MANUAL MILL

1. Do not operate this machine before proper training and approval of MMM Instructor.

2. Do not run this machine without knowing the function of every control key, button, knob, or handle. Ask MMM staff or a qualified instructor for help when needed.

3. Protect your eyes. Wear approved safety glasses (with side shields) at all times.

4. Don't get caught in moving parts. Before operating this machine remove all jewelry including watches and rings, neckties, and any loose-fitting clothing.

5. Keep your hair away from moving parts. Long hair should be pulled up and tucked away.

6. Wear close toed shoes. No sandals or flip-flops.

7. Take off gloves before you start the machine. Gloves are easily caught in moving parts.

8. Remove all tools (wrenches, chuck keys, etc.) from the machine before you start. Loose items can become dangerous flying projectiles.

9. Never operate any machines after consuming alcoholic beverages, or taking strong medication, or while using non-prescription drugs.

10. Protect your hands. Stop the machine spindle and ensure that all movements have stopped:
    - Before changing tools
    - Before changing parts
    - Before you clear away the chips. Always use a chip scraper or brush
    - Before you make an adjustment to the part, fixture, or take measurements

11. Protect your eyes and the machine as well. Don't use a compressed air hose to remove the chips or clean the machine.

12. If you don't know, stop and ask.

13. Observe and practice all shop safety procedures.

14. Prevent slippage. Keep the work area dry and clean. Remove the chips, oil, coolant and obstacles of any kind around the machine.

15. Avoid getting pinched in places where the table, saddle or spindle head create "pinch points" while in motion.

16. Securely clamp and properly locate the workpiece in the vise, on the table, or in the fixture. Use proper holding clamping attachments and position them clear of the tool path.

17. Use proper cutting tools for the job. Pay attention to the rotation of the spindle: Left hand tool for counterclockwise rotation of spindle, and right hand tool for clockwise rotation of spindle.

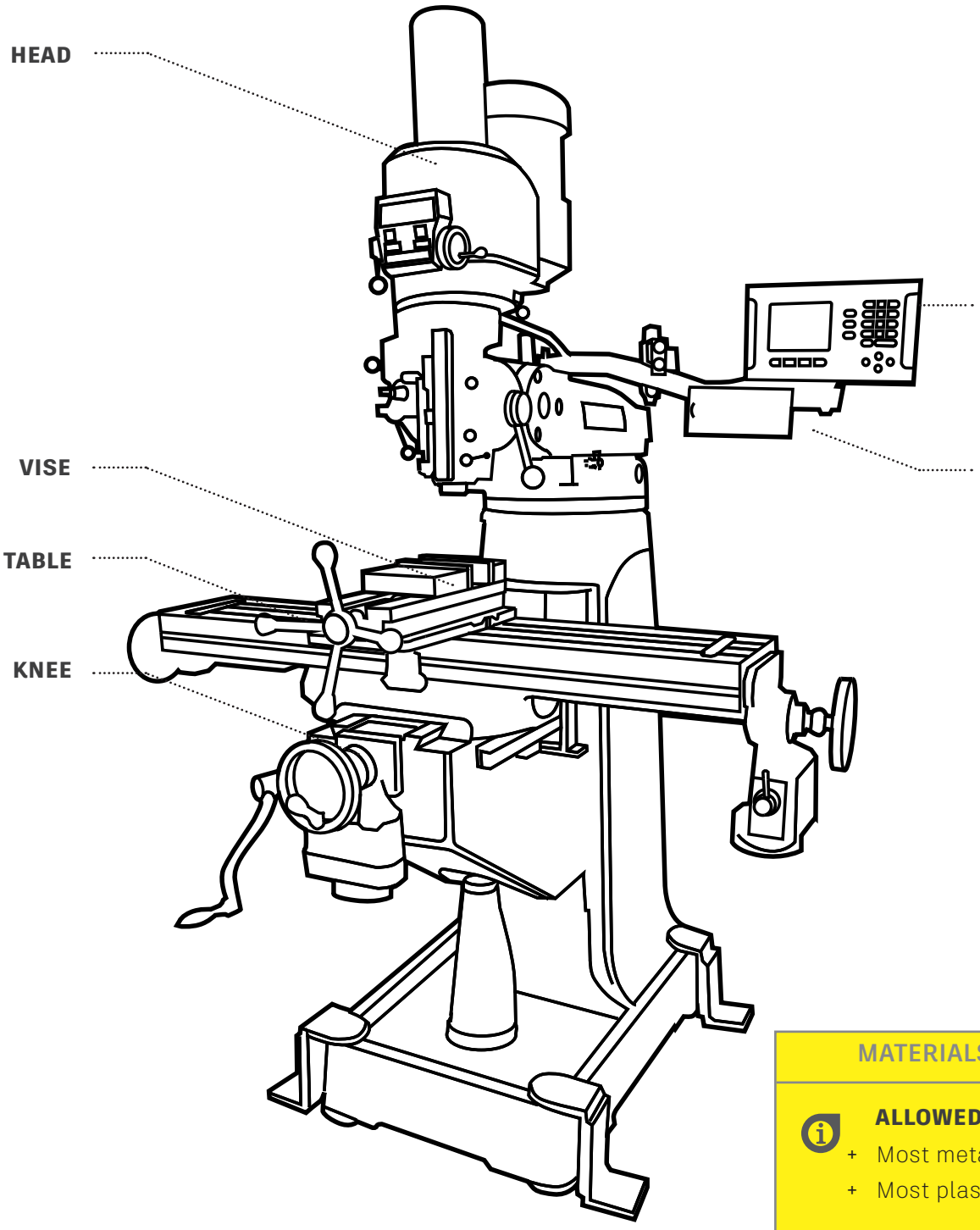
18. Prevent damage to the workpiece or the cutting tool. Never start the machine (including the rotation of the spindle) if the tool is in contact with the part.

19. Check the direction (+ or -) of movement of the table when using the jog or power feed.

20. Don't use dull or damaged cutting tools. They break easily and become airborne. Inspect the sharpness of the edges, and the integrity of cutting tools and their holders. Use proper length for the tool.

MANUAL MILL

THE MILLING MACHINE MAKES PRECISION CUTS IN METALS AND PLASTICS.



