



## HAAS SERVICE AND OPERATOR MANUAL ARCHIVE

### HRT Haas Rotary Table Operators Manual 96-5047 RevC English June 2001

- This content is for illustrative purposes.
- Historic machine Service Manuals are posted here to provide information for Haas machine owners.
- Publications are intended for use only with machines built at the time of original publication.
- As machine designs change the content of these publications can become obsolete.
- You should not do mechanical or electrical machine repairs or service procedures unless you are qualified and knowledgeable about the processes.
- Only authorized personnel with the proper training and certification should do many repair procedures.

**WARNING: Some mechanical and electrical service procedures can be extremely dangerous or life-threatening.  
Know your skill level and abilities.**

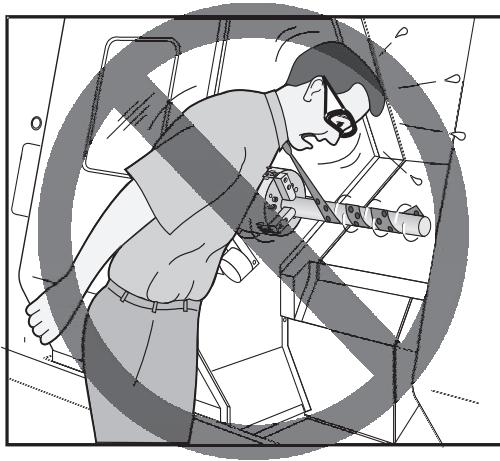
**All information herein is provided as a courtesy for Haas machine owners for reference and illustrative purposes only. Haas Automation cannot be held responsible for repairs you perform. Only those services and repairs that are provided by authorized Haas Factory Outlet distributors are guaranteed.**

**Only an authorized Haas Factory Outlet distributor should service or repair a Haas machine that is protected by the original factory warranty. Servicing by any other party automatically voids the factory warranty.**



# HAAS SAFETY PROCEDURES

# THINK SAFETY!



## DON'T GET CAUGHT UP IN YOUR WORK

All milling and turning machines contain hazards from rotating parts, belts and pulleys, high voltage electricity, noise, and compressed air. When using CNC machines and their components, basic safety precautions must always be followed to reduce the risk of personal injury and mechanical damage.

**Important – This machine is to be operated only by trained personnel in accordance with the Operator's Manual, safety decals, safety procedures and instructions for safe machine operation.**



## READ BEFORE OPERATING THIS MACHINE:

- ◆ Only authorized personnel should work on this machine. Untrained personnel present a hazard to themselves and the machine, and improper operation will void the warranty.
- ◆ Use appropriate eye and ear protection while operating the machine. ANSI approved impact safety goggles and OSHA approved ear protection are recommended to reduce the risks of sight damage and hearing loss.
- ◆ Do not operate the machine unless the doors are closed and the door interlocks are functioning properly. Rotating cutting tools can cause severe injury. When a program is running, the mill table and spindle head can move rapidly at any time in any direction.
- ◆ The Emergency Stop button is the large, circular red switch located on the Control Panel. Pressing the Emergency Stop button will instantly stop all motion of the machine, the servo motors, the tool changer, and the coolant pump. Use the Emergency Stop button only in emergencies to avoid crashing the machine.
- ◆ The electrical panel should be closed and the key and latches on the control cabinet should be secured at all times except during installation and service. At those times, only qualified electricians should have access to the panel. When the main circuit breaker is on, there is high voltage throughout the electrical panel (including the circuit boards and logic circuits) and some components operate at high temperatures. Therefore, extreme caution is required. Once the machine is installed, the control cabinet must be locked and the key available only to qualified service personnel.
- ◆ Consult your local safety codes and regulations before operating the machine. Contact your dealer anytime safety issues need to be addressed.
- ◆ DO NOT modify or alter this equipment in any way. If modifications are necessary, all such requests must be handled by Haas Automation, Inc. Any modification or alteration of any Haas Milling or Turning Center could lead to personal injury and/or mechanical damage and will void your warranty.
- ◆ It is the shop owner's responsibility to make sure that everyone who is involved in installing and operating the machine is thoroughly acquainted with the installation, operation, and safety instructions provided with the machine BEFORE they perform any actual work. The ultimate responsibility for safety rests with the shop owner and the individuals who work with the machine.
- ◆ **This machine can cause bodily injury.**
- ◆ **Do not operate with the door open.**
- ◆ **Do not operate without proper training.**
- ◆ **Always wear safety goggles.**
- ◆ **The machine is automatically controlled and may start at any time.**
- ◆ **The electrical power must meet the specifications in this manual. Attempting to run the machine from any other source can cause severe damage and will void the warranty.**
- ◆ **Do not press POWER UP/RESTART on the control panel until after the installation is complete.**
- ◆ **Do not attempt to operate the machine before all of the installation instructions have been completed.**
- ◆ **Never service the machine with the power connected.**
- ◆ **Improperly clamped parts machine at high feeds/feed may be ejected and puncture the safety door. Machining oversized or marginally clamped parts is not safe.**
- ◆ **Windows must be replaced if damaged or severely scratched - Replace damaged windows immediately.**
- ◆ **The spindle head can drop without notice. Personnel must avoid the area directly under the spindle head.**
- ◆ **Do not reset a circuit breaker until the reason for the fault is investigated. Only Haas-trained service personnel should troubleshoot and repair the equipment.**



♦ **Follow these guidelines while performing jobs on the machine:**

Normal operation - Keep the door closed and guards in place, while machine is operating.

Part loading and unloading – An operator opens the door or guard, completes task, closes door or guard before pressing cycle start (starting automatic motion).

Tool loading or unloading – A machinist enters the machining area to load or unload tools. Exit the area completely before automatic movement is commanded (for example, next tool, ATC/Turret FWD/REV).

Machining job set-up – Press emergency stop before adding or removing machine fixtures.

Maintenance / Machine Cleaner– Press emergency stop or power off the machine before entering enclosure.

**Do not enter the machining area anytime the machine is in motion; severe injury or death may result.**

### **Unattended Operation**

Fully enclosed Haas CNC machines are designed to operate unattended; however, your machining process may not be safe to operate unmonitored.

