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

HiTorque™ Mini Mill Users Guide

Model 3990 • Model 4190 Deluxe • Model 6450 Deluxe, Mirror Display

from LittleMachineShop.com®

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Contents

Introduction

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

Specifications

End Milling Capacity	0.6" (16 mm)
Face Milling Capacity	1.2" (30 mm)
Drilling Capacity	0.5" (13 mm)
Table Size	18.1" x 4.7" (460 mm x 120 mm)
T-slots	3 slots 0.47" (12.0 mm) wide
X-Axis Travel	11.8" (300 mm)
Y-Axis Travel	5.1" (130 mm)
Z-Axis Travel	10.6" (270 mm)
Throat	6.5" (165 mm)
X- and Y-Axis Feed Screws	0.0625" (1.59 mm) per rotation
Positioning Accuracy	0.0004" (0.010 mm)
Spindle Taper	R8
Spindle Motor	0.67 hp (500 Watts)
Spindle Speed	100 - 2500 RPM ±10%
Power Requirements	120 V 60 Hz 8 Amps
Machine Weight 3990/4190	124 lbs (57 kg)
Overall Dimensions (W x D x H) 3990/4190	23.2" x 19.7" x 35.4" (590 mm x 500 mm x 900 mm)
Machine Weight 6450	187 lbs (85 kg)
Overall Dimensions (W x D x H) 6450	23.2" x 19.7" x 36.3" (590 mm x 500 mm x 922 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 mini 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 mini mill is just that, a *mini*, or 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

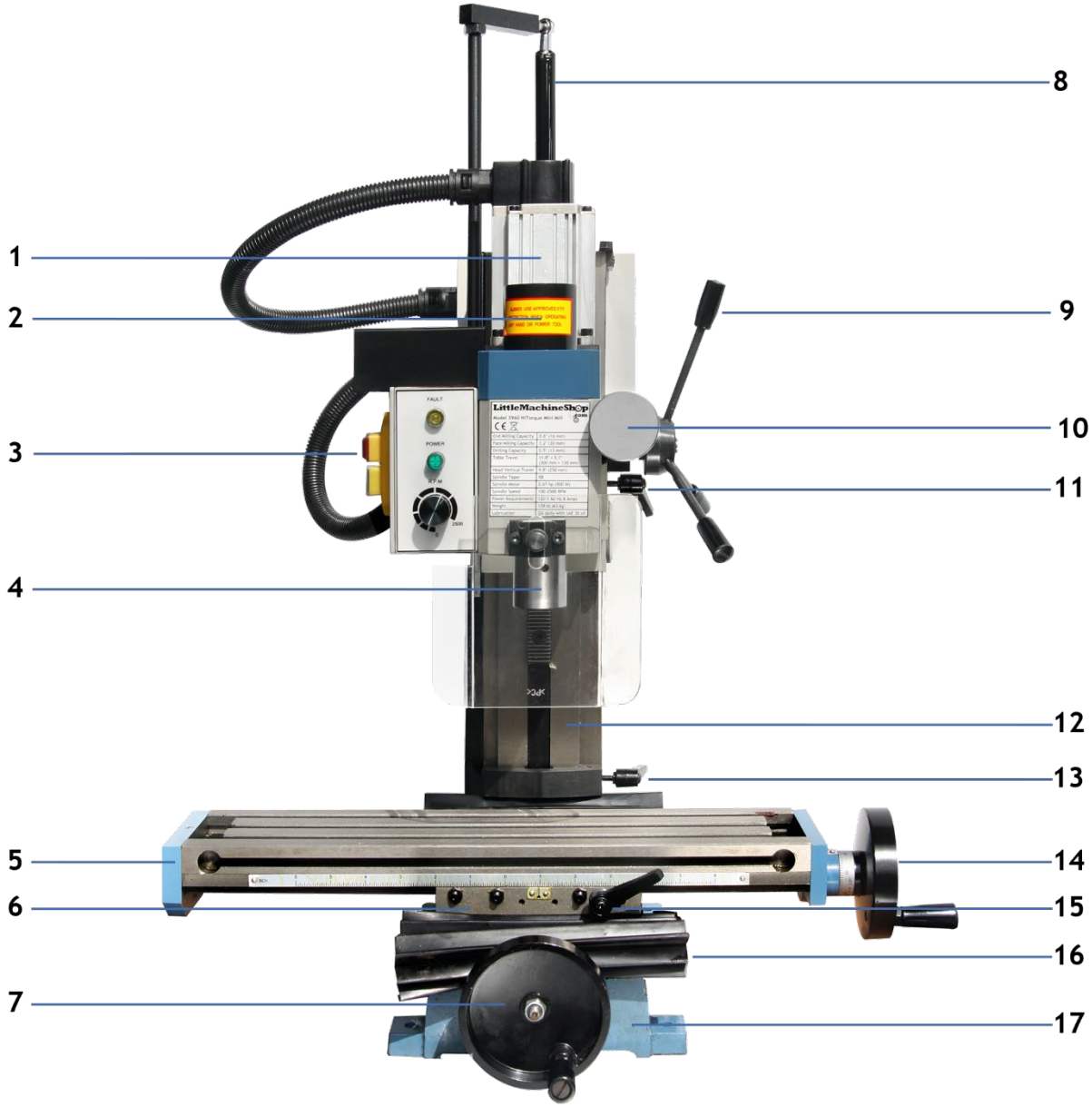
- Plug the machine into a grounded, ground fault protected receptacle.
- Ensure that all components are properly grounded. The easiest way to ensure this is to plug your machines and devices into grounded outlets that you have tested.
- Use caution when using liquids and electricity. Ensure that coolants 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

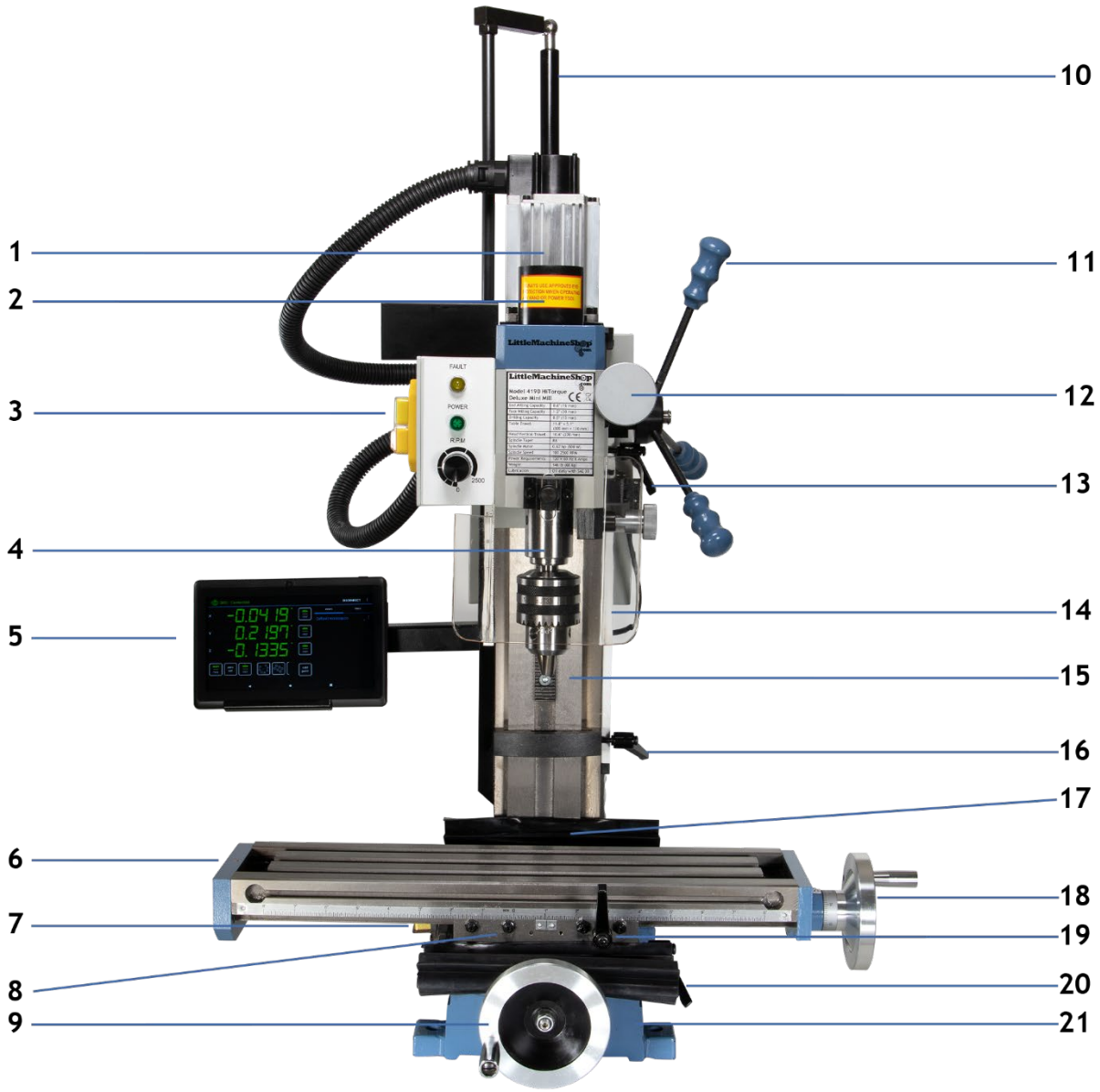
- Keep bystanders, children, and visitors a safe distance away while operating any power tool.
- Read the manual. Know the operation of every control before you attempt any operation of the machine.
- Make sure that all guards are in place and functioning before operating the machine.
- Check for damage 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 two 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



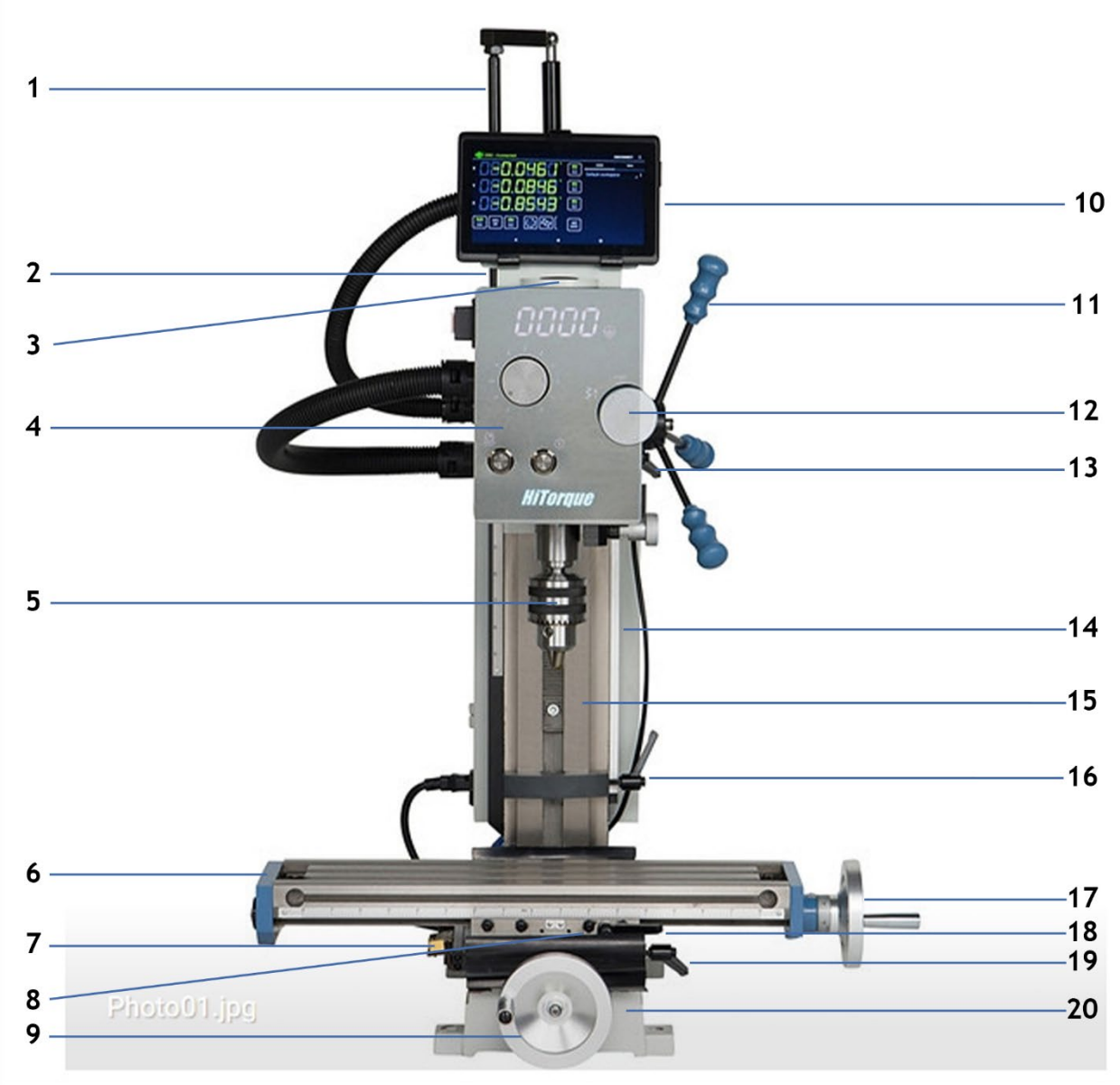
Model 3990 Shown

1. Motor
2. Drawbar (under cap)
3. Motor controls
4. Spindle
5. Table
6. Saddle
7. Y-axis hand wheel
8. Air Spring
9. Z-axis coarse feed handle
10. Z-axis fine feed knob
11. Z-axis lock lever
12. Column
13. Z-axis travel stop
14. X-axis hand wheel
15. X-axis lock lever
16. Y-axis lock lever
17. Base



Model 4190 Shown

1. Motor
2. Drawbar (under cap)
3. Motor controls
4. Spindle
5. DRO Tablet
6. Table
7. Y-axis DRO Scale & Reader
8. Saddle
9. Y-axis hand wheel
10. Air Spring
11. Z-axis coarse feed handle
12. Z-axis fine feed knob
13. Z-axis lock lever
14. Z-axis DRO Scale & Reader
15. Column
16. Z-axis travel stop
17. X-axis DRO Scale & Reader
18. X-axis hand wheel
19. X-axis lock lever
20. Y-axis lock lever
21. Base



Model 6450 Shown

1. Air Spring
2. Motor
3. Drawbar (under cap)
4. Motor controls
5. Spindle
6. Table
7. Y-axis DRO Scale & Reader
8. Saddle
9. Y-axis hand wheel
10. DRO Tablet
11. Z-axis coarse feed handle
12. Z-axis fine feed knob
13. Z-axis lock lever
14. Z-axis DRO Scale & Reader
15. Column
16. Z-axis travel stop
17. X-axis hand wheel
18. X-axis lock lever
19. Y-axis lock lever
20. Base

Basic Accessories

The following accessories come with the HiTorque Mini Mill.