MATERIALS

ALLOWED MATERIALS

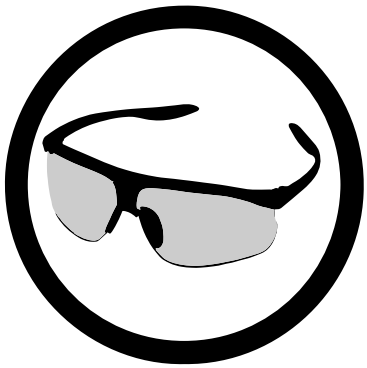
+ Most metal
+ Most plastics

BANNED MATERIALS

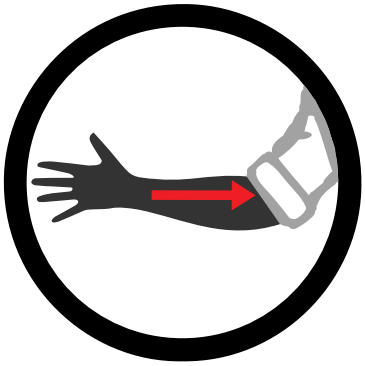
+ Wood
+ Carbon fiber and composites

SEE SHOP STAFF FIRST

+ All other materials

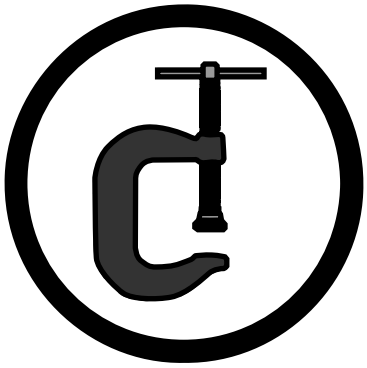


Always
wear safety
glasses.



Always wear short sleeves, or rolled sleeves, pull back and tuck in long hair, remove jewelry and lanyards, etc.

Do not wear gloves.



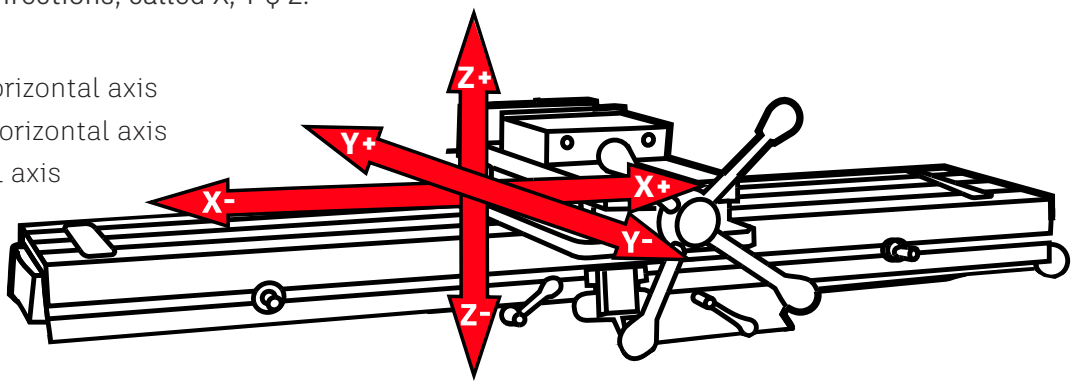
Using the mill vise or strap clamps is required for all work.

MILL BASICS: MOVEMENT

When using a mill, the material is clamped into a vise or directly to the table. The table is moved so that the workpiece moves past a spinning cutter.

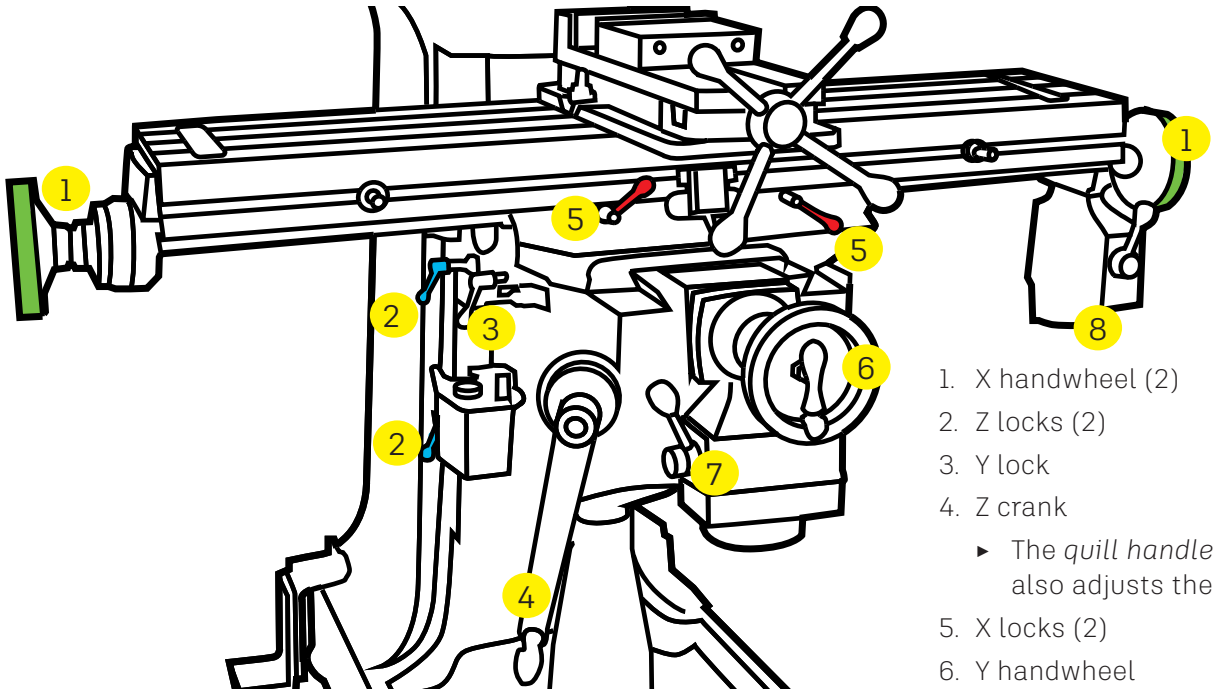
The table can move in 3 directions, called X, Y & Z.

- X is the long horizontal axis
- Y is the short horizontal axis
- Z is the vertical axis



- Handwheels and power feeds move the table horizontally (X & Y).
- Z crank moves the table vertically (Z).

- Locks keep the table from moving.
  - Lock each axis that is not moving.
  - Unlock an axis before moving it.



1. X handwheel (2)
2. Z locks (2)
3. Y lock
4. Z crank
   - The *quill handle* (next page) also adjusts the Z height.
5. X locks (2)
6. Y handwheel
7. Y power feed
8. X power feed

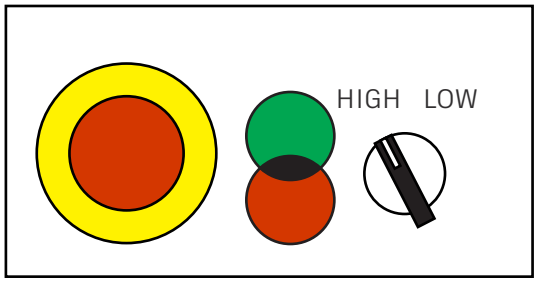
The head of the mill holds the following controls:

+ Hi/low gearbox
+ Speed control and display
+ Brake
+ Quill handle
+ Quill lock

CHANGING THE GEARBOX RANGE

+ **Mill must be *off***

1. Push the lever towards the mill and rotate into high or low range.
2. Rotate the spindle by hand to fully engage the gears.
3. Move the switch on the control panel to match the gearbox switch.
   - ▸ Ex. If the mill is in high range, turn the control panel switch to high.



