

ROTTLER

MANUFACTURING

**THE
CUTTING
EDGE**

F54XSeries

BORING MACHINE

MACHINE SERIAL NUMBER

OPERATIONS AND MAINTENANCE
MANUAL



MANUFACTURED BY:

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NOTE: WHEN ORDERING REPLACEMENT PARTS,
PLEASE GIVE THE MODEL AND SERIAL NUMBER.

ORDER BY PART NUMBER.

CONTENTS:

Introduction / Safety / Installation.....	1
Introduction.....	1.1
Description.....	1.1
Limited Warranty	1.1
Safety Information	1.2
Electrical Power.....	1.2
Machine Operator.....	1.2
Emergency Procedures.....	1.3
Machine Installation.....	1.3
Location.....	1.3
Unpacking	1.3
Shipping Hold Down Bolt	1.3
Leveling.....	1.4
Air Supply	1.4
Power Supply	1.5
Grounding.....	1.5
Electrical Hook-up Illustration.....	1.6
Control Definitions	2
Master Power On/Off Switch.....	2.1
Spindle Start/Stop	2.1
Feed Rate/RPM.....	2.1
Float/Neutral.....	2.1
Clamp	2.1
Up	2.1
Down	2.2
Manual.....	2.2
Auto	2.2
Cycle Start/Stop	2.2
Center.....	2.2
Handwheel.....	2.2
PRG#.....	2.2
Vertical Zero	2.3
Enter	2.3
Machine Parameters	2.3
Vertical Home Sensor	2.4
Vertical Home Switch (early machines)	2.4
Vertical Stop Collar.....	2.4
Down EOT (End of Travel).....	2.4
Spindle Proximity Sensor	2.4
Electronic Handwheel.....	2.4
Emergency Stop Button	2.4
Centering Knob	2.4
Control Panel Illustration	2.5
Machine Control Illustration.....	2.6
Operating Instructions.....	3
Loading In-Line cylinder Blocks	3.1
Block Clamps	3.1
Micrometer	3.1
Centering.....	3.2
Centering Accuracy Check.....	3.2
Boring.....	3.2
Boring Feeds and Speeds.....	3.2
Gold Square.....	3.2
Purple Square.....	3.3

Black Triangle 1/64" Radius.....	3.3
Black Triangle 1/32" Radius.....	3.3
Gold Triangle 1/64" Radius.....	3.3
Gold Triangle 1/32" Radius.....	3.3
Vertical Stops	3.4
Control Display Definitions	3.4
Programming Mode.....	3.5
Building a Program.....	3.6
Using a Program	3.6
Auto	3.6
Manual.....	3.7
Boring Without Auto cycle.....	3.7
Boring Large Truck Blocks.....	3.7
Optional Capacity to 8" Diameter	3.8
Install and Remove Toolholders.....	3.9
Install and remove Cutterheads	3.9
Micrometer Setting Illustration.....	3.10
Maintenance	4
Lubrication	4.1
Vertical Ballscrew.....	4.1
Vertical Ballscrew Bearings.....	4.1
Outer Spindle.....	4.1
Inner Spindle.....	4.1
Clamp Arms.....	4.1
Air Adjustments	4.2
Float	4.2
Tilt	4.3
Pressure Switch.....	4.4
Lubrication illustration.....	4.5
Spindle Sweep	4.6
Outer Spindle Adjustment	4.7
Inner Spindle Adjustment	4.8
Home Switch Adjustment (early machines)	4.9
Home Switch Adjustment Illustration (early machines).....	4.10
Home Sensor Adjustments	4.11
Spindle Index Sensor Adjustments	4.12
Centering Motor and Housing	4.13
Spindle Drive Belt Removal/Adjustment and Replacement.....	4.14
Accessing Spindle Drive Belt.....	4.14
Removing Spindle Drive Belt.....	4.14
Installing spindle Drive Belt	4.14
Belt Adjustment	4.14
Excessive Loads	4.15
Thrust Overload.....	4.15
Spindle Overload	4.15
Vertical Drive Housing.....	4.16
Accessing Vertical drive Housing	4.16
Removing Vertical Drive Housing.....	4.16
Replacing Vertical Drive Belt.....	4.16
Adjusting Vertical Drive Belt	4.16
Replacing Vertical Drive Housing.....	4.16
Inner Spindle Removal	4.16
Upper Housing Removal	4.17
Outer Spindle Removal	4.17

Troubleshooting	5
Spindle Jam	5.1
Vertical Position Jam	5.1
Vertical Down EOT	5.2
Emergency Stop	5.2
Display Will Not come Up	5.2
Parameter Fault	5.2
Will Not Hold Vertical Position	5.2
Spindle Motor Noisy and runs Rough	5.3
No spindle Rotation	5.3
No Vertical Movement	5.3
No Tilt	5.4
Spindle Falling When Power is Off	5.4
Chatter in Bore	5.4
Bore Out of Round	5.4
Taper in Bore	5.4
Spindle Motor Noisy	5.4
Vertical Motor Noisy	5.4
 Machine Parts	 6
Front / Right Side View	6.1
Air Logic Diagram	6.2
Electrical Enclosure	6.3
Spindle Base Assembly	6.4
Spindle Base	6.5
Spindle Base Clamp System	6.6
Horizontal Drive Assembly	6.7
Ballscrew support / Motor	6.8
Control Panel	6.9
Spindle Section Type 1	6.10
Spindle Section Type 2	6.11
Vertical Drive Assembly	6.12
Drawtube Assembly	6.13
Upper Housing Driven Sprocket	6.14
Upper Housing Drive Sprocket	6.15
Block Clamp Assembly	6.16
Tools	6.17

Introduction:

This manual is arranged in sections as listed in the table of contents.

It is required that the new user of the F54X Boring Machine read this manual before operation. Pay close attention to the sections concerning safety.

The Controls Definition and Operating Instructions chapters should be read very carefully in order to familiarize the user with the actual button pushing sequences required to carry out a job. These chapters in the manual should be considered an introduction. As the operators of the F54X series machine gains experience with using different functions of the machine, complicated setups and programs will make more sense.

The rest of the manual contains information and part number reference on fixtures, cutting tools, and machine maintenance. The operator needs to read and become familiar with these areas as well

Description:

The model F54X is a precision, single point, high speed boring machine. The F54X can be equipped with tooling and accessories for re-boring most American passenger car and truck engines, In-lines as well as 60 and 90 degree V-types.

The F54X machines can be easily tooled to machines a wide range of engines, including European and Asian.

The machine is designed to maintain the alignment of cylinder bores to the Pan Rails and Main Bearing bore locations, as was done in the original factory machining. This overcomes the many inaccuracies and out-of-alignment problems associated with the clamping of portable boring bars to the cylinder head surface of the blocks.

Convenient controls, fast block clamping, air floated Spindle Base positioning and clamping, means considerable savings in floor to floor time and operator involvement.

Change over or re-setting time required to set up V-type or In-Line engines is a minimum, making this machine highly suited to the jobber shop where engines cannot be run through in model lots.

Limited Warranty:

Rottler Manufacturing Company Model F54X parts and equipment is warranted as to materials and workmanship. This limited warranty remains in effect for one year from the date of delivery, provided the machine is owned and operated by the original purchaser and is operated and maintained as per the instructions in the manual.

Tools proven to be defective within the warranty period will be repaired or replaced at the factory's option.

We accept no responsibility for defects caused by external damage, wear, abuse, or misuse, nor do we accept any obligation to provide compensation for direct or indirect costs in connection with cases covered by the warranty.

Freight charges on warranty items (non-air shipment only) will be paid by Rottler Manufacturing for a period of 60 days only from the date of installation or set-up by a qualified service technician or sales representative.

Freight charges after the 60 day period are the customers responsibility.

Safety Information:

CAUTION: *This machine is capable of causing sever bodily injury!*

The operator of the F54X should be a skilled machinist craftsman who is well versed in the caution, care, and knowledge required to safely operate metal cutting tools. ***Eye protection must be worn at all times by the operator and all other personnel in the area of the machine.***

The operator should be extremely cautious when working around the cutting tool area.

When boring the machine is capable of throwing metal chips over 1- feet from the cutting area. ***Always use the guards.***

The F54X operates under computerized control and, as is all computerized equipment, and is susceptible to extraneous electrical impulses internally for externally produced. The machine may make moves out of the operator control at any time. The operator should work in and around the machine with caution at all times.

The operator and nearby personnel should be familiar with the location and operation of the Emergency Stop Button.

Electrical Power:

Make sure all electrical equipment has the proper overload protection. The F54X should have ***a fully isolated*** power supply to prevent damage and uncontrolled movement of the machine. If the F54X is on the same power lines that are running to other electrical equipment (grinders, welders, and other AC motors) electrical noise can be induced into the F54X electrical system. Electrical noise can cause the controller to see false signals to move. Not supplying a fully isolated supply to the machine may void factory warranty. Refer to the Power supply section later in this chapter for voltage and amperage requirements of the F54X.

Machine Operator:

The operator of the F54X should be a skilled machinist craftsman who is well versed in the caution, care, and knowledge required to safely operate metal cutting tools. ***Eye protection must be worn at all times by the operator and all other personnel in the area of the machine.***

If the operator is not a skilled machinist he/she must pay strict attention to the Operating Instructions outlined in this manual, and get instruction from a qualified machinist in both production and operation of this machine.

The F54X machines have the following areas of exposed moving parts that you must train yourself to respect and stay away from when they are in motion:

1. **Tool Sharpening** – Must be done with care and dexterity to get good bore results, be alert to the light pressure required for tool sharpening.

CAUTION: *Exposed diamond wheel is a potential hazard to your hands, fingers, and face. Eye protection must be worn when working in this area.*

2. **Cutting Tool Area** – Any operation involving hands in the cutter head area, such as inspection or alignment of the cutter head or tools, changing Centering Fingers, tool insertion, and removal, cutter head changes, and size checking etc. requires the machine to be in Neutral.
3. **Machining** – Eye protection must be worn during all operations of the machine. Hands must be kept completely away from the cutter head. All chip guards must be in position during machine operations.

4. **Work Loading and Unloading** – Carefully develop handling methods of loading and unloading work pieces so that no injury can result if hoist equipment or lift connection should fail. Periodically check lift components for damage that may cause failure of Block Handler Assembly. Lifting Eye can eventually fail if the eye is reset in line with the 502-1-80 lift channel. ***Eye must be at a right angle.***
5. Machine Maintenance – Any machine adjustment, maintenance or parts replacement absolutely requires a complete power disconnection from the machine, ***this is an absolute rule.***

Emergency Procedure:

Assuming one of the following has occurred: tool bit set completely off size, work piece or spindle base not clamped, spindle is not properly centered, these mistakes will become obvious the minute the cut starts

PRESS THE EMERGENCY STOP BUTTON (on the front control panel) IMMEDIATELY!

Find out what the problem is; return the spindle to its up position without causing more damage. To restart the machine, turn the Emergency Stop Button CW until the button pops out. Make sure the button has been depress for at least 1 ½ minutes or the drive will not have time to reset and they will not function.

Be alert to quickly stop the machine in the event of a serious disruption of the boring process either at the top or bottom of the bores.

“REMEMBER” metal cutting tools have the speed and torque to severely injure any part of the human body exposed to them.

Machine Installation:

Location:

The productivity of the F54X will depend a great deal on the proper initial installation. Pay particular attention to the means by which work pieces are lifted into and out of the machine as well as the material handling to and from other operations in your shop. The proper loading arrangements and work location for your F54X is extremely important.

A slow travel (6' to 10' per minute) power hoist, operated from either a bridge or jib crane arrangement works very well. A 1000 lb. Is generally adequate for lifting most engine blocks. An air hoist with speed control makes an ideal method for fast, efficient loading and unloading.

For shops where large production runs are anticipated, the work pieces should be loaded and unloaded directly from a conveyer. If this is not the case, we suggest you pay considerable attention to the crane so that it covers an adequate area to allow the operator to back up and remove work pieces without creating a cluttered, dangerous work area.

Unpacking:

Use care when removing the crate materials from the machine. Be careful not to use force on any part of the machine.

Remove the Toolbox, Parallels and optional equipment form the machine. Completely clean these articles along with the rest of the machine with solvent, rust inhibitor was applied at the time of shipment. Any of the rust inhibitor left on the machine will allow Cast Iron dust to build up and cause premature wear to the machine.

Shipping and Hold Down:

Remove the sheet metal cover from the rear of the Spindle Base by removing the four (4) round head Allen screws.

Pull out the Cotter Key from the Castle nut located in the center of the Spindle Base and loosen the nut. Turn the machine on and place it in Neutral. Hand tighten the nut to take out all the play in the Roller Key assembly. Loosen the nut approximately 1/12 of a turn. Place the Cotter Key in the nearest slot of the Castle Nut. Put the machine in Float and move the machine from side to side and remove the rust inhibitor that was placed under the Spindle Base. This may have to be done several time to remove all of the rust inhibitor.

Switch the machine to Clamp and check for proper operation of the clamp assembly. Check for proper release and movement when put back into Float.

Note: Clamp cylinder rods should move a minimum of 5/8" when Spindle Base is clamped.

Leveling:

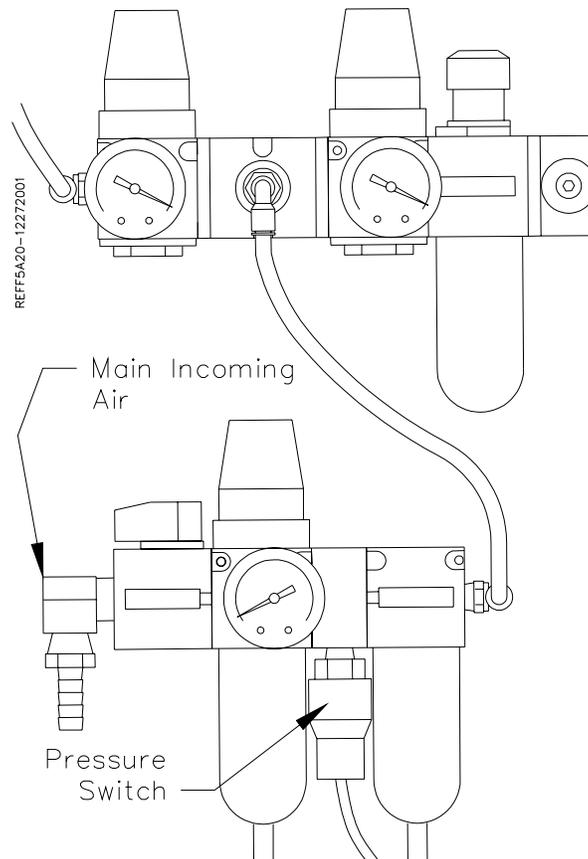
Four square head bolts (504-1-12A), four jam nuts (502-1-12F), and four chamfered washers (502-1-12) are provided with the machine for leveling. Refer to the drawing on page 6.1. Screw the jam nuts all the way onto the bolts, insert the bolts at the base support points (corners). Screw the bolts in until they are just protruding from the bottom of the base casting. Lower the machine onto the washers, making sure the bolts seat into the chamfered area of the washers.

Using a precision level, level the upper table within .003" per foot in both directions. Make sure that the machine weight is equally supported at all four support points.

Air Supply:

It is very important that the air source for the F54X be moisture free. Water and oil in the air lines will result in early cylinder and valve failure as well as introducing moisture into the Inner spindle bearings. **The factory recommends installing a water trap at the machine.**

Attach a 100 P.S.I. air source to the main air intake located on the right hand side of the main rear enclosure.



Power Supply:

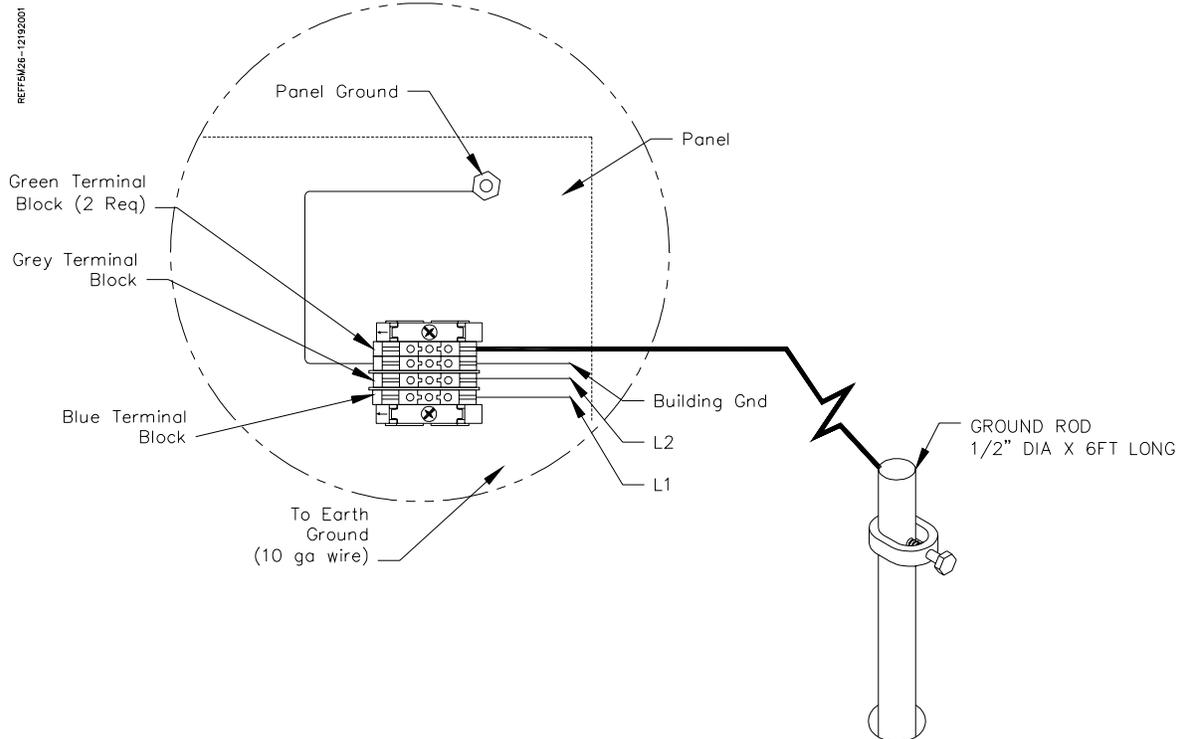
This machine has the following power requirements:

208 to 240 VAC
Single Phase
50 or 60 Hertz
30 amps

See illustration below for correct connection of “measured” incoming power. Connect single phase wiring to the main rear enclosure, located on the right rear of machine base. The connection point for power is located inside the enclosure. The connection termination point is located on the left hand side of the electrical panel about half way up. Connect L1 to the grey terminal block, L2 (neutral) to the blue terminal block and shop ground to the green and yellow terminal block. Attach wire from the grounding rod to the second green and yellow terminal. **Important: Electrically connect in accordance with national and local electrical codes.**

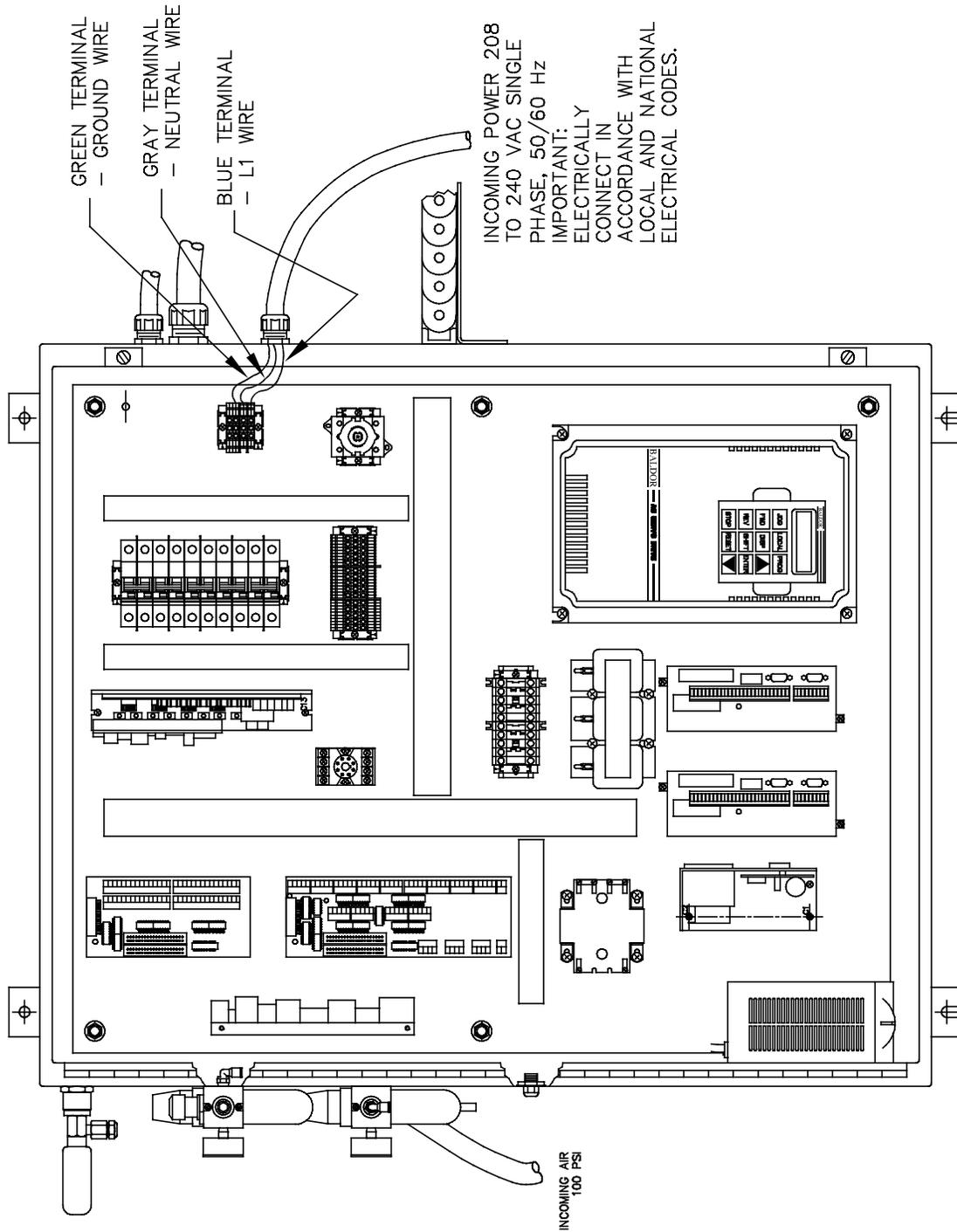
Grounding:

This machine must be connected to a good earth ground rod. A 6 foot, 1/2” diameter, 15 OHM, Copper grounding rod driven into the earth next to the machines is preferred. Not providing a grounding rod could void factory warranty.



Electrical Enclosure:

REF54X1-060899



Control Definitions:

Master Power On/Off Switch:

This switch is located in the large electrical enclosure on the back of the machine. After turning off the machine, you must wait 1 minute to turn it back on. The Spindle and Vertical amplifiers require time to reset themselves. This switch must be turned off in order to open the electrical enclosure door.

Spindle Start:

This button is used to turn the Spindle rotation on. When the Spindle Start button is pressed the spindle will rotate in a clockwise direction at the speed indicated on the display. The Spindle will not start if the machine is in float or neutral.

The Spindle will not start if the machine is in Rapid Up or Down travel.

Spindle Stop:

This button is used to stop the spindle rotation. The button will also stop the spindle rotation if the machine is running an automatic cycle.

Feed Rate:

This button when pressed will display the current Feed Rate. To change the Feed Rate, use the numerical key pad and enter the Feed Rate desired. The decimal and first zero after the decimal are automatic; if you want a Feed Rate of .001 press 1 on the keypad and enter, the computer will automatically put the setting at .001. The Feed Rate is stored individually for each program.

RPM:

This button when pressed will display the current RPM. To change the RPM, use the numerical key pad and enter the RPM desired. The RPM is stored individually for each program.

Float:

This button when pressed will switch the machine to Float. When in Float the spindle base is unclamped and is floating on a cushion of air. The Float button is used to manually center the machine using the Manual Center knob.

Neutral:

This button will switch the machine to Neutral. When in neutral the spindle base is unclamped but is not floated. The Neutral button is used to "bump" the spindle base around when centering with a dial gauge.

Clamp:

CAUTION: *When boring and at all times the spindle is running the machine must be in CLAMP.*

The Clamp holds the spindle base to the tabletop when the machine is boring. Any time you are in Float or Neutral; pressing the Clamp button will clamp the spindle base to the tabletop.

Up:

This button has two functions, when the Spindle is not rotating; pressing the Up button will initiate rapid Up travel. Rapid Up travel will continue until the spindle has reached its Home position or Vertical Stop four is reached, to stop the Rapid Up travel press the Up or Down button again. Rapid travel is set at 120 inches per minute.

When the Spindle is rotating, pressing the Up button will start the Spindle feeding up at the rate specified by the Feed Rate parameter. Feed will continue Up until the Home Switch or Vertical Stop four is reached.