- Mini Mill Users Guide
- 2 T-slot nuts with 3/8"-16 thread
- Three open end wrenches (8/10 mm, 14/17 mm, 17/19 mm)
- Four hex (Allen) wrenches (3, 4, 5, and 6 mm)
- One 45-52 mm spanner wrench
- Spindle lock pin
- One 1/2" drill chuck and R8/JT33 arbor
- Oil can (plastic)
- 7" Android tablet for DRO display (Models 4190 & 6450)
- T-type socket wrench for drawbar (Model 6450)

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 27 for specific recommendations for lubricants.

Assembly

There is only one thing to do to assemble your mill. Install the handles on the X- and Y-axis hand wheels. The handles should turn freely when installed.

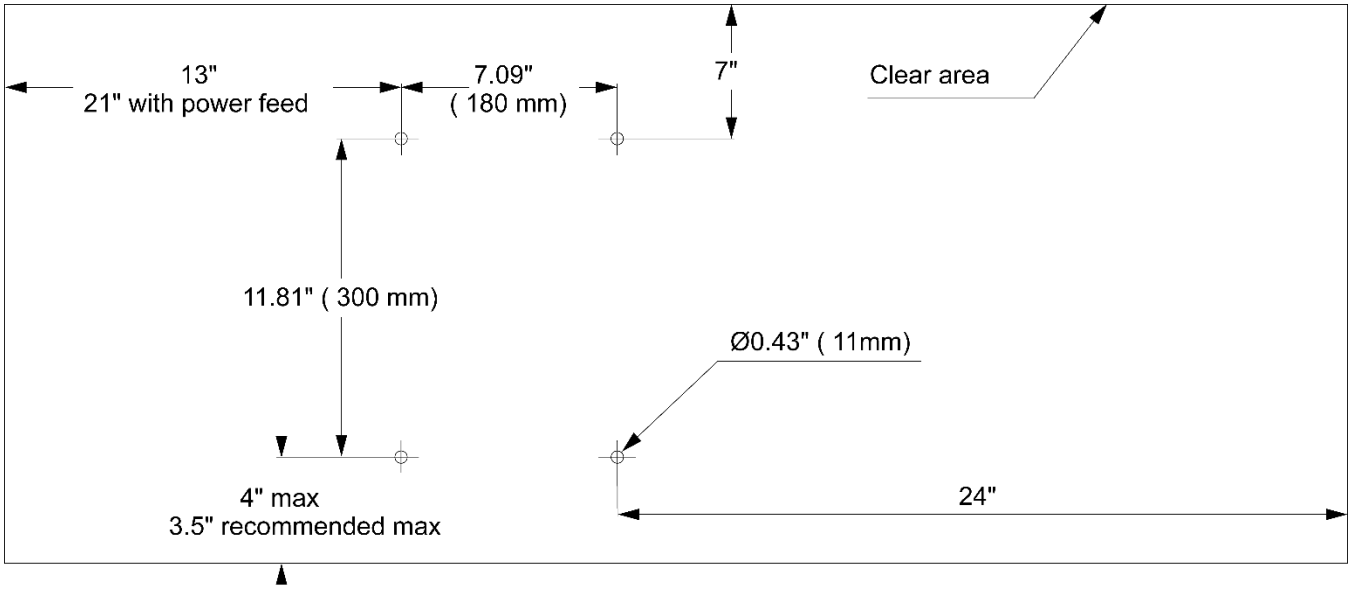
Mounting Your Mill

The mini mill must be bolted down to the workbench because it is top-heavy. It is unsafe to operate the mini mill if it is not bolted to a workbench.

Before you mount your mini mill, plan the positioning carefully. If you simply bolt it to the middle of the workbench, you won't be able to turn the Y-axis hand wheel. Either mount the mini mill at the front edge of the bench so the Y-axis hand wheel hangs over the edge of the bench, or mount the mini mill on a riser about 1.5" 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 mini mill.



Mount the mill to the workbench with 3/8" or 10 mm bolts. The bolts should be about 1" (25 mm) longer than the thickness of the workbench. Use fender washers on the underside of wooden benches to prevent the nuts from pulling through.

Operating Controls

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

Motor Controls

3990 / 4190 Controls

1. Power and emergency stop (E-stop) switch
2. Speed control

Power Switch and Emergency Stop (E-stop) Switch

The green power switch enables input power to the speed control circuit board. The red E-stop switch disconnects the power.

Turn the power off when you are not using the mill.

Speed Control Knob

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

6450 Controls

1. Power switch & Emergency stop (E-stop) switch
2. Spindle speed readout
3. Speed control knob
4. Z-axis fine feed knob
5. Spindle direction button
6. Start/stop button

Power Switch and Emergency Stop (E-stop) Switch

The green power switch enables input power to the speed control circuit board. The red E-stop switch disconnects the power.

Turn the power off when you are not using the mill.

Spindle Speed Readout

The spindle speed readout shows the speed of the spindle in revolutions per minute (RPM). It also indicates the direction of turning, forward or reverse.

Speed Control Knob

The speed control knob adjusts the spindle speed.

Z-axis fine feed knob

See Z-Axis Fine Feed Knob on page 17.

Spindle Direction Button

The spindle direction button controls the direction the spindle turns. After turning on the power and pressing start, the spindle turns in the forward direction - the direction used for normal turning. Press the button to toggle between forward and reverse directions. The button illuminates to indicate reverse direction.

You can change the motor direction at any time and at any speed that safety allows. The motor will make a controlled change of direction.

Start/Stop Button

The Start/Stop button illuminates and starts the spindle when pressed while the power is on. The spindle runs at the last set speed. Press the button again to stop the spindle. Use this button for normal operation of the mill.

Using the Motor Controls

Use the motor controls to turn the spindle.

Models 3990 & 4190

To power up the mill:

1. Turn the speed control to the minimum speed position.
2. 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.

To start the mill:

1. Ensure that the speed control is set to the minimum speed position.
2. Advance the speed control to the desired speed.

To stop the mill:

- Turn the speed control to the minimum speed position.

Model 6450

To power up and start the mill:

3. Turn on the power switch by pressing the green button. The control panel LED displays will illuminate.
4. If you do not remember your previous turning speed or want to begin turning at the minimum speed, turn the speed dial counterclockwise to the lowest RPM.

5. Press the start/stop button to begin the spindle turning. The spindle will begin rotating at the last speed set on the speed dial when the mill was turned off or the start/stop button was disengaged. The start/stop button will illuminate when engaged.
6. Adjust the spindle speed dial to the desired RPM.
7. If you wish to change the spindle direction, press the spindle direction button. The spindle will briefly stop its rotation and then change direction at the same speed it was spinning before the direction change. The spindle direction button will illuminate when engaged.
8. Adjust the speed control as necessary.

To stop the mill:

9. If you do not wish your next operation to begin at the current spindle speed, turn the speed control down to the minimum speed.
10. If the spindle is in the reverse rotation press the spindle direction button. The spindle will momentarily stop and begin spinning in the forward rotation.
11. Press the start/stop button. The spindle will stop rotating.
12. If you want to power down the mill, press the red button to turn off the power. The LED control illumination will turn off.

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 Mini Mill has 62.5 graduations on the dial. Each full turn of the hand wheel moves the table 0.0625" (1/16").

X-Axis Lock Lever

The X-axis lock lever is on the front of the saddle behind the Y-axis hand wheel. Use this lever to lock the X-axis 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 before you can disengage the lever.

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 Mini Mill has 62.5 graduations on the dial. Each full turn of the hand wheel moves the table 0.0625" (1/16").

Y-Axis Lock Lever

The Y-axis lock lever is on the right side of the saddle behind the X-axis hand wheel. Use this lever to lock the Y-axis 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 Coarse Feed Handles

The Z-axis coarse feed handles are on the right side of the spindle housing. The three long handles allow you to quickly lower and raise the head. Use them to position the mill head, and also for drilling.

Z-Axis Fine Feed Knob

The Z-axis fine feed knob is located on the right front corner of the spindle housing. Use this knob to make fine adjustments to the position of the head assembly.

There are 60 divisions on the dial. Each full turn of the knob moves the head assembly 0.060". Each division of the dial represents a movement of 0.001".

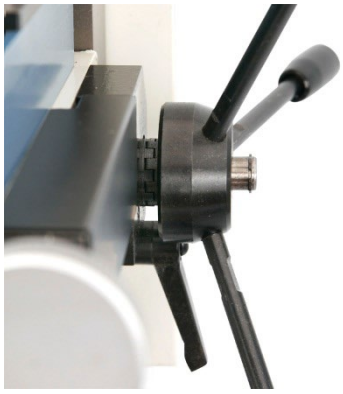
To engage the Z-axis fine feed:

- Move the hub and coarse feed handles in to engage the dog clutch. You might need to turn the Z-axis fine feed knob to align the dogs.

To disengage the Z-axis fine feed:

- Move the hub and coarse feed handles out to disengage the dog clutch. You might need to turn the Z-axis fine feed knob to relieve pressure from the dogs.

Fine feed disengaged



Fine feed engaged

Z-Axis Lock Lever

The Z-axis lock lever is on the right side of the head assembly behind the Z-axis coarse feed hub. Use this lever to lock the Z-axis 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.

Bluetooth DRO (Models 4190 & 6450)

The Android tablet included with your DRO has the SIEG DRO app preinstalled. To begin using it, you must pair the tablet to the DRO scales, and you must configure the app, as described in the following sections.

> Chris' Tip: The table comes with a protective film on the screen. This film is sometimes hard to see but it can be removed to enhance visibility. If you are fine with the display with the film on, it can be left on to protect the device and does not impair operation.

To pair the devices

Be sure the Bluetooth transceiver is plugged in. (If you have the 4190 or 6450 Deluxe Mini Mill, the transceiver is plugged in when the machine is plugged in.) Follow these steps to pair the Bluetooth transceiver with your Android tablet.

On the Android tablet:

1. Turn on the power and swipe up to unlock it.
2. Open Settings. (If you don't see a Settings icon near the center of the screen, open the app drawer—the middle icon of the quick launch bar on the bottom or right edge of the screen.)
3. In Settings, tap **Bluetooth** under Wireless & Networks.
4. Tap **Search For Devices** in the upper right corner of the screen.
5. Tap **HC-06** when it appears under Available Devices.
6. Enter the PIN 1234 and tap **OK**.

The devices are now paired.

> Chris' Tip: If you're using a single display device for multiple DROs, you can change the name from HC-06 to give each machine a unique name. Tap a name under Paired Devices, edit the name, and tap **OK**.

To configure the app:

1. Start the SIEG DRO app.
2. If it appears in the upper-right corner of the screen, tap **Connect** to select the correct Bluetooth device. Tap **HC-06** to select the mill.
3. The vertical ellipsis in the upper right corner of the screen is a menu. Tap it and select **Settings**.

4. Here is where you tell the app about your machine. Verify the following settings.
   - Machine type: Mill
   - Under X Axis
     - Axis CPI: 5080
     - Invert Readout: check
   - Under Y Axis
     - Enable Y Axis: remove check
   - Under Z Axis
     - Axis CPI: 5080
   - Under W Axis
     - Enable W Axis: remove check
5. Tap the Back button at the bottom of the screen when you have made the settings.

Using the app

Your DRO should now be working. Turn a hand wheel and watch the numbers change.

The axis readouts appear at the left top of the screen.

The row of buttons across the bottom affect all axes.

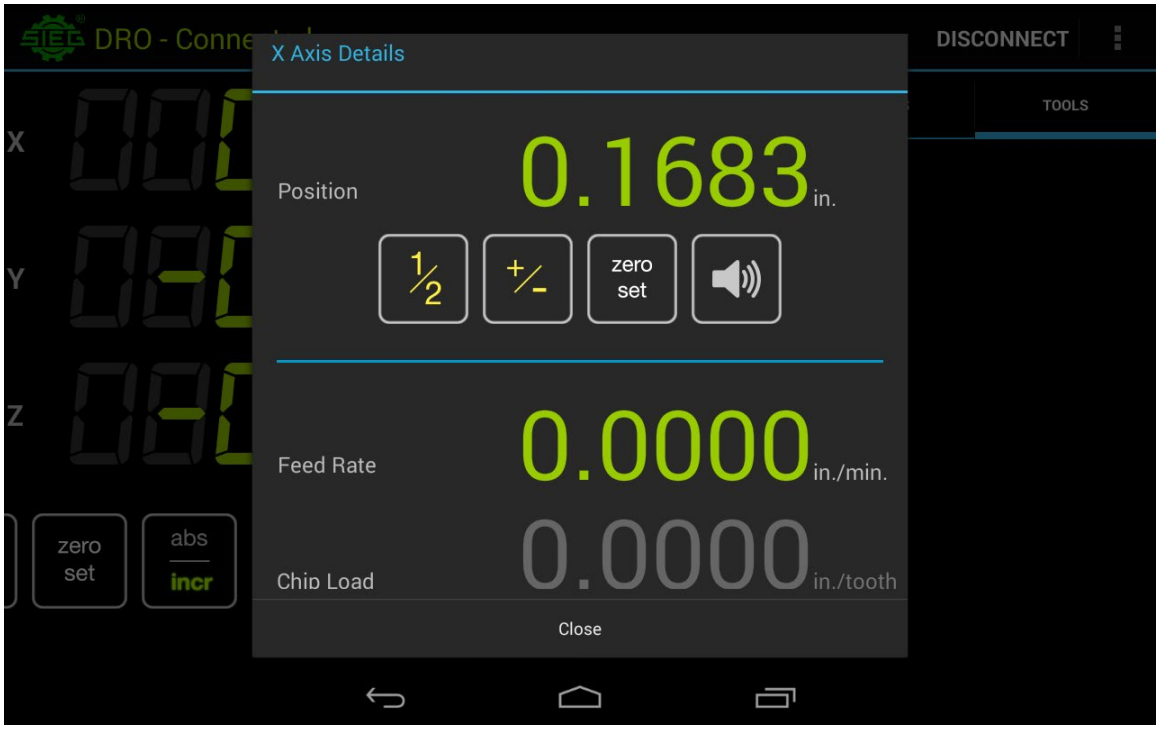
The row of abs/incr buttons to the right of each axis readout affect that axis.

