

Mechanical Axis

The electrical portion of the axis, while providing all of the necessary “brains “ of axis motion, can only turn an electric motor. The mechanical parts of the axis provide the actual mechanism for moving the head, table, and saddle. The major mechanical components of an axis are as follows:

Ways: The ways of the machine provide the surface on which the axis will move. There are two major types:

Linear and Roller Bearing Rails: An I beam shaped rail that is captured by a bearing block containing recirculating bearings. The linear rail provides for higher speeds of motion, and if lubricated will not wear significantly. A linear rail will also have virtually no backlash.

Solid way: A box way or a dovetail way. A way composed of two close fitting surfaces. The fit of the surfaces is tightened using a metal wedge called a gib that is held in place with a screw on each end. The gibs must be periodically retightened to keep a good fit of the way surfaces. A solid way requires more maintenance than a linear rail, but will dampen vibration better and allow for a heavier cut.

Ball Screw: The ball screw provides the force for the axis motion. The ball screw differs from a lead screw in that a ball screw has a “nut” that contains recirculating bearings that allow the screw to maintain high speeds of motion virtually wear free. The nut on the ball screw is attached to the bottom of the table on the “carrier” or “yoke”. The end of the screw will be captured, and the motion of the table results from the nut running along the screw. (some small tool room mills actually have the X axis run through the nut for machine motion.)

Thrust Bearings and Bearing cup: Provide the capture for the end of the screw. It is the thrust bearings that keep the end of the screw tightly in place and allow no end play. If a machine is crashed it will most likely damage the thrust bearings.

Radial Bearing: The radial bearing can be found on the end of the screw opposite the thrust bearings. This bearing supports the end of the screw and prevents wobble in the screw end.

Carrier: Also known as the yoke. It is the connection to the screw and the mass to be moved. The ball screw nut bolts to the face of the yoke, which in turn is bolted to the head/saddle/table. Some tool room type machines use a one piece double yolk for both X and Y axis. Milltronics has avoided using these designs, as they tend to flex considerably.

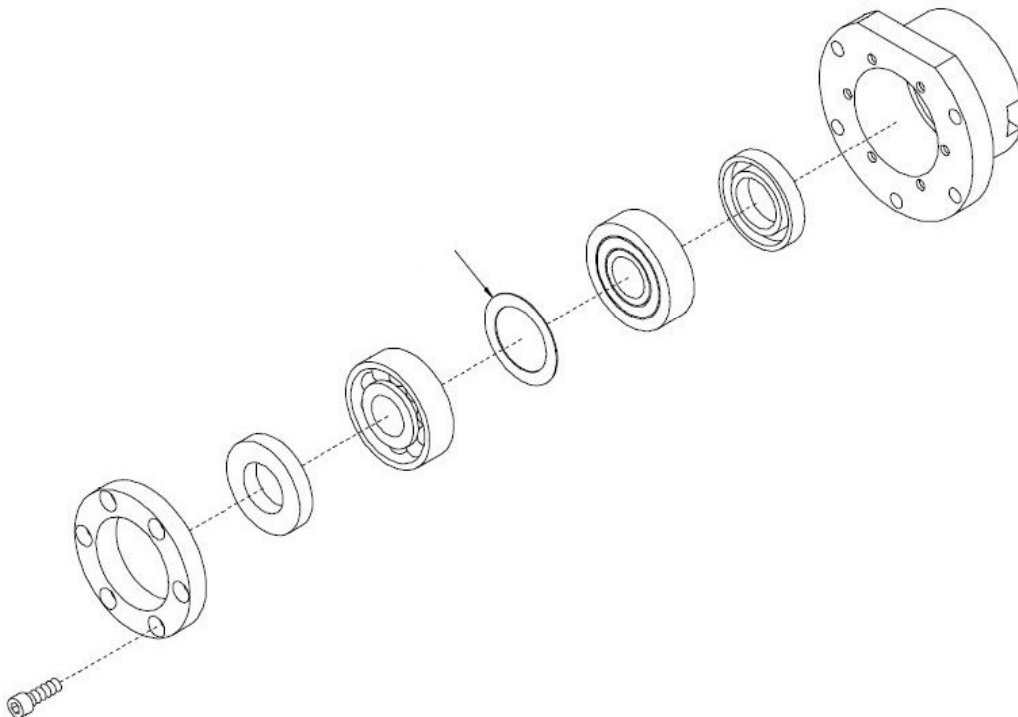
Motor Connection: There must be some kind of connection between the ball screw and the motor. This may be either pulley and belt or a coupler. Many older products are a pulley and belt connection. Most current products are directly coupled to the ball screw shaft.