As it is the shop owner's responsibility to set up the machines safely and use best practice machining techniques, it is also their responsibility to manage the progress of these methods. The machining process must be monitored to prevent damage if a hazardous condition occurs.

For example, if there is the risk of fire due to the material machined, then an appropriate fire suppression system must be installed to reduce the risk of harm to personnel, equipment and the building. A suitable specialist must be contacted to install monitoring tools before machines are allowed to run unattended.

It is especially important to select monitoring equipment that can immediately perform an appropriate action without human intervention to prevent an accident, should a problem be detected.

## **MODIFICATIONS TO THE MACHINE**

**DO NOT** modify or alter this equipment in any way. If modifications are necessary, all such requests must be handled by Haas Automation, Inc. Any modification or alteration of any Haas machining center could lead to personal injury and/or mechanical damage and will void your warranty.



## SAFETY DECALS

To help ensure that CNC tool dangers are quickly communicated and understood, hazard symbol decals are placed on Haas Machines in locations where hazards exist. If decals become damaged or worn, or if additional decals are needed to emphasize a particular safety point, contact your dealer or the Haas factory.

**Never alter or remove any safety decal or symbol.**

Each hazard is defined and explained on the general safety decal, located at the front of the machine. Particular locations of hazards are marked with warning symbols. Review and understand the four parts of each safety warning, explained below, and familiarize yourself with the symbols on the following pages.

### NEVER OPERATE THIS MACHINE WITH THE DOORS OPEN





## MILL WARNING DECALS

### DANGER

Electrocution hazard. Death by electric shock can occur. Turn off and lock out system power before servicing.	Automatic Machine may start at any time. Injury or death could be caused by untrained operator. Read and understand operator's manual and safety signs before using this machine.
Risk of serious physical injury. Machine cannot protect from toxins. Coolant mist, fine particles, chips, and fumes can be dangerous. Follow specific material manufacturer's material safety data and warnings.	Risk of serious bodily injury. The enclosure may not stop every type of projectile. Double-check job set up before beginning any machining operations. Always follow safe machining practices. Do not operate with doors or windows open or guards removed.
Risk of fire and explosion. Machine is not designed to resist or contain blasts or fire. Do not machine explosive or flammable materials or coolants. Refer to specific material manufacturer's material safety data and warnings.	Risk of bodily injury. Serious cuts, abrasions, and physical injury may result from slips and falls. Avoid using the machine in wet, damp, or poorly lit areas.
Severe injury can occur. Moving parts can entangle, trap, and cut. Sharp tools or chips can cut skin easily. Ensure the machine is not in automatic operation before reaching inside.	Risk of eye and ear injury. Flying debris into unprotected eyes can cause loss of sight. Noise levels can exceed 70 dBA. Must wear safety glasses and hearing protection when operating or in the area of machine.

Safety windows may become brittle and lose effectiveness when exposed to machine coolants and oils over time. If signs of discoloration, crazing, or cracking are found, replace immediately. Safety windows should be replaced every two years.

### WARNING

Severe injury can occur. Moving parts can entangle and trap. Always secure loose clothing and long hair.	Risk of serious bodily injury. Follow safe clamping practices. Inadequately clamped parts can be thrown with deadly force. Securely clamp workpieces and fixtures.
Impact hazard. Machine components can crush and cut. Do not handle any part of the machine during automatic operation. Always keep clear of moving parts.	Moving parts can crush. The tool changer will move in and crush your hand. Never place your hand on the spindle and press ATC FWD, ATC REV, NEXT TOOL, or cause a tool change cycle.

- Do not allow untrained personnel to operate this machine.
- Do not alter or modify machine in any way.
- Do not operate this machine with worn or damaged components.
- No user serviceable parts inside. Machine must be repaired or serviced by authorized service technicians only.

©2009 Haas Automation, Inc.  
25-0769 Rev E

### NOTICE

 Coolant Tank Maintenance	Clean the filter screen weekly. Remove the coolant tank cover and clean out any sediment inside the tank weekly. Do not use plain water, permanent corrosion damage will result. Rust inhibiting coolant is required. Do not use toxic or flammable liquids as a coolant.
------------------------------	--



## LATHE WARNING DECALS

### DANGER



Electrocution hazard.  
Death by electric shock can occur.  
Turn off and lock out system power before servicing.



Automatic Machine may start at any time.  
Injury or death could be caused by untrained operator.  
Read and understand operator's manual and safety signs before using this machine.



Risk of serious physical injury. Machine cannot protect from toxins.  
Coolant mist, fine particles, chips, and fumes can be dangerous.  
Follow specific material manufacturer's material safety data and warnings.



Risk of serious bodily injury.  
The enclosure may not stop every type of projectile.  
Double-check job set up before beginning any machining operations.  
Always follow safe machining practices. Do not operate with doors or windows open or guards removed.



Risk of fire and explosion.  
Machine is not designed to resist or contain blasts or fire.  
Do not machine explosive or flammable materials or coolants.  
Refer to specific material manufacturer's material safety data and warnings.



Risk of bodily injury.  
Serious cuts, abrasions, and physical injury may result from slips and falls.  
Avoid using the machine in wet, damp, or poorly lit areas.



Severe injury can occur.  
Moving parts can entangle, trap, and cut. Sharp tools or chips can cut skin easily.  
Ensure the machine is not in automatic operation before reaching inside.



Risk of eye and ear injury.  
Flying debris into unprotected eyes can cause loss of sight.  
Noise levels can exceed 70 dBA.  
Must wear safety glasses and hearing protection when operating or in the area of machine.

Safety windows may become brittle and lose effectiveness when exposed to machine coolants and oils over time. If signs of discoloration, crazing, or cracking are found, replace immediately. Safety windows should be replaced every two years.

### WARNING



Severe injury can occur.  
Moving parts can entangle and trap.  
Always secure loose clothing and long hair.



Risk of serious bodily injury and impact hazard.  
Unsupported bar can whip with deadly results.