The right side of the screen is for more advanced functions.

	Chooses inch or mm display
	Sets the workspace origin to the current position of the machine
	Selects Absolute coordinates or Incremental coordinates for all axes
	Creates circular bolt patterns
	Creates rectangular bolt patterns
	Specifies tool offsets

Axis detail settings

Tap one of the axis position values to see the Axis Details.



Tap the Position value to enter the current position value.

1/2	Reduces the position value to half its value. Use this for centering. If you are viewing an absolute value, it stores half the absolute value in the incremental value. If you are viewing an incremental value, it halves the incremental value.
+/-	Changes the sign of the position value and changes the “positive” direction of that axis.
zero set	Tap to set the incremental value to zero. Hold to set both the absolute value and the incremental value to zero.
	Turns on the warning that you are approaching a defined point.

Absolute vs incremental coordinates

The DRO keeps track of two coordinate systems: absolute and incremental.

Absolute coordinates are the overall coordinates of your work piece. Select a corner of the workpiece and use your edge finder to set the X- and Y-axes to 0.000 at this corner.

Incremental coordinates are used when you want to work on a feature, such as a bolt circle, that exists on your work piece. You can, for example, set an incremental 0, 0 position at the center of a circular bolt circle, and then use incremental values to place the holes.

Points and workspaces

Points are a set of coordinates that define a spot on your work piece. Workspaces keep track of points that you have recorded. The right side of the display window shows a list of recorded points.

You can create points several ways.

To save a point:

Any time you are at a location you want to save, tap **Add Point**. A point with the current coordinates is added to the list.

Creating bolt patterns

Tap to create a circular hole pattern. Enter the required values and tap **Create Circle**. A series of points is saved.

Tap to create a linear or grid hole pattern. Enter the required values and tap **Create Pattern**. A series of points is saved.

To go to a point:

Tap the point in the list. The display changes to show how far from the point you are. Simply move the carriage and cross slide until the Z- and X- positions read zero and you are at the point.

To de-select a point, tap it again.

To preview a workspace

Once you have a collection of points, you can get an idea if they are correct by previewing the workspace. Tap the vertical ellipsis menu to the right of the workspace name. Choose Preview Workspace to see the relationship of the points.

Tools

The DRO can keep track of your tool dimensions. This is useful if your tools maintain their Z-axis position between uses, such as when you use end mill holders or collet chucks to hold your end mills. Replacing a tool like this will return it to the same Z-axis position.

You can enter the values for the current tool using the [Square & Circle] button. Enter the values and tap **Set Tool Offset**.

This is also one way to select a predefined tool when you are using it. Tap the [Square & Circle] button and select the tool from the Predefined Tool list. Tap **Set Tool Offset**.

Adding a tool

To add a predefined tool, tap the vertical ellipsis menu in the upper right corner. Select Add Tool.

Name your tool and add the values for that tool. Tap **Save** to add the tool to the list of tools.

Choosing a predefined tool

To choose a tool and use the predefined offset, simply tap the tool in the list of predefined tools. The Tool Offset window appears. You can adjust any values you need for this job and tap **Set Tool Offset**. These changes are not saved with the tool.

To modify or delete a tool:

Tap and hold the tool's name in the list of predefined tools. Then tap **Edit Tool** or **Delete Tool**.

Starting a work piece

Use this process to set the absolute X- and Y-axis coordinates for a new work piece. We'll describe the process using a mechanical edge finder. Note that using a laser edge finder makes the process significantly simpler because you don't need to account for the diameter of the edge finder.

These instructions set the 0, 0 location on your work piece at the rear left corner.

With the work piece secured in your vise, follow these steps:

1. Tap abs/incr in the bottom row so "abs" is highlighted.
2. Touch off the left side of the work piece.
3. Tap the X-axis value so X Axis Details appears.
4. Hold zero set until the Are You Sure message appears. Tap **Yes**, then tap **Close**.
5. Raise your edge finder to clear the workpiece and turn the X-axis hand wheel so the X axis displays half the diameter of the edge finder. The center of the edge finder is now over the edge of the work piece.
6. Tap the X-axis value so X Axis Details appears.
7. Hold zero set until the Are You Sure message appears. Tap **Yes**, then tap **Close**.
8. Touch off the back side of the work piece.
9. Tap the Y-axis value so Y Axis Details appears.
10. Hold zero set until the Are You Sure message appears. Tap **Yes**, then tap **Close**.
11. Raise your edge finder to clear the workpiece and turn the Y-axis hand wheel so the Y axis displays half the diameter of the edge finder. The center of the edge finder is now over the edge of the work piece.
12. Tap the Y-axis value so Y Axis Details appears.
13. Hold zero set until the Are You Sure message appears. Tap **Yes**, then tap **Close**.

Centering a work piece

Centering a workpiece is as easy as touching off two sides. Follow these steps:

1. Tap abs/incr in the bottom row so "abs" is highlighted.
2. Touch off one side of the work piece.
3. Tap the corresponding axis value so Axis Details appears.
4. Hold zero set until the Are You Sure message appears. Tap **Yes**, then tap **Close**.

5. Raise your edge finder to clear the workpiece and move to the other side of the work piece.
6. Touch off the opposite side of the work piece.
7. Tap the corresponding axis value so Axis Details appears.
8. Tap 1/2. The value changes to half the previous value. Tap **Close**.

Note that the that axis has changed to Incremental. If you want to set the absolute zero to the center of the work piece, follow these additional steps.

1. Move so the axis displays 0.000.
2. Tap the corresponding axis value so Axis Details appears.
3. Hold zero set until the Are You Sure message appears. Tap **Yes**, then tap **Close**.

Using a different tablet as a display device

The DRO app runs on Android devices. Here are the requirements:

- Android OS 4.0 or newer
- 7" multi-touch screen with 1024x600 resolution (recommended); 4" screen with 800x480 resolution (minimum)
- Bluetooth support

LittleMachineShop.com sells a suitable Android tablet, but as you can see from the requirements, almost any Android tablet that has Bluetooth capability will work.

Installing the DRO app

Go to the Apps store at Google Play to find and install Yuriy's Toys TouchDRO. Be sure to set the Counts Per Inch to 5080.

Adjustments

Keeping your mini 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.

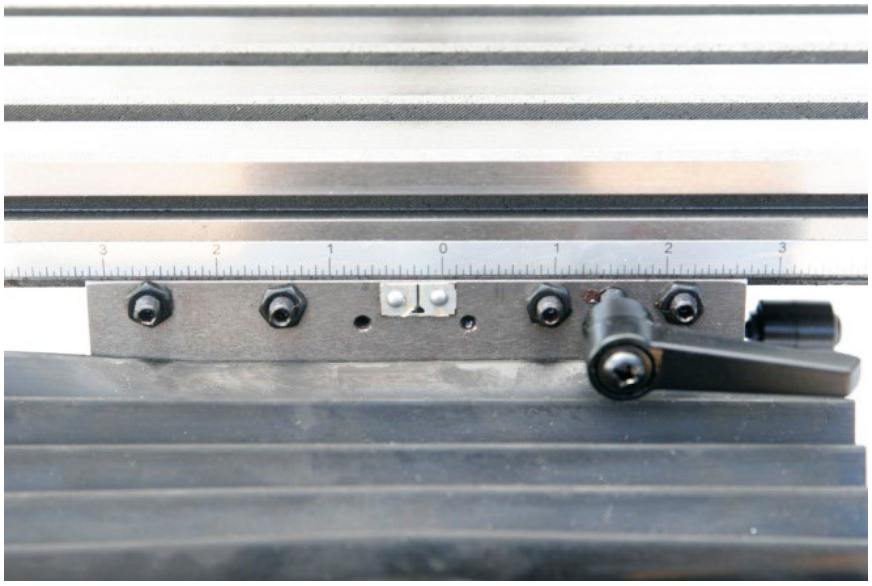
X-Axis Gib

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 mini 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 two 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 right side of the head assembly.
2. Slightly loosen all four setscrews on the right 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 turning the Z-axis coarse feed handles. Loosen or tighten all the setscrews the same amount until the head assembly moves freely, but without play in the dovetail.

Tramming the Mill

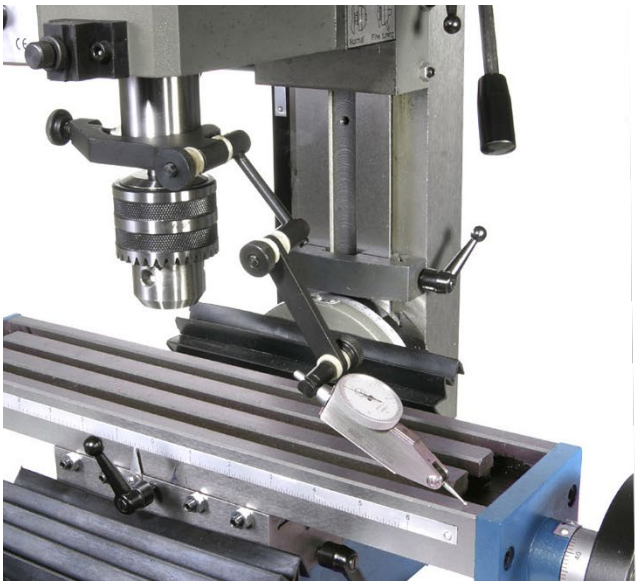
Tramming is the process of squaring the column with the table on a mill. It involves placing shims under the corners of the base of the column where it bolts to the base.

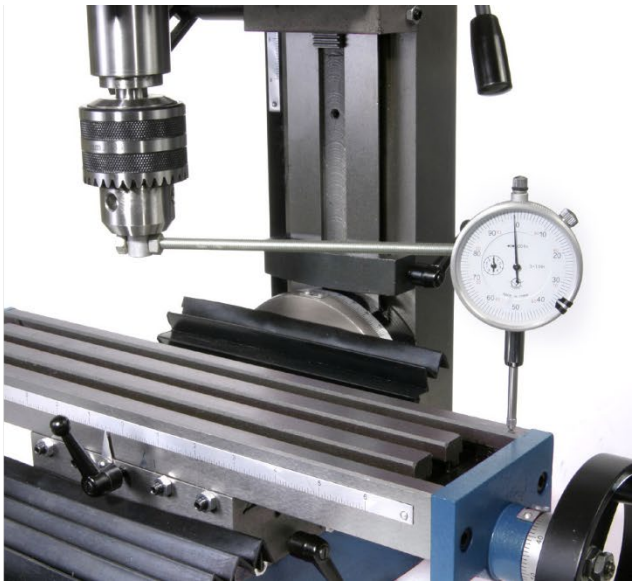
Tramming the mill requires the use of a dial indicator, or better, a dial test indicator. The indicator is mounted so that it rotates with the spindle and reads against the table at the farthest distance possible from the spindle.

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 (part number 3984), 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 mini 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 bearings	Lubriplate 3V Machine Tool Oil	Yearly	

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

Maintenance

Maintenance of the mini mill is simple, but important. Regular maintenance will keep your mini 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 mini 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 mini mill spindle by the R8 taper.

R8 taper end mill holder

The tools are held in the spindle by the drawbar. The drawbar is effectively a long bolt that goes down through the spindle and retains the tool.

To remove a tool from the spindle (Model 3990):

1. Remove the plastic cap from the top of the spindle.
2. Insert the spindle lock pin the hole in the side of the spindle.

3. Use a wrench to loosen the drawbar about ½ turn.
4. Tap the top of the drawbar with a soft-faced hammer to disengage the taper.
5. Hold the tool with one hand to prevent it from dropping and unscrew the drawbar. Remove the tool.

To install a tool into the spindle:

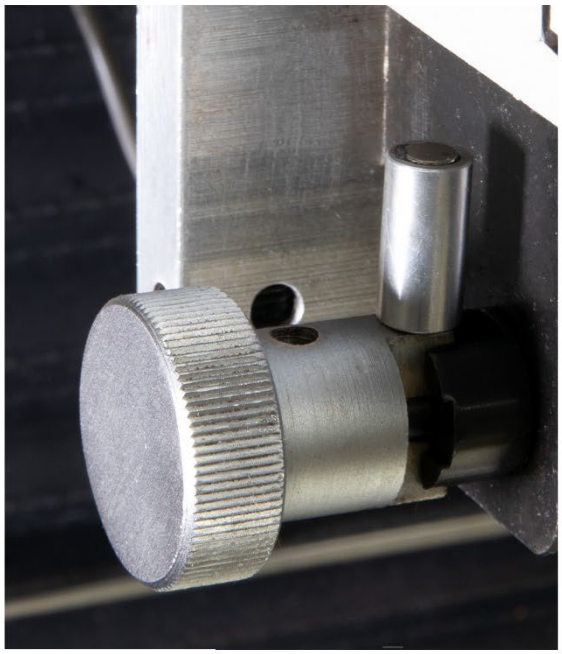
1. Put the drawbar down through the spindle from the top.
2. Put the tool up into the spindle and thread the drawbar into it.
3. Rotate the tool until the locking pin engages the slot in the side of the tool.
4. Hold the tool with one hand and tighten the drawbar with a wrench. Do not use the spindle lock pin to tighten the drawbar, as you will make it too tight.
5. Replace the plastic cap on the top of the spindle.