Homing Vertical:

The F54X machine need to be homed after every power down or the vertical position will be off. Once the machine is fully powered up, press the Up button, the machine should travel to it's Home position and

then slowly creep off of that position. This sets the reference point that all vertical programs operate off of. If the spindle does not travel to Home and creep off it has probably encountered a vertical stop four. Press the Up button again to Home the machine.

Homing Horizontal:

The F54X machine need to be homed after every power down or the Horizontal position will be off. Once the machine is fully powered up, move the machine as far as you can to the right without the Right Limit switch contacting the right hand clamp arm. Press the Horizontal Zero button twice at this position and that will home the Horizontal.

CAUTION: *The machine has been powered down or the Emergency stop has been pressed.*

Down:

This button has two functions, when the spindle is not rotating; pressing the Down button will initiate rapid Down travel. Rapid Down travel will continue as long as the button is being pressed. Releasing the button will stop the Rapid Down travel. Rapid down travel will also stop if Vertical stops 1,2,3 are reached or if the Vertical EOT (End of Travel) is depressed. Rapid travel is set at 120 inches per minute.

When the Spindle is rotating, pressing the Down button will start the Spindle feeding down at the rate specified by the Feed Rate parameter. Feed will continue until a Vertical stop is reached or the Vertical EOT switch is depressed.

Left:

This button will move the machine in Rapid left travel as long as the button is held. If there are programmed horizontal stops the machine will automatically stop at these. You will need to press and hold the button again to resume rapid left travel. All travel will stop, and then be inhibited, if the Left EOT switch is pressed.

Right:

This button will lock the machine in rapid right travel until it gets to its horizontal zero position. After the horizontal zero has been reached the button will then need to be held in, to continue rapid travel. . All travel will stop, and then be inhibited, if the Right EOT switch is pressed.

Manual/Auto:**Manual:**

When in the Manual mode (LED on button not lit) all machine functions are normal except for the end of the automatic cycle. The spindle will index to the 3 O'clock position and stop. You then will manually retract the spindle out of the cylinder. This is done if the exact position of the spindle in the bore is to be maintained.

Auto:

When in the Auto mode (LED on button lit) all machine functions are normal and machine will finish the automatic cycle and return to the number four vertical stop. When the computer executes the auto retract sequence the spindle will bore to the depth set in stop number three. When stop three is reached a washout is executed at a predetermined speed and the cutter is relieved .015" up. The cutter head is then indexed to the 3 O'clock position, the spindle base is shifted to the left .020" and Rapid Up is then initiated until the number four stop is reached. The machine will continue horizontally to the next programmed stop. The Washout time and RPM are programmable, refer to the parameter section in the Operation chapter of this manual.

Cycle Start:

This button starts the machines Automatic cycle. If the machine is not at it's Vertical and Horizontal zero positions the machine will drive under power to that position and then start the Automatic cycle.

If Cycle Start is pressed with the spindle above zero the machine will rapid to the vertical zero position and then continue the automatic cycle.

If the spindle is below stop one but above stop two the machine will rapid to the second stop and then continue the automatic cycle.

If the spindle is below stop two and above stop three the spindle will start and vertical feed will be initiated to the third stop. Automatic cycle will continue from that point on.

If the spindle is below the third stop automatic operation is inhibited.

If the spindle is above the third stop and is at least .010" to the left of a horizontal stop the machine will rapid up to stop number four.

If the spindle is not at a horizontal stop and cycle start is pressed the machine will rapid up to the fourth stop and then continue to the next horizontal stop.

Cycle Stop:

This button will stop the Automatic cycle, any time it is pressed. If it is pressed during the Auto Center cycle, the Auto Center sequence will finish before the cycle is stopped.

Center:

The Center button initiates the entire Auto Center program. The length of the Auto Center program is variable and can be changed. Refer to the Machine Parameters section in the Operation chapter. When the Center button is pressed the cutterhead will index to the 3 O'clock position; Float will come on while the fingers are extending. Once the fingers have stalled against the cylinder wall the float will be turned off and the clamp will be actuated. After the clamp has been turned on the fingers will retract back into the cutterhead. You cannot stop this process once it has started unless you hit the Emergency Stop button.

When the machine is centering the spindle drive is being held at zero speed. At this point there is torque on the motor even though it is not moving. This action causes a slight noise and vibration of the machine and can be disregarded.

Vertical Hand Wheel:

The first press of this button will put the machine in Hand Wheel mode at .001" per detent. A second press switches the Hand Wheel mode to .0001" per detent. Pressing the Up or Down buttons will turn off the Hand Wheel mode.

Horizontal Hand Wheel:

The first press of this button will put the machine in Hand Wheel mode at .001" per detent. A second press switches the Hand Wheel mode to .0001" per detent. Pressing the Left or Right buttons will turn off the Hand Wheel mode.

PRG#:

Pressing this button once puts the machine into programming mode. The display will change to the program display. This display will show the current program and the vertical stops. The cursor will be flashing on the Program number entry area. A second push of this button will switch the cursor to the Vertical stop entry area. A third press of this button will change the display to the horizontal stops screen with the cursor flashing on the first stop. Pressing this button again will exit the program mode and the display will go back to normal operating mode.

Vertical Zero:

This button zeros the machine at its current vertical position. The vertical zero can be set anywhere throughout the machines vertical travel.

Horizontal Zero:

This button zeros the machine at its current horizontal position. The horizontal zero can be set anywhere throughout the machines horizontal travel. Refer to the horizontal home section later in this chapter for setting the horizontal home using the Horizontal zero button.

Clear:

Pressing the Clear button will clear any error the display is showing. It will also clear the display if you are entering data or parameters.

Enter:

The Enter button is used to input machine parameters and enter vertical or horizontal stops. Refer to the Programming section in the Operation chapter of this manual. The Enter button also clears faults and errors from the display after the condition has been cleared.

Machine Parameters:

Machine parameters are the changeable information the computer uses to properly operate and control the performance of the machine.

CAUTION *Changing machine parameters without first consulting the factory could result in a non-operational machine. It could also cause uncontrolled movement that could severely damage machine and operator.*

#	Parameter Label	Factory Setting	Actual Settings	Description
111	Horizontal Acceleration	4000		Sets rate at which Horizontal motor accels to commanded speed.
112	Vertical Acceleration	4000		Sets rate at which Vertical motor accels to commanded speed.
113	Spindle Acceleration	2000		Set rate at which the Spindle motor accels to commanded speed.
114	Horizontal Rapid Speed	17000		Set the maximum horizontal rapid speed.
115	Vertical Rapid Speed	16000		Set the maximum vertical rapid speed.
116	Parameter Lock	9999	9999	Entering 9999 unlocks the machine parameters.
117	Maximum Feed Rate	.012		Set the maximum vertical feed rate.
118	Maximum Spindle Speed	1200		Set the maximum spindle RPM's
119	Horizontal Creep Speed	800		Set the speed at which horizontal will creep.
120	Vertical Creep Speed	800		Set the speed at which the vertical will creep off home.
121	Spindle Creep Speed	25		Set the speed at which the spindle will creep to index
122	Washout Revolutions	02		Set the number of washout revolutions desired at end of bore.
123	Oiler Timer	40		Set the time the spindle oiler is on after Spindle start is pushed.
124	Display Measurement Mode	1		Set for English (1) Metric (2)
125	Washout Speed	125		Set the speed at which the spindle will washout
126	Secondary Lock Code	999		This lock code locks all parameters and all programs.
127	Autocenter Extension Time	2.3		Sets how long the centering cycle will be
128	Spindle Drive Type	1		Set spindle drive type Bipolar (1) Unipolar (2) Open loop (3)
129	Spindle Drive Gain	.5		Set the gain to the Spindle Drive.
130	Spindle Encoder Counts	2825		Set the number of encoder counts per spindle revolution.
131	Spindle Hold	2		Set the spindle drive to hold (2) or not hold (1) during centering.
132	Spindle Timer	1.0		Set the amount of time allowed between spindle pulses.
133	Spindle Index Delay	.4		Set time delay before looking for index pulse when indexing.
134	Spindle Prescale	04		Pre-scales the spindle encoder pulses 1,2,3 or 4
135	Spindle Index Type	3		Set the type of index sensor used. Encoder (1), PNP (2) NPN (3) change of state (4)

136	Autocentering Speed	2047		Set maximum analog speed out of COP controller when centering
137	Horizontal Encoder Counts	1024		Set encoder counts on horizontal motor.
138	Vertical Encoder Counts	1024		Set encoder counts on vertical motor.

Vertical Home Sensor:

The Vertical Home Sensor is located on the top lid of the spindle belt housing. This switch is a electronic proximity switch that is activated by the stop collar at the top of the vertical ballscrew. When the Home switch is activated the machine will not Rapid or Feed up. See Home Sensor in the Maintenance section of this manual for adjustment procedures.

Vertical Home Switch (early machines)

The Vertical Home Switch is located behind the front control panel. The Vertical Home switch should only be activated when the spindle is in the full up position. The Home switch is activated by a ramp at the end of the Spindle Keyway. When the Vertical Home switch is activated the Spindle will not Rapid or Feed up. After the home switch has been actuated the machine will initiate a vertical creep move until the switch is clear of the actuator. The position the spindle is located after the creep move will always remain the same unless the switch itself is moved.

Horizontal Home:

The Horizontal home is set by pressing the Horizontal zero button twice directly after power up. Move the machine to its far right hand position and press the Horizontal zero button twice. The machine then knows where it's Horizontal home is. You will then use the Horizontal zero button as normal in programming.

Vertical Stop Collar:

The Vertical Safety stop is located at the top of the Vertical Ballscrew. This is a mechanical safety, and should be checked periodically to make sure both the setscrews are locked down tight.

Down EOT:

The Down EOT is located on the top of the spindle base where the spindle enters. When this is activated all down travel is stopped.

Left EOT:

This is mounted at the rear of the Spindle base on the left-hand side. When this switch is depressed all left travel is inhibited.

Right EOT:

This is mounted at the rear of the Spindle base on the right-hand side. When this switch is depressed all right travel is inhibited.

Spindle Index Sensor:

The Spindle Proximity Sensor is located on the back right hand side of the belt housing. When the sensor is activated a red light on the back of it will come on. This lets the computer control know the cutter is indexed to the correct position and will allow Auto Retract

Electronic Hand Wheel:

The Electronic Hand Wheel is located just to the right of the control panel. Its function is controlled by the Hand Wheel buttons on the control panel.

Emergency Stop Button:

The Emergency Stop Button is a red button located at the lower left of the front control panel. The Emergency stop button will stop all functions and power drives of the machine. However, the computer control will continue to have power.

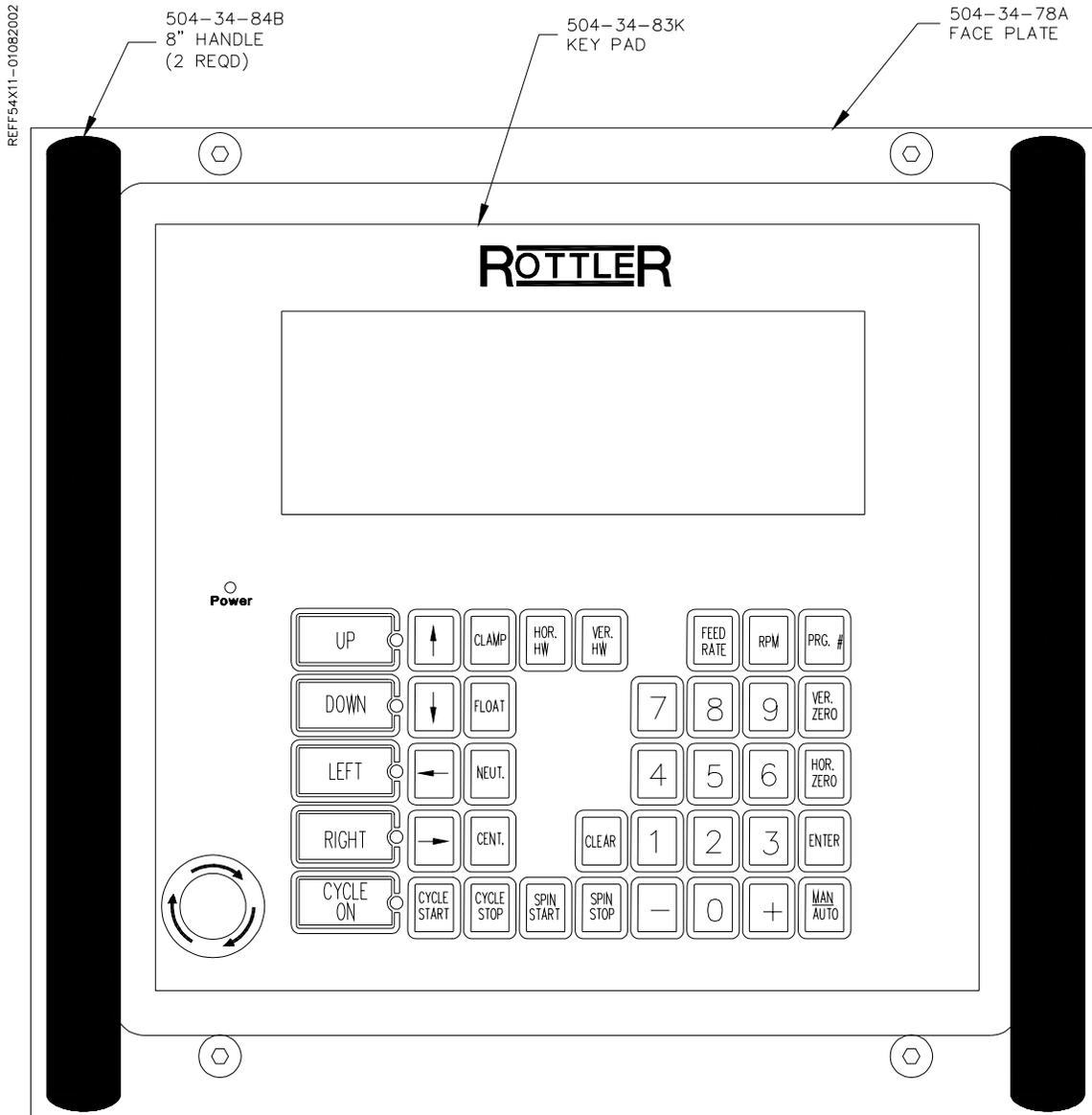
Wait 1 minute before releasing the Emergency Stop button, the drives need this time to power down and reset. If you do not wait a sufficient amount of time the drive will go into fault and they will not operate. To release the Emergency stop button turn it clockwise and it will pop back out.

Centering Knob:

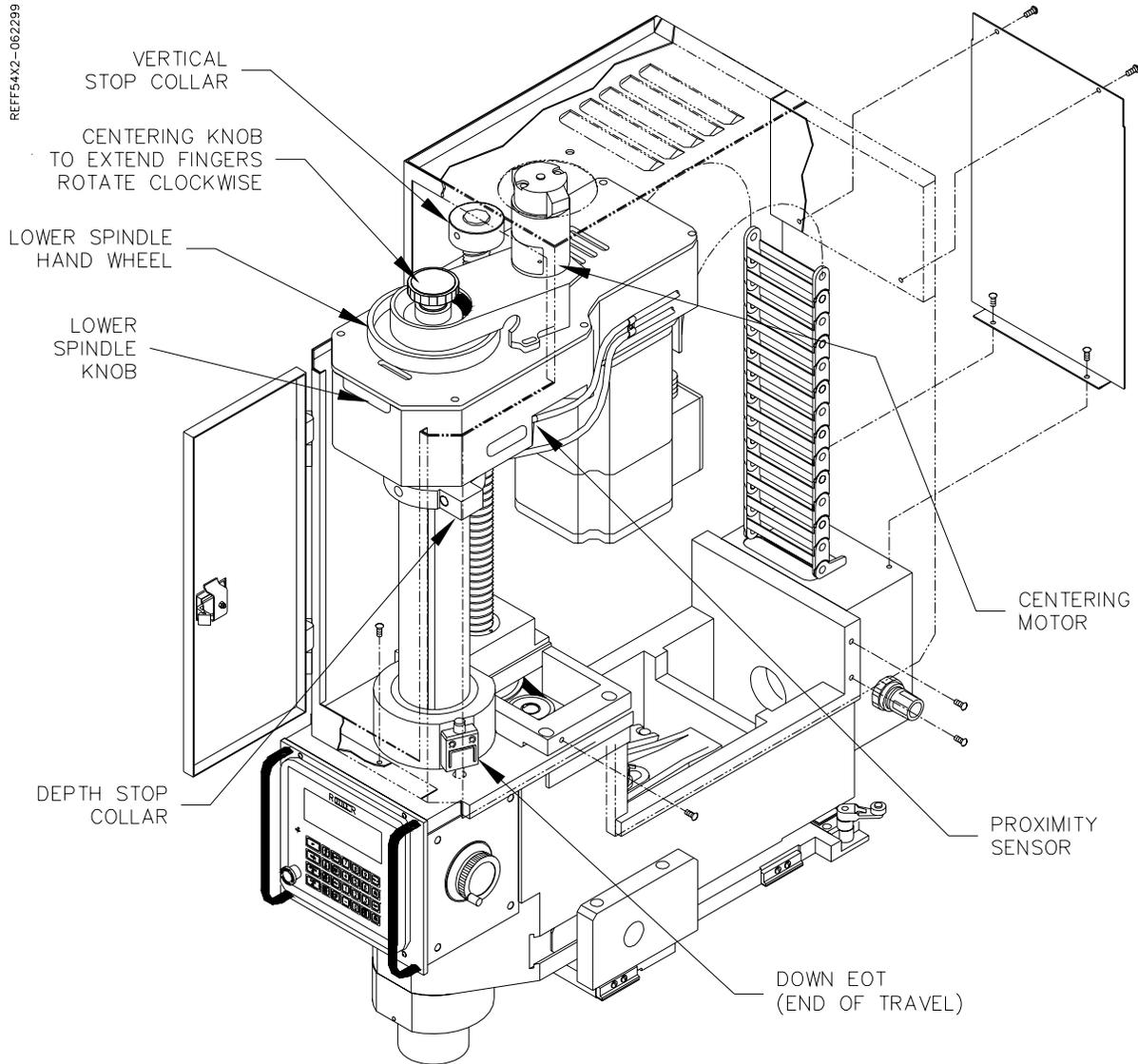
The Centering knob is located at the top of the Spindle belt housing and extends the centering fingers when turned clockwise. Be careful not to over-extend the fingers when the Spindle is not in a bore or they will come completely out of the pinion drive.

CAUTION: *The Spindle drive motor must be stopped when centering. Spindle rotation engagement could severely damage the operator's hands and/or cutterhead parts.*

Control Panel:



Control Location:



Operating Instructions:

We recommend, particularly for operators unfamiliar with boring bar, to practice on a junk block in order to become familiar with the controls and procedures of the boring machine.

Loading In-Line Cylinder Blocks:

Place an inline block in the machine on top of the 5" parallel fixture. Apply weight to the top of the block at each end to be sure the block is supported evenly and does not rock. Dirt or burrs under the pan rails will result in the block not being clamped properly to all four points of the pan rails. (Please note it is necessary to properly deburr and clean pan rails at support points, as opposed to cleaning the top of the cylinder block for a portable bar). You will find that some blocks will rock on the parallel fixture and should be shimmed at proper front support to eliminate this problem.

Locate the block on the parallels so that the cylinders are within the 1-3/4" (in-out travel) centering range of the spindle.

CAUTION: *Blocks can be positioned, forcing the spindle base to its travel limits, causing the spindle not to center. This will cause a mechanical crash.*

Block Clamps:

Position clamp arms so the front of the shoe will contact the block on the ends approximately in the middle.

Tighten clamp arm handles. Lower the shoe onto the block with the cam handle straight up. Tighten clamp leg handles. Lower the cam handle, to clamp the block. If the block is exceptionally long, such as in-line 8 cylinders operate the two cam handles simultaneously so that locking the first handle does not tend to tilt up the opposite side of the block.

The parallel fixture is designed with an L shape. The purpose of this is to extend the back portion of the L outward to prevent cylinder blocks from tilting up when the first clamp is applied.

Micrometer:

Note: *This micrometer is .050 to a revolution rather than .025 as on a conventional micrometer.*

Determine the cylinder bore size you wish to cut.

Choose a tool holder that will require a minimum tool bit overhang. (We recommend a maximum tool bit overhang of 5/8 outside of tool holder.)

Before setting, make sure the tool bit is indexed to a sharp cutting edge or is properly sharpened.

Your boring bar micrometer, as with any other measuring tool, should be used delicately and with care, to be assured of great and continued accuracy. Inserting the tool into the micrometer is very important. Do not let the tool bit snap against the anvil. This will cause nicks in the anvil, and will reduce the accuracy of the micrometer.

Place the tool bit and tool holder into the micrometer. Loosen the tool bit lock screw. Set the micrometer head to the desired bore size. Lightly tighten the tool bit lock screw. Back off micrometer head. Firmly tighten tool bit lock screw. Recheck micrometer reading.

After a period of use the tool bit will force a depression in the micrometer anvil. This will result in inconsistent sizes, particularly after re-sharpening the bit. As necessary turn the anvil slightly, so that a flat surface is always exposed to the tip.

Centering:

Manual:

Insert the tool holder into the cutter head and push back to the index point. Tighten the tool lock screw with the plastic handled hex driver provided in your toolbox.

Move the spindle base to the first hole of the engine block. Press the Rapid Down button and hold it until the cutter head is in centering position, (be very careful not to crash the toolbit into the block).

The proper centering position is with the centering fingers approximately 1/4 inch below the surface of the block.

CAUTION: *Do not center cutterhead with motor running.*

With the machine in Float reach to the top of the spindle belt housing and turn the Centering Knob clockwise (looking from the top). The centering fingers will extend to the sides of the bore. Hold firm pressure and press the Clamp button.

Retract centering fingers turn Centering Knob counter clockwise (looking from the top) while holding the lower spindle knob from turning.

Auto:

Insert the tool holder into the cutter head and tighten the tool lock screw with the plastic handled hex driver provided in your toolbox.

Press the button labeled Cent on the control panel. The machine will float, center and then clamp the spindle base.

Centering Fingers - Remove & Replace:

CAUTION: *All motors must be turned off during any centering finger operation.*

Centering fingers can be removed by rotating the centering knob clockwise until the fingers can be pulled out. When they are replaced in the cutter head, they should be placed in the respective numbered slots. First rotate centering knob clockwise and then counter-clockwise to insure that fingers enter pinion teeth simultaneously.

Centering Accuracy Check:

Centering fingers should be kept accurate, to center the new bore within .002 of the center of the worn hole. Centering fingers should be lapped periodically to obtain near perfect centering.

Check the centering fingers by boring a hole and then without moving the spindle unit, extend the fingers against the wall, checking to see that each fingertip will lock a .001 shim. If the fingers will not do this, they should be lapped. Rotate them back and forth in the test bore while pressing the fingers against the wall. If this does not quickly bring contact and pressure to all the fingers, carefully file the high finger or fingers, and repeat the lapping process.

Boring:

Boring Feeds and Speeds:

Below is a description of cutting inserts available from Rottler manufacturing. The inserts have gone through extensive performance testing. To take full advantage of your F5M boring machine we highly recommend using the Rottler Manufacturing tooling. Your machines performance can be significantly reduced if qualified tooling, feeds and speeds are not used.

Gold Square:

501-29-6B R4

This is a 3/8" I.C. (Inscribed Circle) square insert with a Gold Titanium coating. It is best suited for through boring when removing from .010 - .060 inches on the diameter. This tool has eight cutting corners that can be used. For best tool life it should be used between 400 and 700 RPM's with a feed rate of .006 to .010 for the typical surface finish.

Purple Square:

501-29-6E R2

This is a 3/8" I.C. (Inscribed Circle) square insert with a Purple Ceramic coating. It is best suited for through boring when removing from .010 - .060 inches on the diameter. This tool has eight cutting corners that can be used. For best tool life it should be used between 900 and 1200 RPM's with a feed rate of .006 to .010 for the typical surface finish. On the F5M machine this tool can be used to remove .200 from a 4.2" bore with a Feed Rate of .005 and 1000 RPM's in a single pass.

Black Triangle 1/64" Radius

511-29-20B

This is a 3/8" I.C. (inscribed circle) triangular insert with a black Aluminum Oxide coating and 1/64" cutting radius. The ceramic coating works best for heavy sleeving and counterboring operations. In heavy sleeving operations this insert may last 2 - 3 times longer than the titanium inserts. The finish these inserts leaves is not as clean as the titanium inserts. Usually you will see more "pull outs" in cast iron. The 1/64" radius should be used when machining counterbores where the mating part requires a small radius to eliminate an interference problem. If you are machining a long bore where the spindle must be extended towards the limits of its travel or if a long stub bar is being used the 1/64" radius will minimize the possibility of chatter. A feed rate of .002 - .0075 should be used to obtain a typical required surface finish. When machining large counter bores typically found in Cummins or Cat. blocks a feed rate of .002 - .004/rev. should be used. To get best tool life for the insert use in the 500 - 1200 RPM

Black Triangle 1/32" Radius

511-29-20C

This is the same insert as 511-29-20B, except it has a 1/32" radius. The Aluminum Oxide coating works best for heavy sleeving and counterboring operations. In heavy sleeving operations this insert may last 2 - 3 times longer than the titanium inserts. The finish of these inserts is not as clean as the titanium inserts. Usually you will see more "pull outs" in cast iron. It can be used for sleeve cuts or finish cuts where the 1/64" radius is not required. Use a feed rate of .004 - .010/rev. to obtain the typical surface finish. The 1/32" radius is stronger than the 1/64" radius and will last longer in interrupted cuts. To get best tool life for the insert use in the 500 - 1200 RPM.