Risk of serious bodily injury.  
Inadequately clamped parts can be thrown with deadly force.  
High RPM reduces chuck clamping force.  
Do not machine using an unsafe setup or exceed rated chuck RPM.



Do not extend barstock past end of drawtube without adequate support.  
Do not apply excessive machining forces, doing so can dislodge the bar from support.  
Do not allow the carriage or tool to strike the steady rest or tailstock; the part may come loose.  
Do not over tighten steady rest.



Moving parts can cut.  
Sharp tools can cut skin easily.  
Do not handle any part of the machine during automatic operation.  
Do not touch rotating work pieces.



- Do not allow untrained personnel to operate this machine.
- Restrict access to open frame lathes.
- Use steady rest or tailstock to support long bars and always follow safe machining practices.
- Do not alter or modify machine in any way.
- Do not operate this machine with worn or damaged components.
- Machine must be repaired or serviced by authorized technicians only.

### NOTICE



Clean the filter screen weekly.

Remove the coolant tank cover and clean out any sediment inside the tank weekly.

Do not use plain water, permanent corrosion damage will result. Rust inhibiting coolant is required.

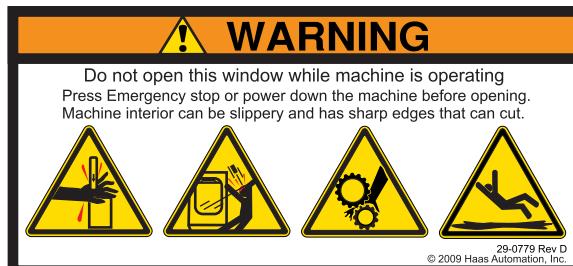
Do not use toxic or flammable liquids as a coolant.

29-0765 Rev F  
© 2009 Haas Automation, Inc.



## OTHER SAFETY DECALS

Other decals may be found on your machine, depending on the model and options installed:





## 1. INTRODUCTION

### 1.1 DESCRIPTION

The HAAS rotary table is a fully automatic, programmable, rotary positioning device. The unit is made up of two parts: the mechanical table that holds the workpiece and the electronic unit that controls the rotation of the table. Positioning of the workpiece is accomplished by programming the angular movements into the memory of the control and then pushing the CYCLE START button on the front panel.

The unit was specifically designed for rapid positioning of parts in secondary operations such as milling, drilling, and tapping. The device is especially suited to automatic machines such as NC mills and automatic production machines. The control can be remotely activated by your equipment and does not require human assistance, resulting in fully automatic operation. Furthermore, one unit can be used on several different machines, thereby eliminating the need for multiple units.

### TABLE

The rotary table can be used in almost all of the applications where a manual rotary table can be used. Positioning of the table is accomplished through a deep-tooth engaging, self-locking worm and worm gear set. The worm is connected to a DC servo motor through a timing belt and pulley set. Odd number bolt circles and uneven hole spacing are easily handled with simple programming. The table is equipped with a pneumatic brake (HRT 450 uses air over oil). A regular shop air line of approximately 100 PSI is all that is needed to activate the brake.

The HRT210SHS (Super-High Speed) Table is unique from the other rotary tables. It has no worm gear set, belt, or pulleys but uses a "Harmonic Drive" gear. It is directly driven by an AC servo motor and is 6 times faster than our standard HRT210.

### CONTROL

The rotary table servo control incorporates the latest in high-speed microprocessors and drive technology. The control was designed using extensive software to replace discrete components, thereby reducing possible failure areas. This same software also checks out the computer system upon power-up, and alerts you to component failures. Only one printed circuit board is used to control all major functions.

The optional RS-232 interface can be used to upload, download, enter data, read position, start, and stop motor operation.

**1.2 LIMITATIONS**

The control and table are described as a "semi-fourth axis". This means that the table cannot do simultaneous interpolation with other axes. Linear moves or spirals can be generated by having an axis of your mill move at the same time the rotary table moves (see the "Programming" section for details).

**1.3 MACHINABLE PART SIZE**

The HRT series was designed for positioning and continuous milling of medium to large size parts. When selecting a rotary table, the size of a typical workpiece and fixture must be considered and the size of the rotary table should be matched to the expected loads. As a general rule, the diameter of the part should not exceed the diameter of the rotary table platter. Also, the combined part and fixture weight should not exceed the weight of the rotary table. However, these are only guidelines. A part with a diameter larger than the platter diameter or a long overhung and unsupported part might require that the weight be less than the weight of the rotary table. Likewise, if the part is well supported (i.e. tailstock or pillow block), and the fixture and support have less than 0.003" T.I.R, then the weight might be able to be more than the rotary table weight. Common sense and good fixturing technique will generally make it possible to machine larger parts.

The HRT210SHS Table was designed for lighter size parts which may require numerous tool changes and indexes, so the speed is important to reduce the cycle time. It has no brake, so this will also be a limiting factor to the size of the part. Maximum part diameter is 8.00" and maximum part weight should not exceed 40 lbs.

**1.4 FEATURES****RIGID DESIGN**

Large bearing surfaces support heavy cutting forces on large or small parts.

**CLASS 30 GREY IRON**

For added damping capacity

**QUICK REPLACEMENT CONDUIT**

For faster replacement and shorter downtime.

**PRE-LOADED ANGULAR CONTACT BEARINGS**

For better reliability and less wear.

**HARDENED AND PRECISION ROTARY GROUND PLATTER**

Ensures more accurate part machining.

**CNC HOBBED WORM GEAR\***

For high accuracy.

**DEEP TOOTH ENGAGEMENT**

For gear set; designed to provide greater accuracy and continuous milling capacity.

**ALUMINUM BRONZE WORM GEAR\***

For long life.

**HARDENED AND GROUND WORM GEAR\***

Made from 8620 chromium-nickel-molybdenum steel, hardened to Rc 60.

**AIR BRAKE\***

Built-in air brake with 100 to 1500 ft.-lb. of holding torque @ 100 PSI. (Except HRT210SHS)

**AC SERVO DRIVE\***

Closed loop 1.0HP (HRT 160, HRT 210), 3.0 HP (HRT 310, HRT 450, HRT 600), .75 HP (HA5C)

**DC SERVO DRIVE\***

Closed loop 0.5 (HRT160, HA5C), or 1.5 (HRT210, HRT310, HRT450, HRT600) HP.

