hint: To keep the tip of the indicator from falling into the T-slots, some machinists keep a large ball bearing on hand. The two surfaces of a precision bearing are generally parallel. The bearing is placed on the mill table centered on the spindle and the indicator is run around the surface of the bearing race, which provides a round, flat, parallel surface for the tip of the indicator to run against.

MODEL 5000-SERIES MILLS...This axis is not adjustable on the 5000-series mills, but it can be checked in the same manner. Again, factory alignment should be quite good, but a slight amount of adjustment can be obtained by loosening the four screws that hold the column to the base and pressing the column to one side or the other while retightening.

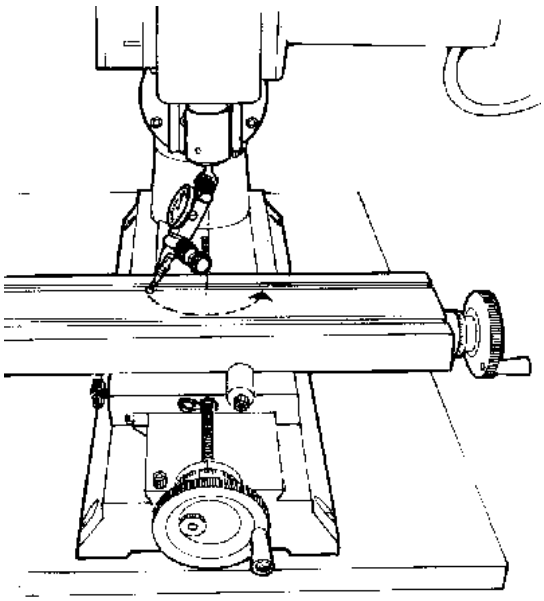

FIGURE 4-Squaring the left to right rotation of the column with the X-axis

Squaring the column with the Y-axis

MODEL 2000 MILLS...(See Figure 5.) Loosen the flange nut on the horizontal pivot pin just enough so that the column can be moved using the adjustment screw in the alignment block but

there is no slop in the assembly. The tilt is harder to set because the spindle doesn't rotate at the pivot point, but once you understand this, the task becomes simpler. This is explained in the example that follows. The alignment block adjustment screw helps make fine adjustments in this direction easy. With the block in place and the flange nut loose, the entire assembly is kept from falling forward by the adjusting screw. This block can be left in place unless the ram is completely retracted or the column is tilted back at an angle that interferes with the block. With the indicator still held in the spindle, take readings parallel with the Y-axis near the front and rear edges of the table. Raise or lower the column with the alignment block adjusting screw until the readings are the same front and rear. Remember the location of the pivot point as you take these measurements and allow for it.

MODEL 5000-SERIES MILLS...This axis is not adjustable on the 5000-series mills, but it can be checked in the same manner. Again, factory alignment should be quite good, but a slight amount of adjustment can be obtained by loosening the two screws that hold the column to the base and shimming the column at the front or back with thin metal shim stock* as needed. Recheck your X-axis alignment after shimming.

*Hint: Shim stock can be purchased from most tooling supply catalogs. If you don't have metal shim stock available, paper or business card stock can be used as a temporary substitute.

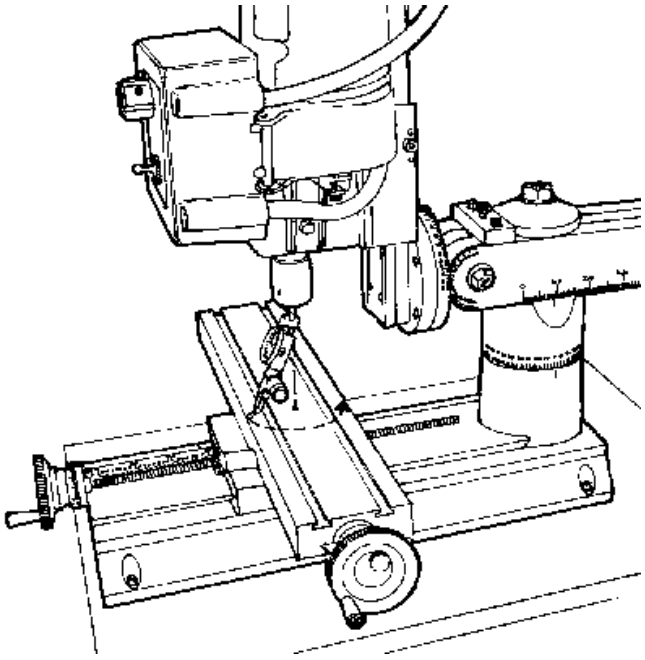

FIGURE 5—Squaring the fore and aft pivot movement of the column with the Y-axis. (See the hint in the section on squaring the X-axis above for a way to keep the tip of the indicator from dropping into the T-slots.)