CHANGING THE RPM

+ **Mill must be *on***

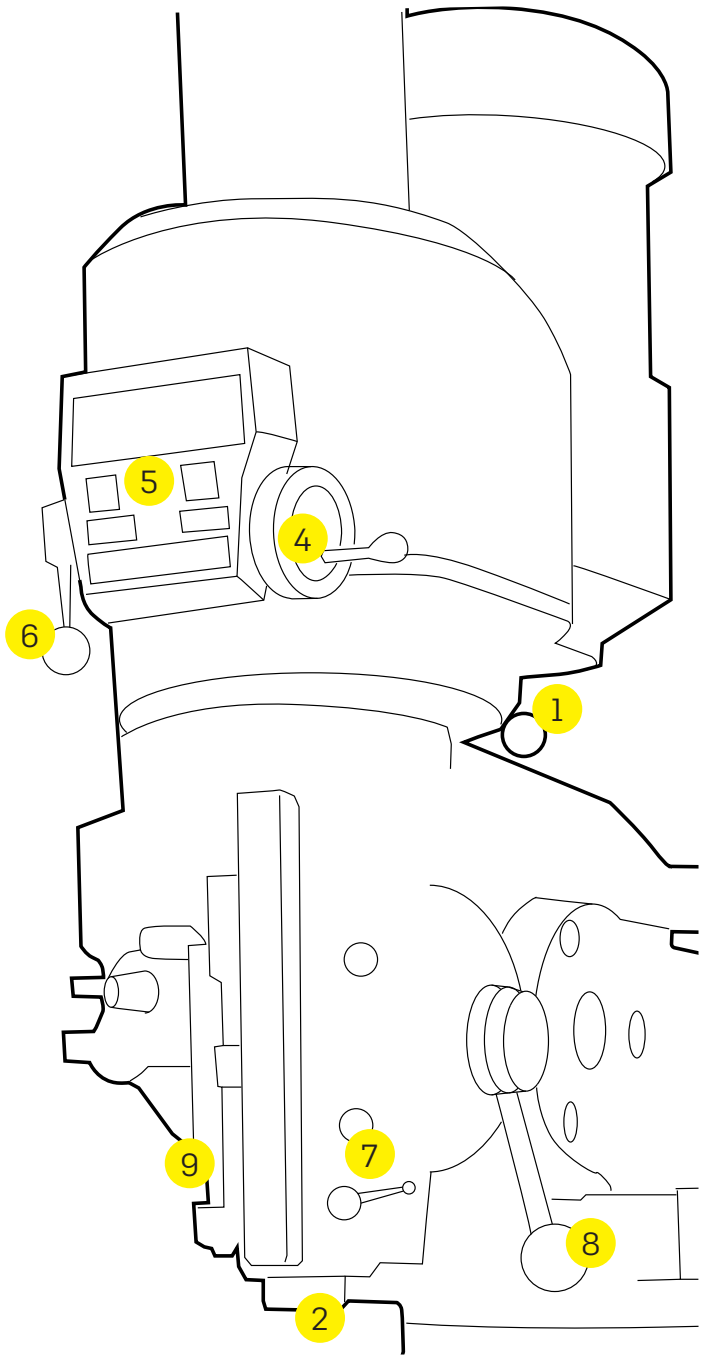
4. Rotate the handwheel clockwise or counterclockwise.
5. Observe the RPM on the display.

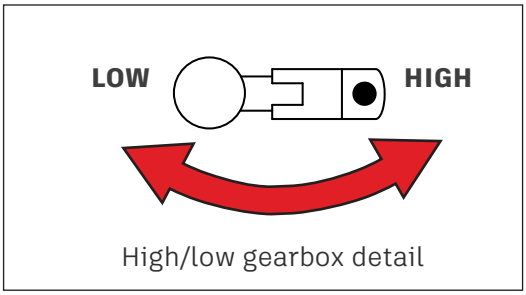
BRAKE

6. Use the brake to stop the spindle after turning off the mill.

QUILL MOVEMENT

7. Engage the quill lock before moving the table.
8. Use the quill handle to move the quill like a drill press.
9. Set the depth stop to limit quill handle travel.





High/low gearbox detail

END MILLS AND COLLETS

End mills and drill bits are the most common cutting tools used in a mill.

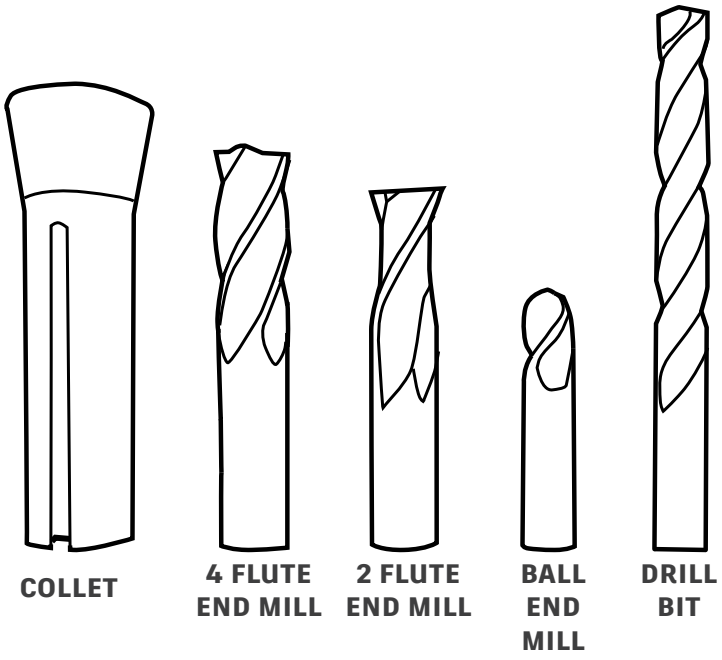
+ End mills are designed to cut while moving sideways through the material, in X or Y.
+ Drill bits can only cut while moving in Z.

End mills come in different diameters, lengths, and shapes.

Each cutter requires a different RPM depending on the material being worked - *speed*.

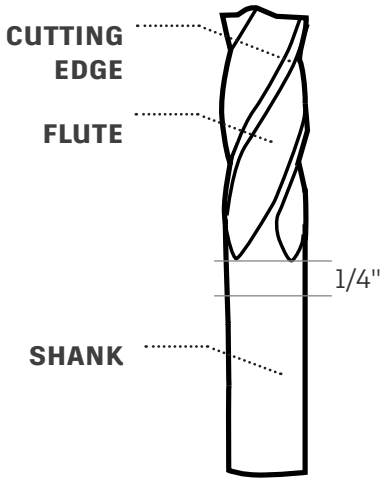
The *flutes* are the cutting edges. In general, use *2 flute* end mills for plastic and aluminum, and *4 flute* end mills for steel.

Ask Shop Staff for assistance selecting an appropriate end mill for your project.