**VARIABLE FEED RATES\***

Variable from .001 deg./sec. to 80 deg./sec (80 deg./sec. for HRT 160, 60 deg./sec. for HRT210, 50 deg./sec. for HRT310, 50 deg./sec. for HRT 450, 40 deg./ sec for HRT 600).

**RESOLUTION**

Standard motor resolution of .001 degrees (.001°).

**PROGRAMMING**

Absolute or incremental programming. Up to 99 different steps can be stored in memory, and each step can be looped 999 more times. The ease and flexibility of programming the Haas control enables a single unit to serve you in many ways.

**SIMPLE EDITING**

Edit a program by simply writing over existing steps, or inserting or deleting a line (or several lines) between steps, with automatic program line re-numbering.

**SUBROUTINES**

Allows sequences to be repeated up to 999 times, saving programming time and memory space.

**AUTOMATIC CIRCLE DIVISION**

Program a step that automatically divides a circle into any number of equal parts (between 2 and 999).

**PROGRAMMABLE PARAMETERS**

Alter many of the basic features by performing your own basic programming.

**PROGRAM STORAGE**

Store and recall from up to seven different programs.

**MEMORY**

A non-volatile memory retains a program even when power is turned off. It also remembers the current spindle position and step number.

**INTERFACING**

Most CNC mills can be interfaced with the HRT Series quickly and easily by using a spare **M** function that provides a switch-closer as a signal between your mill and the RT.

**EMERGENCY STOP/FEED-HOLD**

EMERGENCY STOP can be used to feed-hold spindle movement without losing position on restart.

**ZERO RETURN**

A programmable HOME position returns the spindle to its original starting position from any point.

**LINEAR & SPIRAL MILLING**

For semi fourth-axis capability.

**FAST SET-UPS**

All connectors are "quick-disconnect", ensuring fast and easy set-ups.

**STANDARD POWER**

Operates on 115VAC ±5% @ 15 Amps.

**OPTIONAL RS-232 INTERFACE**

For computer control of sending and receiving programs.

**12-MONTH WARRANTY**

Against any defects in materials or workmanship.

**SYNTHETIC GEAR OIL**

Provides greater worm gear wear protection than conventional gear oils.

\*Except HRT210SHS; see below:

**FEATURES EXCLUSIVE TO THE HRT210SHS**

Harmonic Drive gear set.

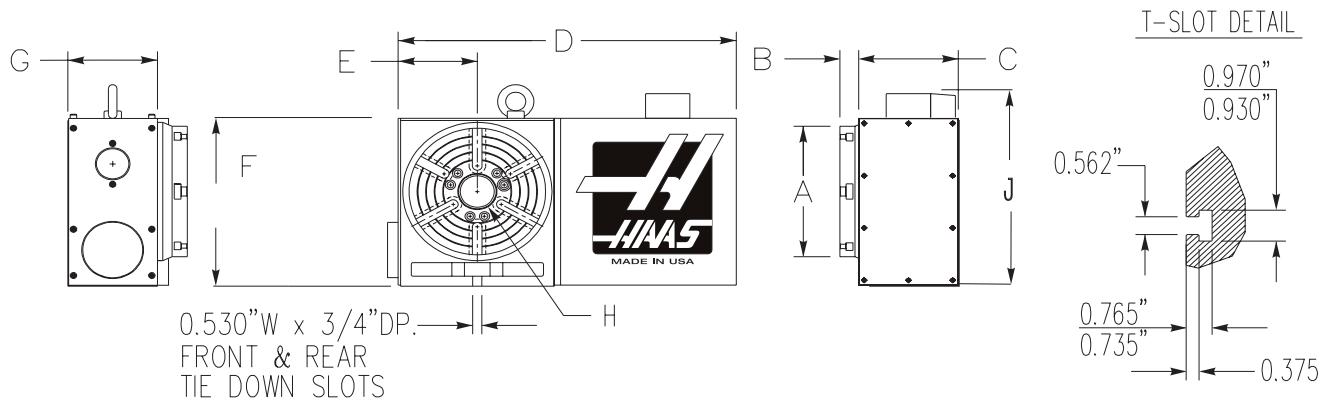
3 HP A.C. Servo Motor

Variable feed rates from .001 deg./sec. to 270 deg./sec. with rapids to 360 deg./sec.