Gold Triangle 1/64" Radius

6301W

This is a 3/8" I.C. (inscribed circle) triangular insert with a gold titanium coating and 1/64" cutting radius. The titanium works best for finishing operations where appearance or minimum hone stock is required. It will work well for heavy sleeving cuts but it is not ideal. The 1/64" radius should be used when machining counterbores where the mating part requires a small radius to eliminate an interference problem. If you are machining a long bore where the spindle must be extended towards the limits of its travel or if a long stub bar is being used the 1/64" radius will minimize the possibility of chatter. A feed rate of .002 - .0075 should be used to obtain a typical required surface finish. When machining large counter bores typically found in Cummins or Cat. blocks a feed rate of .002 - .004/rev. should be used. To get best tool life for the insert use it in the 500 - 800 SFM.

Gold Triangle 1/32" Radius

6301X

This is the identical to 6301W except it has a 1/32" radius. It can be used for sleeve cuts or finish cuts where the 1/64" radius is not required. Use a feed rate of .004 - .010/rev. to obtain the typical surface finish. The 1/32" radius is stronger than the 1/64" radius and will last longer in interrupted cuts. To get best tool life for the insert use in the 500 - 800 SFM.

Vertical Stops:

The vertical travel of the machine when in Auto or Manual is controlled by the programmable vertical stops. There are four programmable vertical stops. The following is a description of these stops:

Vertical Stop One:

The first vertical stop is where the machine will Auto Center. This stop is usually set to 00.000

Vertical Stop Two:

The second stop is a rapid jog from stop one. This is used when the cutter is a large distance from the surface of the block. The second stop can be set to a distance about 1/8" above the cutting surface. The second stop is not generally needed when using the production cutterhead as the cutter is relatively close to the cutting surface when centering. If the rapid jog is not needed program it for 00.0000 also. The rapid jog will not be executed if the first and second stops are the same.

Vertical Stop Three:

The machine will start the spindle and initiate vertical feed from the second stop to the third. This stop should be programmed for the length you want the cylinder to be bored, remembering to add the distance the cutter was from the cutting surface when you zeroed the vertical position.

Vertical Stop Four:

This stop is a rapid up travel from the third position. It should be set to a negative value that will allow the cutterhead to clear the block when the machine is floated to the next hole. A value of -1.5" will always clear the production cutterhead.

Note: *When you are manually running the spindle up and down it will automatically stop at stops one, two and three on its down travel and stop four on its up travel.*

CAUTION: *If all of the Vertical stops are at zero the machine will not stop at the vertical zero position.*

Horizontal Stops:

The horizontal travel of the machine, when in Auto or Manual, is controlled by the programmable, horizontal stops. There are six programmable horizontal stops. The following is a description of these stops:

Horizontal Stop One:

The first horizontal stop is where the center of the first cylinder is located. When you are above this hole you will want to set the horizontal zero by pressing the "horiz zero" button. The machine will base the rest of the horizontal stops from the horizontal zero location. If the horizontal zero is set in the wrong location damage to the machine and any work piece in the machine will result.

Horizontal Stop 2 thru 6:

These stops are referenced from the horizontal zero position. Measure the center to center distance of the cylinders and enter the accumulative length into the horizontal stops. For example if the center of the last cylinder in an in-line 6 was 36 inches from the center of the first cylinder then the horizontal stop #6 should be 36.000. The machine will initiate center and boring sequences at each horizontal stop when running in the Automatic mode. In the manual mode the machine will pause and wait for the operator at each stop.

NOTE: When you are running the machine manually to the left it will stop at all horizontal stops. In the right manual travel the machine will stop at the horizontal zero position.

CAUTION: If all of the Horizontal stops are at zero the machine will not stop at the Horizontal zero position.

Control Display Definition: The control display is a four line with twenty characters per line display. The following is a description of the display in all modes.

Operating mode:

P	R	O	G	#	0	1	V	0	0	.	0	0	0	0	
F	R			.	0	1	0	H	0	0	.	0	0	0	0
R	R	M		0	0	0	0								
C	L	A	M	P	E	D		S	T	O	P	P	E	D	

Indicates the program the machine is currently following.

P	R	O	G	#	0	1	V	0	0	.	0	0	0	0	
F	R			.	0	1	0	H	0	0	.	0	0	0	0
R	R	M		0	0	0	0								
C	L	A	M	P	E	D		S	T	O	P	P	E	D	

Indicates the current vertical position of the spindle. This readout changes as the position of the spindle changes.

P	R	O	G	#	0	1	V	0	0	.	0	0	0	0	
F	R			.	0	1	0	H	0	0	.	0	0	0	0
R	R	M		0	0	0	0								
C	L	A	M	P	E	D		S	T	O	P	P	E	D	

Indicates the current horizontal position of the spindle. This readout changes as the position of the spindle base changes.

P	R	O	G	#	0	1	V	0	0	.	0	0	0	0	
F	R			.	0	1	0	H	0	0	.	0	0	0	0
R	R	M		0	0	0	0								
C	L	A	M	P	E	D		S	T	O	P	P	E	D	

Shows the current speed and feed the machine will run at if started.

P R O G	# 0 1	V	0 0 . 0 0 0 0
F R	. 0 1 0	H	0 0 . 0 0 0 0
R R M	0 0 0 0	H 6	0 5 . 0 0 0 0
C L A M P E D		S T O P P E D	

Indicates the next position the spindle will go to if the Auto Cycle is started. It also shows the next place the spindle will stop if you are operating manually.

P R O G	# 0 1	V	0 0 . 0 0 0 0
F R	. 0 1 0	H	0 0 . 0 0 0 0
R R M	0 0 0 0		
C L A M P E D		S T O P P E D	

Indicates the motion status of the vertical, horizontal and spindle motors.

P R O G	# 0 1	V	0 0 . 0 0 0 0
F R	. 0 1 0	H	0 0 . 0 0 0 0
R R M	0 0 0 0		
C L A M P E D		S T O P P E D	

Shows the status of the spindle base (i.e. clamped, floating, neutral).

Programming mode:

P R O G	# 0 1	1	0 0 . 0 0 0 0
V E R T I C A L		2	0 0 . 0 0 0 0
R P M	1 0 0 0	3	0 6 . 5 5 0 0
C L A M P E D		4	- 1 . 5 0 0 0

Indicates the program number you are making or changing. The cursor will be flashing on the first digit of the program number. After pressing ENTER the cursor will automatically move to the first digit of vertical stop number one.

P R O G	# 0 1	1	0 0 . 0 0 0 0
V E R T I C A L		2	0 0 . 0 0 0 0
R P M	1 0 0 0	3	0 6 . 5 5 0 0
C L A M P E D		4	- 1 . 5 0 0 0

Indicates what set of stops you are changing. (i.e. vertical or horizontal)

P R O G	# 0 1	1	0 0 . 0 0 0 0
V E R T I C A L		2	0 0 . 0 0 0 0
R P M	1 0 0 0	3	0 6 . 5 5 0 0
C L A M P E D		4	- 1 . 5 0 0 0

Shows the vertical stops to be programmed. After entering a value at any of the stops, pressing ENTER will move the cursor to the next stop. After the fourth stop the display will switch to Horizontal stops.

P R O G	# 0 1	3	1 0 . 0 0
H O R I Z O N T A L		4	1 5 . 0 0
1	0 0 . 0 0	5	2 0 . 0 0
2	0 5 . 0 0	6	2 5 . 0 0

Shows the horizontal stops to be programmed. After entering a value at any of the stops, pressing ENTER will move the cursor to the next stop. After the sixth stop the display will switch to Operating Mode.

Building a program:

Use the following sequence as a basic guide in building and changing vertical and horizontal programs.

Decide what program number you are going to use. Press the **PRG#** button. The display will switch to the programming screen and the cursor will blink on the first digit of the program number. To enter the new program number, press the digits on the numerical keypad and then press **ENTER**. The new program number will be entered and the cursor will move to the first digit on vertical stop number one.

Vertical Stops:

It is recommended to have the first vertical stop at 00.0000. If you are going to leave this stop at 00.0000 you can just press **ENTER** or **0** then **ENTER**. The cursor will move to the first digit of the second vertical stop. If a number other than zero is to be entered in the first vertical stop, just type it in. The cursor will move to the next digit automatically.

When the cursor is at the second vertical stop enter the desired number as described above or press **ENTER** to move to the third vertical stop.

Use the same procedure to enter the third and fourth vertical stops. Pressing **PRG#** at any time during the programming sequence will change the display to the horizontal stops.

The feed and speed of the machine are stored individually with each program. To enter the feeds and speeds for the program you are using press the **FEED RATE** or **RPM** button once. The cursor will start blinking on the first digit of the data you want to change. To change the Feed Rate or RPM press the desired number on the numerical keypad and then press **ENTER**. It is not necessary to enter a decimal point in the Feed Rate, the computer knows there is going to be a decimal point in the Feed Rate and compensates for it.

Horizontal Stops:

After the last vertical stop is entered the display will switch to the horizontal stops with the cursor at the first stop.

The first stop in a horizontal program is always going to be 00.0000. The remaining stops are represented by their physical distance from the position at which you zeroed the horizontal. Measuring from the centerline of the first cylinder to the centerline of the other cylinders will give you the correct stop distance. The procedure for entering horizontal stops is the same as entering the vertical stops.

Using a program:

Auto:

Using the rapid travel buttons, bring the cutterhead down and roughly center it above the bore. Bring the cutterhead down to centering level, generally the centering fingers will be about $\frac{1}{4}$ inch below the top of the cylinder. This is your centering position, you will want to press the **Vert Zero** and **Horiz Zero** buttons at this point to zero out the position read out.

You will want to leave the first and second vertical stops at zero if you are using a standard production cutterhead. Using a tape measure, measure the how deep you want the cutterhead to bore. Remember to add the distance the cutter is away from the top of the block and add it to the length of the bore. This number will be entered into the third stop.

The fourth stop will be a negative number great enough for the cutterhead to clear the top of the engine block.

Enter the Horizontal stops by measuring their centerline from the centerline of the first cylinder.

When all of the vertical and horizontal stops are programmed and the feeds and speeds have been entered, press the **Auto** button (a light in the corner of the button should come on) and then press **Cycle Start**.

If the spindle is not at its zero position the vertical and horizontal motors will power drive the spindle to the vertical and horizontal zero position. Once at the zero position the cutterhead will index to the 3 O'clock position, the spindle base will go into float, fingers will extend and the spindle base will clamp. If there is a number two stop programmed the spindle will rapid to that point, if the second stop is the same as the first a rapid jog will not be executed. The cutterhead will then start rotating and feeding down at the programmed speeds. When the third stop is reached the cutterhead will go into the washout cycle for the programmed time and speed set by the machine parameters. After the washout is finished the spindle base will shift .020 to the left and the spindle will execute a rapid up until it gets to the fourth stop. At this point the machine

will then rapid travel to the programmed second horizontal stop and repeat the sequence that was run on the first cylinder.

When the machine has finished with the last programmed horizontal stop it will retract to its vertical home position and its horizontal 00.0000 position. Once the cutterhead has reached its fourth stop the horizontal rapid move to home will be started. Once the machine has reached the horizontal 00.0000 position the base centering cylinders will be activated to re-center the spindle base.

Manual:

When in the manual mode the first part of the auto cycle remains the same. After the washout cycle the machine will not do a rapid up to stop four. The spindle will stop at the third stop and wait to be manually retracted.

Boring without Auto Cycle:

The machine can be used in Auto or Manual without using the auto cycle feature. Enter a program that will be used on the work piece. Position the cutterhead at the centering position like normal. Center the machine manually or by using the Center button. To start boring press the spindle start button and then the down arrow. The machine will start to feed down at programmed speeds until the third stop is reached. Depending if you are in auto or manual the machine will retract or stop as described above. If the machine is in Auto it will proceed to the next programmed horizontal stop and then go to its vertical zero position. The machine will rest at this place until further action is taken.

Boring Large Truck Blocks:

The F5M boring machine has the capacity to bore truck engines such as the in-line Mack and the in-line GMC series 71. It is necessary when boring these large blocks to remove the wear pads (502-1-21) and place the block directly on the main base (502-1-20). The blocks are then bored according to the instructions.

Using a Existing Program:

Power up the machine. When the machine powers up it will be using the program that was last used before it was powered down. Home the Vertical and Horizontal Axis. The horizontal axis is homed by moving the spindle base to the far right and then pressing the Horizontal zero button twice.

Determine what program you want to use. Press the PRG button on the front control panel. This will bring up the programming screen. The cursor will be flashing on the first digit of the program number in the upper left-hand corner of the display. To select a new program, enter the number of the program you want to run on the numeric keypad and press enter. All of the vertical stops will be showing at this point. You can verify the correct numbers are there at this point. To check the horizontal numeric values press the PRG key again. To go back to the boring mode press the PRG key a third time.

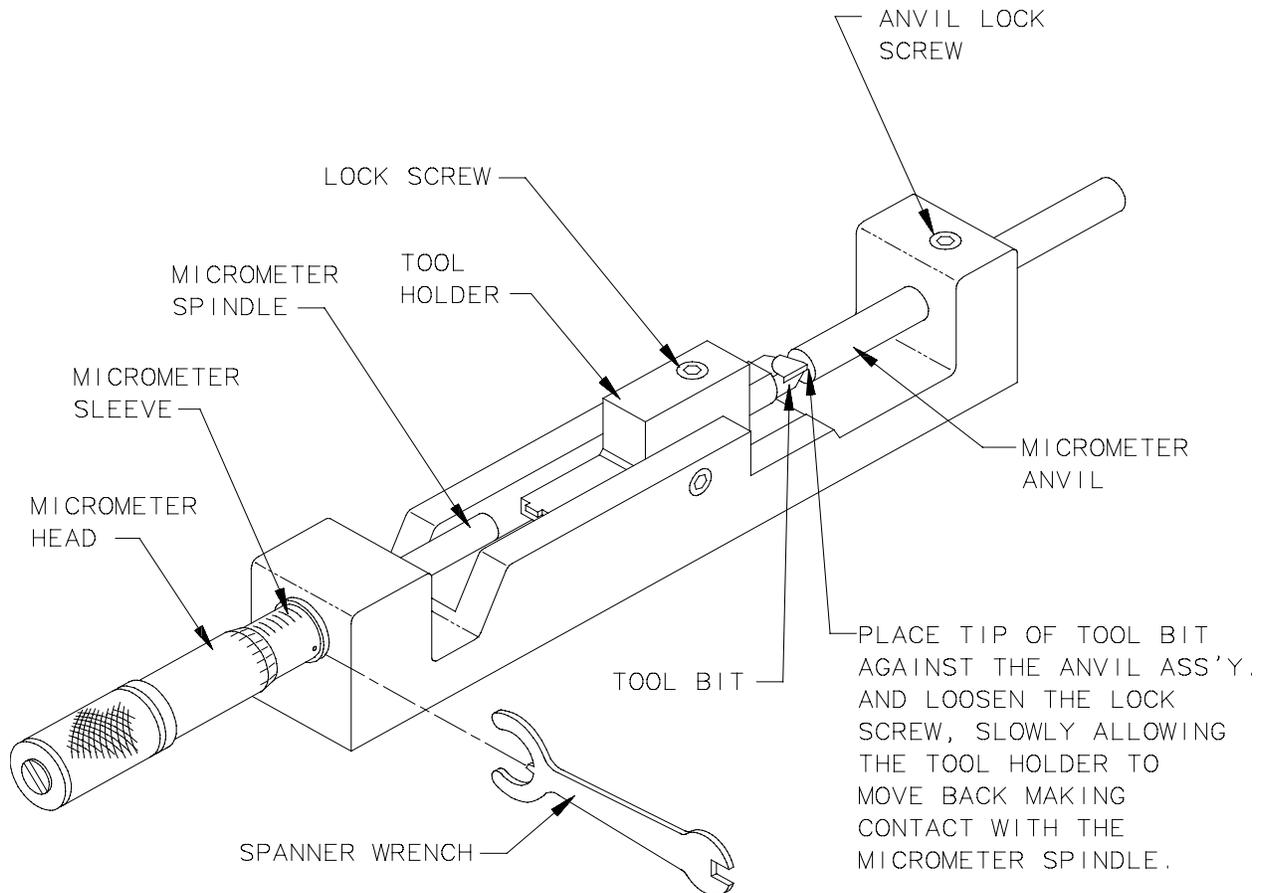
Install a block that matches the program you selected into the machine and secure it. Bring the spindle base over until it is above the first cylinder. Then bring the spindle down to the centering position (Usually the fingers will be about $\frac{1}{4}$ " from the top of the cylinder). Press vertical and Horizontal zero at this position. All stop values will reference these zero positions.

Note: Every time a different type of block is installed in the machine the first cylinder will have to be reference by pressing the vertical and horizontal zero buttons at the centering location.

To run the block press the cycle start button.

Note: Make sure the machine is in the Auto mode or it will stop at the top of the second cylinder.

After the machine has finished the entire block it will return to its vertical home position and horizontal zero. If the same type of block is installed in the machine again, pressing the cycle start button again will run the entire block.



Optional Capacity To 8" Diameter:

For setting F54X micrometer to high and low scale using micrometer with a 2.90 to 6.00 inch reading.

CAUTION: *The standard for your F54X micrometer is not set at the factory. It must be set with a micrometer by adjusting the lock screw.*

NOTE: *Read directly on the micrometer sleeve.*

To set the standard, set the micrometer to 6.00 Place the standard in the micrometer with the adjusting screw towards the anvil. Loosen the adjusting screw until the pin contacts the anvil. Lightly tighten the adjusting screw. Back off the micrometer and remove the standard. Finish tightening the adjusting screw. Recheck and adjust as necessary.

To bore from 2.90 to 6.00 place standard in the micrometer and adjust the anvil so the micrometer reads 6.00"

To bore from 4.9 to 8.0 place the standard in the micrometer and adjust the anvil so the micrometer reads 4.0. The micrometer will read 2.9 to 6.0 but will actually set tool from 4.9 to 8.0 When the micrometer is set for larger bores, remember the bar will bore 2 inches larger than the micrometer reads.

Install and Remove Toolholders:

Use the 7/32 hex driver to loosen the setscrew in the side of the cutterhead. This screw only needs to be loosened it does not need to be removed.

Use the tool puller for removing the tool holder. Obviously it is not necessary to use the tool puller on long tool holders, but you will find it very useful on short ones. Thread the puller in a few turns and gently pull.

Install and Remove Cutterheads:

CAUTION: Turn off power to machine before changing cutterhead.

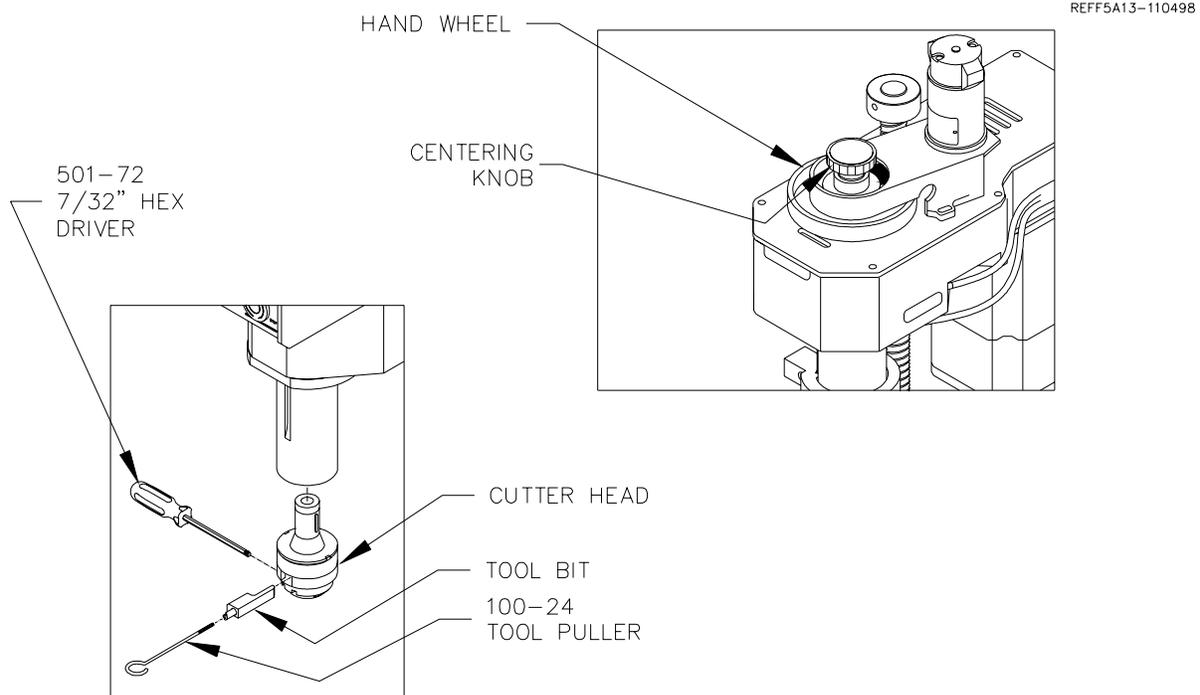
Centering fingers must be removed before changing cutterheads. Damage to the centering fingers could result if they are left in.

Use the spanner wrench in the upper knob on the upper housing. Turn the knob counter clockwise (looking from the top). The knob will be tight. There are a couple of ways to get it to come loose. Pull the spindle clutch lever down and hold it while sharply turning the knob. It may be necessary to insert a long tool holder in the cutterhead to use for leverage. Be careful to avoid damage.

Unscrew the knob the rest of the way. Keep your hand under the cutterhead so it doesn't fall out.

Thoroughly clean the end, including the threads, of the cutterhead that is going to be installed. Be sure the spindle clutch lever is in the up position. Line up the key in the cutterhead, with the key way in the inner spindle and lift the cutterhead in.

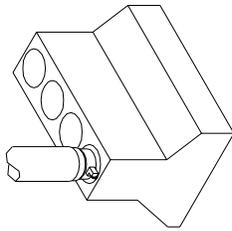
Turn the centering knob on top of the machine, to engage spline inside cutterhead. Holding the cutterhead firmly lock upper knob with spanner wrench.



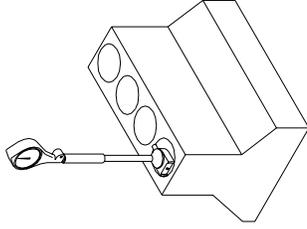
REFAV569-120695

PROCEDURE FOR CALIBRATING MICROMETER

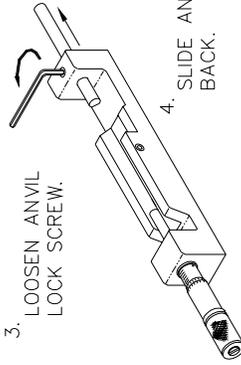
1. USE THE BORING MACHINE TO BORE A HOLE IN A SCRAP BLOCK. WITHOUT CHANGING ANY SIZE SETTING REMOVE TOOL HOLDER.



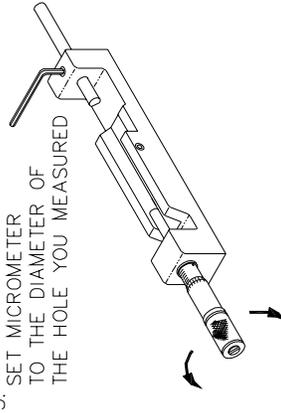
2. MEASURE THE HOLE THAT YOU BORED.