Counterweight/balance: Provides mechanical assistance for the Z axis to counteract the effect of the weight of the head. Some of the machines in the tool room lines use a counterweight, which consists of a block of iron suspended from chains hanging in the column. The chains are run over sprockets and attached to the head bolster.

Axis Thrust Bearings

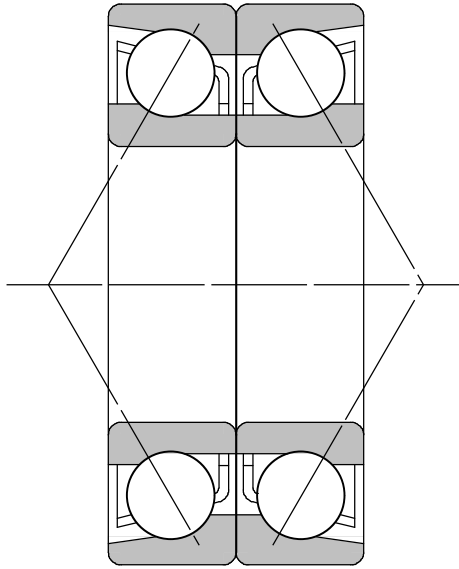
A Milltronics machine typically uses a back to back, or DB, thrust bearing configuration. Three styles of thrust bearing arrangements have been used

- Angular contact – flat ground: These bearings were used in the past for thrust bearings. The inner and outer races are the same width. This type of bearing requires a shim between the outer races of the thrust pair to set the preload.
- Ball screw support pack: An all in one support package that includes the bearing, cup, and mounting flange. These packages began use in approximately 2002. Still used on smaller VM's. They were replaced on VM25 and 30 models by angular contact bearings for ball screw support in 2011.
- Angular contact – ball screw support: Often sold as a set, these bearings are used currently on larger VM machines and many of the import frames. The inner and outer races are ground at different widths to set the proper preload on the thrust pair when the inner races are drawn together. This type of bearing is also used in many of the import frame machines.



A typical thrust bearing assembly.

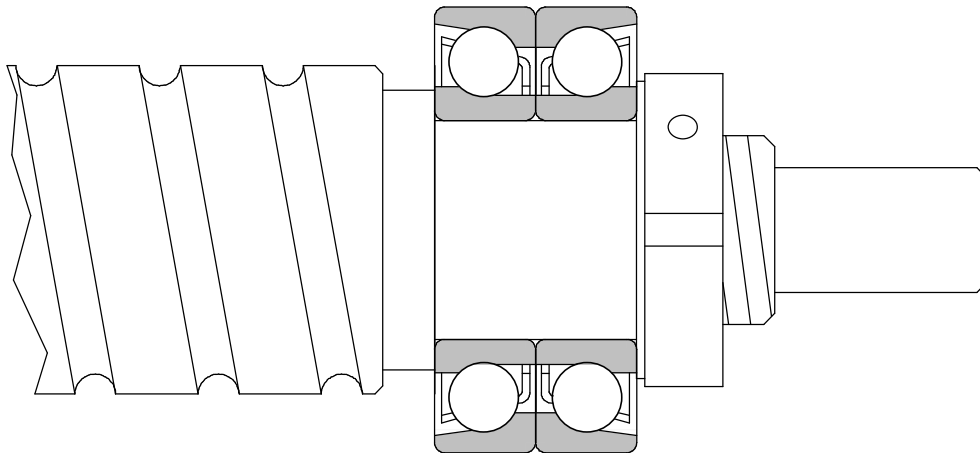
Note the shim between the inner bearing races used only between flat ground bearings.



A back to back, or DB, bearing configuration.