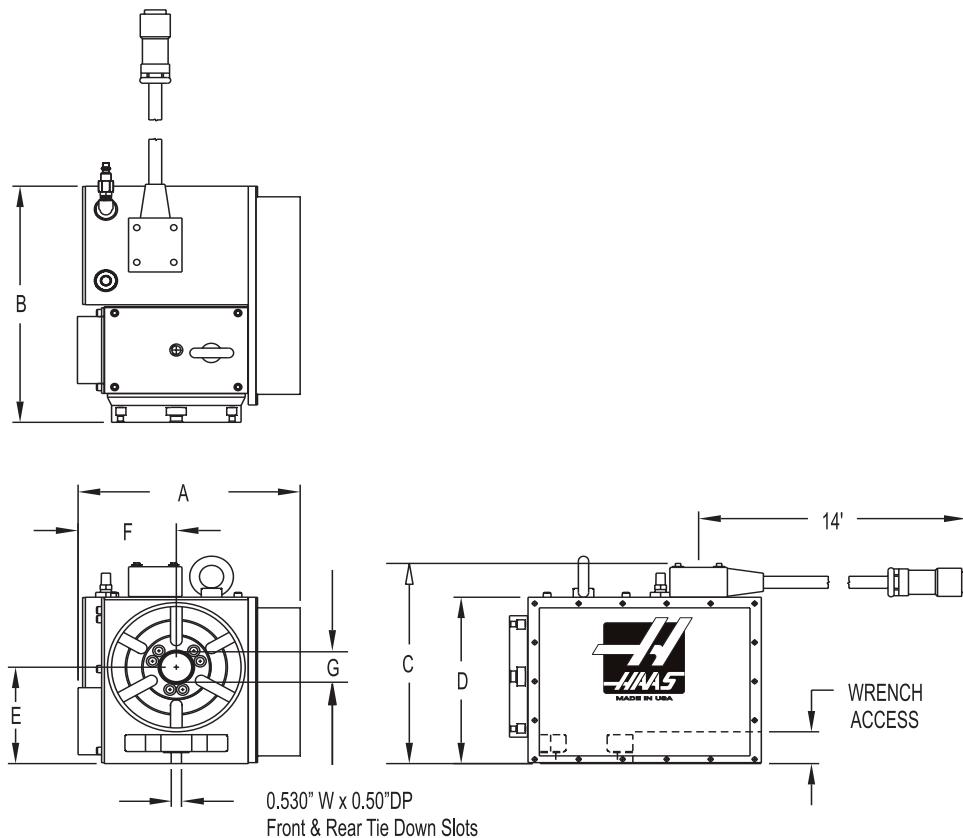
### 1.5 SPECIFICATIONS

MODEL:	HRT 160(SP)	HRT 210(SP)	HRT 310(SP)	HRT 450	HRT 600
<b>SPINDLE</b>					
Table Torque (ft./lbs) DC / AC	100 / 150	210 / 210	200 / 300	325 / 400	380 / 450
Feed Rates (deg./sec.)	.001 to 80	.001 to 60 .001 to 130 <sup>1</sup> .001 to 360 <sup>2</sup>	.001 to 50	.001 to 50	.001 to 40
Spindle Runout (inches)	.0005	.0005	.001	.0015	.0015
Platter Face Runout (in)	.0005	.0005	.0005	.0005	.0005
Backlash (arc/sec.)	30	30 45 <sup>1</sup>	30	30	30
Center Height (inches)	5.000 +/- .001	6.000 +/- .001	9.000 +/- .001	11.500 +/- .001	14.500 +/- .001
Brake Holding Torque @100 PSI (ft./lbs.)	100	200 N/A <sup>2</sup>	500	1500	1500
<b>INDEXING</b>					
Indexing Accuracy (arc/sec.)	+/- 15	+/- 15 +/- 30 <sup>2</sup>	+/- 15	+/- 15	+/- 15
Repeatability (arcsec.)	within 10	within 10	within 10	within 10	within 10
Resolution (deg.)	.001	.001	.001	.001	.001
Max. Resolution (deg.)	999.999	999.999	999.999	999.999	999.999
Worm Gear Dia (in")	4.7	6.3	9.4	13.5	13.5
<b>MOTOR</b>					
DC Servo (Brush) AC Servo (Brushless)	0.5 HP 1.0 HP	1.5 HP 1.0 HP <sup>1</sup> / 3.0 HP <sup>2</sup>	1.5 HP 3.0 HP	1.5 HP 3.0 HP	1.5 HP 3.0 HP
Drive Ratio (Timing Belt and Pulley Set)	2:1	2:1 1:1 <sup>1</sup> / N/A <sup>2</sup>	2:1	3:1	3.5:1
Worm Gear Ratio	63:1	90:1 N/A <sup>2</sup>	72:1	72:1	72:1
Total Gear Reduction	126:1	180:1 90:1 <sup>1</sup> 50:1 <sup>2</sup>	144:1	216:1	252:1
<b>OPERATING SPECIFICATIONS</b>					
Max. Air Pressure	120 PSI				
Power Requirements	115V AC +/- 5% @ 15 Amps				
Lubrication	Mobil SHC-630 synthetic gear oil Mobil SHC-626 synthetic gear oil <sup>2</sup>				
<b>OPERATING ENVIRONMENT</b>					
Maximum Temperature	100 Degrees F				
<sup>1</sup> HRT210HS					
<sup>2</sup> HRT210SHS					

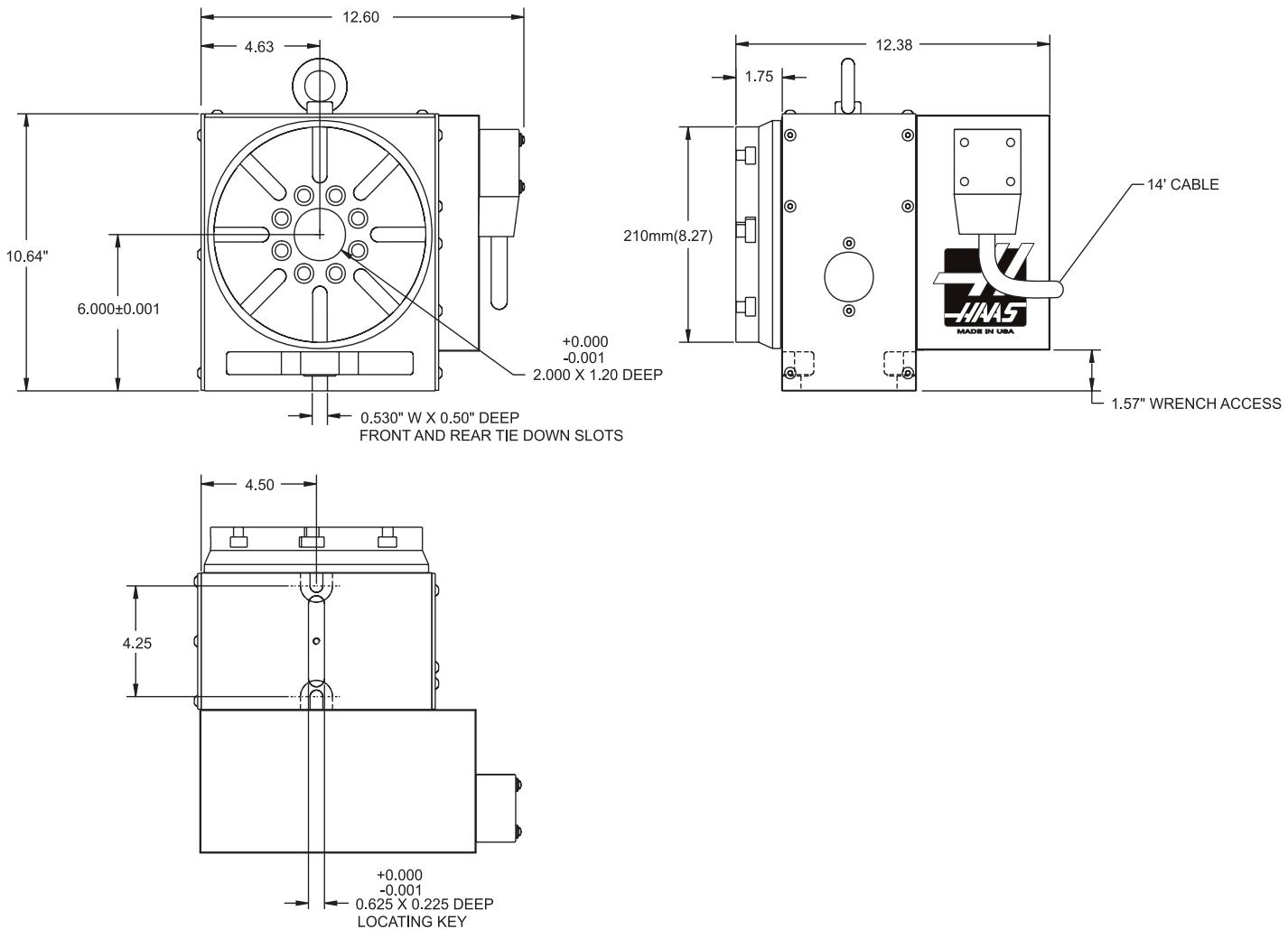
**1.6 MACHINE DIMENSIONS****MODEL****DIMENSIONS**