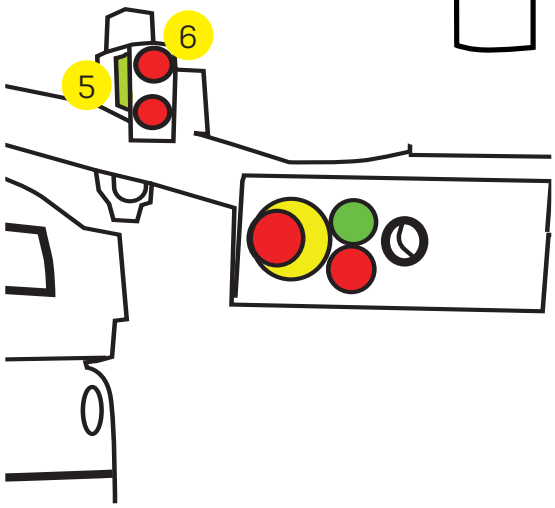
End mills must be held in a *collet*.

+ Never hold an end mill in a drill chuck.
+ The collet must be the same size as the shank of the end mill.
+ Only grip the shank; not the flutes.
+ Leave no more than 1/4" of shank out of the collet.
+ Hold drill bits in a chuck that installs in the mill.



INSTALLING A BIT AND COLLET

1. Slide the shank of the cutting tool into the large end of the collet.
2. Place the small end of the collet into the bottom of the spindle.
3. Push up on the collet, and slowly rotate it until the key in the spindle slides into the keyway in the collet.
   - ▸ Hold the collet in place for the next steps.
4. Push the quill handle to the top of the stroke.
5. Press and hold the gold bar on the power drawbar controller.
6. Press the IN button on the controller.
   - ▸ Hold the button until the pitch changes - about 3-4 seconds.



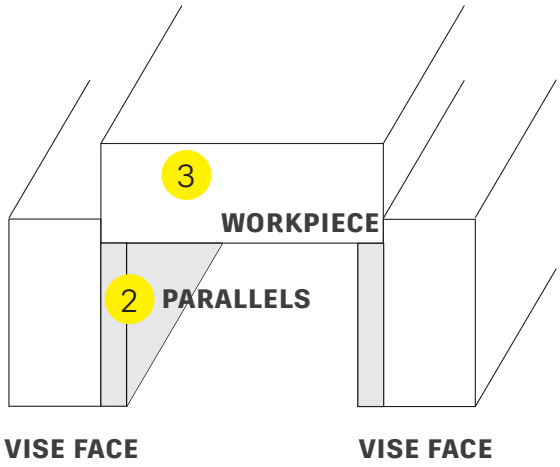
USING THE VISE & PARALLELS

Parallels are used to elevate your workpiece in the vice, and allow working on the top of your material, or to drill through it, without hitting the table or vise.

Only items with two parallel sides and a flat bottom may be held in the vise.

+ For holding complex shapes, see Shop Staff.
+ To install or remove the vise, see Shop Staff.

1. Clean the vise & parallels with a chip brush or shop towel.
2. Set two equal height parallels against the vise faces.
3. Set your workpiece on top of the parallels.
4. Have a minimum of 1/4" of material in the vise.
5. Tighten the vise.
   - ► The parallels will probably loosen a bit.
6. Strike the workpiece straight down with a *deadblow* hammer.
   - ► Never use a metal hammer.
   - ► Do not re-tighten the vise.
7. See if the parallels will move in the vise.
   - ► If so, remove the parts, and start over.

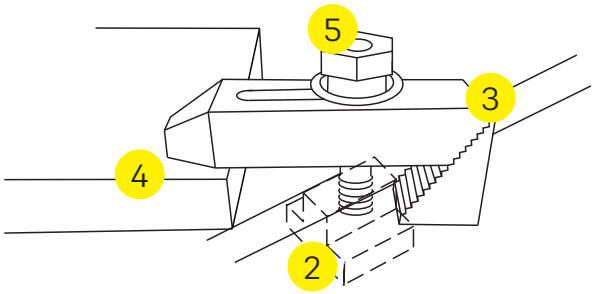


USING STRAP CLAMPS

Strap clamps are used to hold a part that can't fit in the vise.

Use a minimum of 2 strap clamps; more is better.

1. Screw a *threaded stud* into a *t-nut*.
2. Slide the t-nut into a *slot* on the table.
3. Place the stepped end of a *strap clamp* onto the *step block*.
4. Place the nose of the strap clamp onto the workpiece.
   - ► **The nose must be slightly lower than the stepped end.**
5. Tighten the nut on the top of the strap clamp.
6. Check that the part is secure.



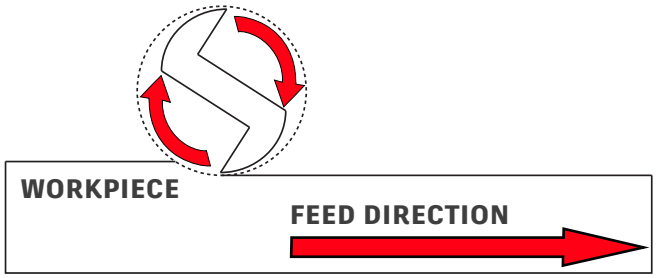
CONVENTIONAL CUTTING VS. CLIMB CUTTING

Conventional cutting is when the workpiece moves against the direction of the cutting bit.

+ All manual mill work should be done with conventional cuts.

Climb cutting is when the workpiece moves in the same direction as the bit.

+ This is not advised on the manual mill.
+ Climb cutting should be reserved for CNC milling.



CONVENTIONAL CUTTING

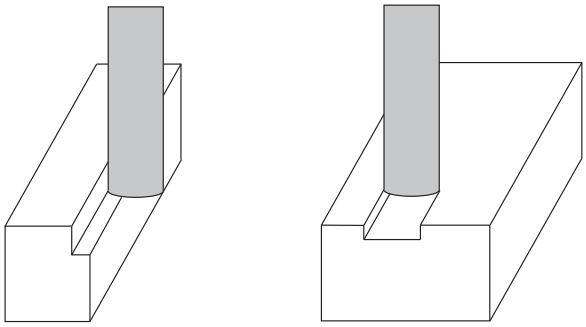
CLIMB CUTTING
NOT RECOMMENDED

CUTTING WIDTH AND DEPTH

An end mill can only remove a certain amount of material at once.

The maximum depth and width of cut is 1/2 of the end mill diameter.

+ For example, a 1/2" end mill can cut no more than 1/4" deep and 1/4" wide in a single pass.
+ A *slotting cut* is an exception to the width of cut rule.

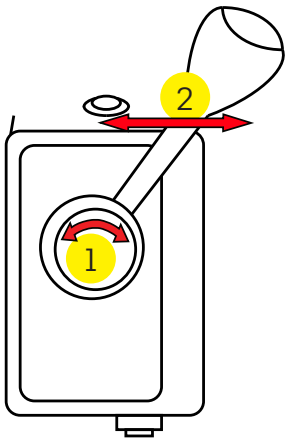


SLOTTING CUT

USING THE POWER FEED

The power feed moves the table at a constant rate, which can help improve finish quality.