3. LOOSEN ANVIL LOCK SCREW.

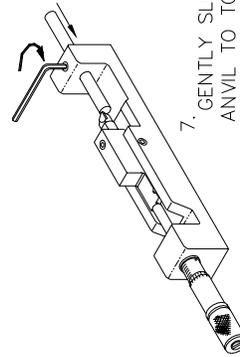


4. SLIDE ANVIL BACK.

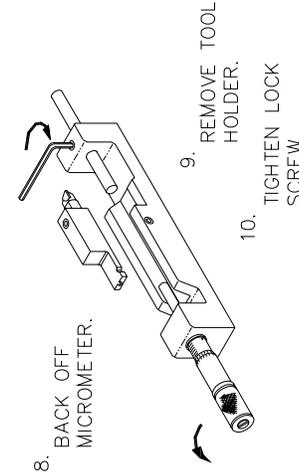


5. SET MICROMETER TO THE DIAMETER OF THE HOLE YOU MEASURED

7. GENTLY SLIDE ANVIL TO TOUCH CUTTING CHIP. AND LIGHTLY TIGHTEN LOCK SCREW.

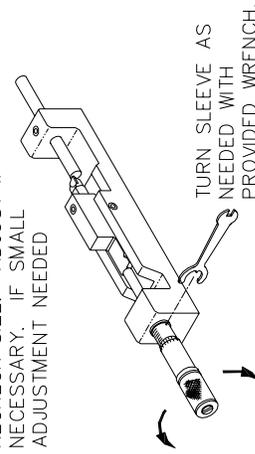


8. BACK OFF MICROMETER.

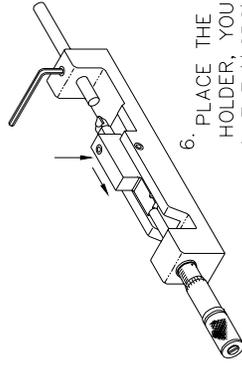


9. REMOVE TOOL HOLDER.
10. TIGHTEN LOCK SCREW.

11. RECHECK SIZE. ADJUST IF NECESSARY. IF SMALL ADJUSTMENT NEEDED



6. PLACE THE TOOL HOLDER, YOU USED, IN THE MICROMETER FRAME.



Maintenance:

Lubrication:

Refer to the illustration on page 4.5. Below are directions, that explain where and how to add oil to the various lubrication systems.

Vertical Ballscrew:

The vertical ballscrew runs through the upper housing. Run the machine down to its lowest travel position. Open the door on the front of the machine, the ballscrew is now fully exposed.

Every 175 hours, Grease the ballscrew using **76 Unoba EP2 Grease**, or equivalent NLGI- 2 grease. Wipe a small amount of grease on the screw just above the upper housing (with the machine at its lowest travel position).

Vertical Ballscrew Bearings:

The bearings are located at the bottom of the ballscrew inside the lower feed drive housing. Access the grease fitting on the left, outside of the spindle base.

Every 175 Hours, These bearings should be greased with, **76 Unoba EP2 Grease**, or equivalent NLGI- 2 grease.

Outer Spindle:

The outer spindle is the chromed cylinder that travels up and down. It is supported in two bushings located in the spindle base. The outer spindle supports the inner spindle, bearings, seals, etc.. and maintains the boring rigidity.

Every 40 Hours the outer spindle surface should be cleaned with kerosene. Occasionally with **a lightweight #10 oil.** should be wiped onto the outer spindle to prevent excessive dryness.

Inner Spindle: Oiler Setting

An air driven oil lubricator is located on the lower right of the main electrical rear enclosure. This lubricates the Inner spindle. Every time the Spindle Rotation button is pressed the oiler comes on for 30 seconds. If there is too much oil coming out of the Inner spindle turn the dial on the oiler counter clockwise. There should always be a slight amount of oil coming from the Inner Spindle, if there is not turn the dial clockwise to increase the amount of oil in the airline. Look at the top sight glass on the oiler, the oil should be set to drip at a rate of approximately 1-drop per minute.

There is air regulator located just to the left of the oiler. This should be set at 30 PSI for proper oil atomization. As mentioned above the oiler is only activated for 30 seconds every time the spindle is started. To set the oiler at one drop per minute you may have to start and stop the spindle several times.

At the beginning of each shift, check the level in the reservoir. **Fill with a lightweight #10 oil.** Top off as necessary, There is a plug threaded into the top of the oiler for filling.

Horizontal Ballscrew Nut:

The ballscrew nut is located on the left-hand side of the spindle base. Under the sliding cover. The bearings on the end of the ballscrew are permanently sealed and require no lubrication.

Every 175 hours, the ballscrew nut should be greased. Use **Unoba EP 2 Multi-purpose grease, or equivalent NLGI-2 grease.** Grease through the grease fitting if one is provided, otherwise wipe a small amount of grease directly on the ballscrew.

Clamp arms:

There is a grease fitting located on each clamp arm cam body.

Every 175 hours, these fittings should be greased with **76 Unoba EP2 Grease**, or equivalent NLGI- 2 grease.

Air Adjustments:

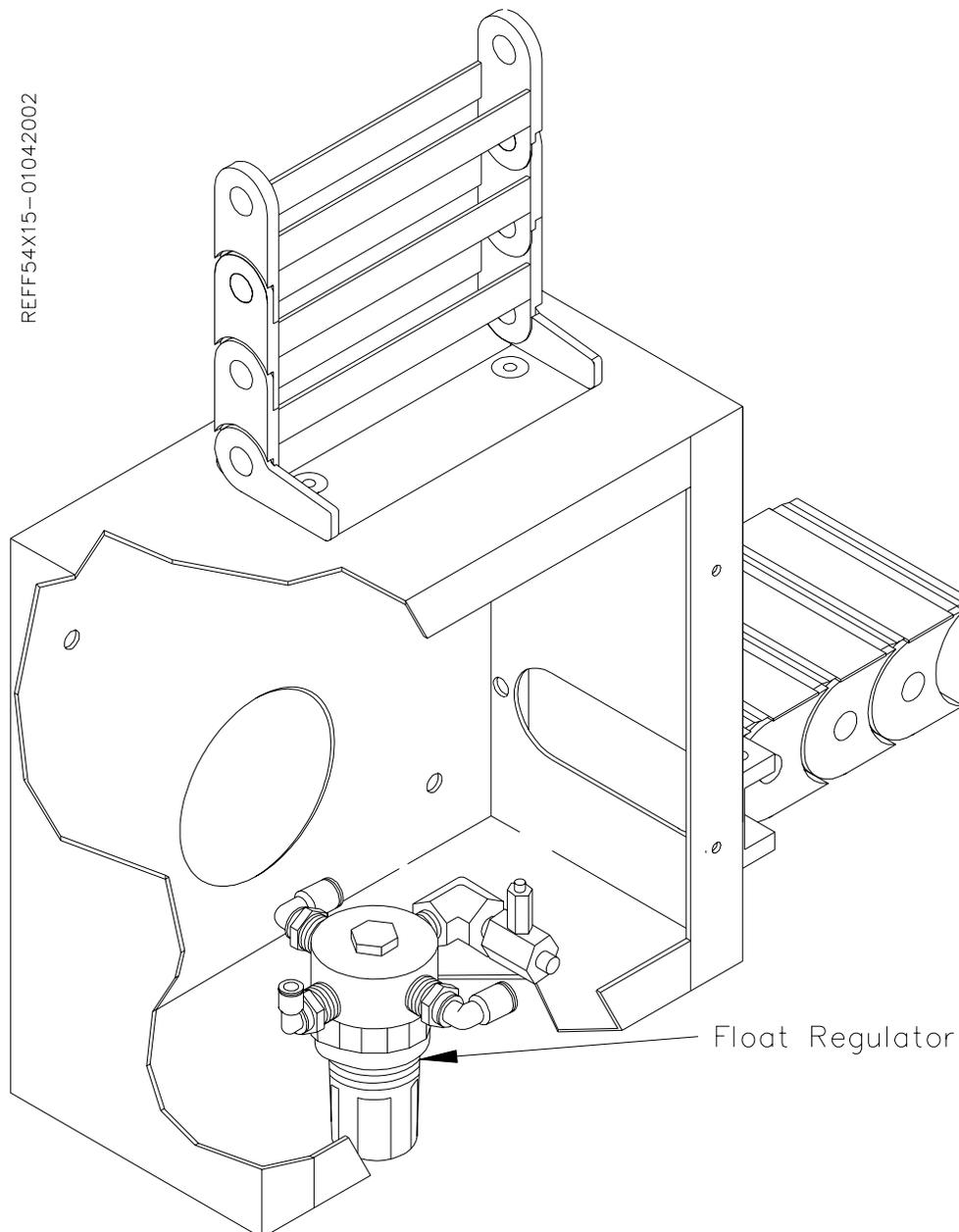
Float:

The float regulator is located at the rear of the spindle base on the bottom of the interconnect box.

If the machine is not floating properly it could be from too much or too little air from the regulator. Turn the regulator all the way off (full counter clockwise). Start turning the regulator slowly clockwise while continually checking the spindle base for proper floatation. Once the correct float is established lock the regulator into place by pushing in on the black adjusting knob.

CAUTION: Use as little air as possible to achieve correct floatation. Using too much air will could cause the spindle base to move slightly to the right when going into tilt. This will cause a scratch up the side of the cylinder.

If you cannot get the spindle base to float properly by adjusting the regulator refer to “Not Floating” in the troubleshooting section of this manual.



Pressure Switch:

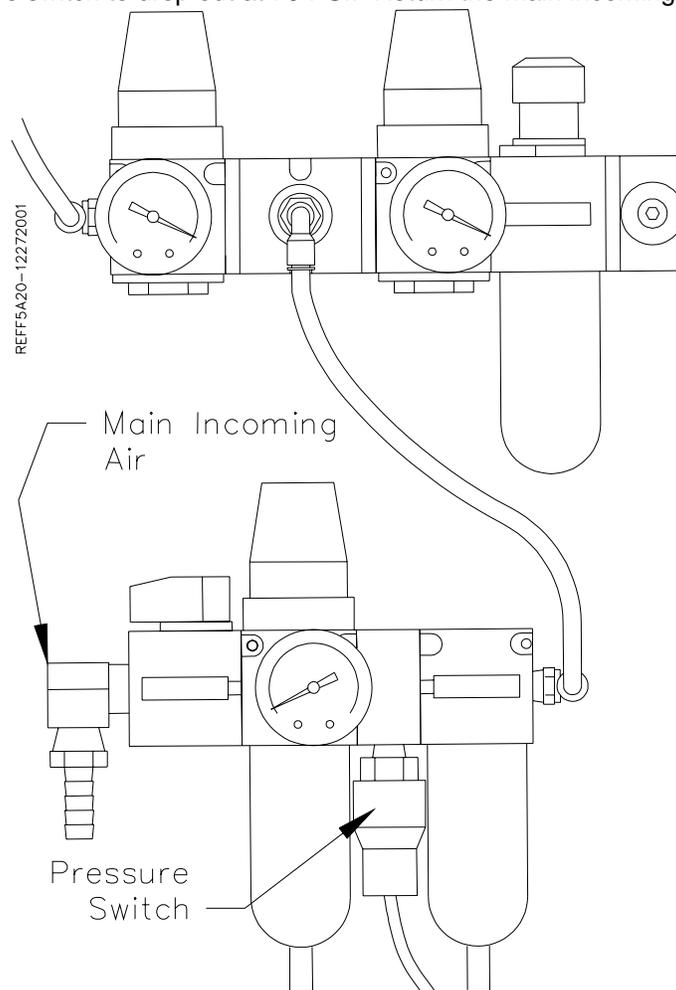
The pressure switch is located on the main intake air manifold, located on the right hand side of the rear electronic enclosure. The pressure switch is a solid state device that opens and closes at certain air pressure settings. It should be set on the F54X to 70 PSI. If the main intake pressure goes below 70 PSI the pressure switch is designed to open and cut power form all drives. This is so the spindle base clamps do not break loose during a bore with the spindle still rotating.

Turn the main input air regulator down to 70 PSI. Remove the main airline to the machine to relieve any pressure in the system that may be over 70 PSI. Re-attach the main air to the machine. Locate the main contactor in the rear electronic enclosure (Refer to page 6.2, Illustration). This contactor has a 1 and a 0 on the front of it. 1 means the contactor is closed and the machine should be operational. 0 means the contactor is open and machine will not operate as all power is removed from drives when contactor is in this state.

If the contactor is still closed (1) at 70 PSI adjust the thimble counter clockwise until it opens (0). Then reverse direction and start rotating it clockwise until it closes. As soon as the contactor closes stop turning the thimble on the pressure switch.

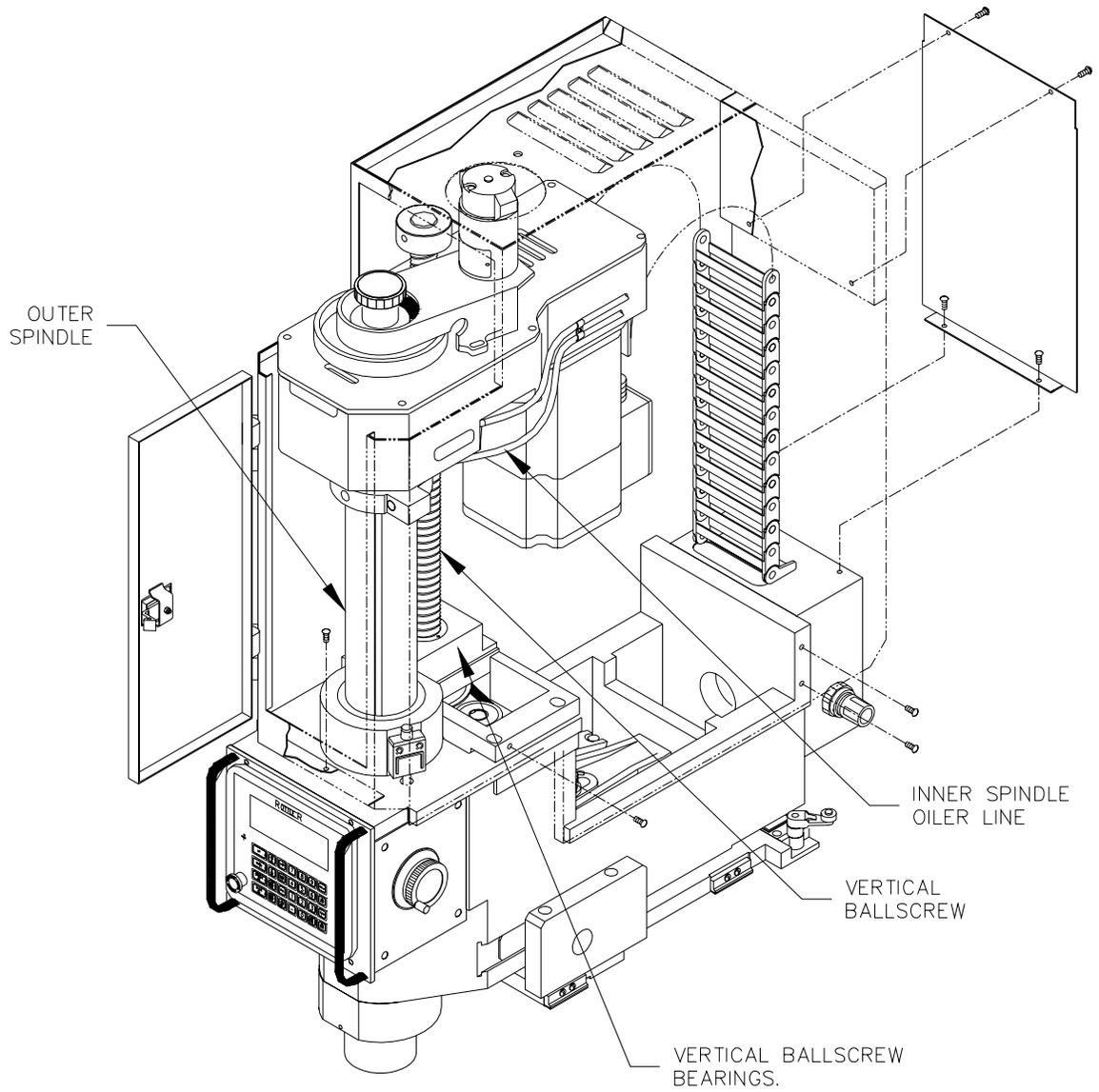
If the contactor is open (0) at 70 PSI adjust the thimble clockwise until it closes (1). As soon as the contactor closes stop turning the thimble on the pressure switch.

This will set the pressure switch to drop out at 70 PSI. Return the main incoming pressure to 100 PSI.



Lubrication Illustration:

REF F54X3-062499



Spindle Sweep:

The spindle must be swept into the main bed for accurate boring. If you are seeing “shadowing” in the bore the spindle may need to be swept in.

Note: *If the fixturing is not square to the main bed, this may also cause “shadowing”*

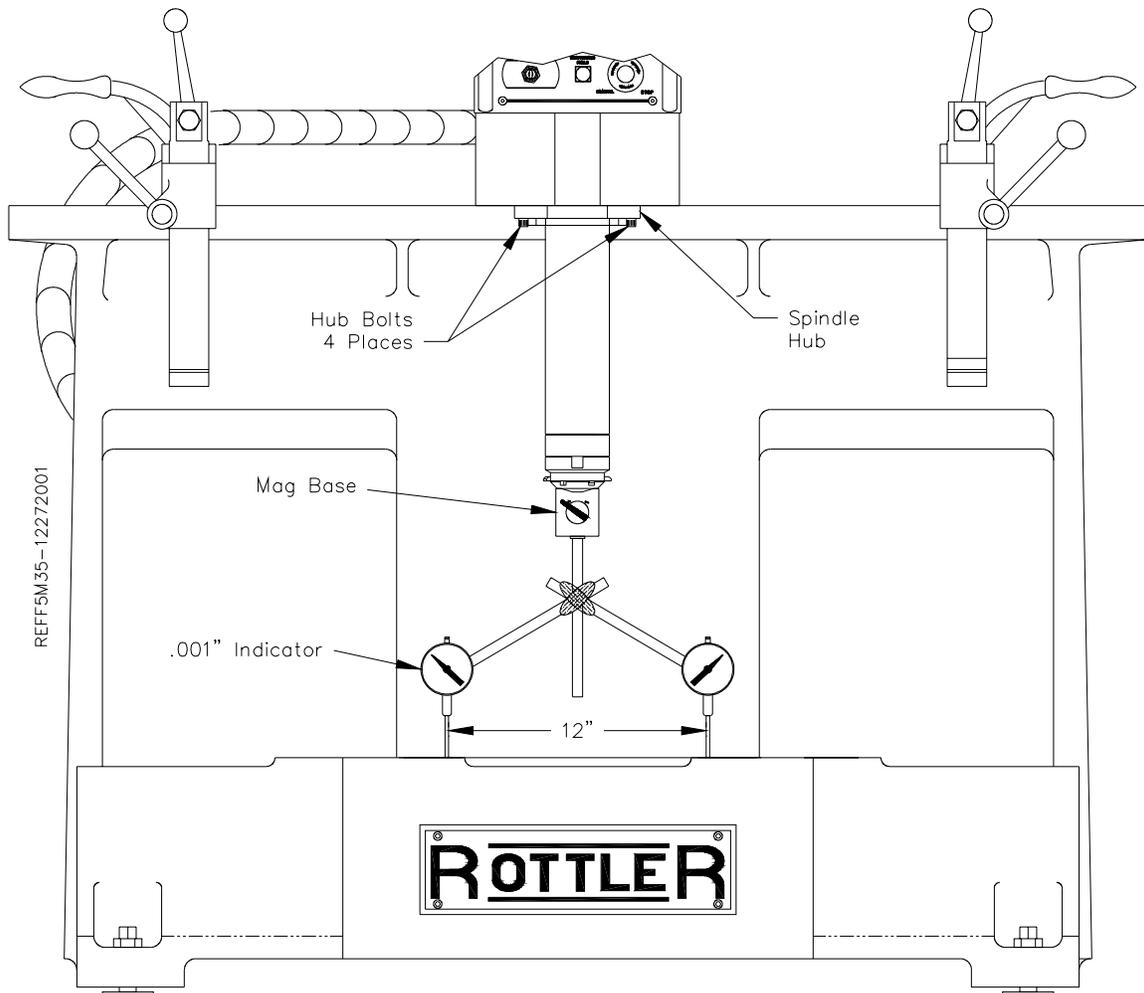
Adjustment:

Remove all fixturing from the machine. Loosen the four Spindle Hub bolts and then bring them back up to a “snug” condition. If the bolts are too loose Hub will bounce when it is adjusted. The spindle Unit should be Clamped.

Attach a Mag Base to the bottom of the cutter head. Attach an indicator to the Mag Base and adjust it for a minimum of a 12” sweep diameter.

Bring the Spindle down until the indicator is touching the Main Base. You want no more than .010” pressure on the indicator. Zero the indicator. Sweep the indicator around the Main Base. If the spindle is more than .0005” off of zero on the indicator, it will need to be adjusted.

Use a Brass Drift and a Hammer to lightly tap the Spindle Hub in the direction it need to go. Once you are within .0005” all the way through the sweep area, tighten the Spindle Hub Bolts. Check the sweep area again to be sure the sweep did not move as you tightened the bolts.



Outer Spindle Adjustment:

The main spindle bearings are tapered split cast iron rings, held in a seat by an adjustment nut. These bearings normally require no adjustment for many boring cycles.

The upper bearing is preloaded by a Belleville spring washer, located below the adjustment nut. This adjustment should be checked **after** the shipment of the machine. Shock to the machine during shipment may result in some setting of the spring.

CAUTION: *Be careful not to over tighten these bearings. An over tight condition only serves to wear out the machine and make control operation difficult.*

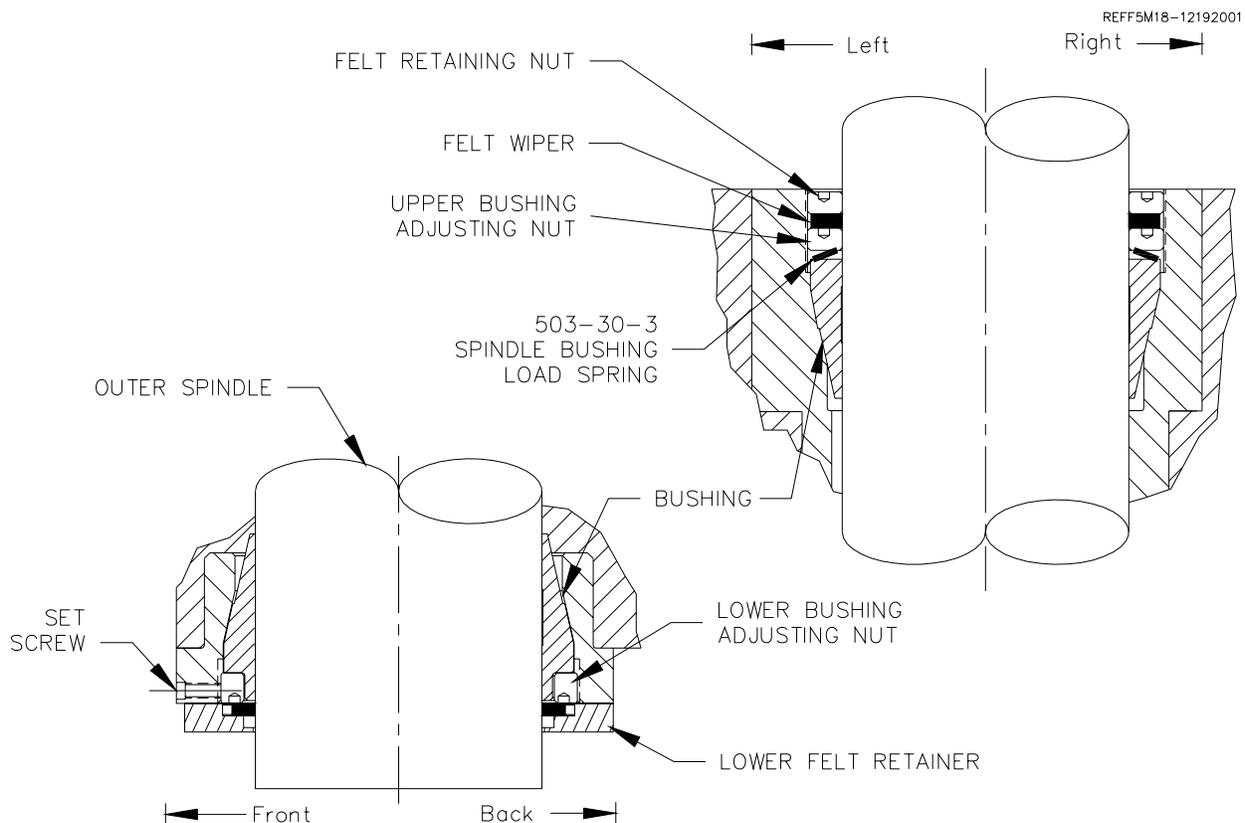
If it is necessary to adjust, see the following instructions:

Move the spindle base to a clear position making sure the spindle can travel its full vertical length. Thoroughly clean and lightly oil the Outer Spindle before adjustment.

Remove the upper felt retaining nut and felt wiper from the flange sleeve. Tie a rag around the outer spindle to hold them up at the top of the spindle. This will expose the upper bushing adjustment nut. Remove the lower wiper retainer ring along with the wipers and felts to expose the lower spindle bushing adjustment nut.

Loosen the setscrews located on the front of the upper and lower portion of the Spindle Base. Loosen the upper and lower bushing adjustment nuts to remove any pressure on the bushings. Tighten the upper and lower adjustment nuts evenly until they are lightly touching, but have no load on them.

Move the spindle down to pull the Upper Bushing into the upper hub. Using a punch and hand pressure only, tighten the Upper adjustment nut until it bottoms out on the Upper Bushing (collapsing Load Spring). Move the spindle up to pull the Lower bushing into the Lower Hub. Tighten the lower bushing the same as the top again only using hand pressure. If there is taper in the bore on large cuts tighten the lower bushing slightly more using a hammer.