\*Values are for brush and brushless models, unless noted

	A	B	C	D	E	F	G	H	J
<b>HRT160 8.64</b>	160 mm (6.30")	1.50	5.50	16.20	3.63	5.000 $\pm 0.001$	4.50	$\varnothing 1.50^{+0.0005}$	11"max.
<b>HRT210 10.64</b>	210 mm (8.27")	1.75	5.84	20.00	4.63	6.000 $\pm 0.001$	5.25	$\varnothing 2.00^{+0.0005}$	13"max.
<b>HRT 210B (Brushless)</b>									
10.64	210 mm (8.27")	1.75	5.84	17.80	4.63	6.000 $\pm 0.001$	5.25	$\varnothing 2.00^{+0.0005}$	13"max.
<b>HRT310</b>	310 mm (12.20")	2.00	7.82	24.30	6.88	9.000 $\pm 0.001$	7.875	$\varnothing 3.25^{+0.0005}$	18.25"max.
<b>HRT 310B (Brushless)</b>									
15.9	310 mm (12.20")	2.00	7.82	22.80	6.88	9.000 $\pm 0.001$	7.875	$\varnothing 3.25^{+0.0005}$	18.25"max.
<b>HRT450 20.62</b>	450 mm (17.72")	2.25	9.00	28.55	9.26	11.500 $\pm 0.001$	9.00	$\varnothing 7.50^{+0.001}$	22.98"max.
<b>HRT600 26.62"</b>	600 mm (23.62')	2.50	9.00	34.82	12.13	14.500" $\pm 0.001$	9.00	$\varnothing 7.50^{+0.001}$	25.55"

**HRT SP DIMENSIONS****MODEL****DIMENSIONS**

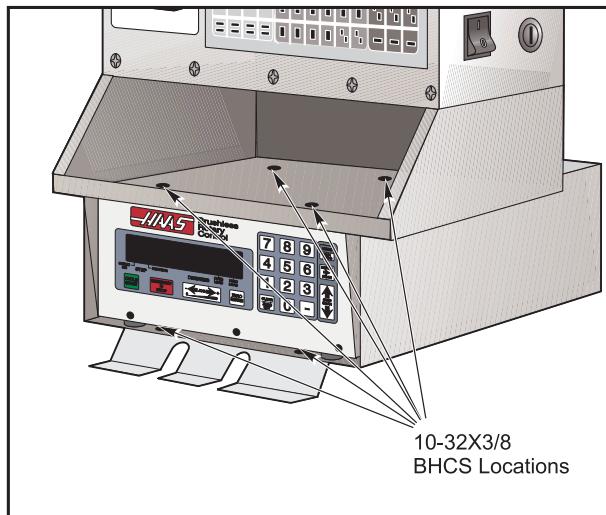
	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>
<b>HRT 160SP</b>	10.80"	12.25"	10.39"	8.63"	5.000" $\pm$ 0.001"	4.78"	1.500Ø x 6.00 Depth
<b>HRT 210SP</b>	12.28"	13.77"	12.39"	10.64"	6.000" $\pm$ 0.001"	5.26"	2.000Ø x 7.000 Depth
<b>HRT 310SP</b>	16.26"	17.80"	17.60"	15.90"	9.000" $\pm$ 0.001"	6.88"	3.250Ø x 9.875 Depth

**HRT210SHS MACHINE DIMENSIONS****MODEL****DIMENSIONS**

A	B	C	D	E	F	G	H	I	J
HRT210SHS-HD 1.75" 8.27"		10.63"	12.60"	4.63"	10.64"	10.63"	2.00" +0.000" -0.001"	4.25"	12.60"