1. Turn the speed dial to 0.
2. Move the lever in the direction you want the table to move.
   - ▸ In the illustration, the table will be moving to the right.
3. Adjust the feed rate by turning the speed dial.

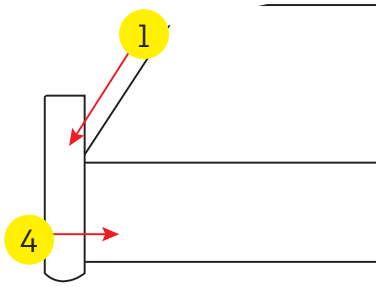


For accurate work, each axis needs to have a known zero point (origin).

There are two ways to determine zero; create it or find it.

CREATING A ZERO

X or Y axis



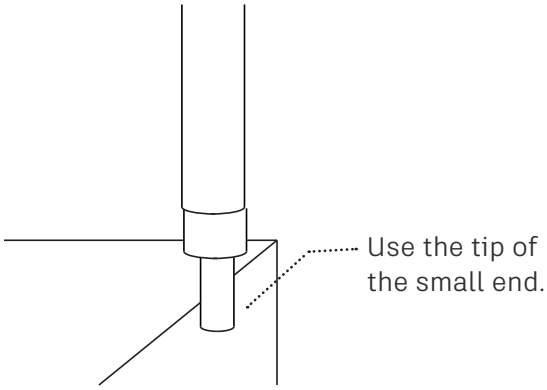
1. Take a light cutting pass to make the edge flat and square.
2. Turn off the mill.
3. On the DRO (see next page) zero the axis.
   - In this example, zero the X axis.
4. Move the end mill 1/2 its diameter towards the center of the workpiece.
   - This will center the spindle over the edge of the material.
5. Zero the axis on the DRO again.

Z axis

1. Take a light cutting pass across the top of the part.
2. Set the Z axis to zero.
   - The zero will need to be reset if the quill moves, or you change the end mill.

FINDING A ZERO

X or Y axis



1. Install an *edge finder*.
2. Push the bottom of the edge finder over 1/8".
3. Start the mill and adjust to 800 RPM.
4. Very **slowly** move the edge finder into the edge of the material until the bottom pops over to one side.
5. Zero the axis on the DRO.
6. Repeat step 4 to double check.
7. Move the edge finder 1/2 its diameter towards the center of the workpiece.
   - This will center the spindle over the edge of the material.
8. Zero the axis on the DRO again.

Z axis

1. Install the end mill.
2. Lower the quill (or raise the table with the quill locked) until the end mill gently touches the table.
3. Lock the quill.
4. Set the Z axis to zero.
   - The zero will need to be reset if the quill moves, or you change the end mill.

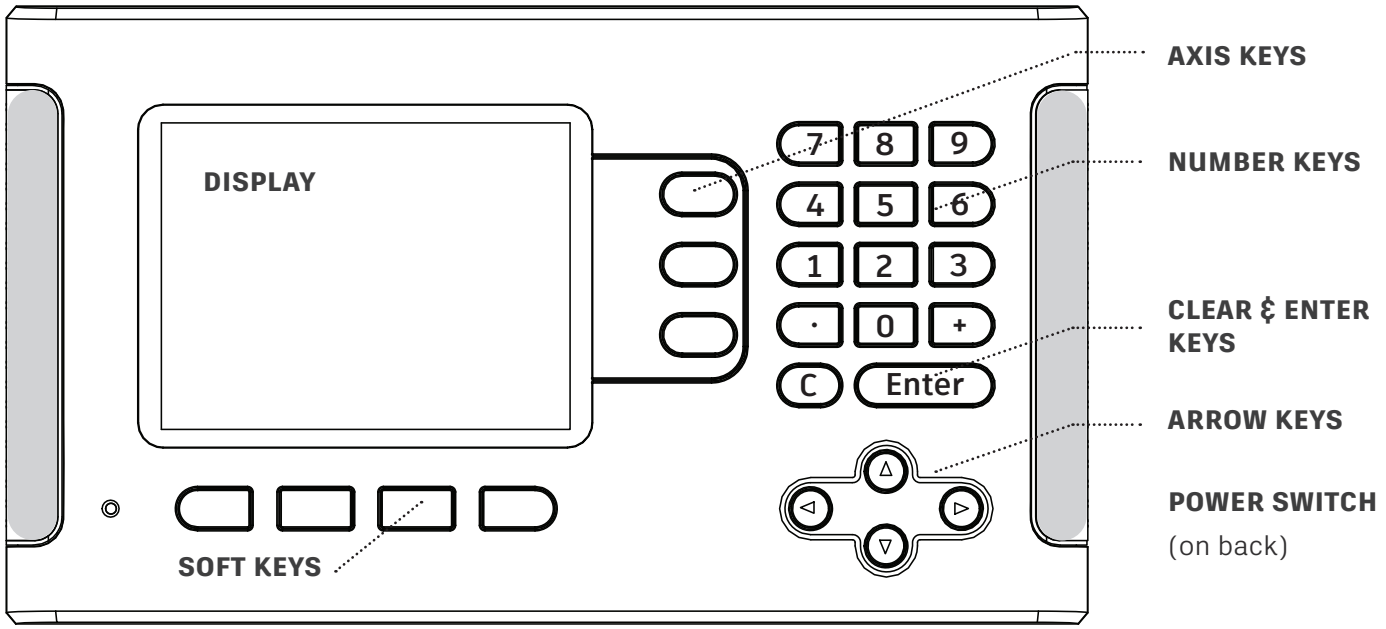
UNITS OF MEASUREMENT

Most of the cutting tools are measured in decimal inches by 0.001" (1/1000"). For example, 1/4" is 250 one-thousandths of an inch, and written as 0.250".

The *digital readout* (DRO), as well as the digital calipers, display in decimal inches or millimeters.

DIGITAL READ OUT (DRO)

The DRO displays the position of the X and Y axis in increments of 0.0002" or 0.005mm



The *Soft Keys* change using the left/right arrows. Look at the label above the key to see its current function.

+ Press **NO REF** when the DRO first starts up.
+ Press **INCH/MM** to switch to metric.

Press the **ZERO/SET** soft key to switch between zero or set mode (displayed in the upper right).

+ ZERO mode: press the axis key to set that axis to zero.
  - ▸ Ex. Press the X axis key in **ZERO** mode and the X axis will be set to 0.
+ SET mode: enter a number and press the axis key to set that axis to the number entered.
  - ▸ Ex. Enter 1.25 and press the X axis key in **SET** mode and the X axis will be set to 1.25.

The DRO has built-in advanced features, such as circular or linear patterns. Explore the interface or talk to Shop Staff.

AREA AND MACHINE PREPARATION

1. Clean and clear the table.
2. Secure the workpiece.
   - See Shop Staff if you need assistance.
3. Select a cutting bit & collet.
4. Install the bit & collet.
5. Lookup the RPM (speed) for your cutter and material.
6. Change the hi/low gearbox if needed.
7. Lock the quill (unless drilling).
8. Lock any axis not being moved.
9. Determine which way the table will need to move to avoid climb cutting.
10. Place the shield in front of the work area.