Example:

If the indicator reading is larger at the front of the table than the back, then that means the column must be tilted back. Say your reading is "0" at the back and .010" (.25mm) at the front. If you tipped the column back until the indicator read zero at the front, the reading at the back would not remain at "0" but would now be a negative reading. This is caused because the pivot point is located far enough behind the spindle so that both front and rear measuring points are still in front of it. Swinging the column back actually raises both points. The front point raises more than the back point, but both do go up. You will have to keep tilting the column back and measuring until you get the same reading front and back. This may require more movement that you first thought based on the difference between the initial measurements.

Fine tuning the headstock alignment

ALL SHERLINE MILLS...(See Figure 6.) It is time to make the final adjustments to the rotating column, but first I'll add a little more confusion to your life. Remember when I said that alignment pins are somewhat useless to line up a machine? Well, as much as I hate to admit it, in a sense we already have one. It is the alignment key that holds the headstock assembly square to the column saddle, which is mounted on the column bed. Removal of this key is what allows you to pivot the headstock on the Sherline lathes and mills. It is one of the features that make our machines easy to use, versatile and very adaptable. It is also another thing you have to consider when searching for "perfect" alignment. If you have more than one key, try not to mix them up because they are matched during assembly to fit as closely as possible. I have found the best way to deal with this potential problem is to push the head square against the key before tightening the cone point screw that locks the headstock in place. If you ever want to check alignment of the key to the column bed, mount a dial indicator in the spindle. Raise and lower the head while reading the vertical edge of a precision square. Adjust the rotating column until there is no error as the indicator moves up and down the square. Now read the table with the indicator. If the slot and key are perfect there shouldn't be any error, but in most cases there will be a small amount. This can usually be eliminated by taking advantage of what play does exist in the alignment key and slot. With the cone point set screw loosened slightly, tap the headstock with a plastic mallet to take out play in the direction you want to go. Then retighten the set screw.

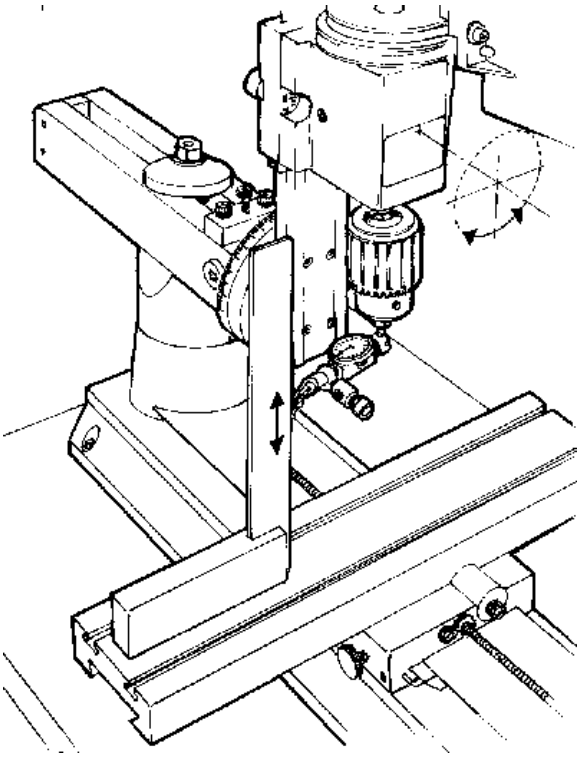

FIGURE 6-Fine tuning the headstock rotation alignment with a machinist's square and dial indicator. The headstock pivots on the saddle pin. Even with the alignment key in place, slight adjustment can be made to get the headstock perfectly square.