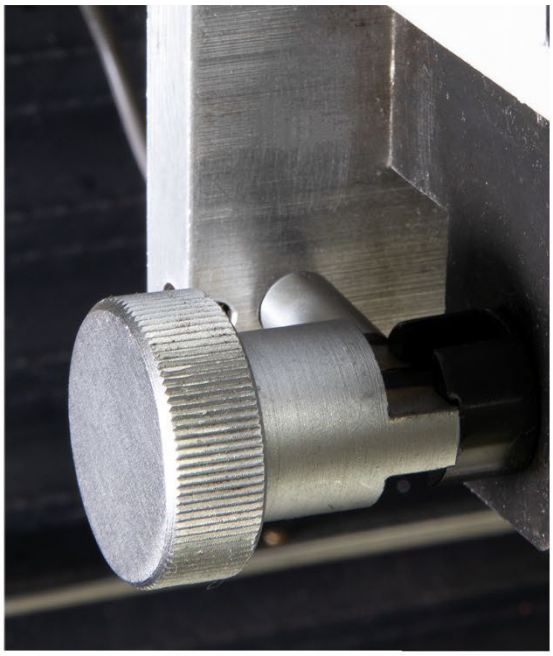
Chris' Tip: You can upgrade your Model 3990 mini mill with an electronically interlocked spindle lock with the following kit available from LittleMachineShop.com:

Part number 4762: Spindle Lock, Interlocked, HiTorque Mini Mill

To remove a tool from the spindle (Models 4190 & 6450):

The models 4190 & 6450 mini mills come equipped with an electrically interlocked spindle lock. This mechanism makes tool changes easier, faster and safer. When engaged, the plunger automatically drops into the locking hole as the spindle is rotated. An electro-magnetic interlock disables power to the motor, locking the spindle.





1. Stop the spindle rotation. (When the spindle lock is engaged, the mill will power down so you can turn off the power at this time if designed.)
2. Engage the spindle lock.
3. Remove the drawbar protective cap from the top of the spindle.
4. Use a wrench to loosen the drawbar about ½ turn.
5. Tap the top of the drawbar with a soft-faced hammer to disengage the taper (Model 4190).
6. Hold the tool with one hand to prevent it from dropping and unscrew the drawbar. Remove the tool.

To install a tool into the spindle:

1. Put the drawbar down through the spindle from the top.
2. Put the tool up into the spindle and thread the drawbar into it.
3. Rotate the tool until the locking pin engages the slot in the side of the tool.
4. Hold the tool with one hand and tighten the drawbar with a wrench. Do not use the spindle lock pin to tighten the drawbar, as you will make it too tight.
5. Replace the drawbar protective cap on the top of the spindle.

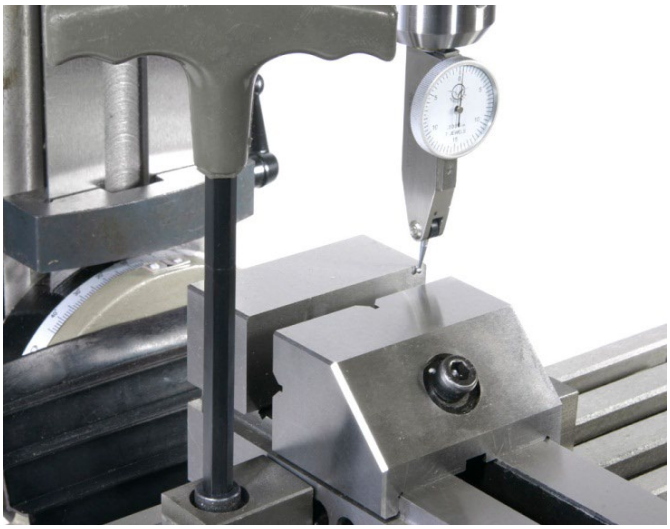
Squaring a Vise

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:

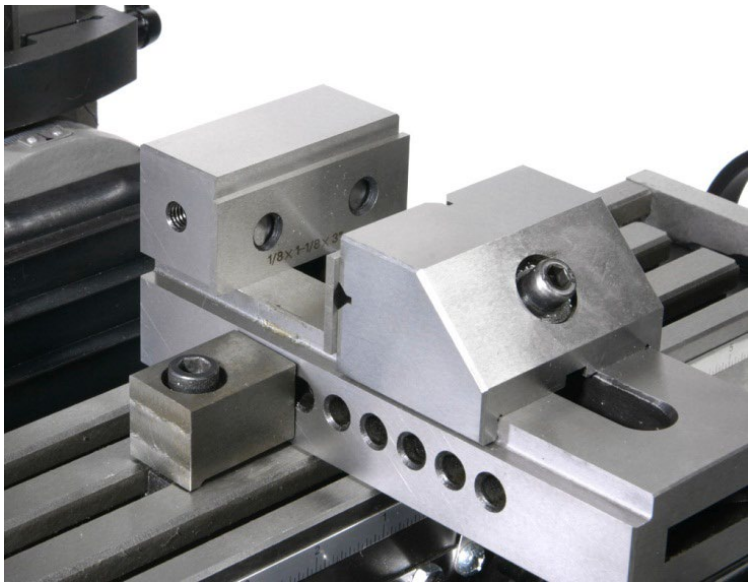
1. Mount the vise on the table and snug, but don't tighten, the mounting bolts.
2. Open the vise jaws at least 1".
3. Put the 3/8" diameter post on the top dovetail of a dial test indicator.
4. Put the dial test indicator post in a drill chuck, end mill holder, or collet in the mill's spindle with the 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

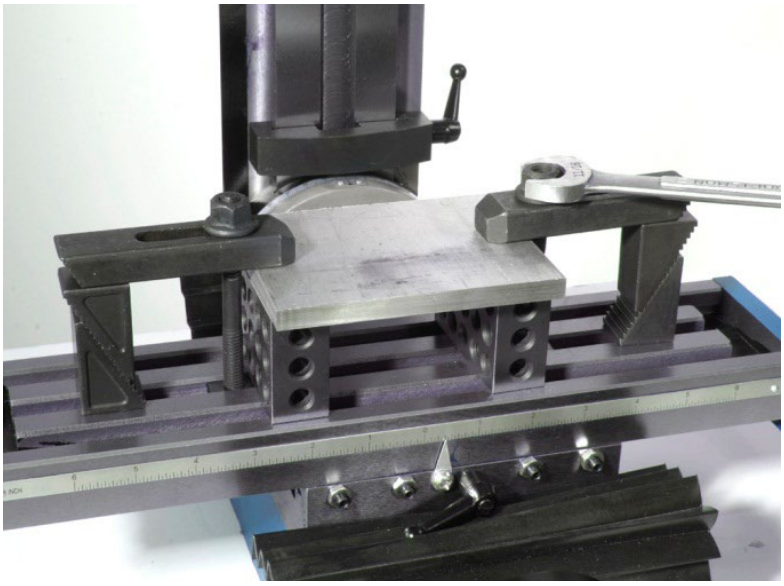
Precision parallels are used to raise the workpiece off the bed of the vise to a position where you can mill the top surface. Parallels come in sets of graduated heights. Choose a pair of parallels that position the top surface of the work above the top of the vise jaws, while keeping enough material 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 half of full speed in the low speed range or about one third of full speed in the high speed range.

   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 62.5 divisions, you turn one full turn plus 37 and one half divisions.

    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.
13. Note the location of the pointer relative to the X-axis scale across the front of the table. You may want to rotate the pointer so that it aligns with one of the tic marks on the scale.

    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 mini mill to drive. If power is an issue, use smaller drills to reach the final diameter in steps.

Milling

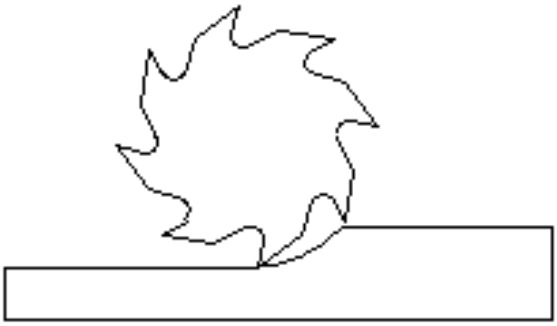
You can use collets or end mill holders to hold end mills. The world is split about 50/50 on which is better. We will give you the arguments for both sides and let you decide.

	
Collets	**End Mill Holders**
Collets are shorter than end mill holders and so give you more vertical work area.	End mill holders are longer than collets and so let you reach nearer the mini mill's table.
Collets grip the end mill all the way around and so provide a better grip.	End mill holders have a setscrew that bears on the flat on the shank of the end mill and so ensure that the end mill cannot slip.
Collets are more concentric than end mill holders because they grip all the way around the end mill's shank.	Because they fit the end mill closely end mill holders ensure concentricity.
Collets are less expensive than end mill holders and so can be replaced when they wear out.	End mill holders are more robust than collets and are less prone to wear out.
It's fun juggling an end mill, a collet, and a drawbar all at the same time	It is easier to replace an end mill in an end mill holder because the end mill holder can remain in the spindle.

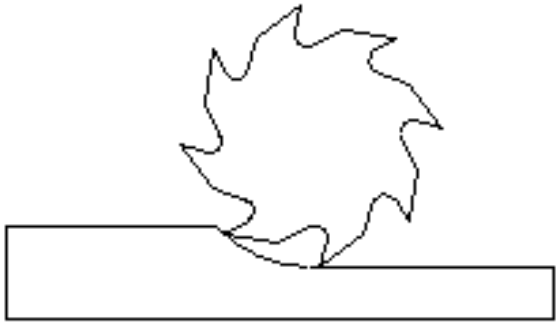
Whether you choose end mill holders or collets, they are used to hold an end mill in the spindle of the mini mill.

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



Climb Milling



Conventional 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 into 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 mini 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 mini 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 mini 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 mini 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.

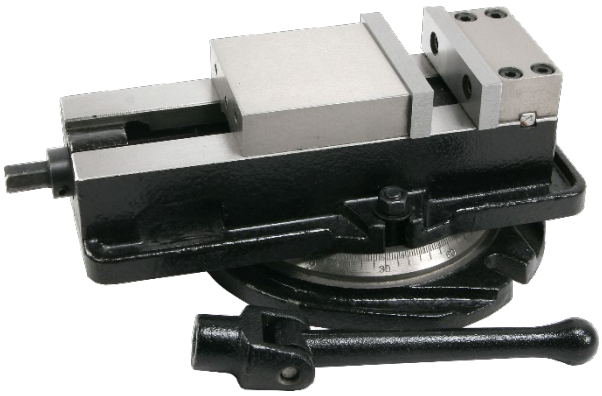
The 6-piece end mill sets we sell are economical starter sets. Because all the end mills in the set have 3/8" shanks, you only need one end mill holder or collet to use the entire set.

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 mini mill.

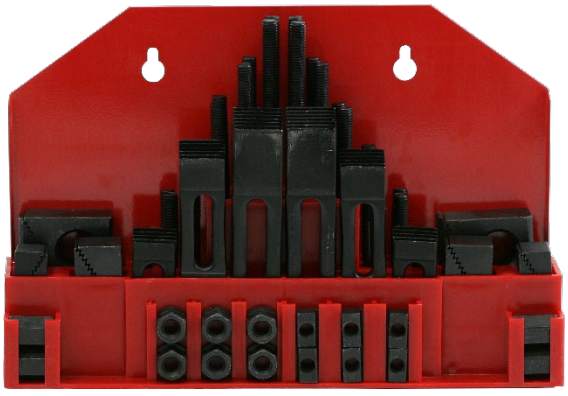


Choose a vise that will handle the work you do. You don't need a 3" vise if the parts you make are a half inch long. While you can usually put small parts in a large vise, it is more convenient to use an appropriate-size vise.

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 mini 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.