ALL WORK MUST BE CLAMPED AT ALL TIMES.

MAKING THE CUT

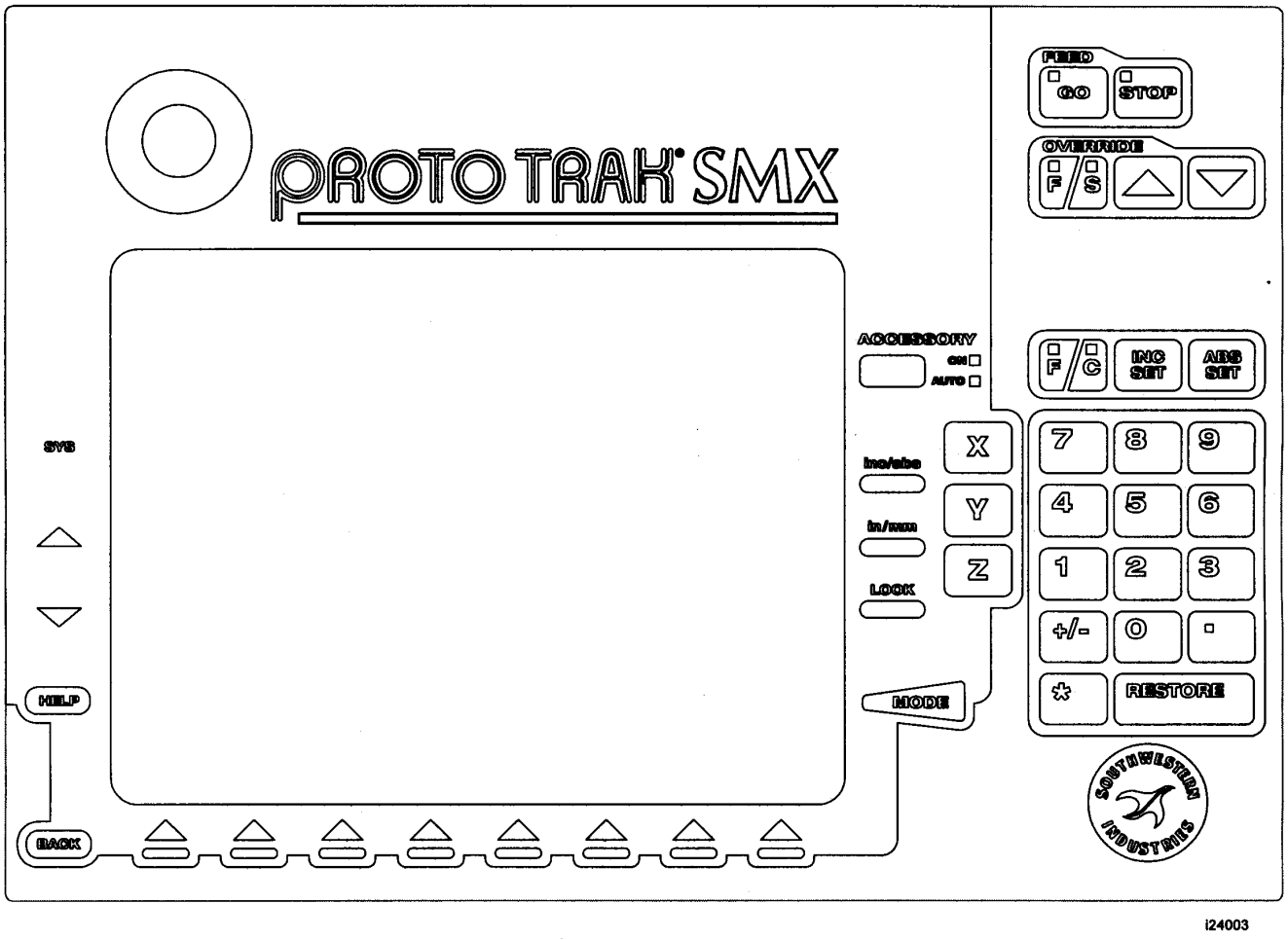
1. Start the mill.
2. Change the RPM.
3. Engage the end mill into the material.
   - Take no more than 1/2 the diameter of the cutter in depth or width of cut.
   - Avoid climb cutting.
4. Unlock an axis before moving it.
   - Lock the axis after movement.
5. Use the power feed for a better surface finish.

DO NOT CLIMB CUT.

CLEANUP

1. Clean the mill and the area nearby.
   - Use brushes and a vacuum.
   - Never use compressed air.
2. Clean up any coolant spills.
3. Put away end mills, drill bits and tools.
4. Recycle scraps and put reusable pieces in the storage bin in the metal shop.

NEVER CLEAN OFF THE TABLE WHILE THE END MILL IS SPINNING.



Keyboard Hard Keys

Feed Keys:

GO: initiates motion in Run. The green LED on the GO key will be lit when the servomotors are moving the machine either in jog or when the program run has been initiated by the GO key.

STOP: halts motion during Run. The red LED on the STOP key will be lit when the servos motors are not moving the machine.

Override Keys:

F/S: selects the function for the override operation. F is for feedrate. When the LED above the F is lit, arrow presses will increase or decrease axis feedrate. S is for spindle RPM. When the LED above the S is lit, arrow presses will increase or decrease the spindle RPM. Note: the spindle override is active only when the Programmable Electronic Head Option is installed.

↑: Feedrate Override to increase feedrate or spindle rpm up to 150%.

↓: Feedrate Override to decrease feedrate or spindle rpm down to 10%.

Each button push Modifies the feedrate in 10% increments and the spindle speed in 5% increments.

INC SET: loads incremental dimensions and general data

ABS SET: loads absolute dimensions and general data

INC/ABS: switches all or one axis from incremental to absolute or absolute to incremental

IN/MM: causes Inch to Metric or Metric to Inch conversion of displayed data

LOOK: part graphics in Program mode

X, Y, Z: selects axis for subsequent commands

RESTORE: clears an entry, aborts a keying procedure

MODE: to change from one mode of operation to another

SYS: To shut down the ProtoTRAK SMX CNC

HELP: displays help information, math help or additional functions. Active for additional functions when the help symbol (a blue question mark) is displayed on the screen next to the HELP key.

Soft Keys:

Beneath the display are 8 keys that are labeled with arrows. These keys are called software programmable or soft keys. A description of the function or use of each of these keys will be shown at the bottom of the display directly above each key. If, at any time, there is no description above a key, that key will not operate.

Sometimes the description or function of the key is visible but grayed out. This indicates that the particular function is not available because of some other condition. For example, if there is no program in the current memory, the EDIT Mode softkey will be grayed out because there is no program to edit.