Note that the thicker outer races are together. Bearings with V marks on the outer races should be placed < >.

The ball screw will be held into the bearing assembly with a nut that is typically under the coupler half or pulley. This may be a square nut or a spanner nut. The nut will have brass tipped set screws to help lock it into place. If the nut is removed and reinstalled the brass tip setscrews should be replaced. Use of non-brass tip set screws will damage the threads of the screw and may result in difficulty removing the nut without severe damage to the nut or screw threads.



The nut will draw the inner races together and capture them between the nut and the shoulder on the ball screw. The outer races will be captured inside of the bearing cup. Spanner type nuts can be tightened to torque specs found on the torque chart. Reasonable tightening force should be sufficient if torquing the nut proves impractical as the bearing stack is being tightened with steel to steel contact.

Lathes, VM2016s, and other models may have different axes bearing configurations. Consult the mechanical drawings for the specific machine in question.

Axis Motor – Ball Screw Connection

The motor shaft must be connected to the end of the screw to translate the motor rotation to the ball screw to create the linear motion of the axes. Two types of connections are typical.

Belt and Pulley

Pulleys and belts are most often found on older Milltronics' products, but can still be seen on lathe X axes and some other applications.

A belt and pulley system is not too particular about alignment but is susceptible to positioning problems related to belt tension and wear. Belts should be replaced on a regular basis to avoid this. A belted system may not have a 1:1 ratio of the pulleys to enhance axis torque or speed of movement.

Positioning problems related to belts are relatively easy to diagnose. See the "Pulley Marking Procedure" later in this section for more details on belted system troubleshooting. A machine that shows movement of an axis on the screen while not moving the axis itself and NOT generating any other alarms may have a broken belt.

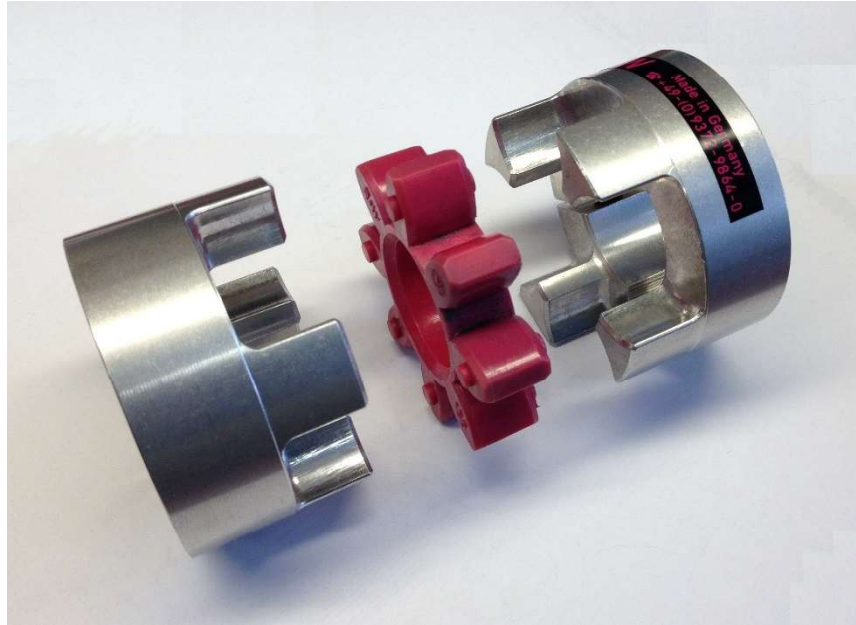
Belts on horizontal axes can usually be tensioned with the weight of the axis motor. An axis belt should not be tight such that there is no deflection when pressed. Excessive belt and bearing wear and/or motor noise can result from a belt that is too tight. Vertical axes often require additional tensioning of the belt to account for the force of gravity against the pulley belt combination.

Direct Coupling

Most current products utilize a direct coupled connection of the motor to the ball screw. The direct coupling eliminates many of the concerns of wear and breakage that a belted system will have while also allowing increased speeds, acceleration, and deceleration.