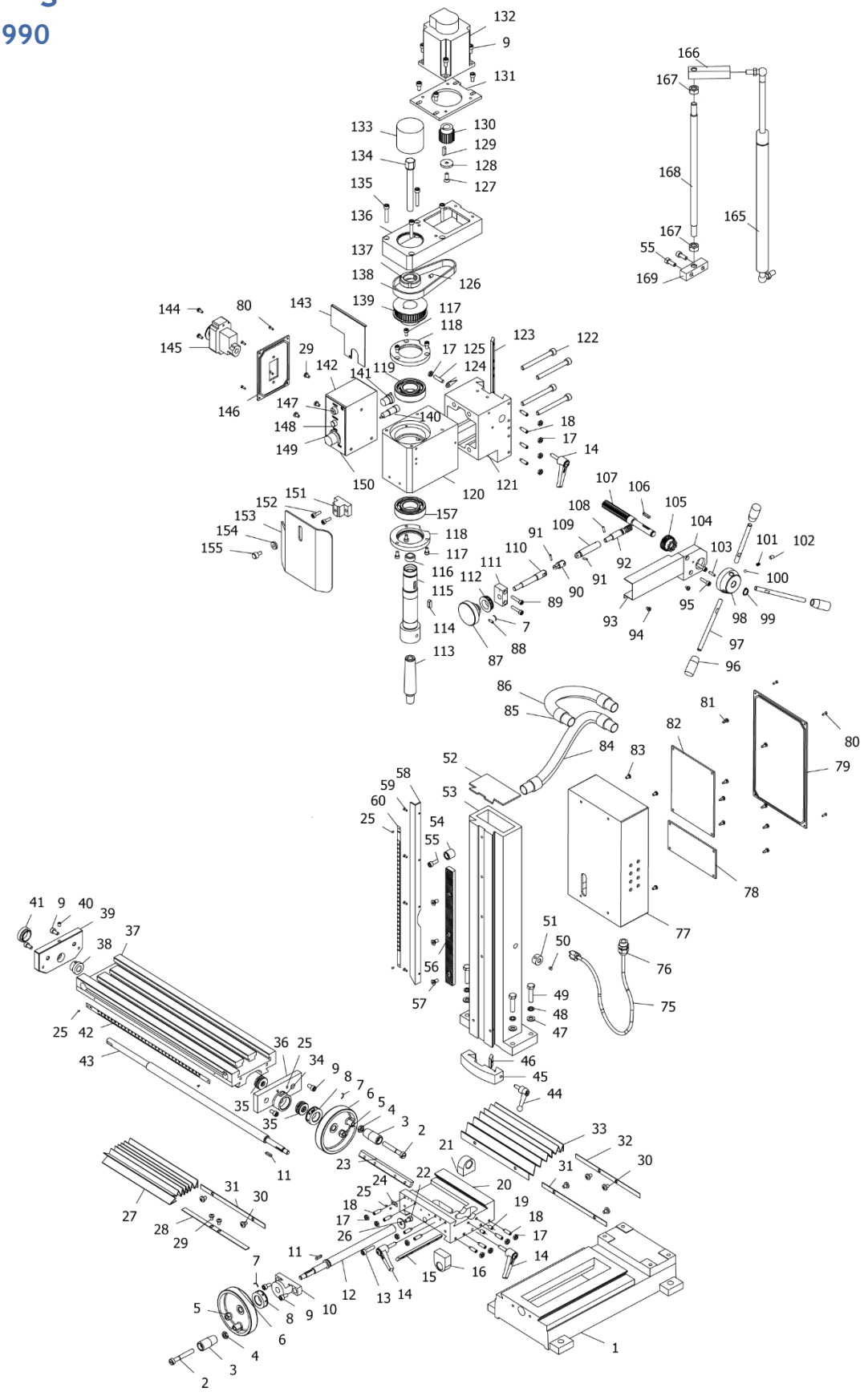
Setup Tools

Once you have your workpiece mounted on the mini 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.

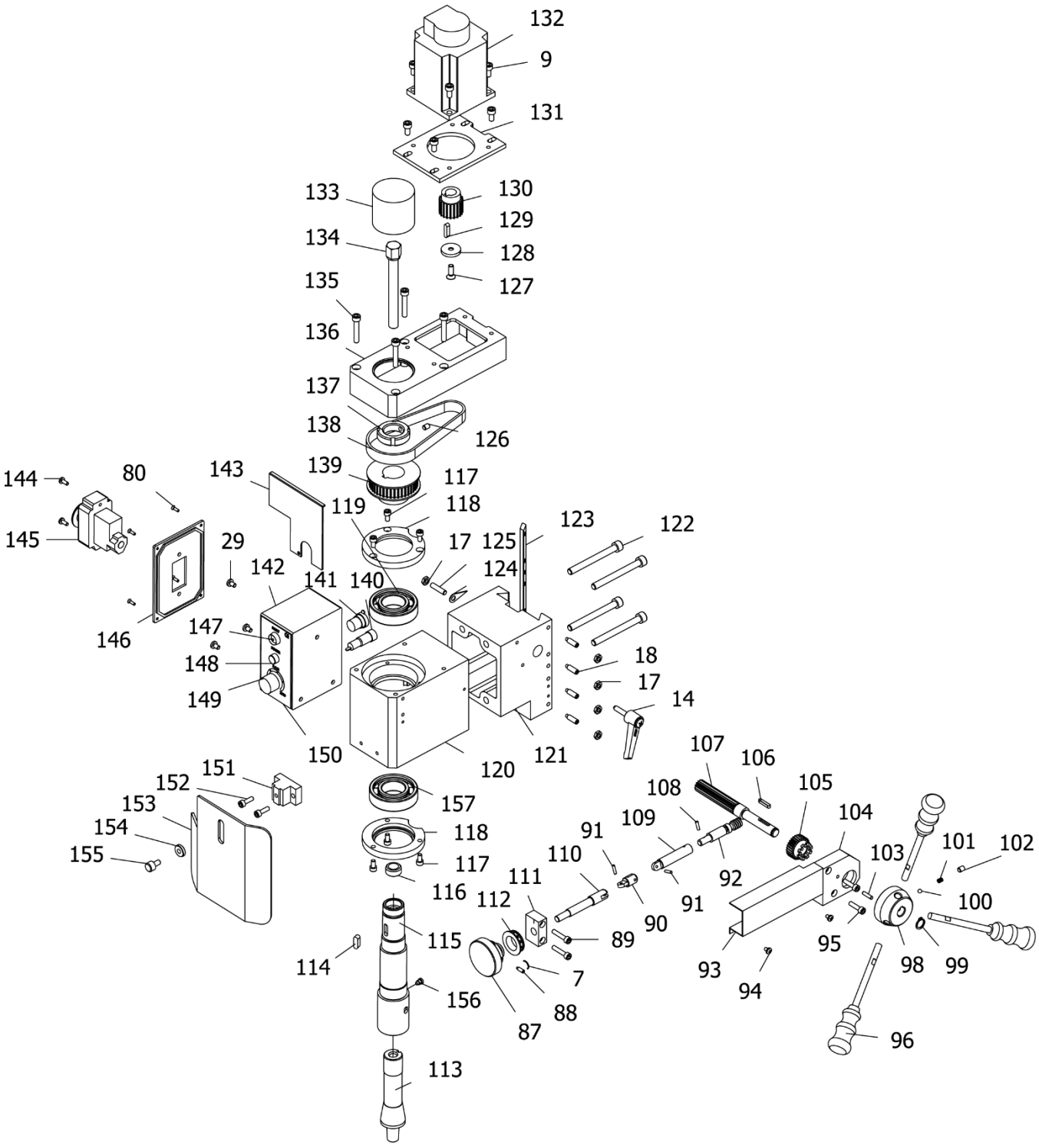
Edge finders locate the edge of the workpiece. Center finders locate the center of existing holes. Wigglers locate the intersection of scribed lines on the workpiece.

Parts Diagrams

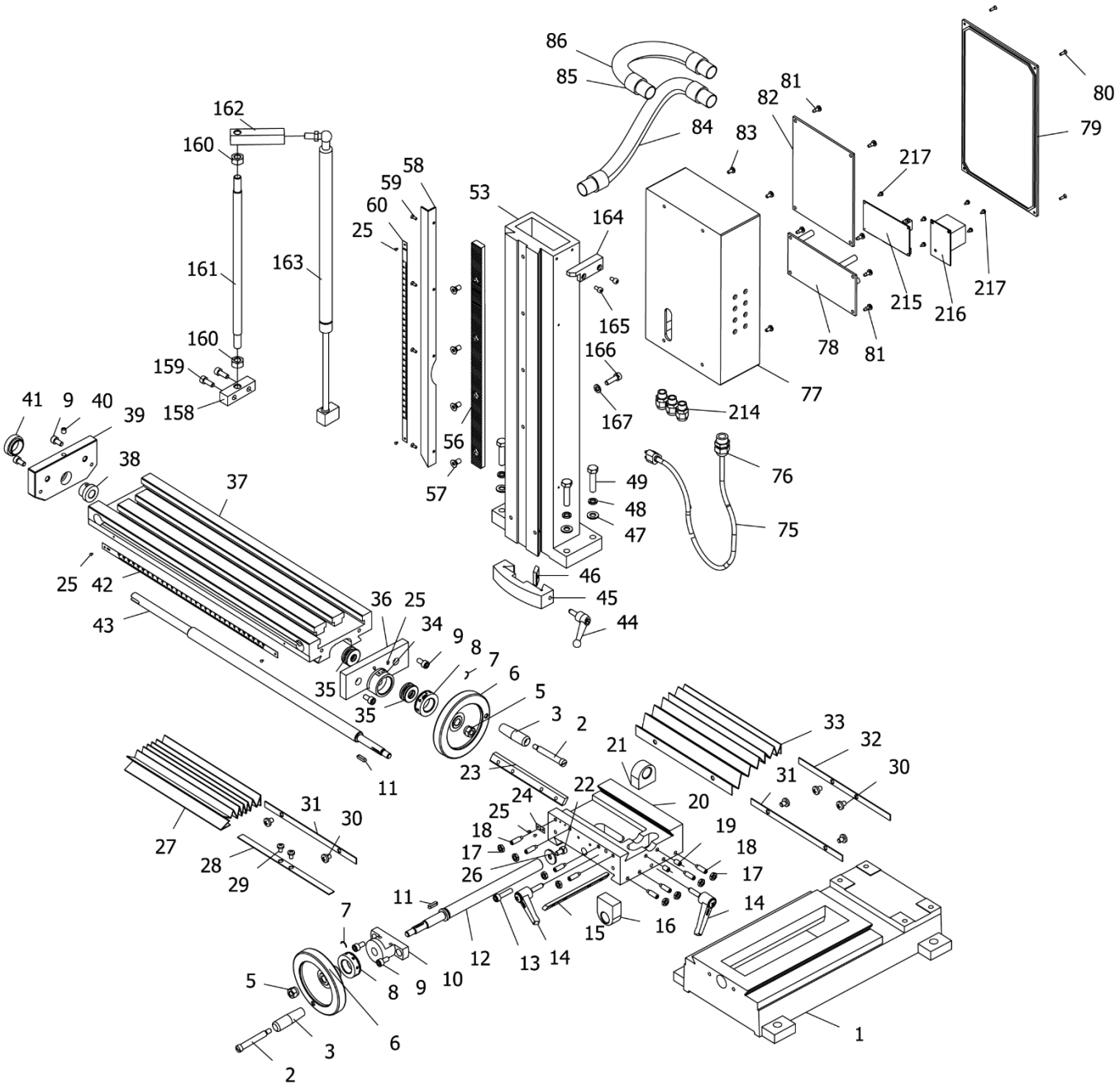
Model 3990



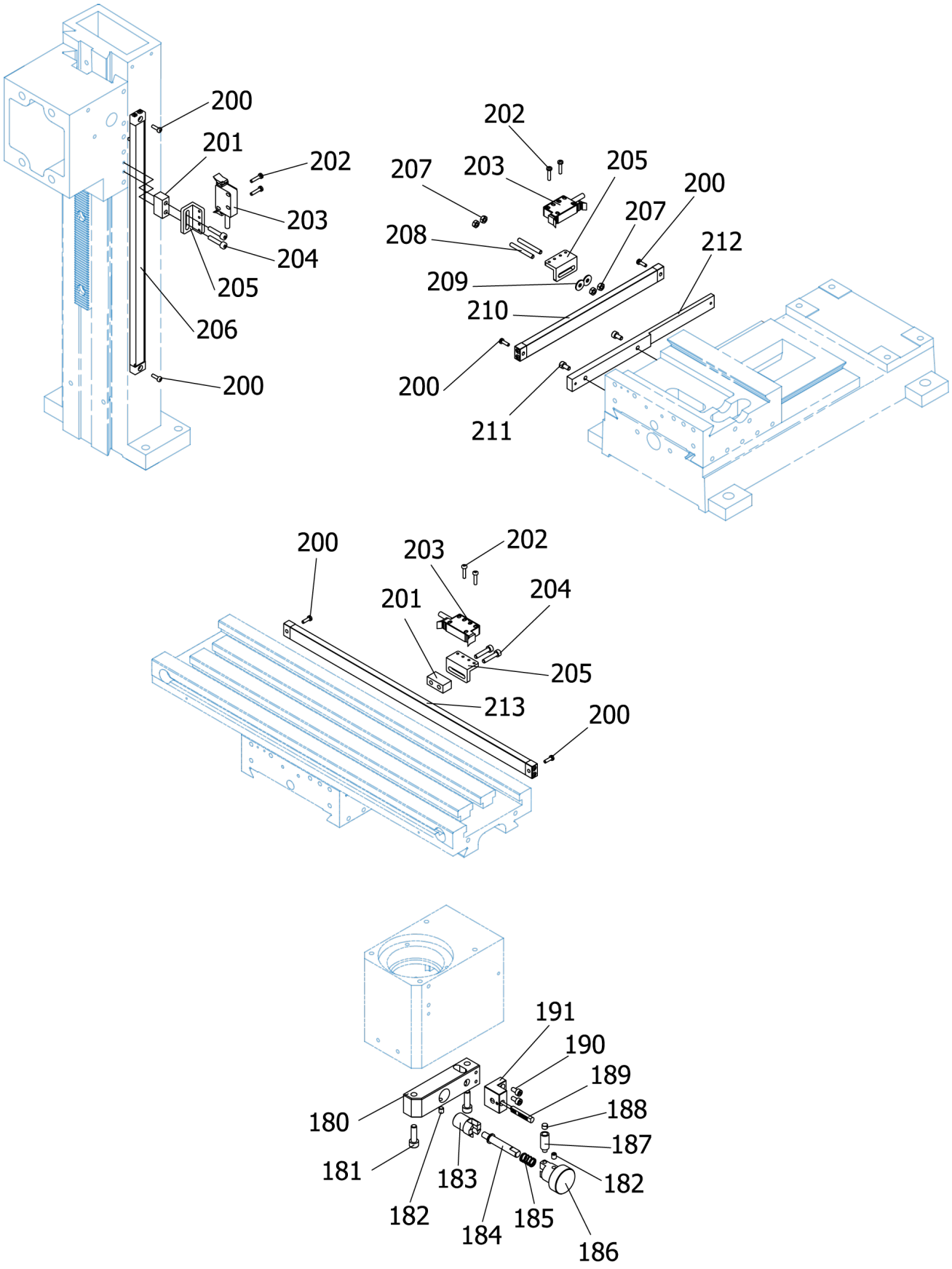
Model 4190 (1 of 3)