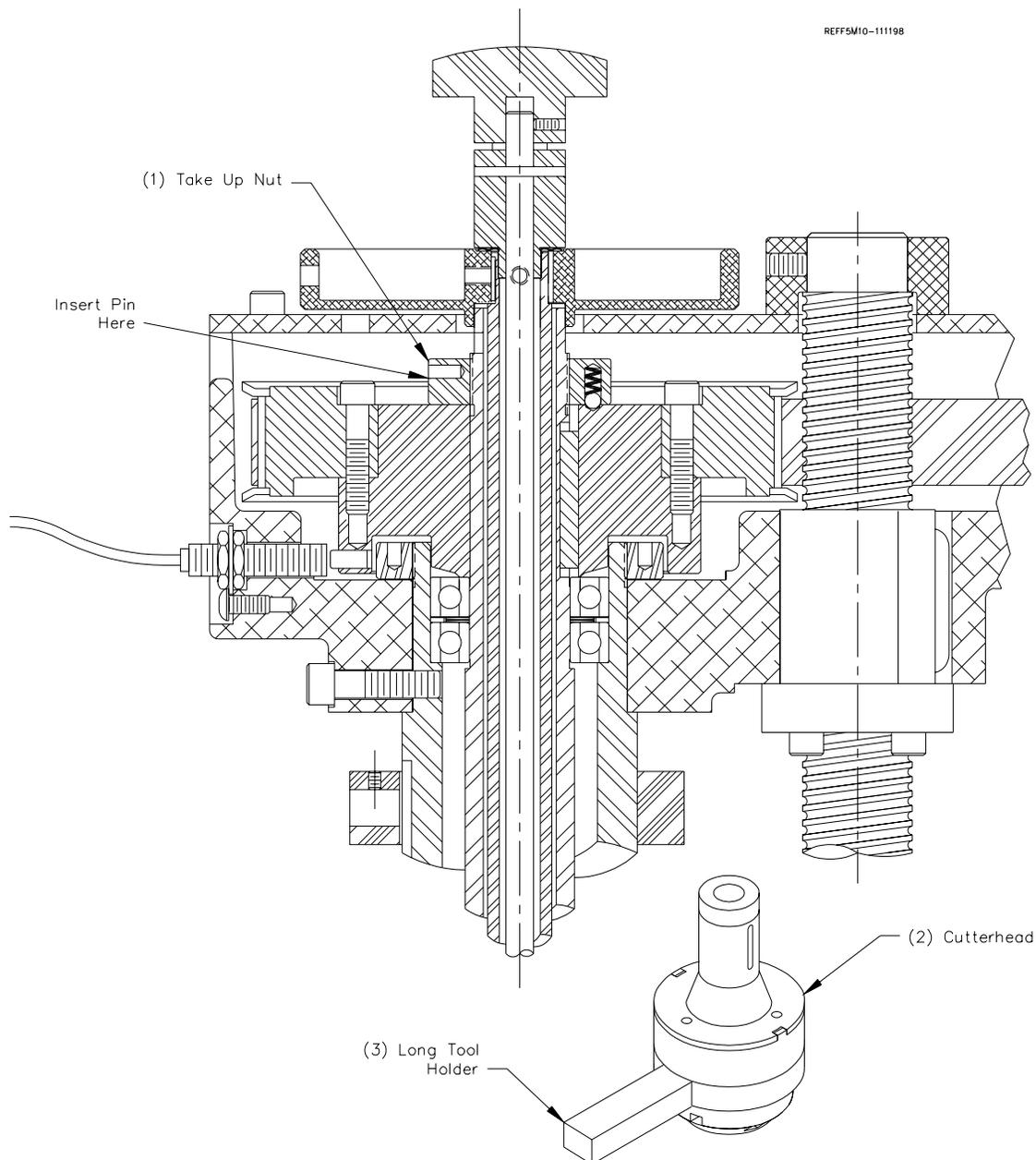
Inner Spindle Adjustment:

This machine is equipped with anti-friction bearings at the top and bottom of the Inner Spindle. It is very important to properly adjust the pre-load of these bearings. Setting these bearings either too tight or too loose can greatly reduce bearing life or destroy them all together.

Adjustment:

Insert a pin (diameter .180 or less) in one of the holes in the Outer Diameter of the Take Up Nut (this is located on top of the main spindle pulley). Secure a cutterhead (2) in the spindle, with a long tool holder (3) in place. Hold the cutterhead with your hand while turning the take up nut, to the left (clockwise). You will note the nut ratchets in notches as you take it up. Continue taking it up until the nut tightens up and then back off 1 notch. **Do not over tighten the nut, this will cause a crushing of the bearings and it will have to be replaced.**

CAUTION: Be sure the detent is in a notch, not midway between, this would cause the nut to slip backwards off adjustment.



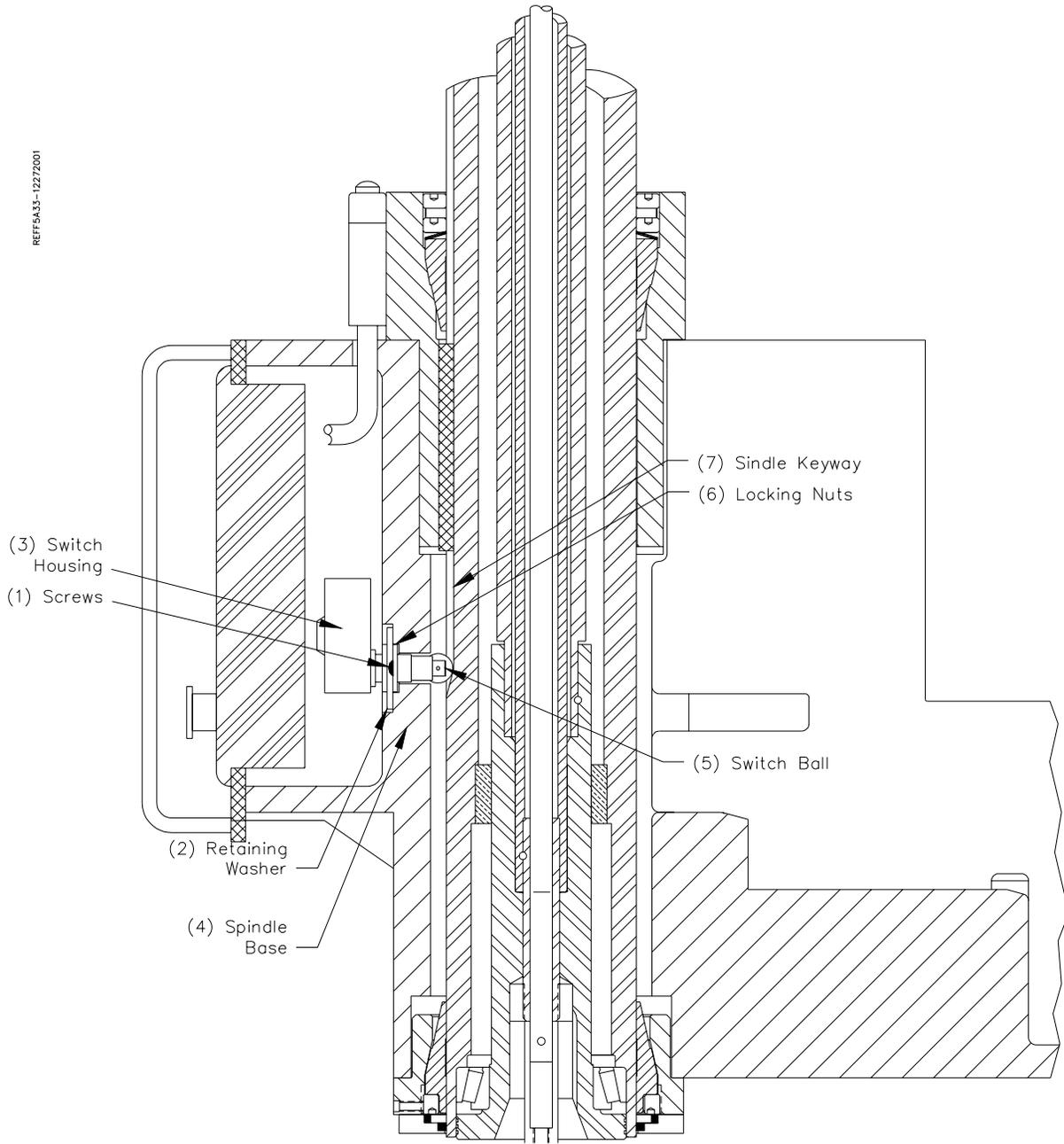
Home Switch Adjustment (early machines)

The first Rottler F54X machines that came out had a Home Switch located behind the front control Panel. The switch is mounted to the spindle base casting with the actuating roller going through the casting. The actuating roller runs up and down the spindle keyway and the bar is moved. During normal operation this switch is not activated until it gets to the Home position. If the spindle is running into the Stop Collar or will not travel up the switch may need adjustment.

Adjustment:

Refer to the illustration on the following page. Lower the spindle about 4 inches down from the Home position. Remove the cover from the right hand side of the Spindle Base. Remove the two screws (1) that are holding the Retaining Washer (2) in place. Remove the Switch Housing (3) from the spindle Base (4). Make sure the Switch is clean. When depressing the Ball (5) you should be able to hear a click inside the switch. If not, the switch is defective and you will need to replace it. Loosen the Locking Nuts (6) on both sides of the Retaining Washer. Back the nuts off a couple of turns. Insert the Switch Housing back into the spindle Base, you should be able to the switch click as the Ball bottoms out on the Spindle Keyway (7). Start moving the nuts forward until you can no longer hear the switch click when it is fully inserted into the Spindle Base. There is a ramp at the end of the keyway that will activate the switch when it is in the Home position.

Home Switch Adjustment Illustration (early machines)



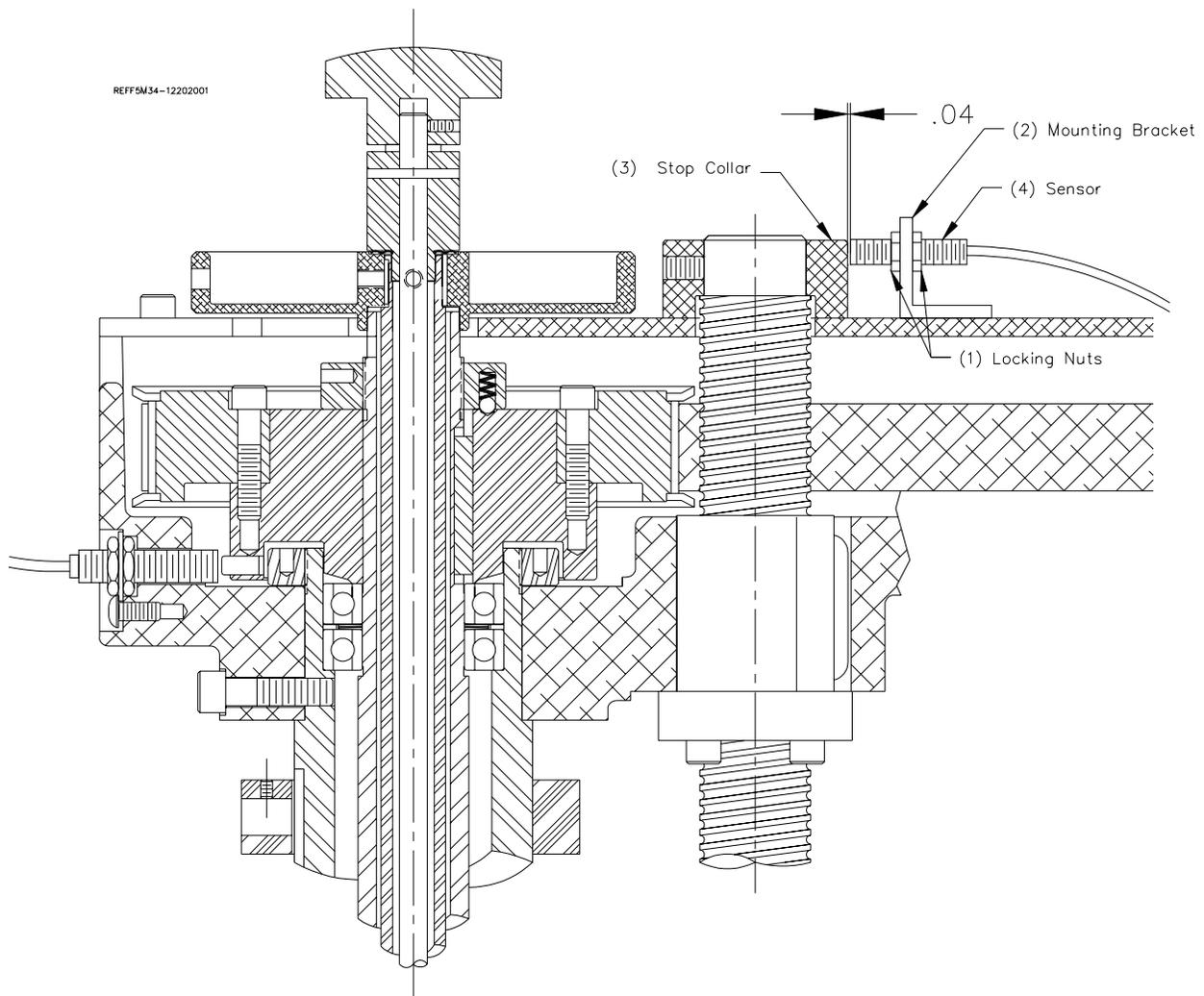
Home Sensor Adjustment

The Home sensor is located on the top of the belt Housing Cover (1). When the machine reaches the Home position the Stop Collar (2) activates the Home Sensor. If the spindle is running into the Stop Collar or will not travel the Sensor may need adjustment.

Adjustment:

Remove the shroud from the machine. Make sure the shroud is supported from the top by an overhead-lifting device before removing all of the screws. Remove the four Allen screws located on each side. Remove the two from the back cover. Open the front door on the shroud and remove the screw located just below the door. Lift the shroud from the machine, being careful it doesn't hang up on anything as you lift.

Move the machine to the Home position (Sensor (4) even with Stop collar). Loosen the two Locking Nuts (1) on both sides of the Sensor Mounting Bracket (2). Bring the Sensor to within .040 of the Stop Collar (3). Tighten Locking Nuts.



Spindle Index Sensor Adjustment:

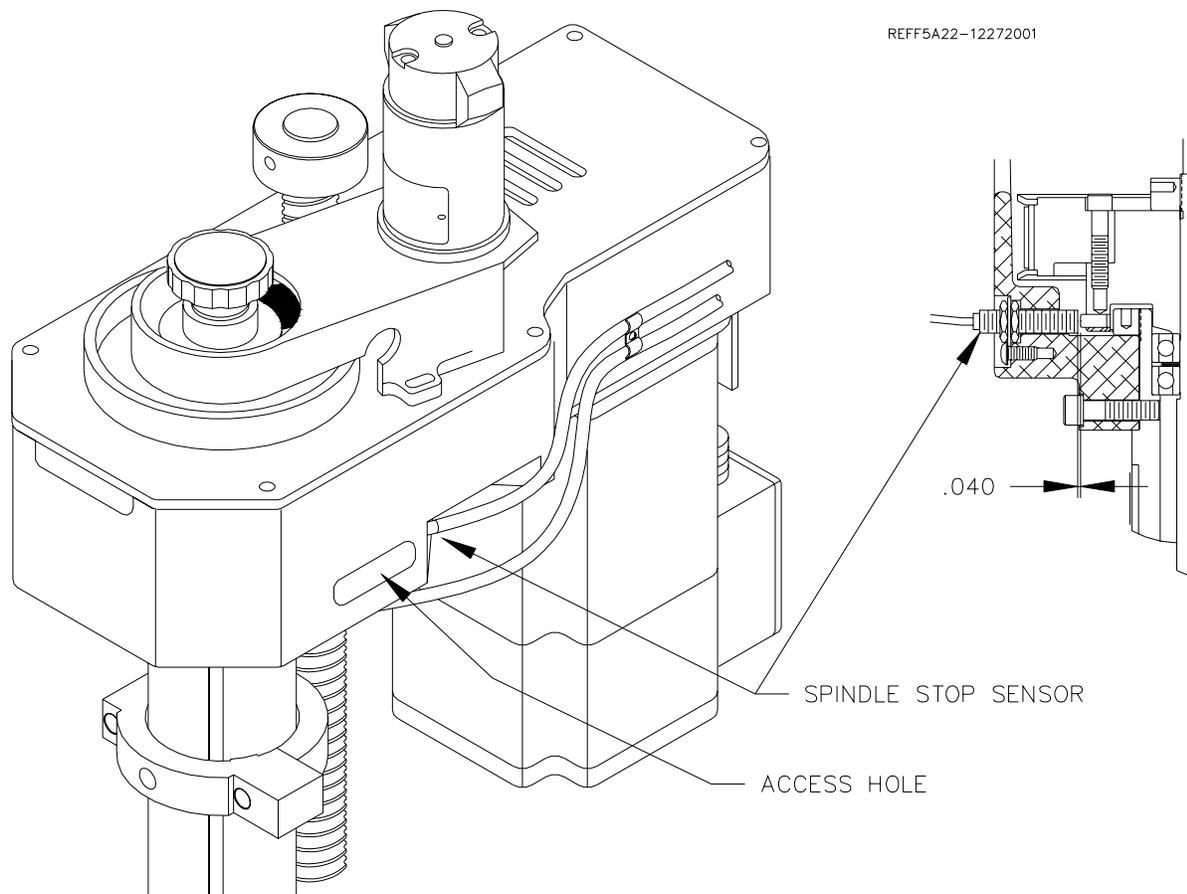
The purpose of the Spindle Index Sensor is to stop the spindle from turning with the tool bit facing in the correct direction. In order for the machine to rapid return from the bottom of a bore without scoring the cylinder wall as it comes up, the spindle must stop with the tool facing to the operators right. If the spindle will not index properly, it may need to be adjusted.

Remove the shroud from the machine. Make sure the shroud is supported from the top by an overhead-lifting device before removing all of the screws. Remove the four Allen screws located on each side. Remove the two from the back cover. Open the front door on the shroud and remove the screw located just below the door. Lift the shroud from the machine, being careful it doesn't hang up on anything as you lift.

The spindle stop sensor is located on the right side of the belt housing, just to the backside of the spindle. You will see a threaded chrome piece extending from the belt housing with a gray wire attached to it. When the spindle is indexed to the 3 o'clock position a light will come on at the rear of the sensor. If the sensor light does not come on when the Spindle is in the correct index position, it may need to be adjusted.

Locate the elongated access hole on the right side of the spindle housing, looking into it you should be able to see the end of the sensor and the dowel pin extending from the spindle hub. When lined up correctly there should only be about a .040" gap between the two. To adjust this gap, remove the slotted head screw from the belt housing, holding the sensor. Loosen the two nuts on the sensor holding the washer. Adjust the position of the washer until the correct gap is reached. Lock the nuts into place and re-install into belt housing.

If the sensor light still does not come on contact the factory for assistance in trouble shooting other possible causes.



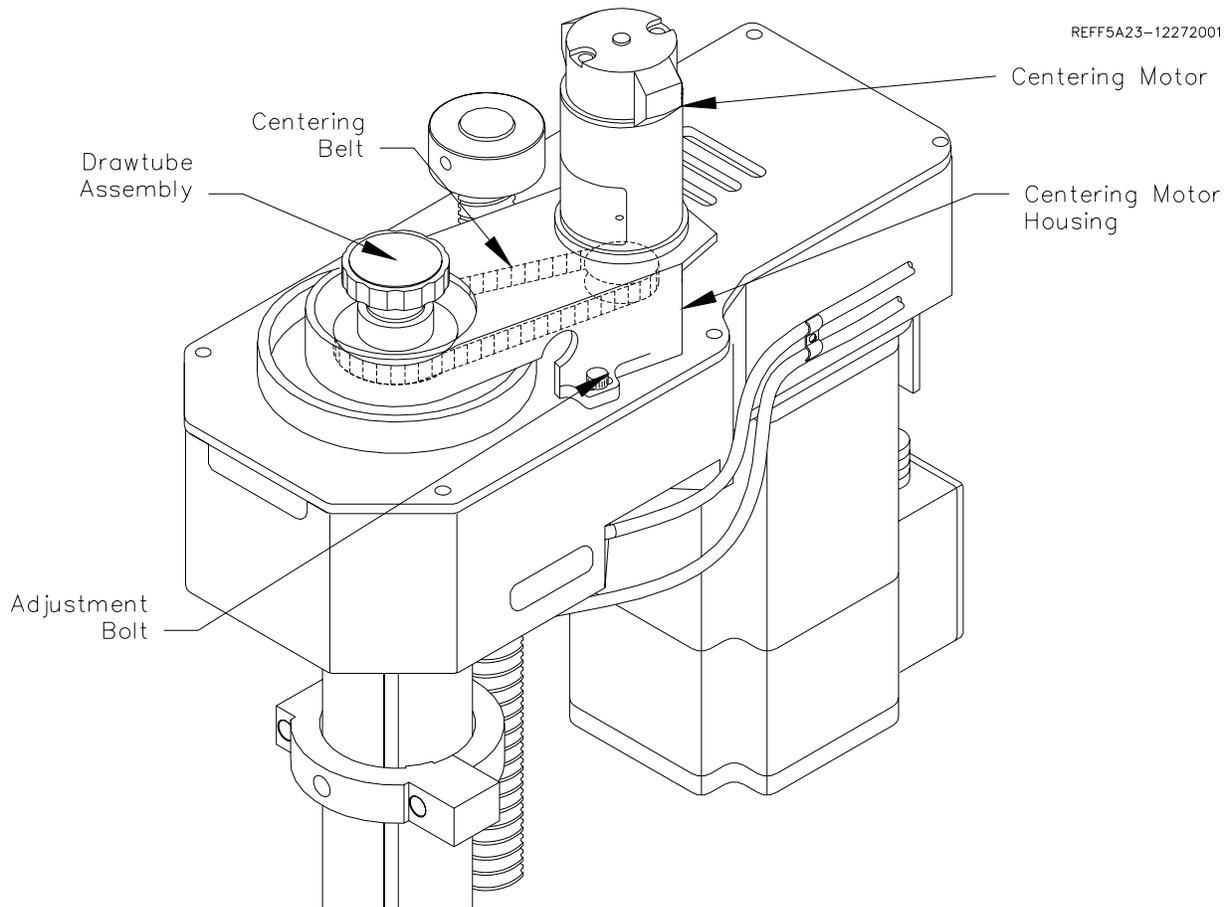
Centering Motor and Housing:

The Centering Motor Housing is located on top of the Upper Housing. The Centering Motor is mounted to the top of this housing.

The Centering Motor and Housing can be accessed without taking off the machine shroud, however it is much easier to work on when the shroud is removed.

Belt Adjustment:

If the tension on the Centering belt is too tight it could cause the centering Fingers to start to come out of the cutter head when the spindle is rotating. The belt may need adjustment also if the belt is slipping on the pulleys. These are cog type belt and pulleys, if the belt is slipping it will be very audible. Loosen the two adjustment bolts slightly. Push back on the Centering Motor Housing until you feel a small amount of resistance. Tighten the Adjustment bolts back down. **Be careful not to put too much tension on the Drawtube.**



Spindle Drive Belt Removal/Replacement and Adjustment:

CAUTION: *Disconnect all power to the machine before proceeding.*

Accessing Spindle Drive Belt: (see illustrations pages 6.10 & 6.12)

Remove the shroud from the machine. Make sure the shroud is supported from the top by an overhead-lifting device before removing all of the screws. Remove the four Allen screws located on each side. Remove the two from the back cover. Open the front door on the shroud and remove the screw located just below the door. Lift the shroud from the machine, being careful it doesn't hang up on anything as you lift.

Remove the setscrews in the mechanical stop on top of the vertical ballscrew. Remove the stop. Remove any cutterheads in the machine. Lift the centering shaft and drawbar from the machine by lifting straight up on the centering knob. Remove 5 screws holding the upper housing cover, lift the cover off the housing.

Loosen, DO NOT REMOVE, the four screws securing the spindle drive motor. Loosening the screw at the very back of the upper housing will take the tension off the belt, by allowing the motor to slide forward (some machines may require the plastic cable carrier be loosened to expose the screw head).

Removing Spindle Drive Belt:

Loosen the four screws attaching the driven pulley to its bushing. Lift the pulley and the belt straight up. ***Do not loosen the inner-spindle adjustment nut.***

Installing Spindle Drive Belt:

Place the belt around the driven pulley and slide them together down over the driven pulley bushing. Rotate the pulley until you can line up the four mounting screw holes. Install the screws, and tighten. Pull the motor to the back of the upper housing, with the motor adjusting screw, to tighten the belt.

Belt Adjustment:

Tighten the motor adjusting screw until you can deflect the belt .12 inch (3.17mm) when a pressure of 4.5 to 5 pounds (9.92kg to 11.02kg) is applied to the belt midway between the drive and driven pulleys.