Alignment of the ball screw journal and motor shaft are critical to this type of connection. This is often achieved through tight fits of the thrust bearing assembly and the motor mount bore. Gross misalignments can result in premature coupler wear or possibly even a broken motor shaft (solid coupler).

The coupler is designed to take up whatever small residual alignment issues remain. The center element in the coupler is a polymer that deforms to take up any potential misalignments. The color of the insert denotes the hardness of the insert. The type of insert used can vary depending upon the product on which the coupler is installed. Axes that carry more weight will use couplers with a harder insert.



The R+W coupler allows for easy removal of the axis motor. The coupler halves will pull apart and remain on their respective shafts. The insert can be removed, cleaned, and replaced if need be. Inserts should be lubricated with Vaseline or similar petroleum jelly prior to installation. Bearing grease is not recommended for lubricating the insert as it may cause some degrading of the insert over time.

Mark the coupler halves together with a permanent marker or paint marker before separating them. This allows for reassembly of the coupler in the original alignment so that there will not be a change in home location or a loss of position if a motor is removed and reinstalled. Look for such marks on any motor removed at the factory for shipping purposes and align accordingly on reinstallation.

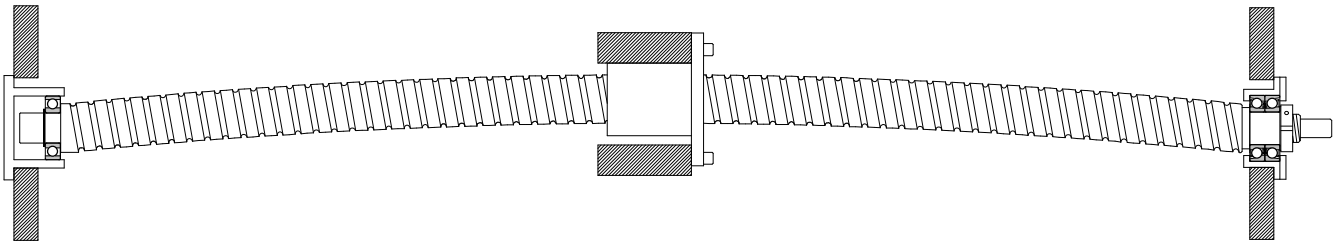


When installing a coupler make sure to leave one half loose until all other motor / ball screw / bearing cup hardware has been tightened. This will insure that coupler insert is not squeezed and that there is not excessive end load on the motor. Set a 2.5 mm gap between the metal halves of the coupler with an allen wrench or other spacer prior to final tightening.

Ball Screw Alignment

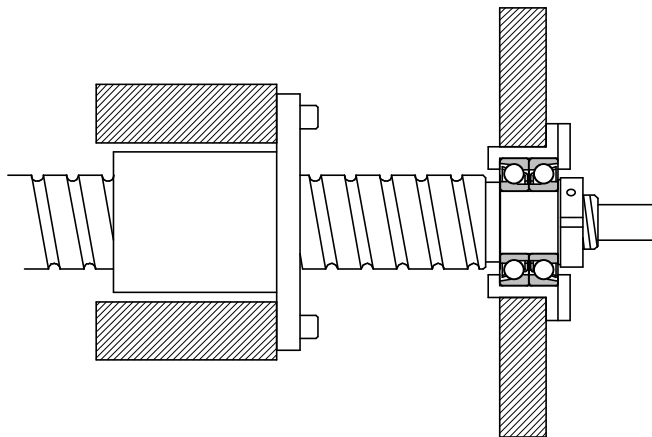
Alignment of the ball screw is key to the proper operation of the machine tool. Improper alignment will cause binding. This can result in premature wear of the bearings and screw, faults and overloading of the motor, and axis positioning problems.

Binding due to misalignment will be most apparent at the ends of travel where the distance between the ball nut and the bearings is shortest. Binding in the center of travel may be minimal as the screw has the most ability to bend to compensate for the misalignment. Binding can be best detected either by monitoring the load on the axis drive or by turning the screw by hand.