**1.7 OPTIONAL SERVO CONTROL BRACKET**

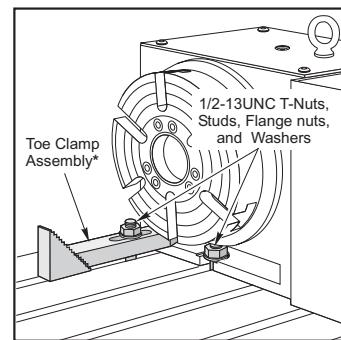
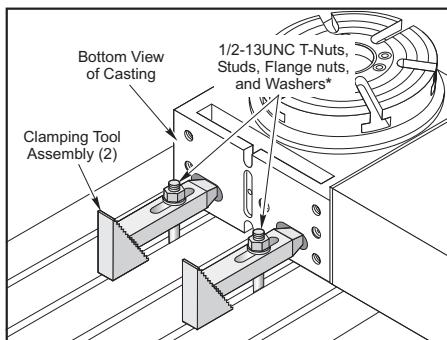
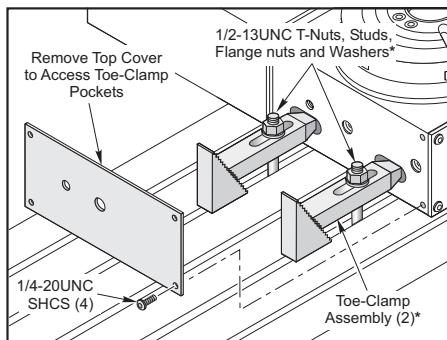
Designed to work specifically with the Haas line of CNC mills. This bracket keeps the Servo Control in easy reach of the operator, allowing for easy programming between the Haas mill and Rotary table. Contact your Haas dealer to order. (Haas part number: SCPB)

*Installed Servo Control Bracket*

**2. SETTING UP THE HAAS ROTARY TABLE****2.1 GENERAL SETUP**

1. Fill out the warranty card and mail it in. (Very Important).
2. Place the indexer on your machine. Route the cable from the table such that it avoids tool changers and table edges. Slack must be provided for your machine's movements. If the cable is cut, the motor will fail prematurely. Secure the HRT Rotary Table to your machine's T-Slot table as shown below.

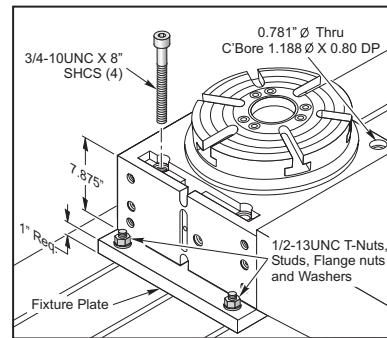
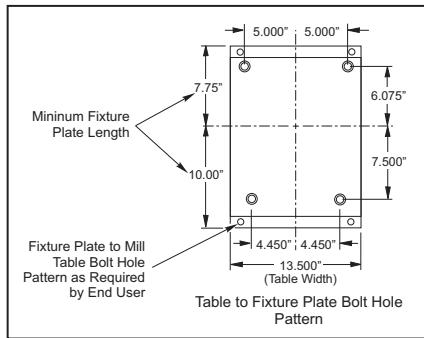
NOTE: The HRT 160, 210, 450, and 600 Rotary Tables can be secured as shown:



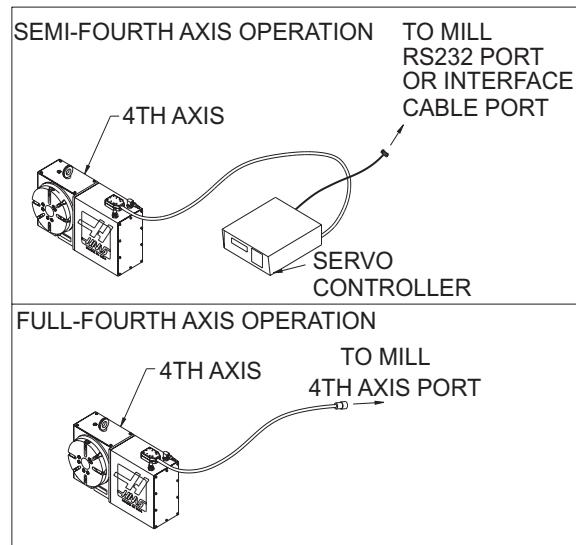
\*NOTE: Toe-Clamp Fasteners are not supplied.

\*Standard stud mounting, front and rear. For extra rigidity, use additional Toe-Clamps.

NOTE: The HRT 310 can be secured as shown:

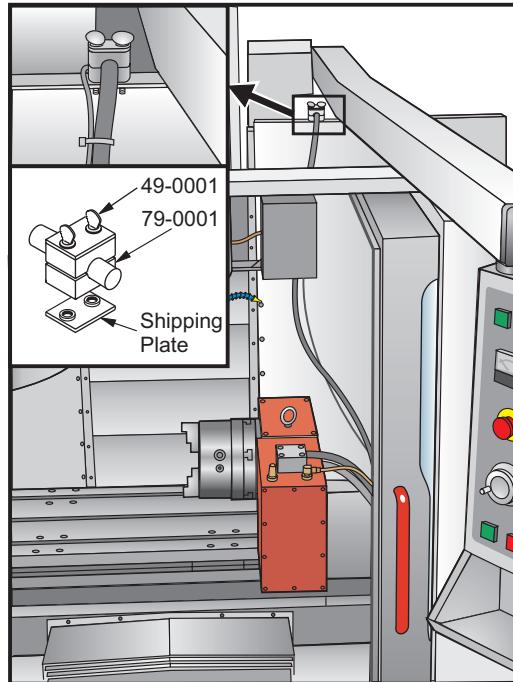


3. Connect the indexer to run as a full-fourth or semi-fourth axis. See the following figure. For full-fourth axis, the indexer is connected directly to the HAAS mill control at the connector labeled "A-Axis", and is the desired connection.



**Note:** Your HAAS mill must have the 4th axis option to run full-fourth and must be configured as brush or brushless to be compatible with your indexer. Brush configuration uses one cable and one connection at the A-axis port on the control. Brushless uses two cables and two connectors at the A-axis port.

4. Route the cable over the back of the mill sheetmetal and install the cable clamp. The bottom plate of the clamp assembly must be removed and discarded before installing the clamp to the mill. Assemble the clamp to the mill as shown.





5. If adding an indexer to a Haas mill the settings must be set for the specific table. Refer to the instructions in the mill manual or call the Haas service department.
6. **Semi-Fourth Axis:** Secure the servo control in servo pendant bracket (Haas part number SCPB) as seen at the end of the introduction section.
7. Connect the large black cable from the table to the controller.

