SIEG® X2D

Mini Mill

Instruction Manual

Please read this instruction manual thoroughly and follow all directions carefully.

Imported by **LittleMachineShop.com**
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Contents

Introduction

This user's guide covers operation and care of the SIEG X2D Mini Mill. Be sure to read and understand the safety guidelines presented in this book before using your 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	9.3" (235 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	0.48 hp (350 Watts)
Spindle Speed	100–2500 RPM
Power Requirements	120 V 60 Hz 6 Amps
Machine Weight	126 lbs (57 kg)
Overall Dimensions (W x D x H)	23.2" x 19.7" x 35.4" (590 mm x 500 mm x 900 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

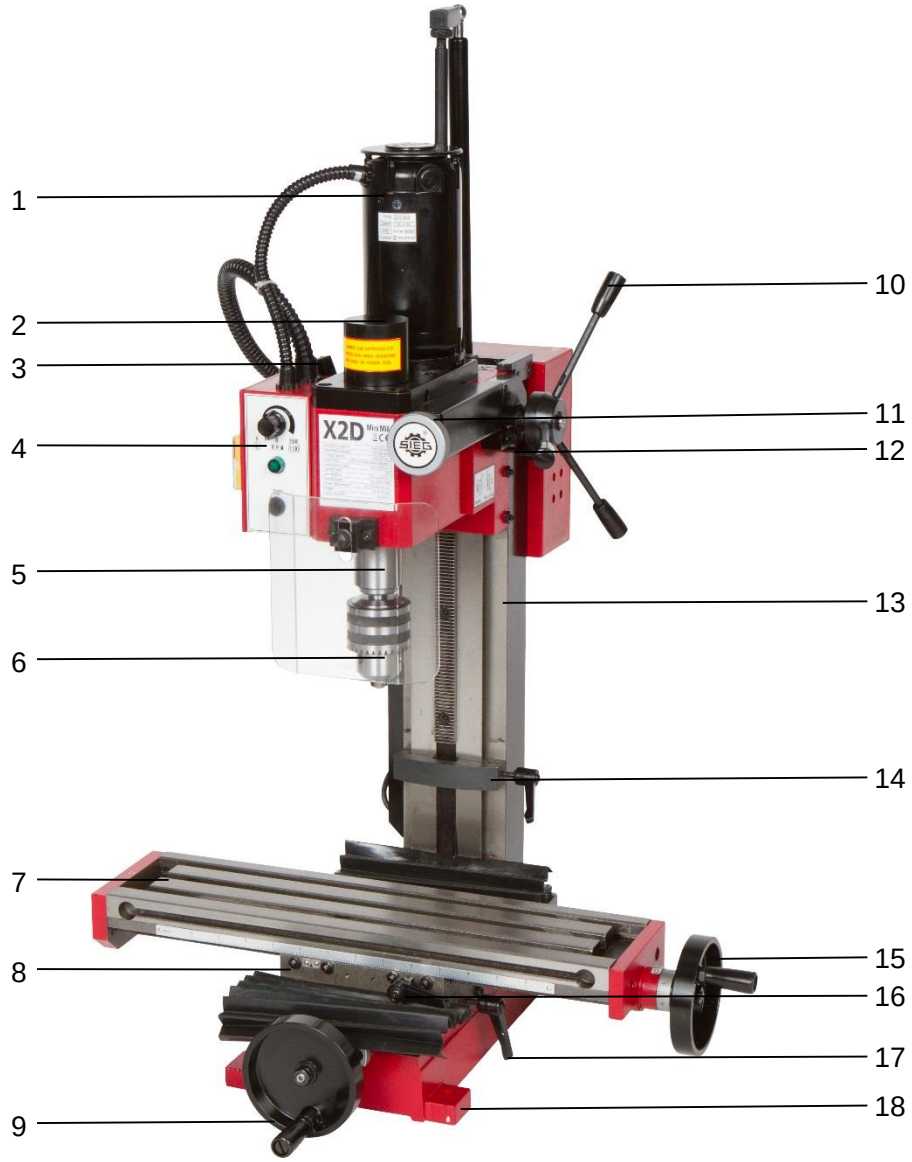
- Plug the machine into a grounded, ground fault protected receptacle.
- Ensure that all components are properly grounded. The easiest way to ensure this is to plug your machines and devices into grounded outlets that you have tested.

- 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



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

Basic Accessories

The following accessories come with the SIEG Mini Mill.