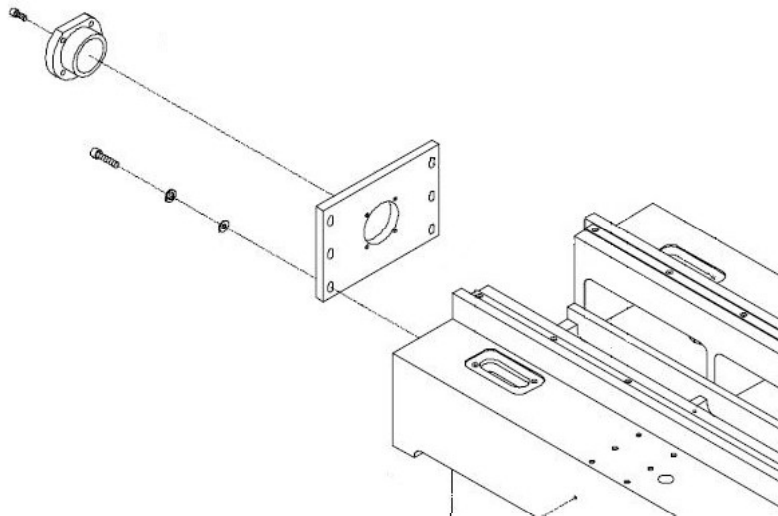


The screw must be aligned by “floating” the ball nut and/or bearings into place. Typically this involves moving the axis so that the nut is closest to an end of travel, then loosening and retightening the bolts on the ball nut or bearing assembly at that end. This may need to be done more than once to “fine tune” the alignment.

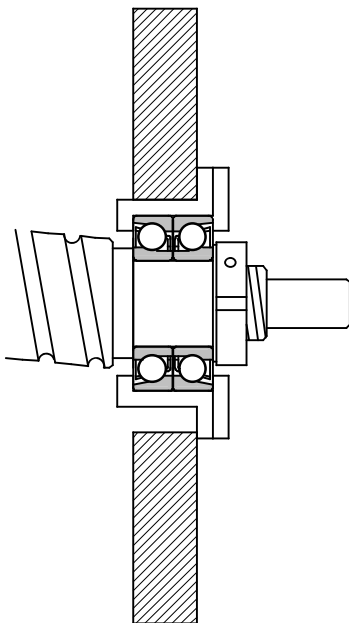
The starting point depends upon what is “unmovable” in the given axis. Always start alignment on the non-moveable end. Some machines have tight bore around the thrust bearing assembly while some do not. If the thrust bearing assembly is in a tight bore then the nut must be adjusted to the position of the thrust bearings first. There is typically a hole in the bottom of the saddle to access the ball nut bolts. Final tightening will have to be done with a long extension with the table moved to the other side of travel.



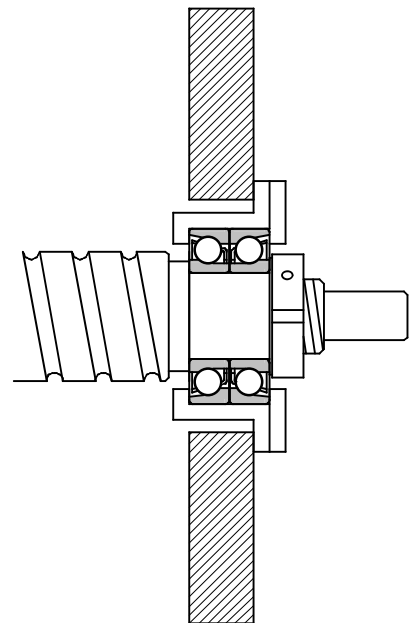
Once this is done the radial support assembly can be adjusted to the position of the ball nut. Move the nut down near the radial support assembly and loosen and retighten the bolts holding the radial support plate.



If the thrust assembly is in a loose bore it can be adjusted to the position of the nut so long as there is room. Make sure the sides of the assembly are not hard against the bore it is fitted into by removing the bolts from the thrust assembly and making sure that it can be spun around the screw without rubbing the sides.



Thrust assembly against side of bore. Adjust the ball screw nut on the carrier to allow the bearing cup to be moved back to center so the assembly is not bound inside the hole.



Thrust assembly with room all of the way around inside the bore. Assembly can be floated so long as it does not contact the side of bore.