Tighten the motor mount screws. Replace the upper housing cover, and tighten the mounting screws. Replace the drawbar / centering shaft assembly, by sliding it back down into the inner spindle from the top. Replace the vertical stop to the top of the ballscrew and tighten the setscrews. Lower the shroud back onto the machine and fasten the mounting screws.

Excessive Loads:

Thrust Overload:

The drive that controls the vertical motor on the F5 series machines, will trip out when a vertical stall occurs. This is a condition that happens when the machine is fed or rapid traveled into the top of a work piece. It would not make any difference if the spindle was turning or not. This can happen, by misaligning the machine with the bore, or by boring into a hole with an obstruction at the bottom. A vertical stall can also be caused by rapid traveling up into the mechanical stop at the top of the ballscrew.

The first step in correcting a vertical overload condition is to determine what happened to cause it. You will probably have to move the spindle off the obstruction manually, because the machine will tend to physically jam in position and the motor once reset will not be able to move.

Once the jam is cleared press the E-stop button on the face of the machine, wait for at least 1 ½” Minutes. Turn the E-stop button to release it. The machine will reset itself, and be ready to run again.

Be sure you have determined the cause of the crash before continuing.

Spindle Overload:

If the spindle is turning, as in boring or counter-boring, and the tool bit hits an obstruction, the drive that controls the spindle motor will trip out. This can happen if there is an unseen web at the bottom of a bore, or if the machine is extremely off center when a cut is started.

The first step in correcting a spindle overload condition is to determine what happened to cause it. You will probably have to move the spindle off the obstruction manually, because the machine will tend to physically jam in position and the motor once reset will not be able to move.

Once the jam is cleared press the E-stop button on the face of the machine, wait for at least 60 seconds. Turn the E-stop button to release it. The machine will reset itself, and be ready to run again.

Be sure you have determined the cause of the crash before continuing.

Vertical Drive Housing:

CAUTION: *Disconnect all power to the machine before working on the Vertical Drive Housing.*

All work being done to the vertical drive housing, such as replacing or adjusting the belt, replacing the motor, or the ballscrew bearings, requires the housing be removed from the spindle base. Following are details for working on the housing.

Accessing Vertical Drive Housing:

Remove the shroud from the machine. Make sure the shroud is supported from the top by an overhead-lifting device before removing all of the screws. Remove the four Allen screws located on each side. Remove the two from the back cover. Open the front door on the shroud and remove the screw located just below the door. Lift the shroud from the machine, being careful it doesn't hang up on anything as you lift.

Removing Vertical Drive Housing:

Remove the four mounting screws located at the left and right sides of the housing. Place an engine block or something under the end of the outer spindle to support its weight. Remove the electrical connections on the vertical drive motor. The two cables unscrew at the motor connection box. Manually, turn the ballscrew counter-clockwise to raise the housing up out of the spindle base.

Replacing Vertical Drive Belt:

With the Vertical Drive Housing lifted, loosen, **do not remove**, four screws securing the motor mount. Remove the screw and the bevel gear from the top of the motor shaft. Locate two, belt tension adjusting set screws on the side of the motor mount plate. Back off the setscrews until the motor will slide all the way toward the ballscrew. Remove the motor, mount plate, and belt from the vertical drive housing. Place a new belt around the driven pulley, raise the motor and drive pulley into place. Adjust as described below.

Adjusting Vertical Drive Belt:

If you installed a new belt, or if you disassembled the drive housing for another reason you need to adjust the belt. The vertical drive housing must be up out of the spindle base, and the motor mount plate screws in, but not tight. Make sure the drive pulley (attached to the motor) and the driven pulley (attached to the ballscrew) are lined up so the belt runs level. Screw in the belt tension adjusting set screws until the belt can be deflected .12" (3.17 mm) when 3 to 4 lbs.(6.61 to 8.82kg) pressure is applied midway between the drive and driven pulleys. Tighten the motor mount plate screws.

Replacing Vertical Drive Housing:

Be sure the belt is adjusted properly and the motor mount plate is tightened down securely. Manually, turn the ballscrew clockwise to lower the vertical drive housing back into position. Put in the screws to secure the vertical drive housing but don't tighten them yet. Hook up the cables to the vertical drive motor. Turn on the machine and run the spindle all the way to the bottom. Loosen up the vertical drive housing mounting screws, and then tighten them fully. This ensures the ballscrew is lined up properly.

Place the bevel gear on the end of the motor shaft. Be sure the drive pin is lined up properly, and tighten the mounting screw. See *page 4.8* for mounting the mechanical hand feed gear housing.

Inner Spindle Removal:

Raise the spindle all the way to the top of its travel. Move the spindle base to the extreme left of its travel.

CAUTION: *Disconnect all power to the machine before removing the inner spindle.*

Remove the drive belt as described on *page 4.6*.

Be sure to support the inner spindle with a block of wood or something to keep it from falling out. (see *page 6.10*) Loosen the upper nut, remove it and the index bushing from the inner spindle. The inner spindle can now be lowered out of the outer spindle. The lower tapered bearing should come out with the

inner spindle, its outer race will stay inside the outer spindle. The upper ball bearings will stay inside the upper housing.

Clean the bearings and re-install or install new bearings, on the inner spindle. Lubricate the bearings with several drops of oil prior to installing (*see page 4.1 Inner Spindle section for recommended oil*). Slide the spindle up in the outer spindle. Place a block or something under the inner spindle to hold it in place. Replace the upper bearings and Belleville springs. Be sure the springs are inserted correctly as shown on *page 6.10*. Place the index bushing on the inner spindle and thread on the upper spindle nut. (*see page 4.4 for inner spindle adjustment procedure*) (*Refer to page 4.6 for re-assembly and belt adjusting procedure*)

Upper Housing Removal:

Remove the inner spindle as described above. Disconnect the motor cables from the connection box on the rear of the spindle motor. Remove the spindle stop sensor from the right side of the upper housing. Disconnect the oiler line from the fitting located on the right side of the upper housing by pushing in on the outer ring of the fitting then pull the line free. Disconnect the electrical conduit-mounting bracket at the rear of the upper housing. Place some sort of block under the outer spindle to keep it from falling. Remove the outer spindle nut from inside the upper housing. (*see page 6.10*) Remove the three bolts from the outside of the upper housing that bolt it to the outer spindle. Remove the four screws securing the ballscrew nut to the upper housing. The upper housing should now be free to lift off the outer spindle.

Outer Spindle Removal:

Remove the upper housing as described above. Refer to the directions on page 4.3, and loosen the upper and lower bushing adjusting nuts all the way. The outer spindle should lift out of the spindle base.

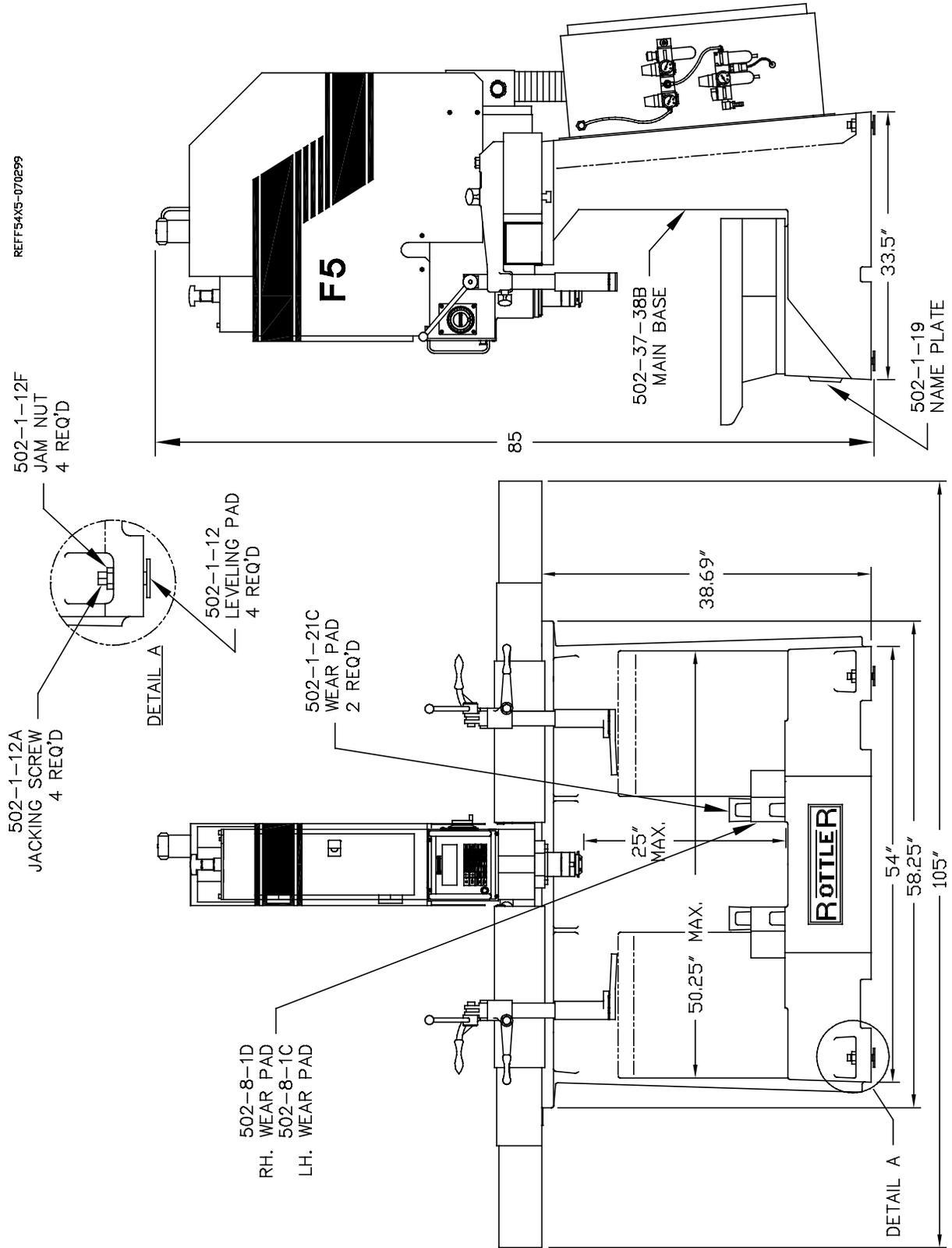
Display Faults and Errors:

Fault	Possible Causes	Possible Solutions
Spindle Jam	Following Error – Feedback from the motor to the controller is not what it should be	<p>Bad resolver in spindle motor. Replace spindle Motor</p> <p>Bad resolver cable from motor to Spindle Drive. Check all connections at motor and drive. Replace cable if necessary.</p> <p>Bad cable or connection from spindle drive to FCM card. Check all connections and replace cable if necessary.</p> <p>No simulated encoder output from drive. Spindle drive faulty. Consult factory for replacement.</p> <p>FCM card bad. Consult factory for possible replacement.</p> <p>Ribbon cable between FCM card and controller bad. Check security of connections at both ends of cable.</p> <p>Gains set in machine parameters or in spindle drive too low. Consult factory for possible gain adjustments.</p>
	No power to spindle drive – spindle drive keypad is dark.	<p>Check breakers and reset if needed. If breaker keeps tripping check for shorts and replace drive if needed.</p> <p>Main power relay not pulling in. Check air pressure switch. Air supply must be at 80 PSI or above.</p> <p>Main power relay not pulling in. Make sure Emergency Stop relay is not pushed in.</p>
	Drive Fault	Check display on drive. If there is a fault present press reset on the key pad. If fault returns consult drive manual that was supplied with machine. Consult factory for adjustment or replacement.
Vert. Pos. Jam	Following Error	<p>Bad Resolver in Vertical motor. Replace vertical motor.</p> <p>Bad Resolver cable from Motor to vertical drive. Check all connection and replace cable if necessary.</p> <p>Bad Cable from vertical drive to FCM encoder board. Check all connections and replace cable if necessary.</p> <p>No encoder output from vertical drive. Replace spindle drive. Consult factory.</p> <p>Bad FCM encoder board. Replace encoder board. Consult factory.</p> <p>Check ribbon cable from encoder board to computer control. Make sure connections are good.</p> <p>Gains set in vertical drive too low. Consult factory for possible gain adjustments.</p>
	No power to Vertical drive	<p>Check breakers and reset if needed. If breaker keeps tripping check for shorts and replace drive if needed.</p> <p>Main power relay not pulling in. Check air pressure switch. Air supply must be at 80 PSI or above.</p> <p>Main power relay not pulling in. Make sure Emergency Stop relay is not pushed in.</p>

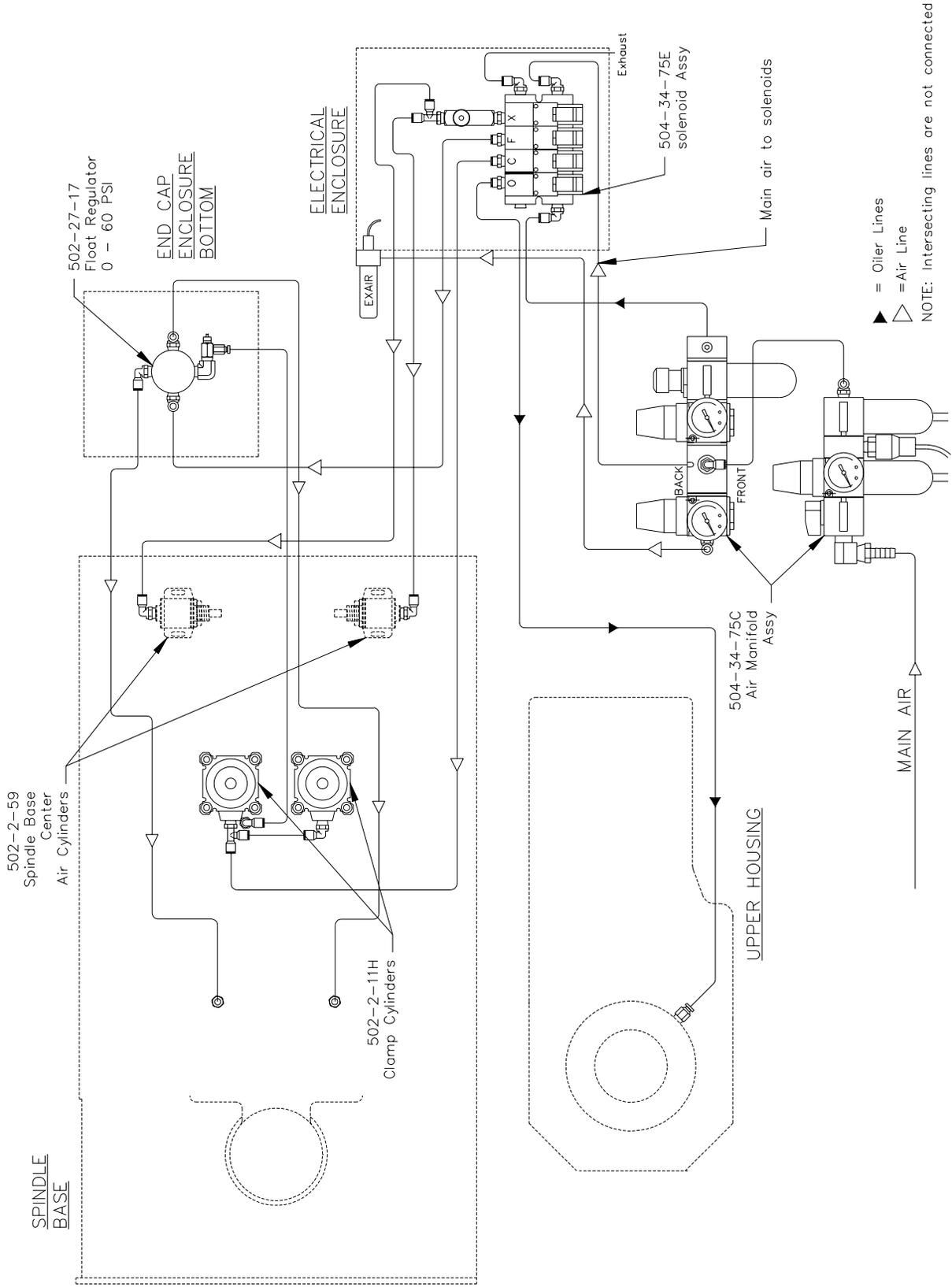
Fault	Possible Causes	Possible Solutions
	Drive Fault	Check display on drive. If there is a fault present press reset on the key pad. If fault returns consult drive manual that was supplied with machine. Consult factory for adjustment or replacement.
Left EOT	Switch depressed	Check EOT switch located on the left rear of the spindle base. Error will clear itself when condition is cleared.
	Switch damaged	Switch may be damaged, use an OHM meter to watch the switch transition from open to close. If transition does not occur when switch is depressed, replace switch.
Right EOT	Switch depressed	Check EOT switch located on the Right rear of the spindle base. Error will clear itself when condition is cleared.
	Switch damaged	Switch may be damaged, use an OHM meter to watch the switch transition from open to close. If transition does not occur when switch is depressed, replace switch.
Vert. Down EOT	Switch Depressed	Check EOT switch located on spindle base where spindle enters it. Error will clear itself when condition is cleared.
	Switch Damaged	Switch may be damaged, use an OHM meter to watch the switch transition from open to close. If transition does not occur when switch is depressed, replace switch.
Emergency Stop	Emergency Stop in	Release Emergency stop and press ENTER to clear. Check cabling.
Display will not come up.	No power to display unit	Check cabling to back of display. Check cabling to computer control in rear enclosure. Check all breakers in rear enclosure. Turn power off for one minute to reset computer control. Check fuse on COP controller in rear enclosure.
Parameter Fault	Machine parameters lost	Re-enter machine parameters listed in this manual. Battery back-up on computer controller has failed. Contact factory for replacement.
Will not hold Horizontal position	Drive unstable	Contact factory for drive adjustments.
Will not hold Vertical position	Drive unstable	Contact factory for drive adjustments.
Spindle Motor noisy and runs rough	Drive unstable	Contact factory for drive adjustments.
Spindle Falling when power is off.	Outer bushings too loose.	Refer to operator manual for adjustment procedures.
Chatter in bore.	Inner spindle out of adjustment.	Refer to operator manual for adjustment procedures.
	Cutterhead has oil in it.	Remove cutterhead from machine, disassemble and clean counter weight. Counter weight must be dry and have free movement.
Bore out of round.	Inner spindle out of adjustment	Refer to operator manual for adjustment procedures..

Fault	Possible Causes	Possible Solutions
	Fixturing is moving	Check fixturing for security
Taper in Bore	Outer spindle out of adjustment Dull tooling	Refer to operator manual for adjustment procedures. Sharpen tool or change corners on indexable tooling
Vertical motor noisy	Drive and motor out of tune	Refer to drive manual supplied with machine for adjustment procedures. Contact factory for assistance.
Horizontal motor noisy	Drive and motor out of tune Castle nut too tight Air settings incorrect	Refer to drive manual supplied with machine for adjustment procedures. Contact factory for assistance Back Castle nut off until the washer below has free movement in the neutral mode. Refer to machine manual for correct settings.

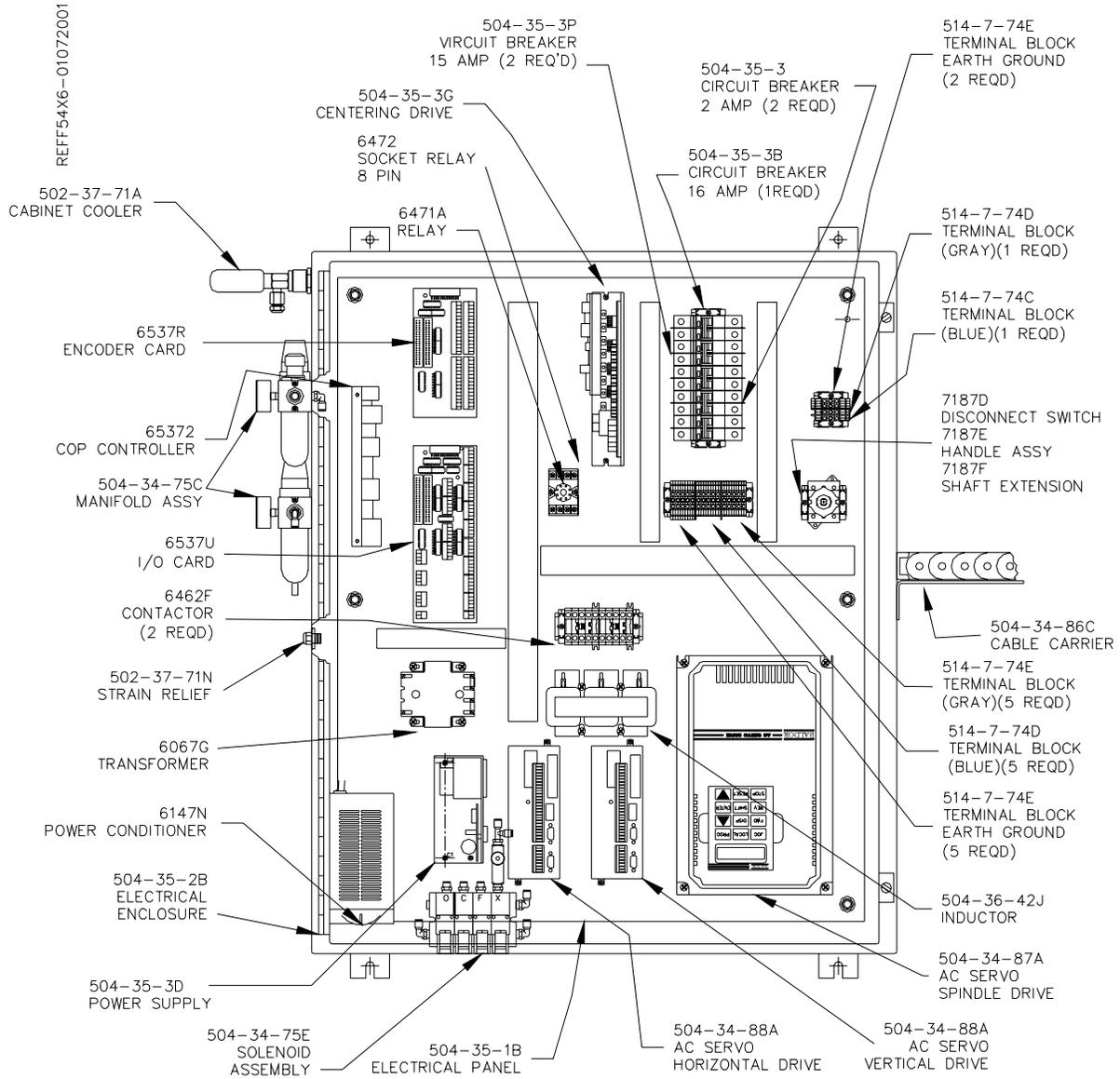
Front Right Side View:



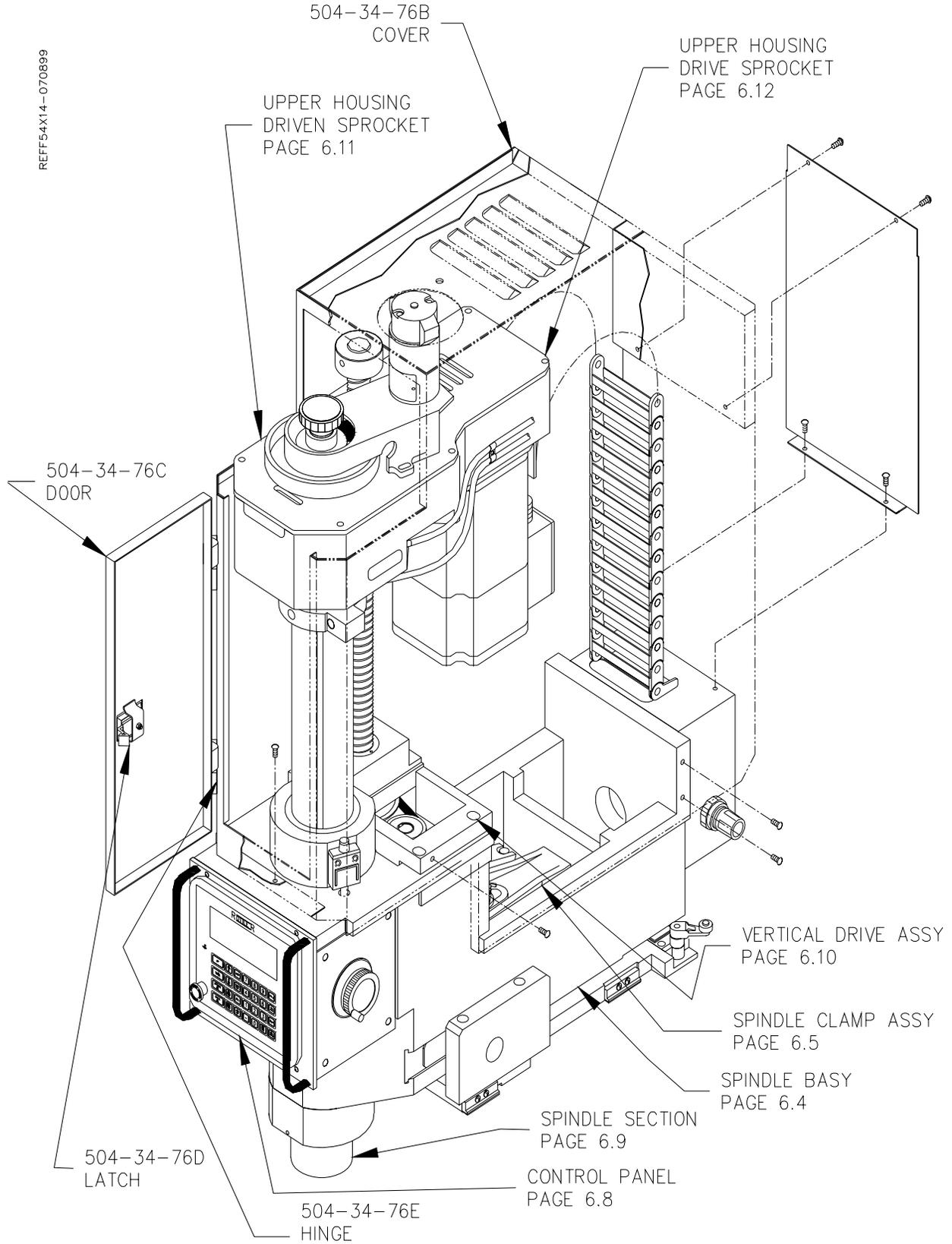
Air Logic Diagram:



Electrical Enclosure:

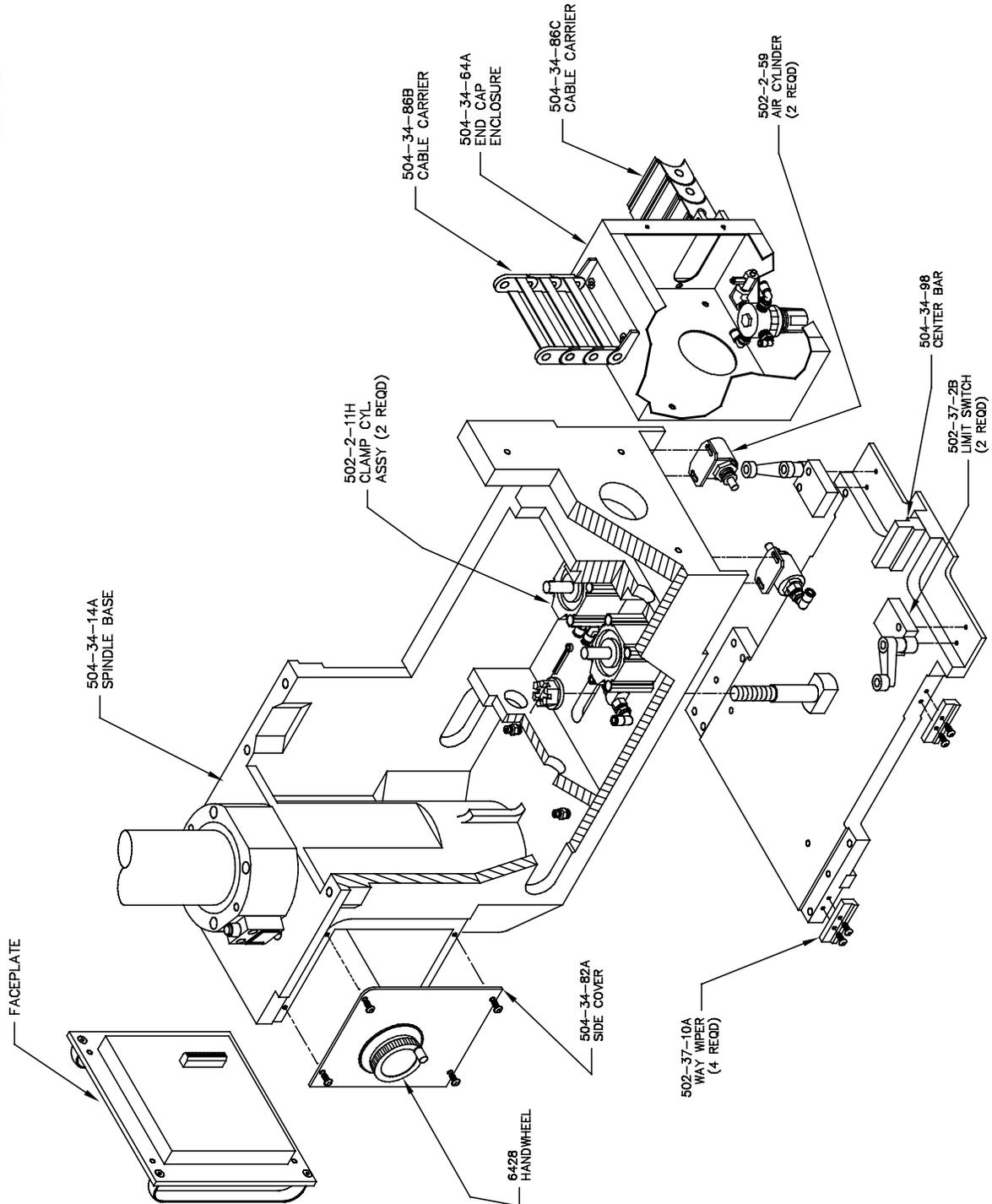


Spindle Base Assembly Illustration:



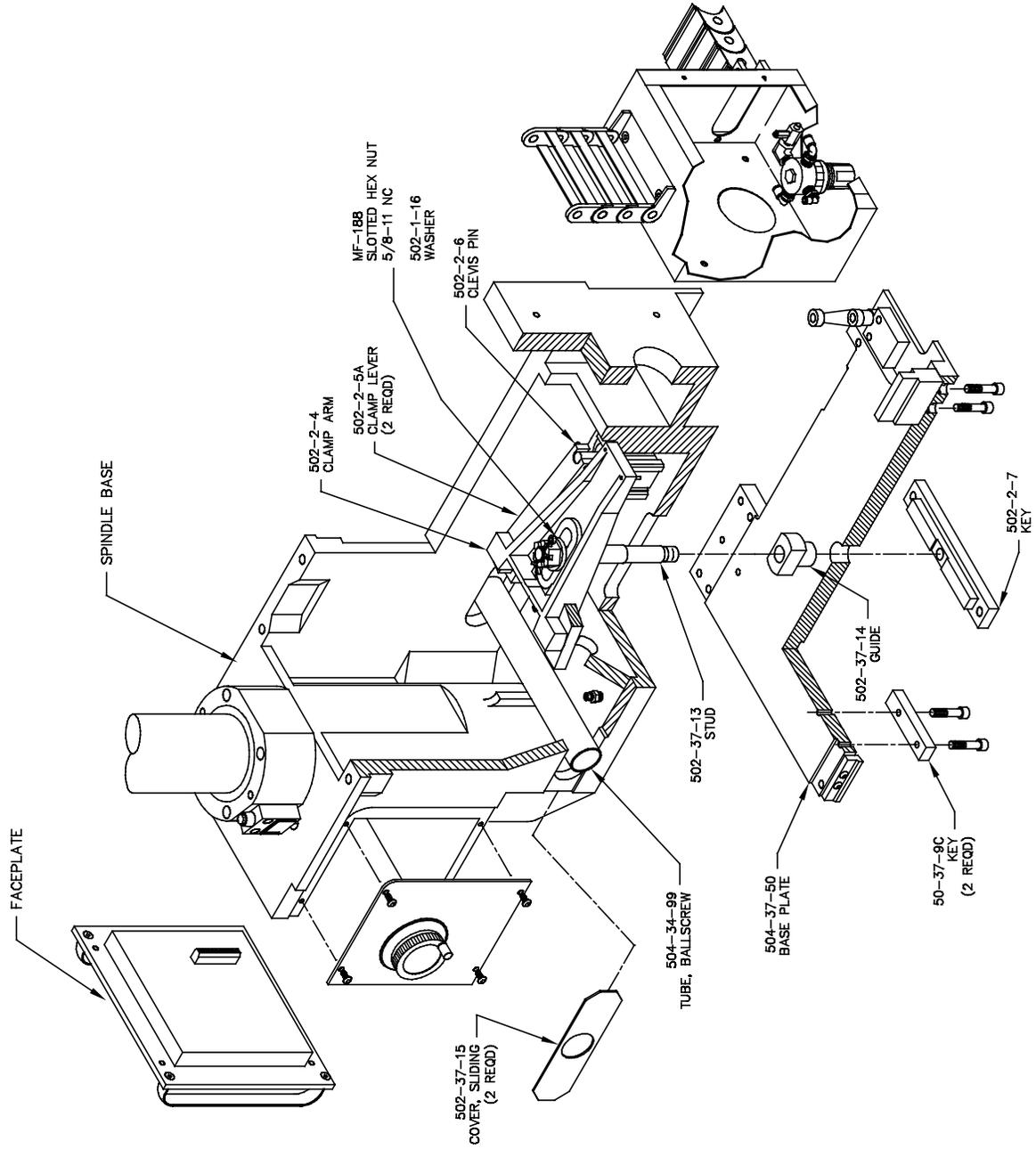
Spindle Base:

REF54K7-070199



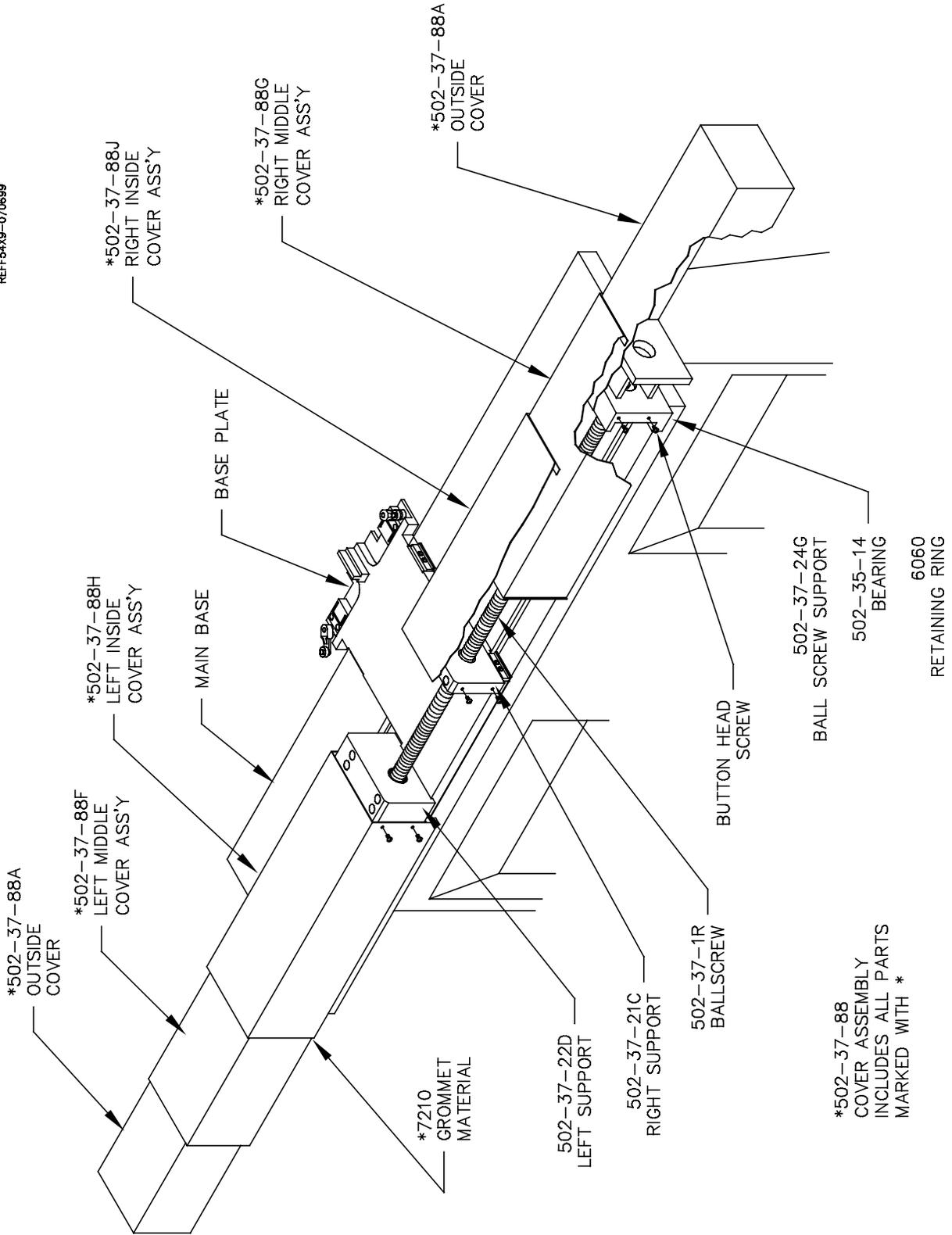
Spindle Base Clamp System:

REF:54X-070689



Horizontal Drive Assembly:

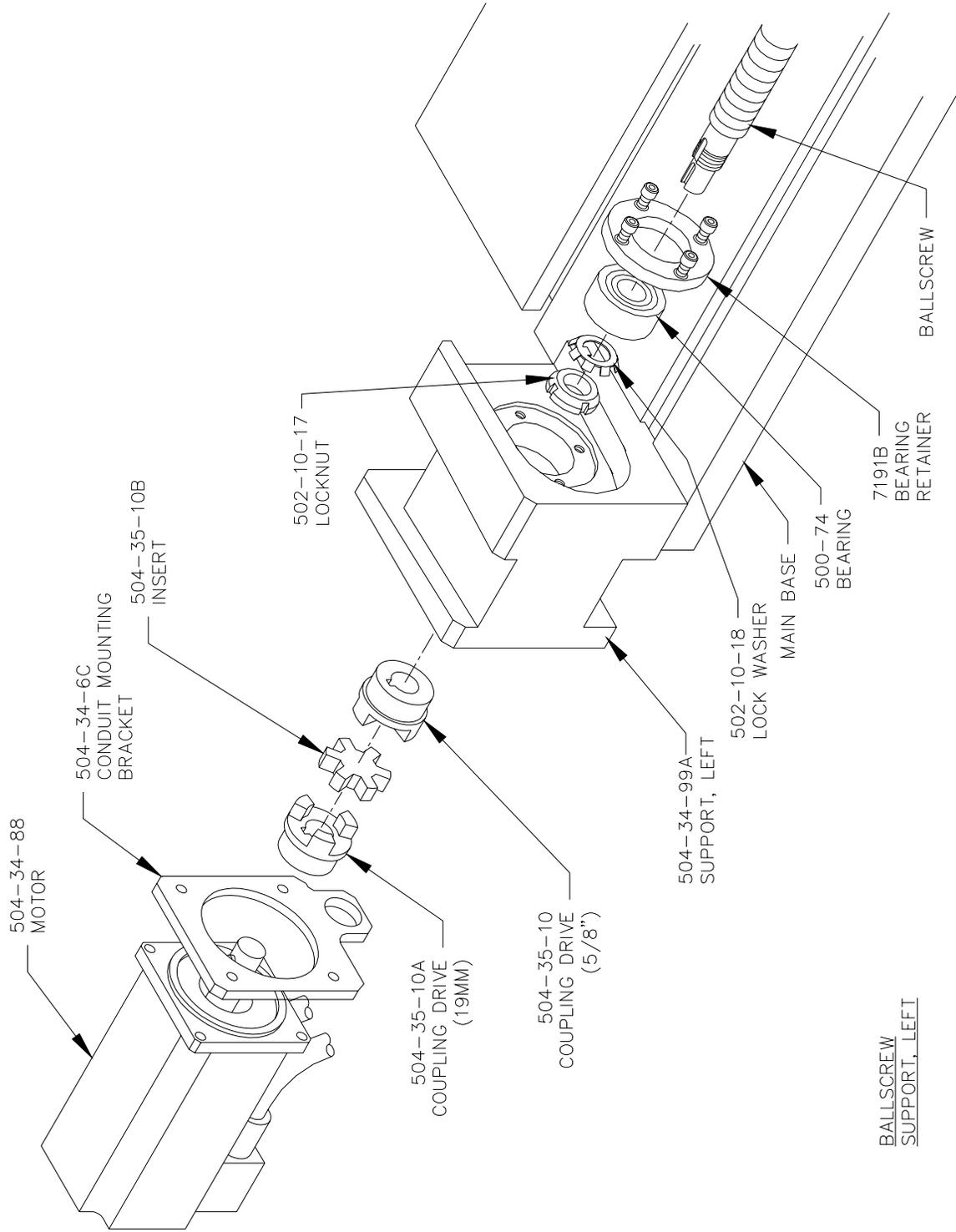
REF F54X9-070699



*502-37-88 COVER ASSEMBLY INCLUDES ALL PARTS MARKED WITH *

Ballscrew Support / Motor:

REF F54X10-01072002



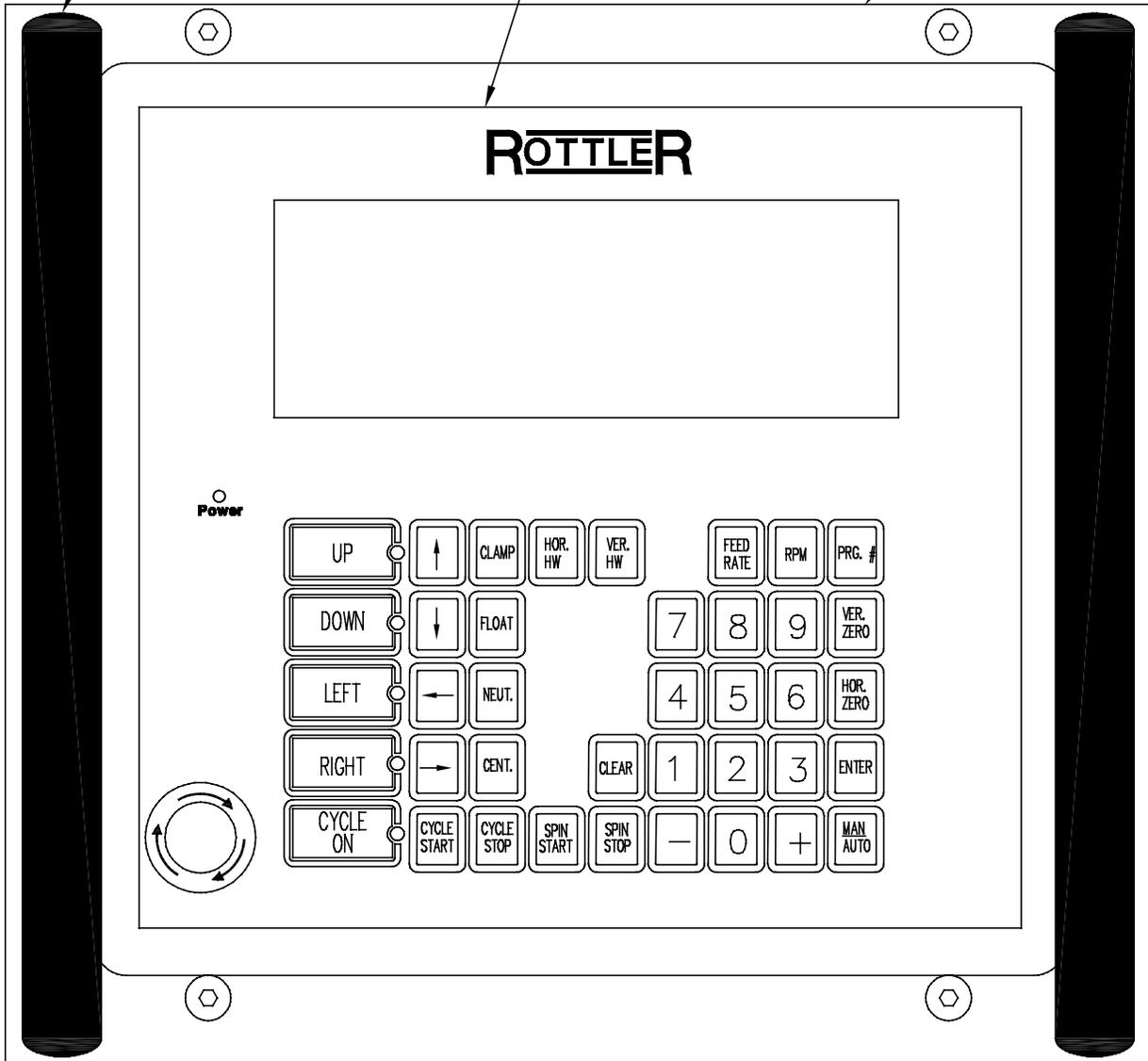
Control Panel:

REF54X11-062599

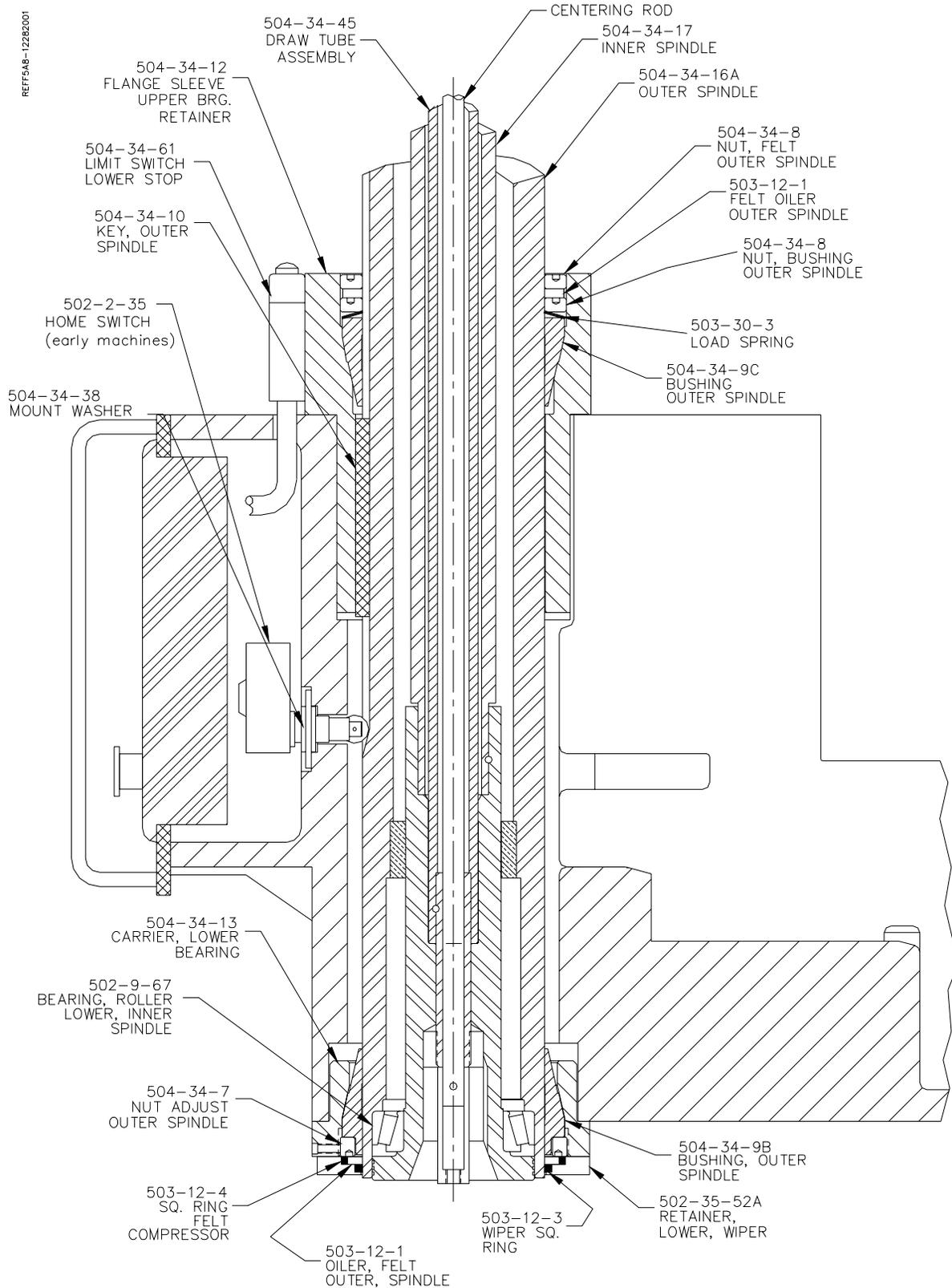
504-34-84B
8" HANDLE
(2 REQD)