Emergency Stop Switch

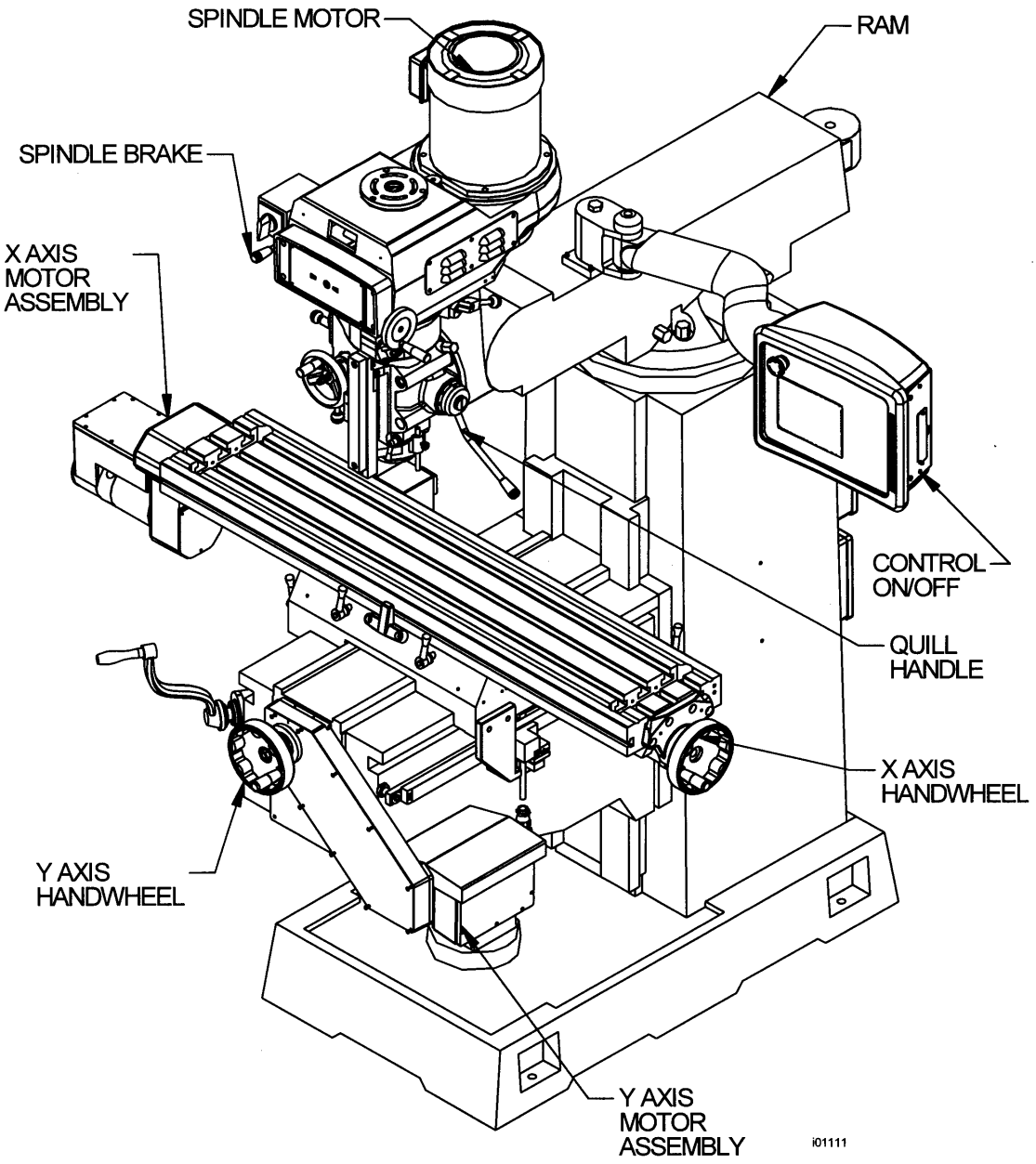
The emergency stop (E-stop) switch kills all power to the spindle and ProtoTRAK's servomotors. The computer and pendant remain powered.

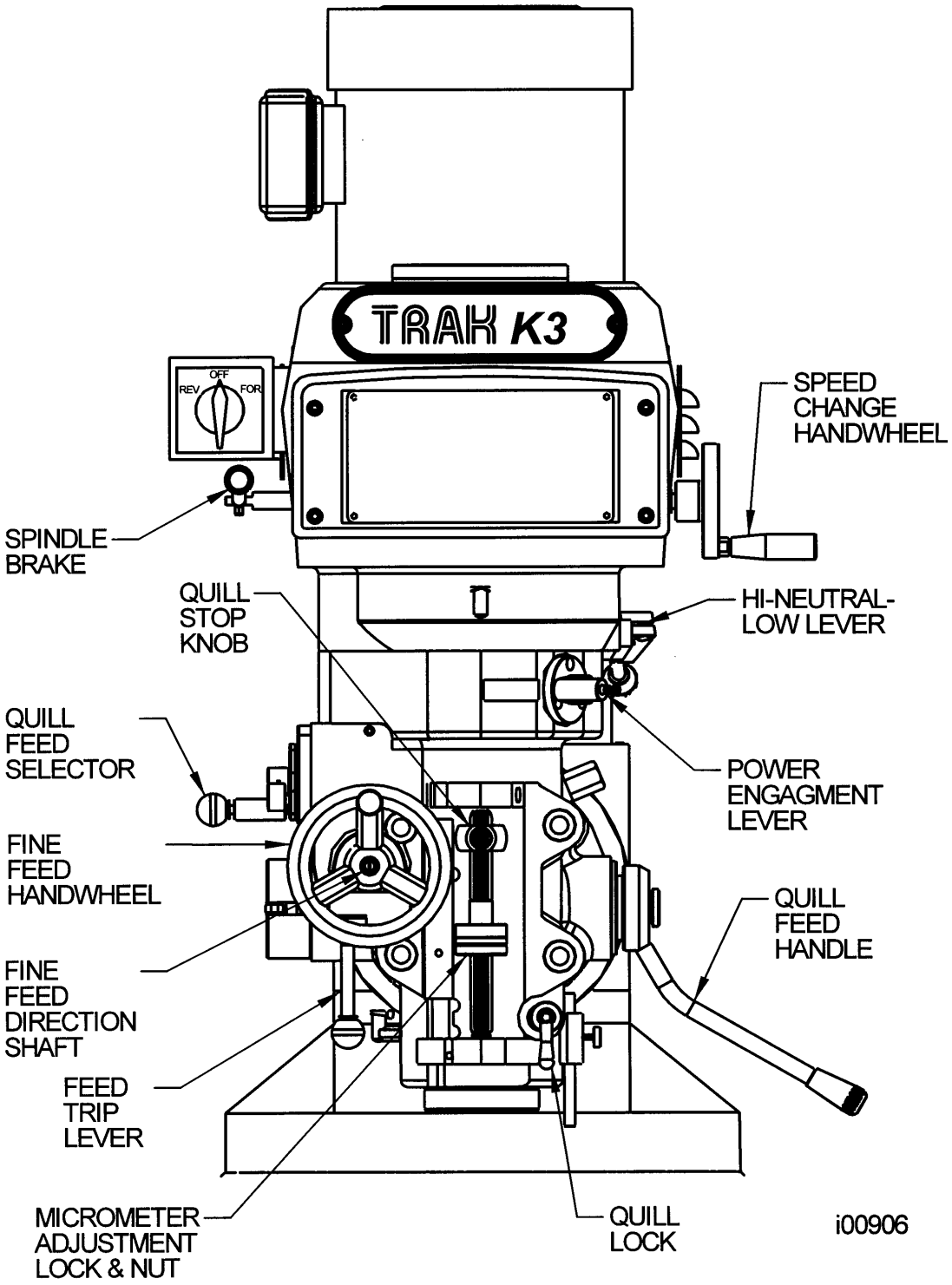
The Liquid Crystal Display (LCD)