1. Spindle locking pin
2. Spanner wrench for spindle nut
3. Open end wrenches 8/10, 14/17 mm, and 17/19 mm
4. Oil can
5. Drill chuck arbor
6. Drawbar
7. Hex wrenches 3, 4, 5, and 6 mm
8. Two T-slot nuts

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 13 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.

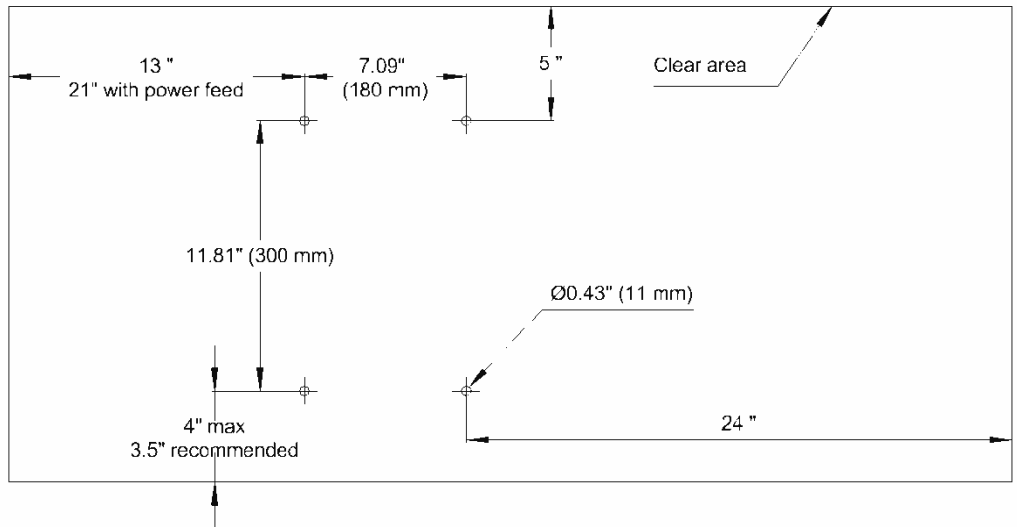
Mounting Your Mill

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.

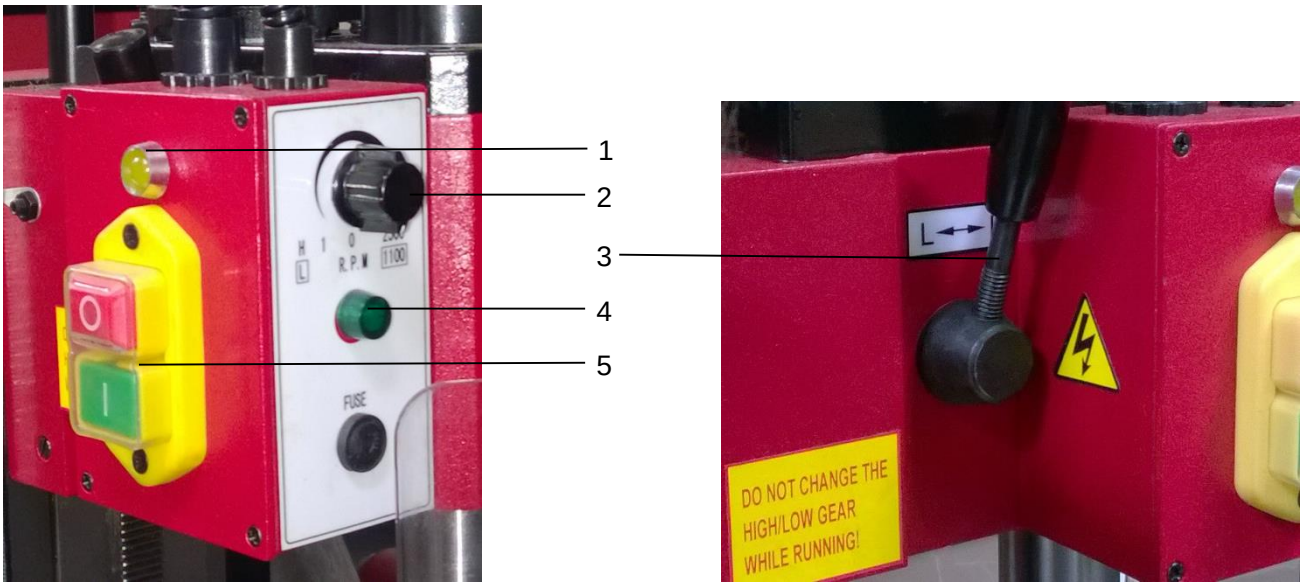


Mount the mill to the workbench with 3/8" or 10 mm bolts. The bolts should be about 1" (25 mm) longer than the thickness of the workbench. Use fender washers on the underside of wooden benches to prevent the nuts from pulling through.