Model 4190 (2 of 3)

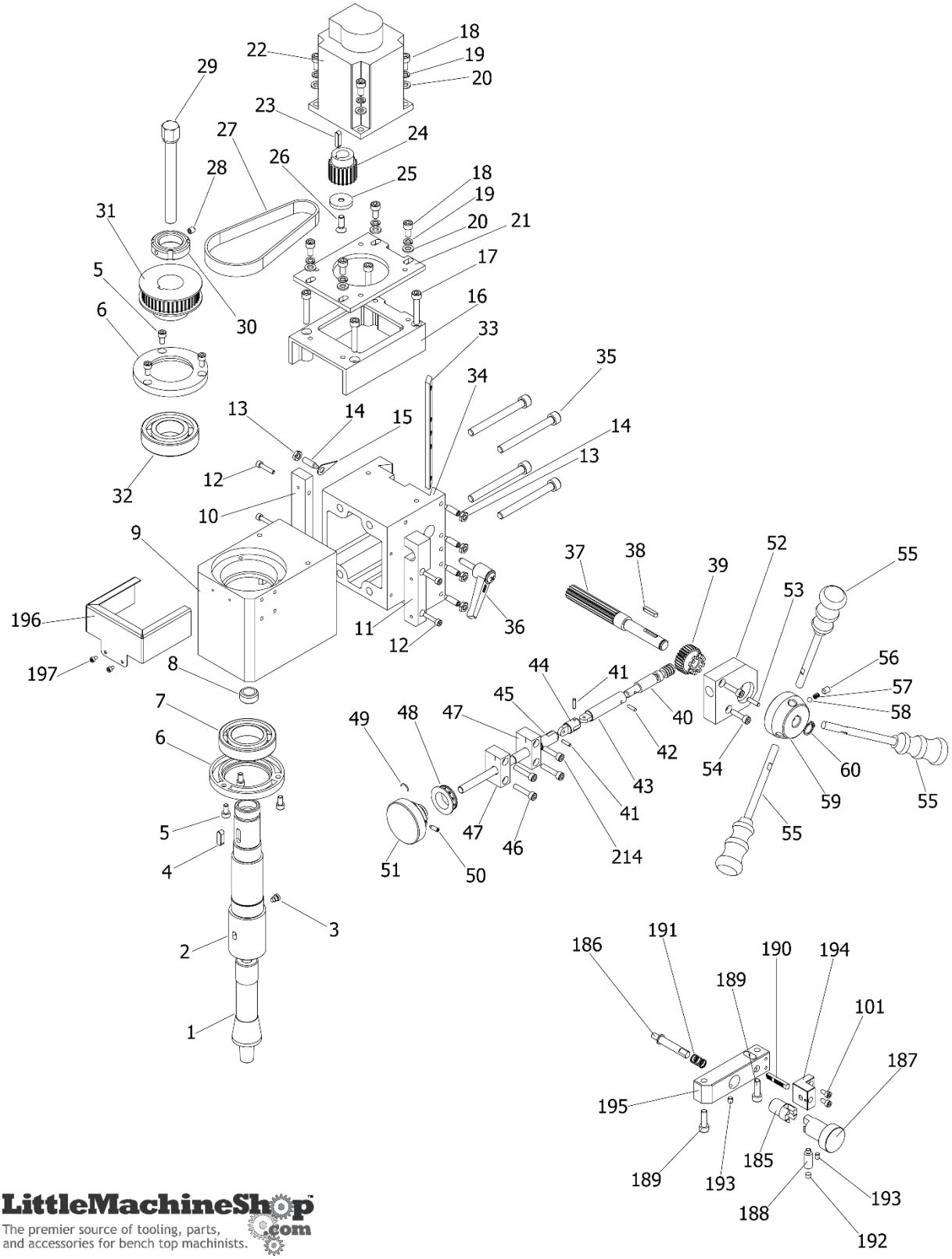


Model 4190 (3 of 3)



Model 6450 (1 of 4)

HiTorque Deluxe Mini Mill, Model 6450 (SX20)
Page 1 of 4



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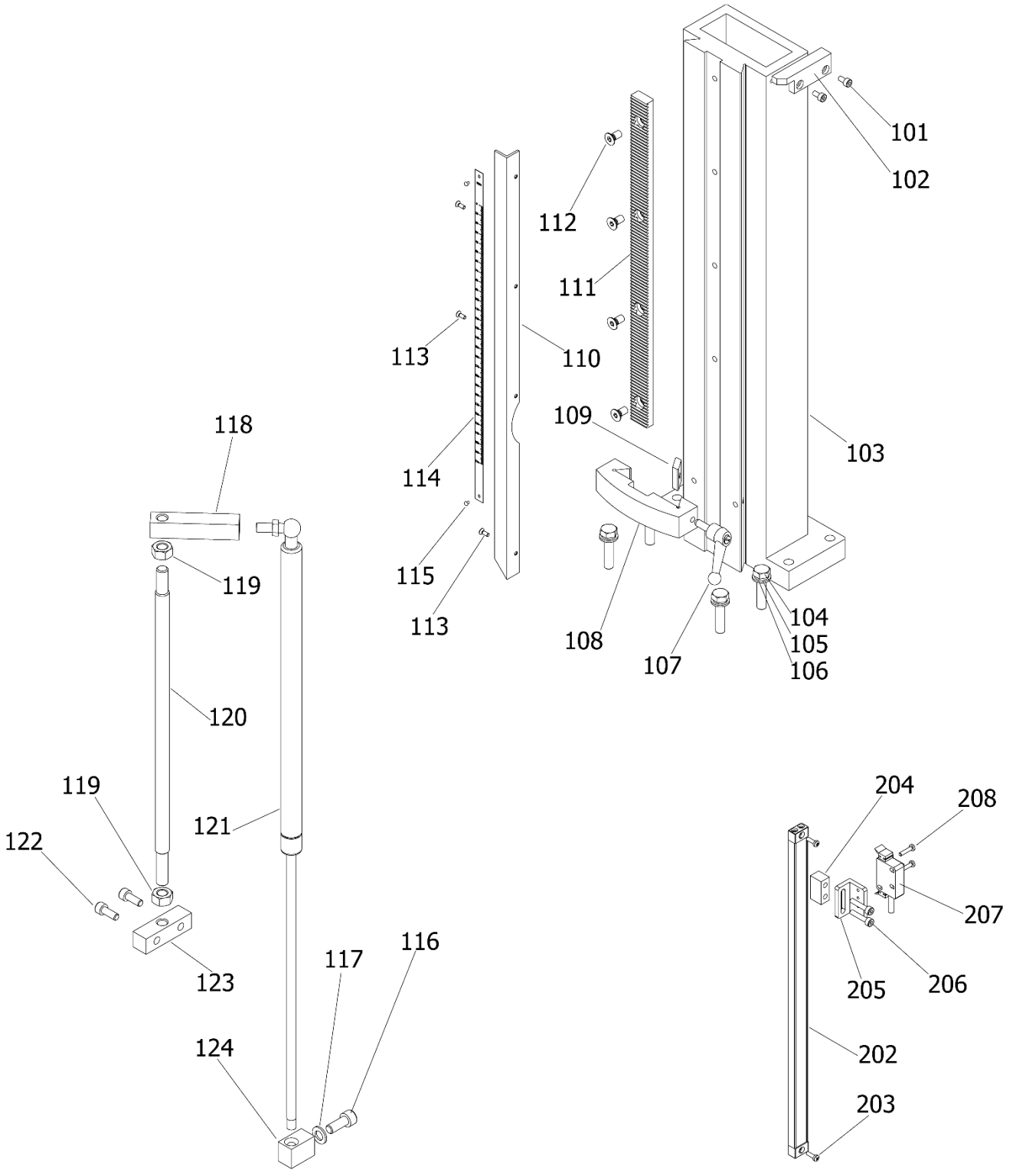

Model 6450 (3 of 4)

HiTorque Deluxe Mini Mill, Model 6450 (SX20)
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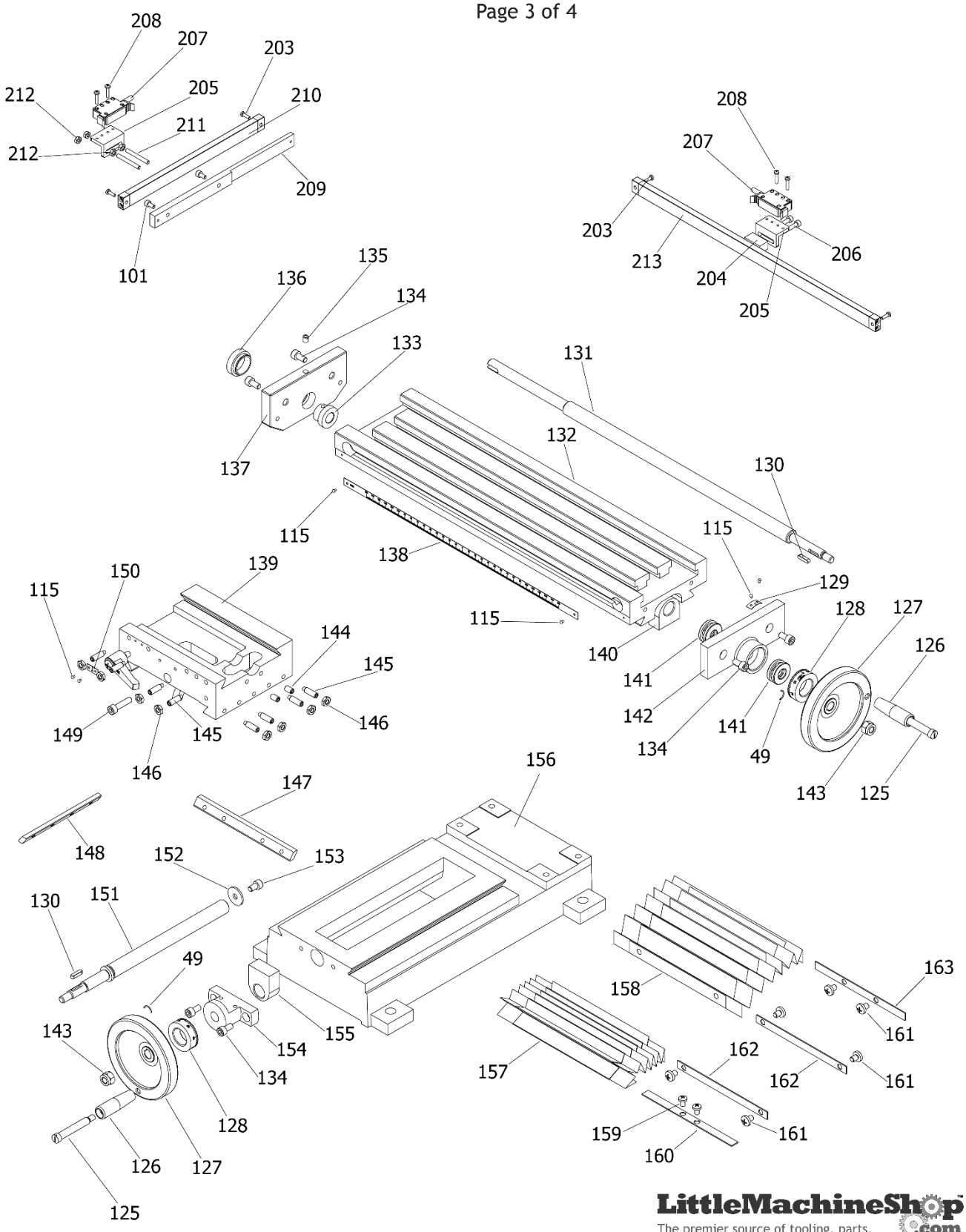
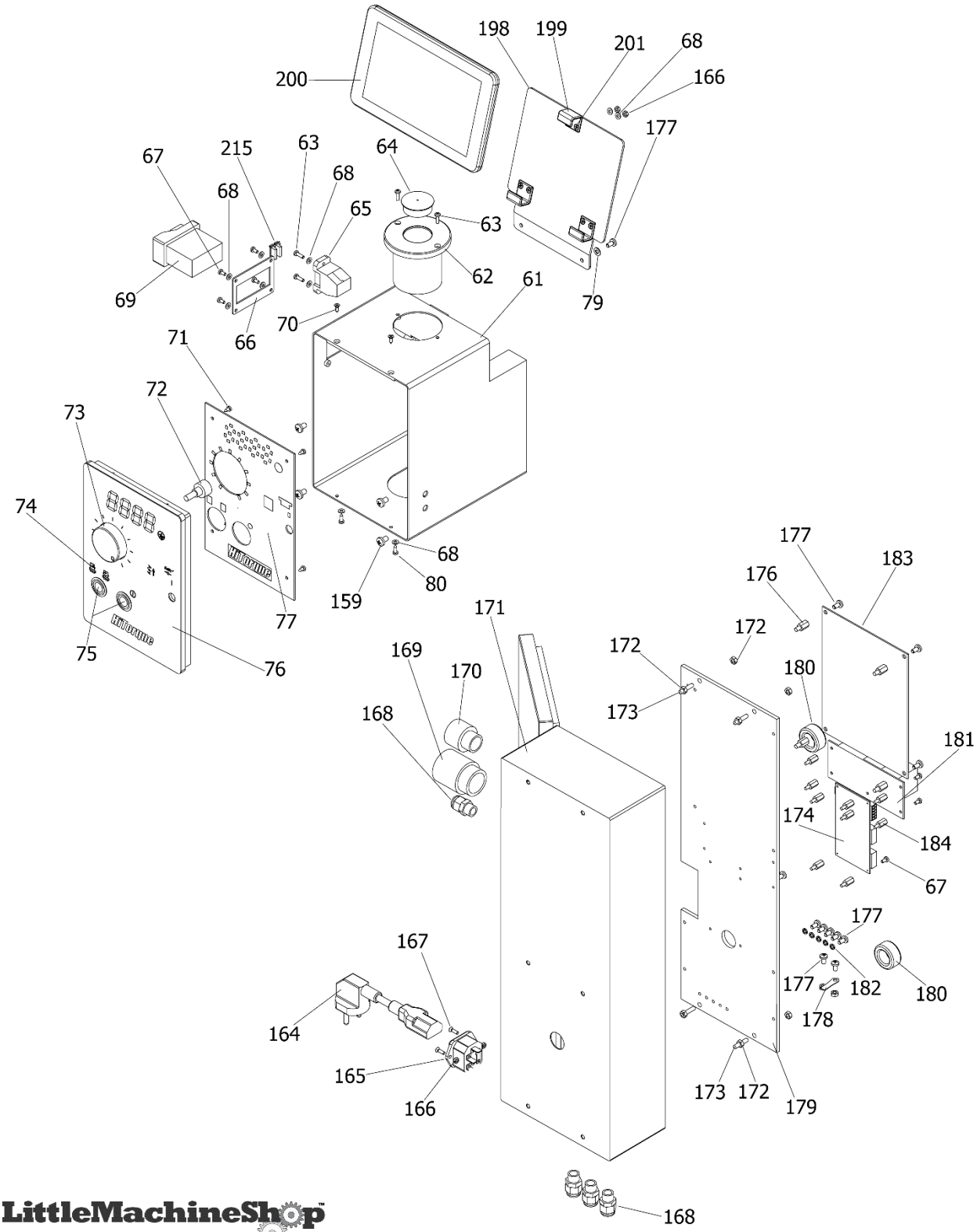