The display of the ProtoTRAK SMX CNC is a 10.4" active-matrix color LCD. The very top is the Status Line that shows the overall status of the ProtoTRAK SMX CNC. This includes the current Mode, the current program part number, the current tool number, 2 or 3-axis mode and whether the X, Y and Z dimensions are in inch or millimeter (mm).

Just above the soft keys is a data input line that appears when an input is required.

TRAK Knee Mill Specifications



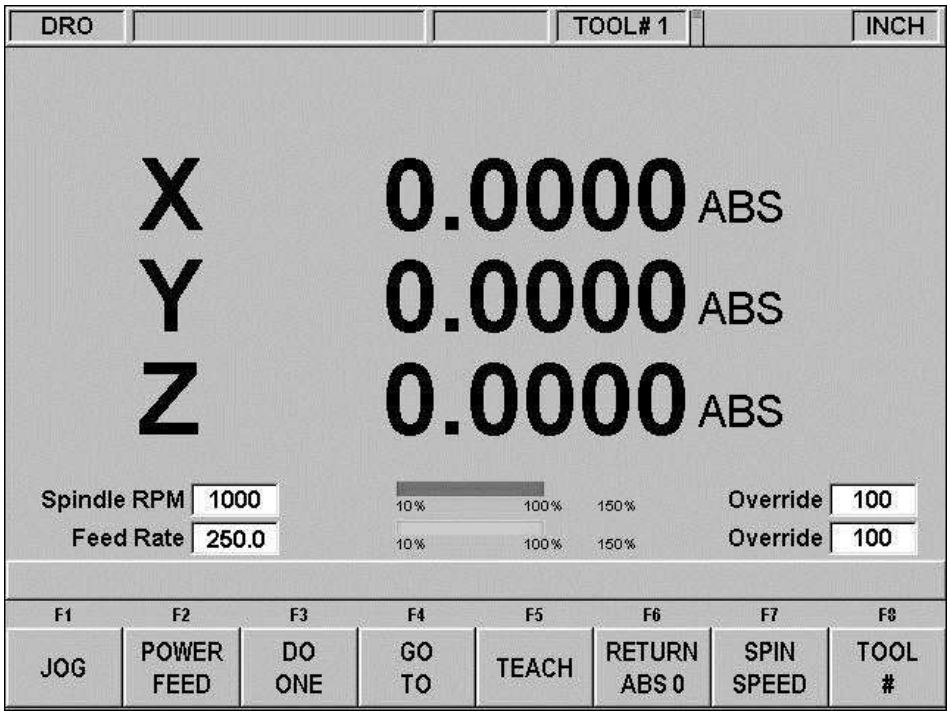

TRAK K3
OFF
REV
FOR
SPEED CHANGE HANDWHEEL
SPINDLE BRAKE
QUILL STOP KNOB
HI-NEUTRAL-LOW LEVER
QUILL FEED SELECTOR
POWER ENGAGMENT LEVER
FINE FEED HANDWHEEL
QUILL FEED HANDLE
FINE FEED DIRECTION SHAFT
FEED TRIP LEVER
MICROMETER ADJUSTMENT LOCK & NUT
QUILL LOCK
i00906

DRO MODE

The ProtoTRAK SMX CNC operates in DRO Mode as a sophisticated 3-axis digital readout with jog and power feed capability.

Enter DRO Mode

Press **MODE**, select **DRO** soft key. The screen will show:



DRO Functions

Clear Entry: Press RESTORE**,** then re-enter all keys.

Inch to MM or MM to Inch: Press IN/MM and note LCD screen status line.

Reset One Axis: Press X or Y or Z, INC SET. This zeros the incremental position in the selected axis.

Preset: Press X or Y or Z, numeric data, INC SET to preset selected axis.

Reset Absolute Reference: Press X or Y or Z, ABS SET to set selected axis absolute to zero at the current position.

Preset Absolute Reference: Press X or Y or Z, numeric data, ABS SET to set the selected axis absolute to a preset location for the current machine position.
Note: This will also reset the incremental dimension if the absolute position is being displayed when it is preset.

Recall Absolute Position of All Axes: Press INC/ABS. Note the dimension for each axis is labeled INC or ABS. Press INC/ABS again to revert to the original reading.

Recall Absolute Position of One Axis: Press X or Y or Z, INC/ABS. Note the INC or ABS label for each axis. Repeat to get selected axis back to original reading.

Jog

The servomotors can be used to jog the table, saddle and ram.

a. Press the **JOG** soft key.

b. A flashing message will appear saying "CAUTION: JOG KEYS ARE ACTIVE".

c. To jog, press the X, Y or Z hard keys.

d. To stop jogging, release the key.

e. The speed of jog is displayed in the box next to the words "Feed Rate" on the lower left side of the LCD screen.

f. Press the **+/-** hard key to reverse direction. When the number in the Feed rate box is negative, this indicates the minus direction.

g. Press the RATE keys to reduce and to increase the jog speed in 10 percent increments. The changes in speed may be seen in the Feed rate box and on the green feed rate indicator. The amount of override is displayed in the Override box.

h. To jog at a certain rate, simply enter that number as inches or mm per minute and then press the X, Y or Z key. You may also use the override key to adjust this number.
Press **RSTR** to return to 150 ipm or 3800mm/min.

i. Press **RETURN** soft key to return to manual DRO operation.

Power Feed

The servomotors can be used as a power feed for the table, saddle or quill, or all three simultaneously.

a. Press the **POWER FEED** soft key.

b. A message box will appear that shows the power feed dimensions. All power feed moves are entered as incremental moves from the current position to the next position.

c. Enter a position by pressing the axis key, the distance to go and the +/- (if needed). Input the entry by pressing INC SET. For example, if you wanted make a power feed move of 2.00" of the table in the negative direction, you would enter: X, 2, +/-, INC SET.

d. Initiate the power feed move by pressing GO.

e. The feedrate is automatically set to 10 ipm (or 254 mm per min). Press **FEED ↑** or **FEED ↓** to adjust the feedrate from 1 ipm to 100 ipm.

f. Press **STOP** to halt power feed. Press **GO** to resume.

g. Repeat the process beginning at "c" above as often as you wish.

h. Press **RETURN** soft key to return to manual DRO operation.