Operating Controls

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

Motor Controls



1. Yellow (overload) lamp
2. Speed control
3. High/low speed shifter
4. Green (power) lamp
5. Power and emergency stop (E-stop) switch

The power switch interrupts the input power to the speed control circuit board. To turn the power on, press the green button; the green lamp illuminates to indicate that power is on. To turn the power off, press the red button.

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

Always turn the speed control to the minimum speed position before starting the mill. Starting the mill with the speed control set to a higher speed can damage the speed control circuit board.

If you overload the mill motor (say, by drilling too fast or milling too deep in one pass), the motor stops and the yellow lamp illuminates. Turn the speed control off and then turn it on again to reset the overload protection.

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.

High/Low Speed Shifter

The high/low speed shifter is on the left side of the spindle housing. It selects the spindle speed range.

Low speed range	0-1100 RPM
High speed range	0-2500 RPM

CAUTION: Never move this lever when the mill is turning. You might need to turn the spindle slightly by hand as you move the high/low speed shifter.

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 SIEG 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 SIEG 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 find adjustments to the position of the head assembly.

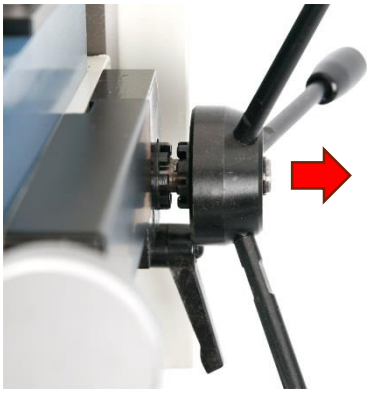
There are 60 divisions on the dial. Each full turn of the knob moves the head assembly 0.060". Each division of the dial represents a movement of 0.001".

To engage the Z-axis fine feed:

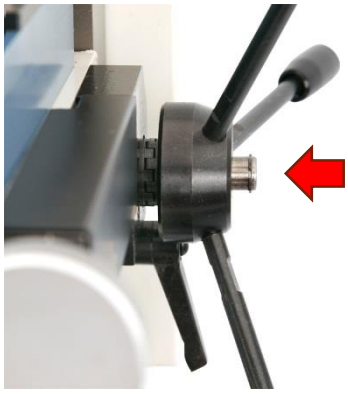
- Move the hub and coarse feed handles in to engage the dog clutch. You might need to turn the Z-axis fine feed knob to align the dogs.

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.

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.

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

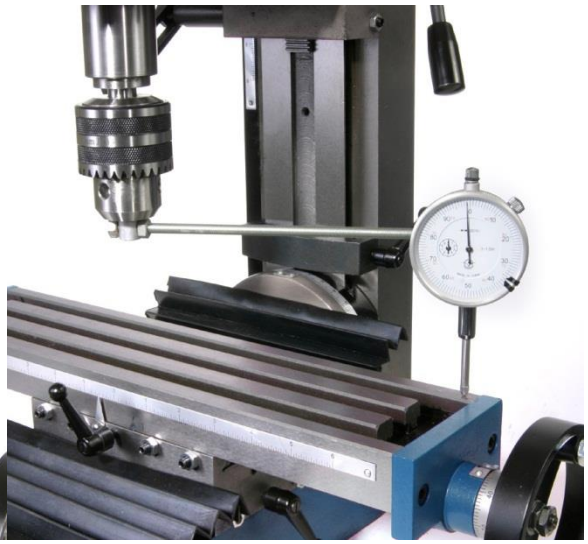
Tramming is the process of squaring the column with the table on a mill. It involves placing shims under the corners of the base of the column where it bolts to the base.

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.

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. A good alternative is 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. White lithium grease is a plastic-friendly general use grease that is easy to find and easy to use.

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.