Parts List

Models 3990

Dwg #	Description
1	Base, Solid Column
2	Screw, M8x55
3	Handle Set, Handwheel
4	Nut, M8 Thin Chamfered
5	Nut, M8 Nylon Locking
6	Handwheel
7	Dial Spring
8	Graduated Dial, 62.5 Divisions
9	M6x12 Cap Screw
10	Y-Axis Screw Retainer
11	M4x16 Key
12	Y-Axis Feed Screw
13	M6x25 Cap Screw
14	M6 Locking Lever
15	Y-Axis Gib
16	Y-Axis Feed Screw Nut
17	M6 Thin Chamfered Hex Nut
18	M6x20 Socket Dog Point Set Screw
19	M6x10 Socket Flat Point Set Screw
20	Saddle
21	X-Axis Feed Screw Nut
22	M6x10 Button Head Cap Screw
23	X-Axis Gib
24	Position Indicator Label
25	M2x4 Rivet
26	M6 Large Dia. Flat Washer
27	Chip Guard Bellows
28	Bellows Front Retainer
29	M5x8 Machine Screw
30	M6x8 Machine Screw
31	Bellows Table Retainer
32	Bellows Rear Retainer
33	Chip Guard Bellows
34	Position Indicator Label
35	Thrust Bearing 51200
36	X-Axis Bearing Retainer
37	Table
38	X-Axis Feed Screw Bushing
39	X-Axis Feed Screw End cover
40	6mm Oil Fitting
41	Feed Screw End Cover
42	X-Axis Scale
43	X-axis Feed Screw

Dwg #	Description
44	M6 Locking Lever
45	Z-Axis Stop
46	Z-Axis Gib
47	M8 Flat Washer
48	M8 Lock Washer
49	M8x35 Cap Screw
50	M5x6 Set Screw
51	Set Collar
52	Column Cover
53	Column (Solid)
54	Head Travel Stop
55	Cap Screw M6 x 16
56	Z-Axis Rack, 11"
57	M6x12 Flat Head Machine Screw
58	Scale Bracket
59	M3x8 Flat Head Machine Screw
60	Z-Axis Scale
75	Power Cord with Plug
76	16mm Strain Relief
77	Box, Motor Control Board
79	Cover, Motor Control Board
80	M2.9x9.5 Flat Head Tapping Screw
81	M4x10 Round Head Tapping Screw
82	Motor Controller Board
83	M4x8 Pan Head Machine Screw
84	16mm Dia. Flex Conduit
85	16mm Dia. Flex Conduit Connector
86	16mm Dia. Flex Conduit
87	Z-Axis Fine Feed Knob
88	M4x12 Dog Point Set Screw
89	M5x25 Cap Screw
90	Z-Axis Fine Feed Universal Joint
91	M3x12 Pin
92	Z-Axis Fine Feed Worm
93	Z-Axis Fine Feed Cover
94	M4x6 Machine Screw
95	M5x20 Cap Screw
96	8mm Knob
97	Z-Axis Course Feed Lever
98	Z-Axis Course Feed Pivot
99	M12 External Retaining Ring
100	5mm Ball bearing
101	5mm x 10mm Spring

Dwg #	Description
102	M6x8 Flat Point Set Screw
103	M4x16 Pin
104	Z-Axis Fine Feed Housing
105	Worm Gear 29T
106	M4x20 Key
107	Z-Axis Pinion
108	M3x12 Pin
109	Z-Axis Fine Feed Shaft
110	Z-Axis Fine Feed Universal Shaft
111	Z-Axis Fine Feed Bracket
112	Z-Axis Fine Feed Graduated Dial
113	R8 to 33JT Drill Chuck Arbor
114	M6x18 Key
115	R8 Spindle
115A	R8 Spindle Pin
116	Drawbar Bushing
117	M5x10 Cap Screw
118	Spindle Bearing Cover
119	6206-2RS Bearing
120	Spindle Housing
121	Spindle Housing Mount
122	M8x80 Cap Screw
123	Spindle Gib
124	Z-Axis Pointer
125	M6x25 Set Screw
126	M6x8 Set Screw
127	M6x18 Flathead Machine Screw
128	Motor Shaft Washer
129	M5x20 Key
130	Motor Timing Pulley
131	Motor Adjusting Plate
132	500 Wat Brushless Motor

Dwg #	Description
133	Drawbar Cover
134	R8 Drawbar
135	M6x35 Cap Screw
136	Motor Mounting Bracket
137	Spindle Nut, Left Hand Thread
138	Timing Belt
139	Spindle Timing Pulley
140	Fuse Holder
141	Fuse Holder
142	Control Box
143	Control Box Connection Plate
144	M4x16 Flat Head Machine Screw
144	M4 Nut
145	Power Switch
146	Control Box Cover
147	Yellow Lamp
148	Green Lamp
149	Speed Control Knob
149	Potentiometer
150	Control Panel Label
151	Chip Guard Bracket
152	M5x16 Cap Screw
153	Chip Guard
154	Chip Guard Washer
155	Chip Guard Thumb Screw
157	Bearing 6007-2RS
165	Air Spring
166	Air Spring Upper Mount
167	M10 Nut
168	Air Spring Head Support Shaft
169	Air Spring Lower Mount

Model 4190

Dwg #	Description
1	Base, Solid Column
2	Bolt, Handwheel - Chrome
3	Handle, Handwheel - Chrome
5	Nut, M8 Nylon Locking
6	Aluminum Handwheel
7	Dial Spring
8	Graduated Dial, 62.5 Divisions
9	M6x12 Cap Screw
10	Y-Axis Screw Retainer
11	M4x16 Key
12	Y-Axis Feed Screw
13	M6x25 Cap Screw
14	M6 Locking Lever
15	Y-Axis Gib
16	Y-Axis Feed Screw Nut
17	M6 Thin Chamfered Hex Nut
18	M6x20 Socket Dog Point Set Screw
19	M6x10 Socket Flat Point Set Screw
20	Saddle
21	X-Axis Feed Screw Nut
22	M6x10 Button Head Cap Screw
23	X-Axis Gib
24	Position Indicator Label
25	M2x4 Rivet
26	M6 Large Dia. Flat Washer
27	Chip Guard Bellows
28	Bellows Front Retainer
29	M5x8 Machine Screw
30	M6x8 Machine Screw
31	Bellows Table Retainer
32	Bellows Rear Retainer
33	Chip Guard Bellows
34	Position Indicator Label
35	Thrust Bearing 51200
36	X-Axis Bearing Retainer
37	Table
38	X-Axis Feed Screw Bushing
39	X-Axis Feed Screw End cover
40	6mm Oil Fitting
41	Feed Screw End Cover
42	X-Axis Scale
43	X-axis Feed Screw
44	M6 Locking Lever
45	Z-Axis Stop
46	Z-Axis Gib

Dwg #	Description
47	M8 Flat Washer
48	M8 Lock Washer
49	M8x35 Hex Head Cap Screw
53	Column (Solid)
56	Z-Axis Rack, 11"
57	M6x12 Flat Head Machine Screw
58	Scale Bracket
59	M3x8 Flat Head Machine Screw
60	Z-Axis Scale
75	Power Cord with Plug
76	16mm Strain Relief
77	Motor Control Board Box
79	Motor Control Board Cover
80	M2.9x9.5 Flat Head Tapping Screw
81	Tapping screw M4.2x9.5
82	Motor Controller Board
83	M4x8 Pan Head Machine Screw
84	16mm Dia. Flex Conduit
85	16mm Dia. Flex Conduit Connector
86	16mm Dia. Flex Conduit
87	Z-Axis Fine Feed Knob
88	M4x12 Dog Point Set Screw
89	M5x25 Cap Screw
90	Z-Axis Fine Feed Universal Joint
91	M3x12 Pin
92	Z-Axis Fine Feed Worm
93	Z-Axis Fine Feed Cover
94	M4x6 Machine Screw
95	M5x20 Cap Screw
96	Fancy Z-Axis Handle
97	Z-Axis Course Feed Lever
98	Z-Axis Course Feed Pivot
99	M12 External Retaining Ring
100	5mm Ball bearing
101	5mm x 10mm Spring
102	M6x8 Flat Point Set Screw
103	M4x16 Pin
104	Z-Axis Fine Feed Housing
105	Worm Gear 29T
106	M4x20 Key
107	Z-Axis Pinion
108	M3x12 Pin
109	Z-Axis Fine Feed Shaft
110	Z-Axis Fine Feed Universal Shaft
111	Z-Axis Fine Feed Bracket

Dwg #	Description
112	Z-Axis Fine Feed Graduated Dial
113	R8 to 33JT Drill Chuck Arbor
114	M6x18 Key
115	R8 Spindle
116	Drawbar Bushing
117	M5x10 Cap Screw
118	Spindle Bearing Cover
119	6206-2RS Bearing
120	Spindle Housing
121	Spindle Housing Mount
122	M8x80 Cap Screw
123	Spindle Gib
124	Z-Axis Pointer
125	M6x25 Set Screw
126	M6x8 Set Screw
127	M6x18 Flathead Machine Screw
128	Motor Shaft Washer
129	M5x20 Key
130	Motor Timing Pulley
131	Motor Adjusting Plate
132	500 Wat Brushless Motor
133	Drawbar Cover
134	R8 Drawbar
135	M6x35 Cap Screw
136	Motor Mounting Bracket
137	Spindle Nut, Left Hand Thread
138	Timing Belt
139	Spindle Timing Pulley
140	Fuse Holder
141	Fuse Holder
142	Control Box
143	Control Box Connection Plate
144	M4x16 Flat Head Machine Screw
144	M4 Nut
145	Power Switch
146	Control Box Cover
147	Yellow Lamp
148	Green Lamp
149	Speed Control Knob
149	Potentiometer
150	Control Panel Label
151	Chip Guard Bracket
152	M5x16 Cap Screw
153	Chip Guard
154	Chip Guard Washer

Dwg #	Description
155	Chip Guard Thumb Screw
156	R8 Spindle Pin
157	Bearing 6007-2RS
158	Air Spring Lower Mount
159	M6x16 Cap Screw
160	M10 Nut
161	Air Spring Head Support Shaft
162	Air Spring Upper Mount
163	Air Spring
164	Z-Axis Upper Stop
165	M4X8 Cap Screw
166	M8x20 Cap Screw
167	M8 Flat Washer
180	Spindle Lock Bracket
181	M6x20 Cap Screw
182	M5x6 Set Screw
183	Spindle Lock Shaft Bracket
184	Spindle Lock Shaft
185	M9x15 Spring
186	Spindle Lock Knob
187	Spindle Lock Magnet Shaft
188	M4x6 Magnet
189	Spindle Lock Magnetic Switch
190	M4x8 Cap Screw
191	Spindle Lock Magnetic Switch Bracket
200	M3x10 Pan Head Machine Screw
201	DRO Reader Cushion Block
202	M3x14 Pan Head Machine Screw
203	DRO Bluetooth Read Head
204	M4x20 Cap Screw
205	DRO Reader Bracket
206	DRO Magnetic Scale
207	M4 Nut
208	DRO M4x28 Bracket Studs
209	M4 Large Dia. Washer
210	DRO Magnetic Scale
211	M4x8 Cap Screw
212	Y-Axis DRO Magnetic Scale Bracket
213	DRO Magnetic Scale
214	Control Box Plugs
215	Bluetooth Sender
216	Power Supply
217	M2.9x6.5 Flat Head Tapping Screw

Model 6450

Dwg #	Description
1	R8 to 33JT Drill Chuck Arbor
2	R8 Spindle
3	R8 Spindle Pin
4	M6x18 Key
5	M5x10 Cap Screw
6	Spindle Bearing Cover
7	Angular Contact Bearing 7007AC
8	Fixed Sleeve
9	Spindle Housing
10	Left Housing Support Block
11	Right Housing Support Block
12	M4x20 Cap Screw
13	M6 Thin Chamfered Hex Nut
14	M6x20 Socket Dog Point Set Screw
15	Z-Axis Pointer
16	Motor Mounting Bracket
17	M6x35 Cap Screw
18	M6x12 Cap Screw
19	M6 Locking Washer
20	M6 Flat Washer
21	Motor Mounting Bracket
22	500 Watt Brushless Motor
23	M5x20 Key
24	Motor Timing Pulley
25	Motor Shaft Washer
26	M6x18 Flathead Machine Screw
27	Timing Belt
28	M6x8 Set Screw
29	R8 Drawbar
30	Spindle Nut, Left Hand Thread
31	Spindle Timing Pulley
32	Angular Contact Bearing 7206B
33	Spindle Gib
34	Spindle Housing Mount
35	M8x80 Cap Screw
36	M6 Locking Lever
37	Z-Axis Pinion
38	M4x20 Key
39	Worm Gear 29T
40	Z-Axis Fine Feed Worm
41	M3x12 Pin
42	M3x12 Pin
43	Z-Axis Fine Feed Shaft
44	Z-Axis Fine Feed Universal Joint
45	Z-Axis Fine Feed Universal Shaft