504-34-83K
KEY PAD

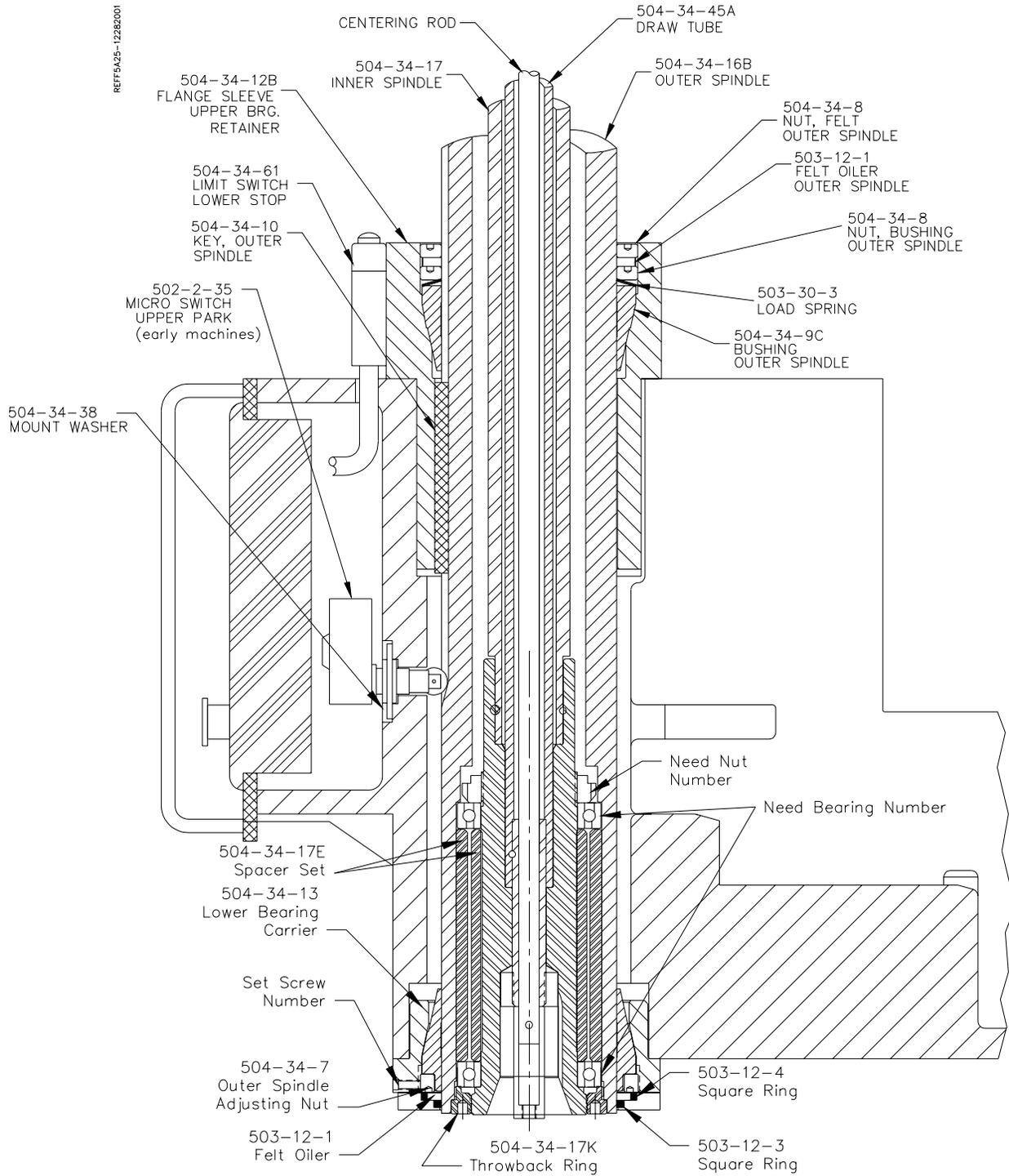
504-34-78A
FACE PLATE



Spindle Section Type 1:

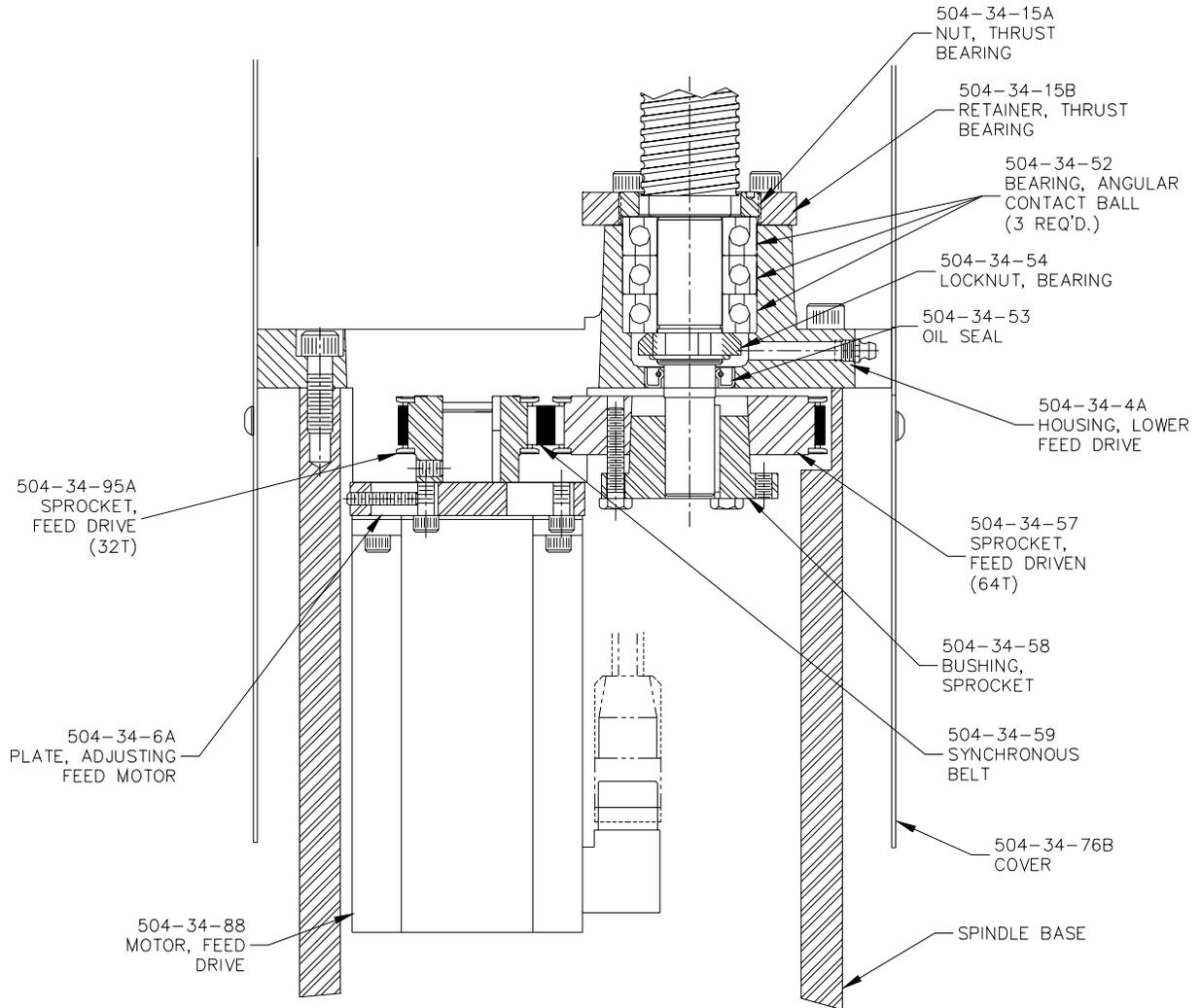


Spindle Base Type 2:

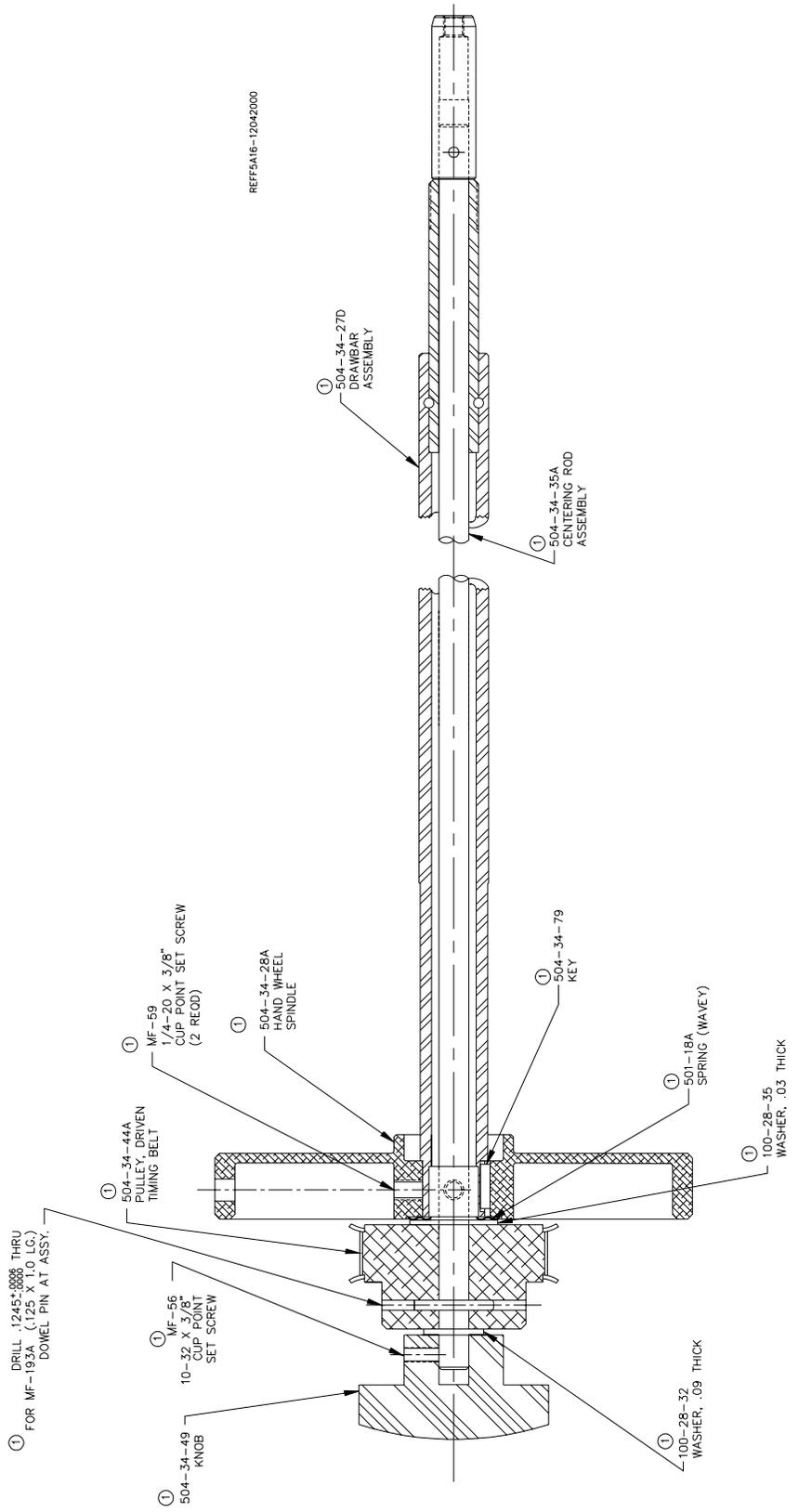


Vertical Drive Assembly:

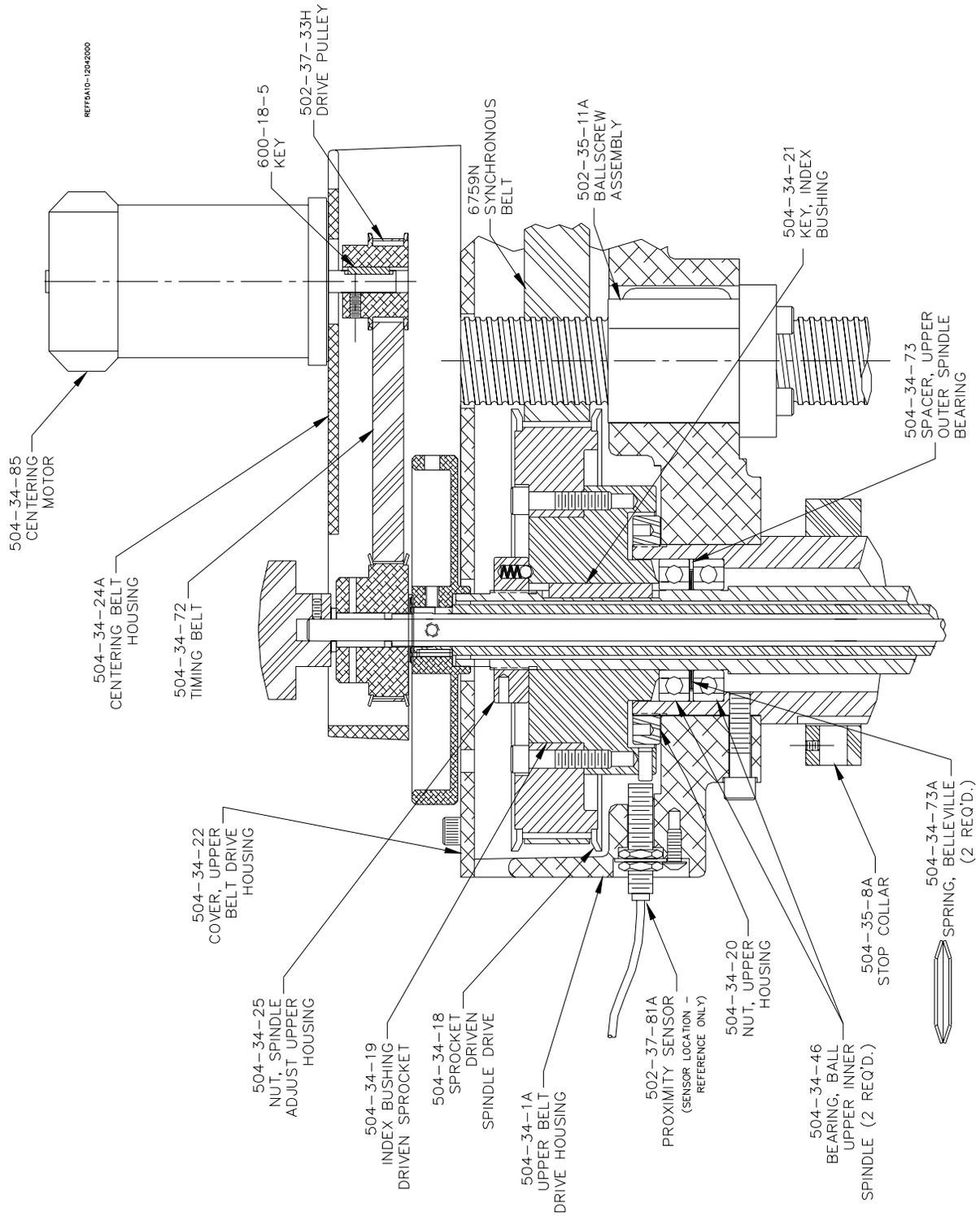
REF5A9-122820C



Drawtube Assembly: 504-24-45D

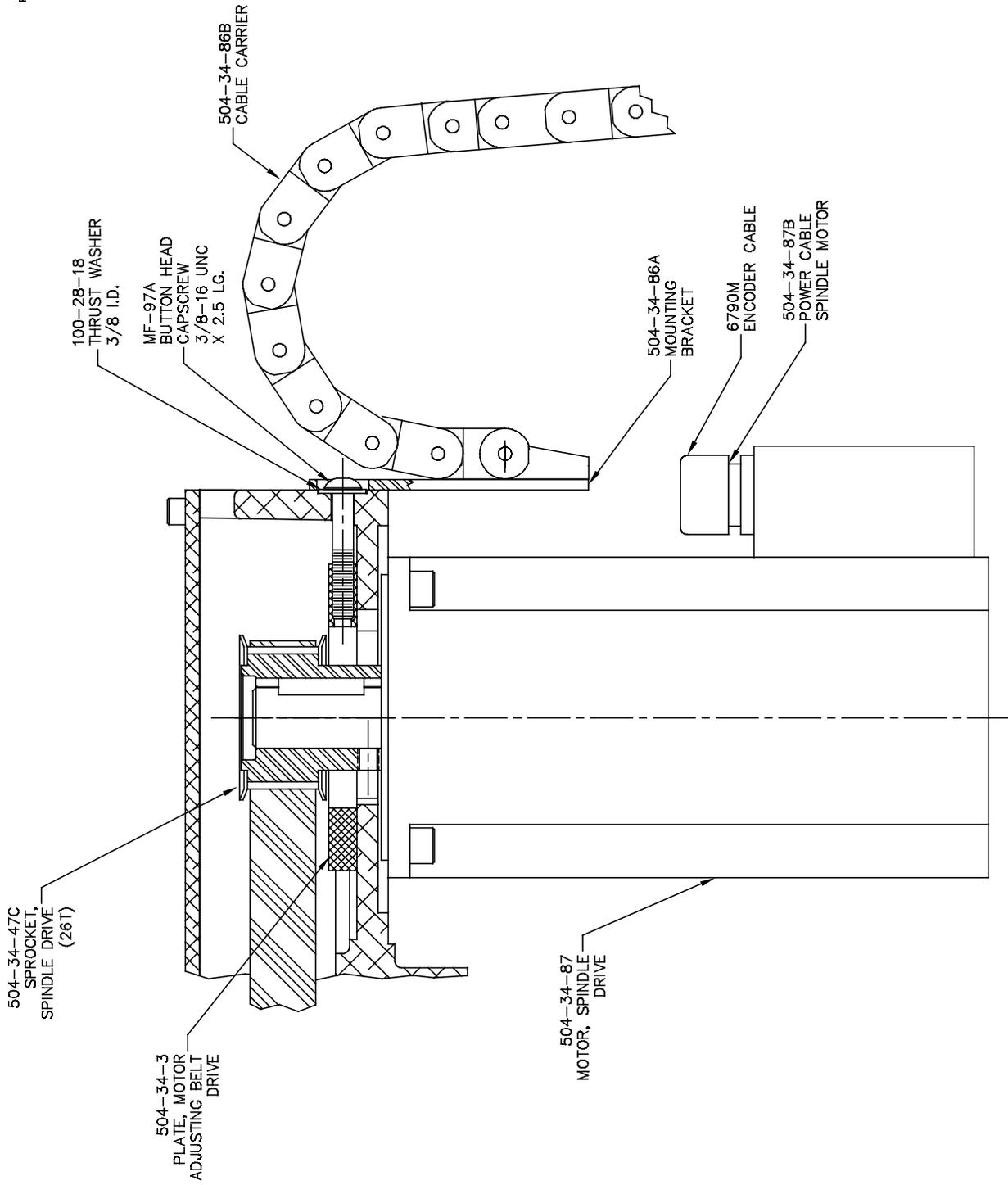


Upper Housing Driven Sprocket:

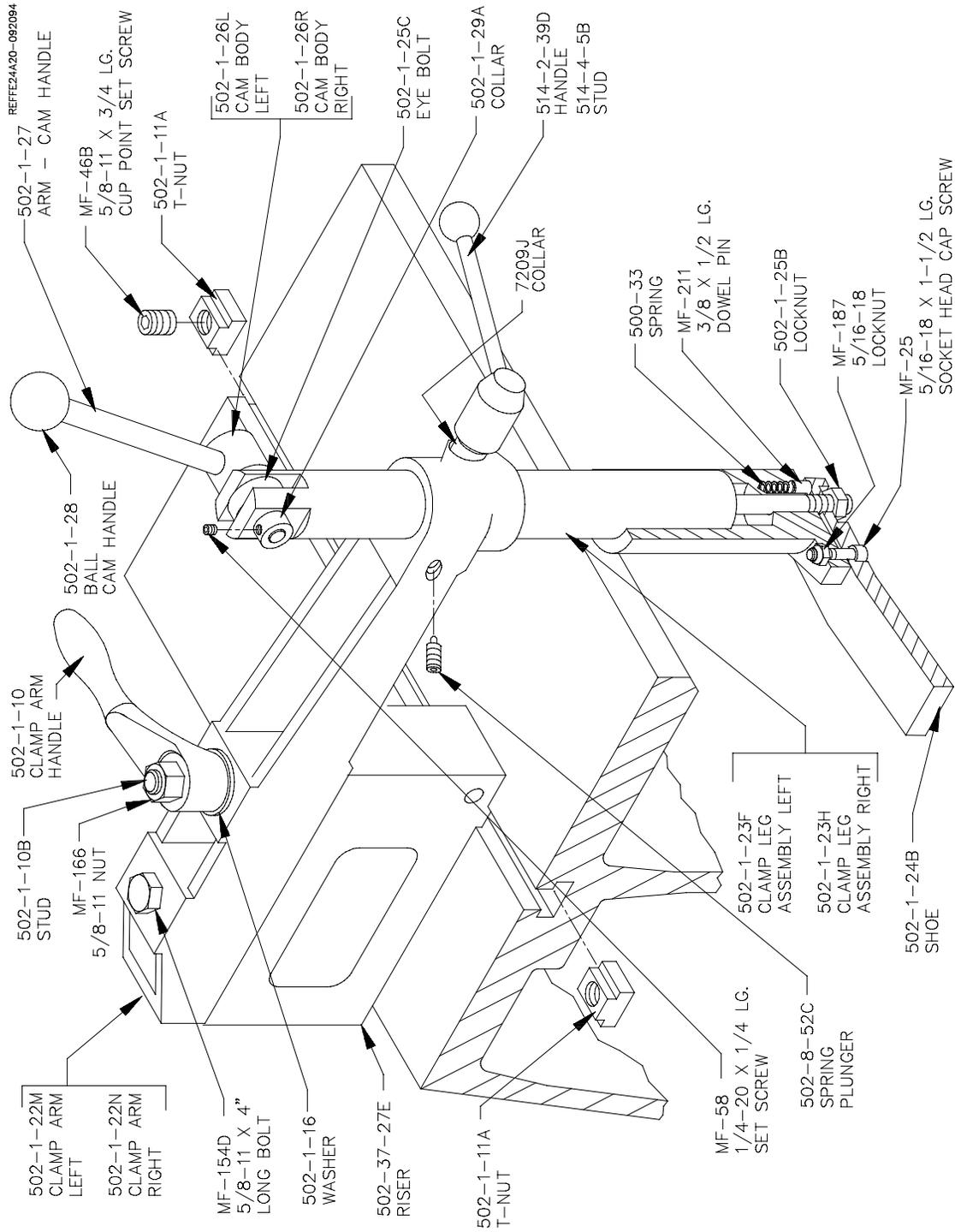


Upper Housing Drive Sprocket:

REFSMT1-020689

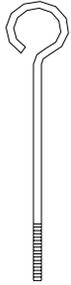


Clamp Arm Assembly:

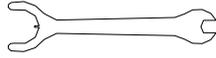


Tools:

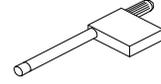
REF5M8-12202001



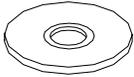
100-24
TOOL
PULLER



MICROMETER
WRENCH



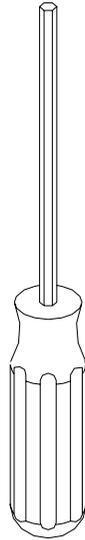
511-29-12D
TORX WRENCH



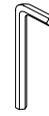
502-1-12
WASHERS
(4 REQUIRED)



502-1-12A
JACKING SCREW
(4 REQUIRED)



501-72
7/32"HEX
DRIVER



501-72H
1/4" ALLEN
WRENCH



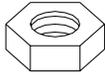
501-72C
7/64" ALLEN
WRENCH



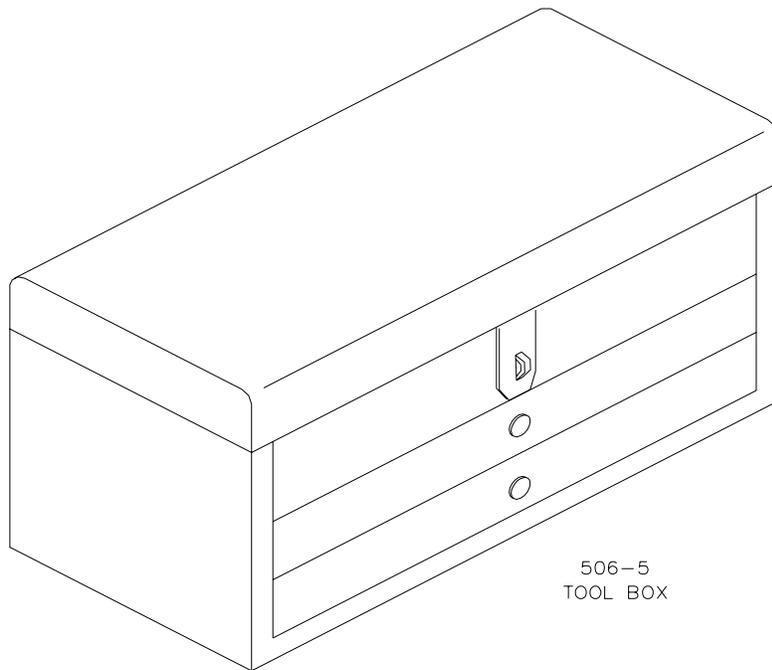
501-72B
3/32" ALLEN
WRENCH



501-72G
5/64" ALLEN
WRENCH



502-1-12F
JAM NUT
(4 REQUIRED)



506-5
TOOL BOX