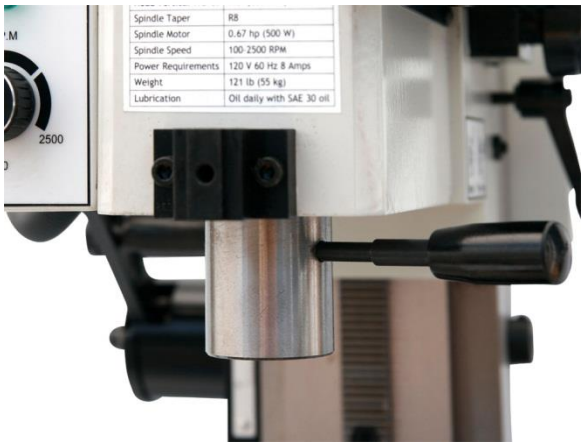
- Clean swarf from the mill, from top down after each use.

Changing Spindle Tools

The tools you work with are centered in the mini mill spindle by the R8 taper.

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:



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.

Squaring a Vise

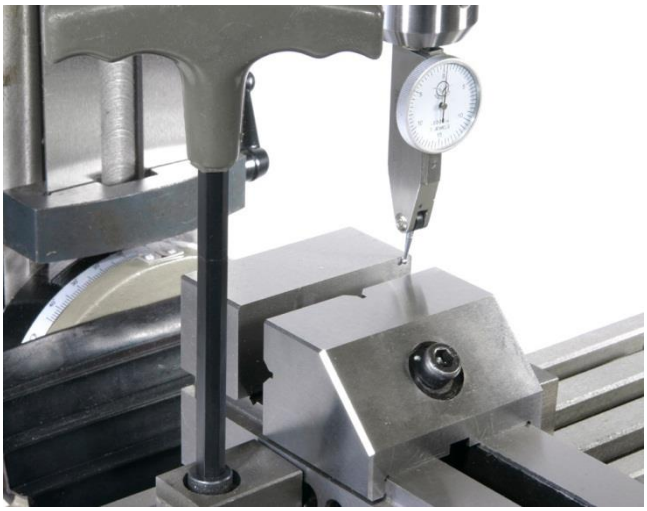
When you mount a vise on the mill table, it is important that it be mounted square to the table. If your vise is not square to the table, you will not be able to produce accurate work.

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.

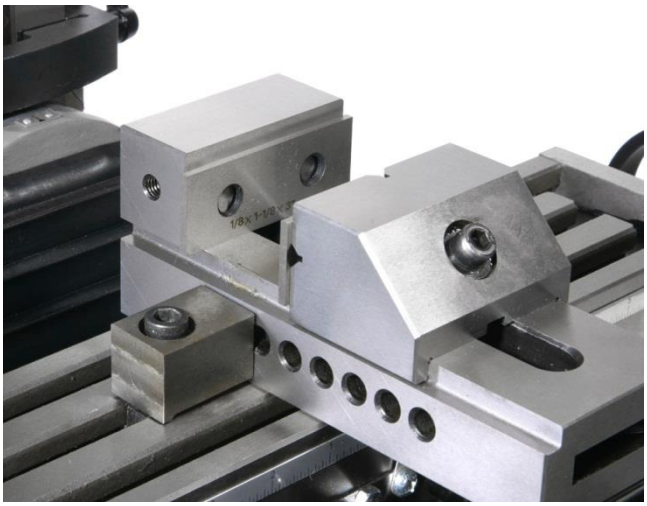
5. Move the X-, Y-, and Z-axis controls so the point of the dial test indicator is between the vise jaws and about 1/8" below the top of the vise jaws.
6. Move the X-axis so the dial test indicator's point is about 1/16" inside of one end of the vise jaws.
7. Move the Y-axis so that the dial test indicator's 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.

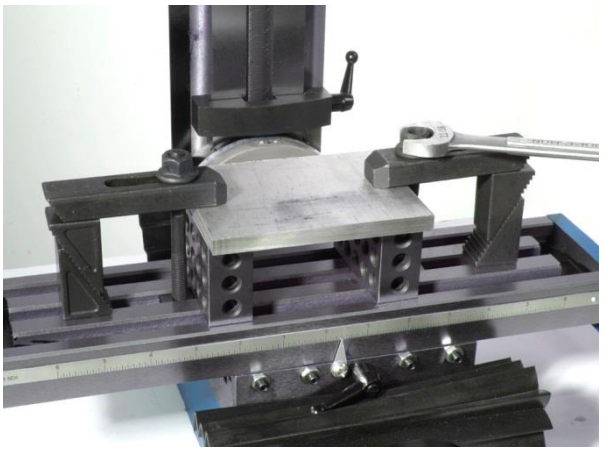


Clamping with a Clamping Kit

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

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.