Dwg #	Description
46	M5x25 Cap Screw
47	Z-Axis Fine Feed Bracket
48	Z-Axis Fine Feed Graduated Dial
49	Dial Spring
50	M4x12 Dog Point Set Screw
51	Z-Axis Fine Feed Knob
52	Z-Axis Fine Feed Housing
53	M4x16 Pin
54	M5x20 Cap Screw
55	Fancy Z-Axis Handle
56	M6x8 Flat Point Set Screw
57	5mm x 10mm Spring
58	5mm Ball bearing
59	Z-Axis Course Feed Pivot
60	M12 External Retaining Ring
61	Spindle Box Cover
62	Drawbar Cover
63	M3x10 Pan Head Machine Screw
64	Drawbar Cover Plug
65	USB Line
66	Power Switch Mounting Plate
67	M3x6 Pan Head Machine Screw
68	M3 Flat Washer
69	Power Switch
70	Tapping Screw M2.9x9.5
71	Tapping Screw M2.9x6.5
72	Potentiometer
73	Speed Control Knob
74	LED Spindle Direction Indicator
75	Start / Stop Button
76	Control Panel Face Plate
77	LED Lighting Board
79	M4 Flat Washer
80	Tapping screw M2.9x9.5
101	M4X8 Cap Screw
102	Z-Axis Upper Stop
103	Column (Solid)
104	M8x35 Hex Head Cap Screw
105	M8 Flat Washer
106	M8 Lock Washer
107	M6 Locking Lever
108	Z-Axis Stop
109	Z-Axis Gib
110	Scale Bracket
111	Z-Axis Rack, 11"

Dwg #	Description
112	M6x12 Flat Head Machine Screw
113	M3x8 Flat Head Machine Screw
114	Z-Axis Scale
115	M2x4 Rivet
116	M8x20 Cap Screw
117	Washer M8
118	Air Spring Upper Mount
119	M10 Nut
120	Air Spring Head Support Shaft
121	Air Spring
122	M6x16 Cap Screw
123	Air Spring Lower Mount
124	Air Spring Rod End
125	Bolt, Handwheel - Chrome
126	Handle, Handwheel - Chrome
127	Aluminum Handwheel
128	Graduated Dial, 62.5 Divisions
129	Position Indicator Label
130	M4x16 Key
131	X-axis Feed Screw
132	Table
133	X-Axis Feed Screw Bushing
134	M6x12 Cap Screw
135	6mm Oil Fitting
136	Feed Screw End Cover
137	X-Axis Feed Screw End cover
138	X-Axis Scale
139	Saddle
140	X-Axis Feed Screw Nut
141	Thrust Bearing 51200
142	X-Axis Bearing Retainer
143	Nut, M8 Nylon Locking
144	M6x10 Socket Flat Point Set Screw
145	M6x20 Socket Dog Point Set Screw
146	M6 Thin Chamfered Hex Nut
147	X-Axis Gib
148	Y-Axis Gib
149	M6x25 Cap Screw
150	Position Indicator Label
151	Y-Axis Feed Screw
152	M6 Large Dia. Flat Washer
153	M6x10 Button Head Cap Screw
154	Y-Axis Screw Retainer
155	Y-Axis feed screw nut
156	Base, Solid Column
157	Chip Guard Bellows
158	Chip Guard Bellows
159	M5x8 Machine Screw

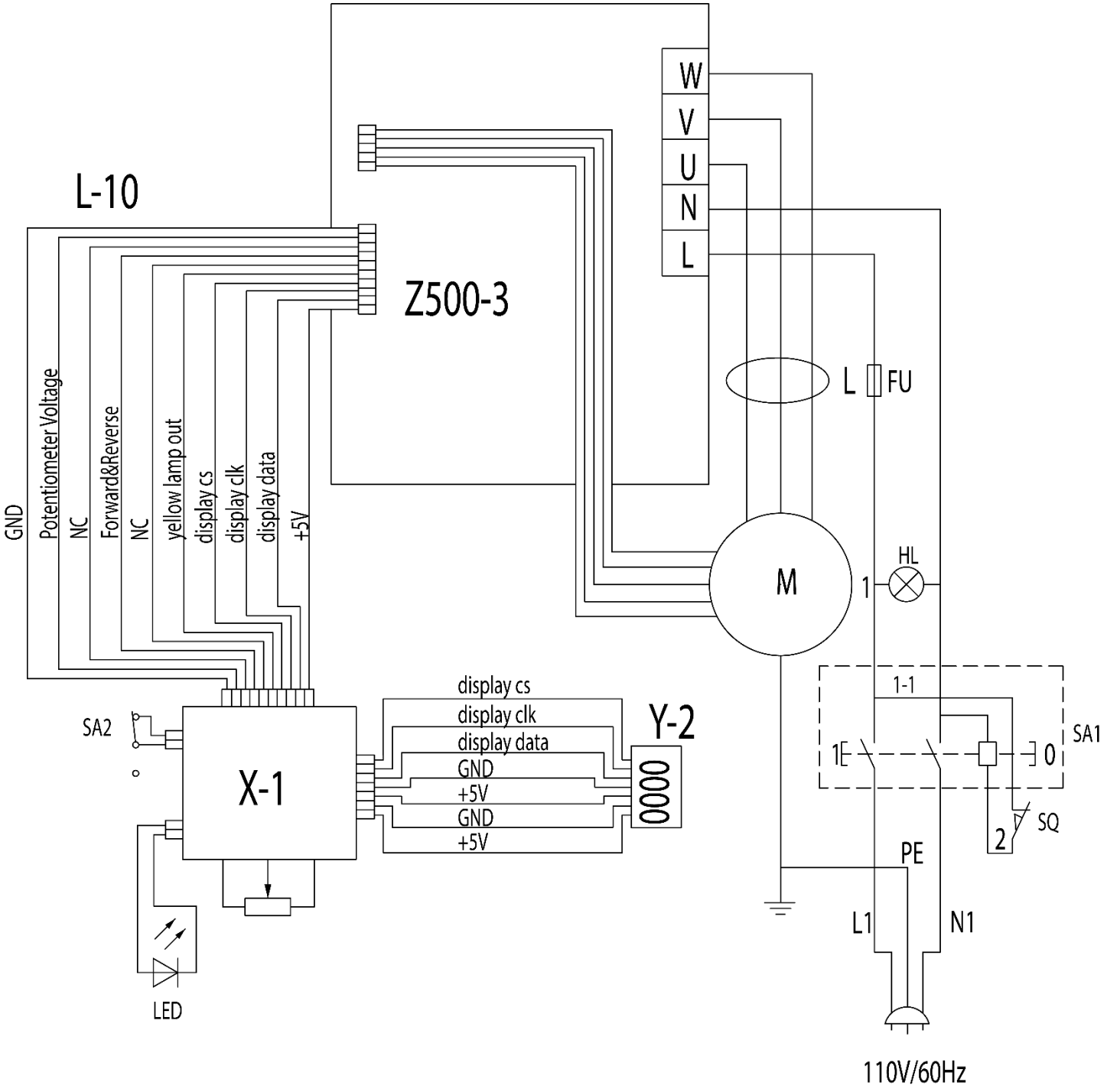
Dwg #	Description
160	Fixed plate
161	M6x8 Machine Screw
162	Bellows Table Retainer
163	Bellows Rear Retainer
164	Power Line
165	Power Socket
166	M3 Nut
167	M2.9x9.5 Flat Head Tapping Screw
168	Control Box Plugs
169	Flex Conduit Connector
170	Flex Conduit Connector
171	Control Board Box
171-1	Control Board Box Latch
172	M4 Nut
173	M4x20 Cup Point Set Screw
174	Bluetooth Board
176	Control Board Spacer HTS-410
177	M4x8 Pan Head Machine Screw
178	Hot Transducer
179	Base Plate
180	Magnet Ring
181	Power Supply
182	M4 Locking Washer
183	Motor Controller Board
184	Control Board Spacer HTS-310
185	Spindle Lock Shaft Bracket
186	Spindle Lock Shaft
187	Spindle Lock Knob
188	Spindle Lock Magnet Shaft
189	M6x20 Cap Screw
190	Spindle Lock Magnetic Switch
191	M9x15 Spring
192	M4x6 Magnet
193	M5x6 Set Screw
194	Spindle Lock Magnetic Switch Bracket
195	Spindle Lock Bracket
196	Front Cover
197	M3x5 Cap Screw
198	Tablet Support
199	Tablet Bracket
200	Android Tablet
201	M3x8 Flat Head Machine Screw
202	DRO Magnetic Scale
203	M3x10 Pan Head Machine Screw
204	DRO Reader Cushion Block
205	DRO Reader Bracket
206	M4x20 Cap Screw
207	DRO Bluetooth Read Head

Dwg #	Description
208	M3x14 Pan Head Machine Screw
209	Y-Axis DRO Magnetic Scale Bracket
210	DRO Magnetic Scale
211	DRO M4x28 Bracket Studs

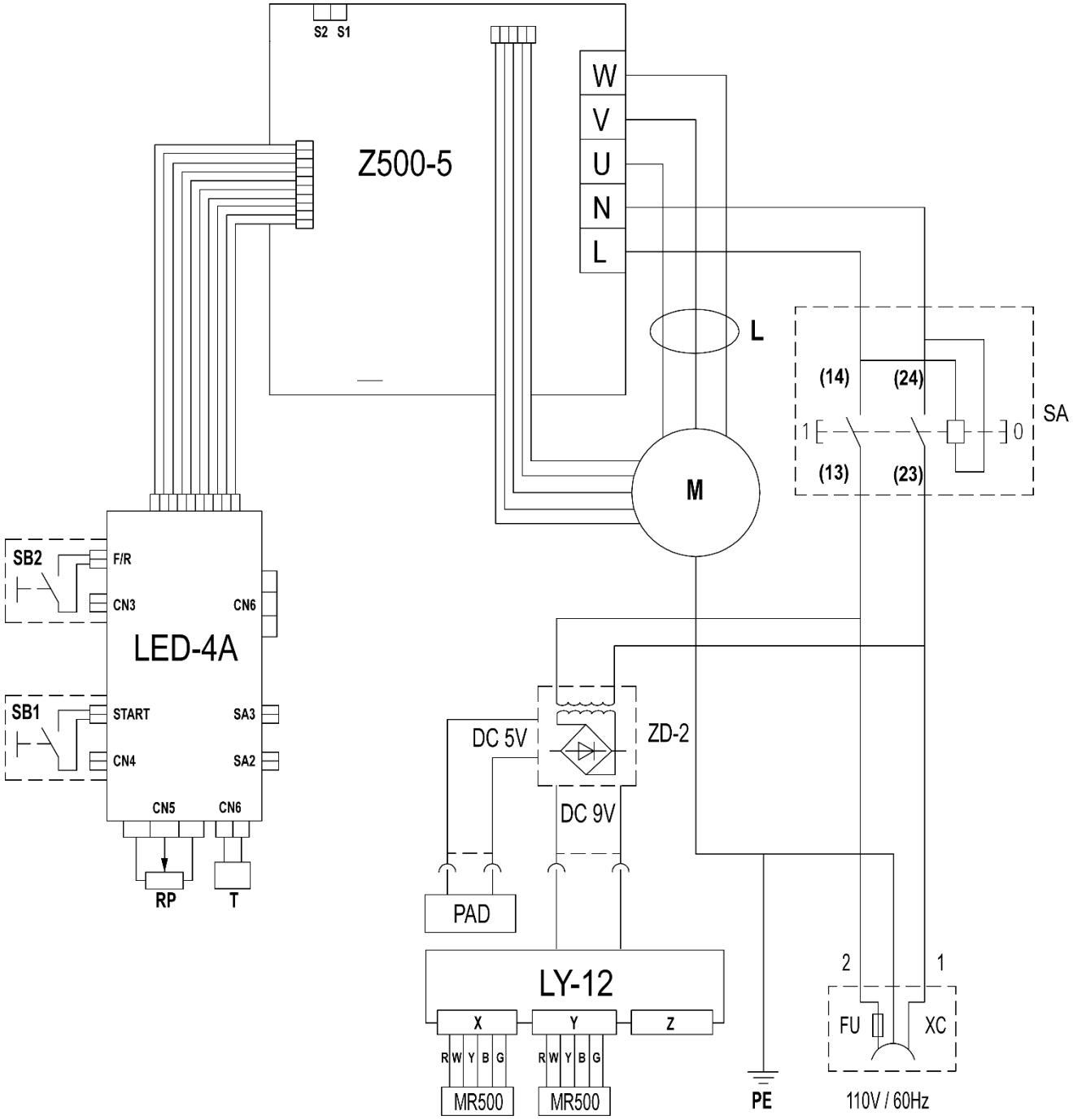
Dwg #	Description
213	M4 Nut
213	DRO Magnetic Scale
214	Fine Feed Bracket Screw
215	USB Interface Plug

Wiring Diagrams

Models 3990/4190 (SX2LF)



Model 6450 (SX20)



Z500-5/110V: Main board

LED-4A: LED

SA: Electromagnetic switch

M: Brushless motor

RP: Potentiometer

ZD-2: DC power board

L: Magnet ring

SB2: FWD/REV button

PAD: Tablet

LY-12: Bluetooth board

MR500: Readout unit of MDRO

XC: Socket with fuse

FU: Fuse (10A)

SB1: ON/OFF button