Making final adjustments

The rotating column and tilting adjustments can be finalized so the indicator reads "0" as the spindle is rotated, however the error we measured when checking the table flatness could be accounted for now if need be. If the pointer on the back of the rotary column disk doesn't line up with the zero mark, loosen the screw holding it in place and reset it to indicate zero for future reference. *(Model 2000 mills and 5000-series mills with rotary column attachment only.)*

Your machine is now "indicated in" and ready to use. As you get a feel for your machine and go through this adjustment procedure a few times, the time it takes to get good results will decrease. Being able to accurately indicate in a mill is one of the skills that must be developed by any machinist who plans on making accurate parts. Though the adjustments on larger machines may be made in slightly different ways, the skills and procedures you learn here can be applied to other machines as well.

Using the column spacer block

MODEL 2000 MILLS (Standard)...In normal use the column spacer block will not be required. However, if you are working on a larger part or your setup requires more clearance under the swing arm, the spacer block can be installed to raise the column an additional two inches. (Installation will be made easier if you first remove the headstock/motor unit to reduce the

weight of the column.) To install the spacer block, remove the flange nut on top of the column hold-down bolt, and lift off the hold-down washer so that the entire column top and swing arm assembly can be lifted off of the hold-down bolt. Screw the extension bolt onto the end of the column bolt and tighten with an adjustable wrench. Slide the column spacer over the bolt and reinstall the column top and swing arm assembly. Reinstall the headstock/motor unit.

NOTE: The column spacer block is included as standard with the Model 2000 mill. It is optional at extra cost on all mill column upgrades and 8-direction vertical milling columns and upgrades.

MODEL 5000 AND 54OO MILLS (Optional)...There is now an optional column spacer block available for use with the standard mill column. It is P/N 1300 and includes longer bolts needed to attach the column to the base through the spacer block. The spacer block will add 2" of additional distance between the table and the spindle. If you simply need more travel, there is also an optional 15" column bed (P/N 45260) and matching leadscrew (P/N 45270/45280), allowing your column to be converted from the standard 11" height to add 4 more inches of Z-axis travel.

Working with setups that require extremely low or high column travel

MODEL 2000 MILLS ONLY...An upgrade to the Model 2000 mill was introduced in March, 1999. It adds 1.6" of travel to the lower end of the Z-axis movement so that end mills can be brought down below the surface of the table for working on the edge of parts. This travel extension is now standard on all Model 2000 mills. The headstock may be lowered even more by placing the column top (P/N 5655) above the swing arm instead of below it. Remove the flange nut, hold-down washer and swing arm. Place the swing arm over the hold-down bolt directly on top of the column base (P/N 5666). Place the column top back onto the hold-down bolt upside down and replace the hold-down washer and flange nut. Although you cannot use the alignment lines to help square up the head, this makes for a very strong and stable setup. In most cases, however, the new travel extension will make this procedure unnecessary.

Should you wish to work on extremely tall setups that combine several holding devices (i.e., a chuck on top of a rotary table on top of a tilting angle table) you can extend Z-axis travel on the top end by either adding an additional spacer block to the column or by removing the saddle travel extension and attaching the saddle directly to the saddle nut as is done on standard Sherline mills.

Using the saddle locking lever

ALL SHERLINE MILLS...Along with the travel extension, a new saddle locking lever was installed to replace the old saddle friction lock used prior to 2/99. This new locking lever is standard on all mills and vertical milling columns as of that date. This lever is located on the Z-axis leadscrew behind the saddle. When turned to the full clockwise position the saddle will move freely. A spring-loaded ball locates in a detent in the bottom of the lever to hold it in this position. To lock the saddle in position, move the lever to the full counterclockwise position. This locks the lever against the saddle nut which prevents the leadscrew from turning. The exploded view at the bottom of this page shows the location of the components.

Engineering compromises

I'm always at odds with myself when I write instructions on complicated procedures like describing the alignment procedure for this mill. By giving you this much information I know that I am making life easier for some customers by answering their questions. At the same time I am probably confusing another customer who would never have asked the question because of the type of work that the mill or lathe is being used for. I don't want to create a customer who spends all his time trying to achieve perfect alignment for work that doesn't require it and ends up never using the machine. Engineering is always a compromise. I deal with this fact with each new product that I design. While our machines aren't accurate enough for some customers, they are still too expensive for others. I hope you are pleased with the new capabilities this multi-direction mill can bring to your shop. I think you will find the combination of features to offer a very good machining value.

Joe Martin, President and Owner
SHERLINE Products