Collets vs. End Mill Holders

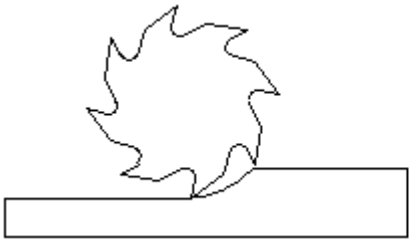
You can use a collet or an end mill holder to hold an end mill in the spindle of the mini mill. The world is split about 50/50 on which is better. We will give you the arguments for both sides and let you decide.

Collet

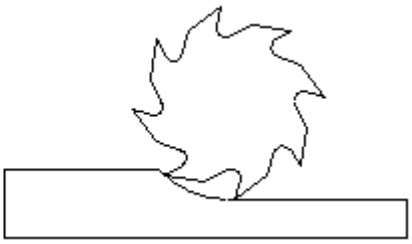
End mill holder

- Collets are shorter than end mill holders and so give you more vertical work area.
- Collets grip the end mill all the way around and so provide a better grip, whereas 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.
- Collets are less expensive than end mill holders and so can be replaced when they wear out. However, end mill holders are more robust than collets and are less prone to wear out.
- It is easier to replace an end mill in an end mill holder because the end mill holder can remain in the spindle; with collets, you're forced to juggle the end mill, the collet, and the drawbar simultaneously.

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 in to material with a climbing action, and the workpiece and rotation of the cutter are going in the same direction. With this forward stroke the tooth starts with a full chip and pushes the workpiece down against the table or holding device. This requires less machine power, the cutter does not dull as soon, and a better surface finish is produced.

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

On light mills like the 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.

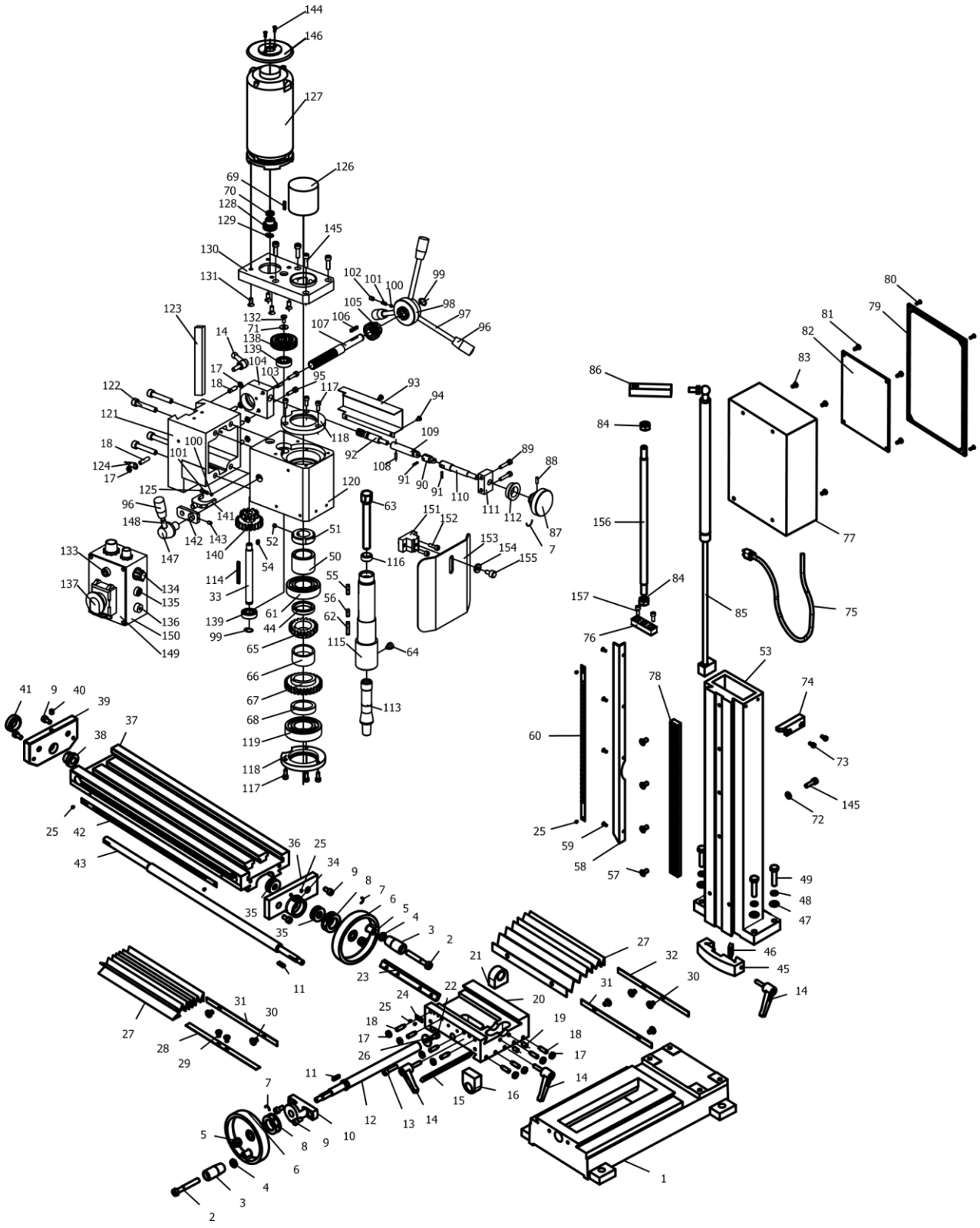
And, if you use an end mill where the diameter of the end mill is the same as the width of the slot, you are conventional milling on one side of the slot, and climb milling on the other. You will see markedly different surface finishes on the two sides of the slot. But since slots usually need to provide 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.

Parts Diagram



Parts List

No.	Description
1	base
2	slotted cheese head screw
3	handle
4	hex nut
5	screw
6	hand wheel
7	spring
8	dial
9	cap screw
10	cross leadscrew seat
11	key
12	leascrew
13	cap screw
14	handle
15	wedge
16	leadscrew nut
17	hex nut
18	cylindrical tight setscrew
19	setscrew with flat end
20	saddle
21	leadscrew nut
22	cap screw
23	wedge
24	label
25	rivet
26	washer
27	Protecting cover
28	fixed plate
29	phillips head screw
30	phillips head screw
31	fixed plate
32	fixed plate
33	I axis
34	guide finger
35	Ball thrust bearing
36	bearing seat
37	worktable
38	shaft sleeve
39	end cover
40	oil cup
41	cap
42	ruler
43	leadscrew
44	spacer
45	limited block
46	wedge
47	washer
48	spring washer
49	screw
50	spacer
51	spindle nut

No.	Description
52	setscrew with cone point
53	column
54	key
55	key
56	key
57	screw
58	ruler support
59	flat head screw
60	ruler
61	bearing
62	key
63	drawbar
64	pin
65	spindle gear
66	spacer
67	spindle gear
68	spacer
69	key
70	washer
71	washer
72	washer
73	cap screw
74	limited block
75	power line with plug
76	fixed plate
77	control box
78	rack
79	cover
80	flat head screw
81	screw
82	pc board
83	flat head screw
84	hex nut
85	gas strut
86	connecting block
87	hand wheel
88	cylindrical tight setscrew
89	cap screw
90	adjustable unit
91	pin
92	worm
93	cover
94	phillips head screw
95	cap screw
96	handle sleeve
97	operating lever
98	handle stock
99	ring
100	steel ball
101	spring
102	setscrew with flat end

No.	Description
103	pin
104	worm support
105	bevel gear
106	key
107	shaft gear
108	pin
109	sleeve
110	shaft
111	support
112	dial
113	spindle shank
114	key
115	R8 spindle
116	sleeve
117	cap screw
118	bearing cover
119	bearing
120	spindle box
121	spindle box seat
122	cap screw
123	wedge
124	guide finger
125	setscrew with flat end
126	Protecting cover
127	motor
128	Motor gear 21/29T
129	Intering ring 9.0
130	Motor seat

No.	Description
131	screw
132	phillips head screw
133	yellow lamp
134	speed control knob
135	green lamp
136	fuse box
137	switch
138	Gear 30T
139	Ball bearing 80101
140	Transmission gear 20/12T
141	fork
142	linking board
143	setscrew with cone point
144	Self-tapping Screw ST2.9 x 8
145	cap screw
146	Motor cover
147	handle shaft
148	screw
149	electric box cover
150	electric box
151	support of dust cover
152	cap screw
153	dust guard
154	washer
155	adjustable unit
156	connecting bar
157	cap screw

Wiring Diagram