---

**CAUTION:** Never connect or disconnect this cable with the power on! Instant failure will result!

---

8. **Semi-Fourth Axis:** Connect the AC line cord to a 120V AC grounded receptacle. The cord is a three-wire ground type, and the ground must be connected. Power is 120VAC. The power service must supply a minimum of 15 amps continuously. Conduit wire must be 12 gauge or larger and fused for at least 20 amps. If an extension cord is to be used, use a three-wire ground type and the ground line must be connected. Avoid outlets that have large electric motors connected to them. Use only heavy duty 12 gauge extension cords capable of 20 amp load. Do not exceed a length of 30 feet.
9. **Semi-Fourth Axis:** Connect the remote interface lines. See "Interfacing to Other equipment" section.
10. Connect the table to a standard shop air line (120 PSI Max). The line pressure to the brake is not regulated. Do not exceed the maximum pressure.

---

**NOTE:** HAAS recommends the use of an in-line air filter/regulator for all tables. The air filter will keep contaminates from entering the air solenoid valve.

11. Check the oil level. If it is low, add oil. Use MOBIL SHC-630 synthetic gear oil (Viscosity Grade ISO 220). For the HRT210SHS use Mobil SHC-626 synthetic gear oil (Viscosity Grade ISO 68).
12. Save the packing materials in case you need to ship the unit.
13. At the end of the workday or shift, it is important to clean the rotary table. The table should be free of any chips or grime. Clean with a chip brush and apply a coat of a rust preventative.

---

**CAUTION!** Do not use air gun around front or rear seals. Chips may damage seal if blown in with an airgun.

---

14. Turn on the mill (and servo control, if applicable) and home the table. All Haas indexers home in the clockwise direction as viewed from the platter. If the table homes counter-clockwise, press E-stop and call the Haas service department.




---

**2.2 INTERFACING TO OTHER EQUIPMENT**


---

### Semi-Fourth Axis Operation

**Interfacing** is an unfriendly word that inspires fear in most non-electrical people. In reality, you are interfacing objects all the time. Hooking up a stereo, computer, or VCR requires many connections, or interfaces. Plugging a lamp into the wall and turning the switch on is really interfacing a 100 watt incandescent lamp up to a 15 Megawatt generating plant. While there are hundreds of connections between your lamp and the power company, it is really a simple process. The HAAS control is just as simple.

The control can be installed to communicate with your mill two different ways: RS-232 Interface or CNC Interface Cable. These connections are detailed in the following sections.

The HAAS control has two signals: one input and one output. Your equipment tells the HAAS control to index (an input), it indexes, and then sends a signal back to your equipment that the index (an output) has been completed. These signals are simply switch closures, or in mechanical terms, relays. A switch (relay) is closed inside your machine that tells us to index, we index and then close a switch (relay) inside our control to tell your machine that we are done. This interface requires four wires; two for each signal. They are from the remote input on the back of the HAAS control and from your equipment or CNC (Computer Numerically Controlled) machine.

### The Relay In The HAAS Control

The relay inside the control has a maximum rating of 2 amps at 30 volts D.C./ 120V AC. It is programmed as either a normally closed or a normally open relay, closed during cycle or after cycle (see "Parameters" section). It is intended to drive other logic or small relays. It will not drive other motors, magnetic starters, or loads exceeding 100 watts. If you use the feedback relay to drive another D.C. relay (or any inductive load), remember to install a snubber diode across your relay's coil in the opposite direction of coil current flow. Failure to use this diode or other arc suppression circuitry on inductive loads, no matter how small they may be, will result in the contacts of the relay arcing together in a very short time.

To test the relay, use an ohmmeter to measure the resistance across pins 1 and 2. With the control off, the reading should be infinite. If a lower resistance is measured, the contact points have failed and the relay must be replaced. Radio Shack sells a relay that can be used as a replacement (Cat. #275-241). This part should only be replaced by a qualified technician.

---

**2.3 THE RS-232 INTERFACE**


---

There are two connectors used for the RS-232 interface. They are both DB-25 connectors, one male and one female. Multiple controllers are connected by daisy-chaining the boxes. The cable from the computer connects to the female connector. Another cable can connect the first box to the second by connecting the male connector of the first box to the female connector of the second. This can be repeated for up to nine controllers.

Since the RS-232 connector on the back of most PC's is a male DB-25, only one type of cable is required for connection to the controller, or between controllers. This cable must be a DB-25 male on one end and a DB-25 female on the other. Pins 1, 2, 3, 4, 5, 6, 7, 8, and 20 must be wired one-to-one. It cannot be a Null Modem cable, which inverts pins 2 and 3. To check cable type, use a cable tester to check that communication lines are correct. The controller is DCE (Data Communication Equipment). This means that it transmits on the RXD line (pin 3) and receives on the TXD line (pin 2). The RS-232 connector on most PC's is wired for DTE (Data Terminal Equipment), so no special jumpers should be required.



The Down Line DB-25 connector is only used when more than one controller is to be used. The first controller's down line connector goes to the second controller's up line connector, etc.

The RS-232 interface sends and receives **seven data bits, even parity, and two stop bits**. The data rate can be between 110 and 19200 bits per second. When using RS-232, it is important to make sure that Parameters 26 (RS-232 Speed) and 33 (X-on/X-off Enable) are set to the same value in the controller and PC.

If Parameter 33 is set to **on**, the controller uses X-on and X-off codes to control reception, so be sure your computer is able to process these. It also drops CTS (pin 5) at the same time it sends X-off and restores CTS when it sends X-on. The RTS line (pin 4) can be used to start/stop transmission by the controller or the X-on/X-off codes can be used. The DSR line (pin 6) is activated at power-on of the controller and the DTR line (pin 20 from the PC) is not used. If Parameter 33 is 0, the CTS line can still be used to synchronize output.

When more than one HAAS controller is daisy-chained, data sent from the PC goes to all of the controllers at the same time. That is why an axis selection code (Parameter 21) is required. Data sent back to the PC from the controllers is OR'ed together so that, if more than one box is transmitting, the data will be garbled. Because of this, the axis selection code must be unique for each controller.

The serial interface may be used in either a remote command mode or as just an Upload/Download path.

## RS-232 Remote Command Mode

Parameter 21 must be non-zero for the remote command mode to operate, as the controller looks for an axis select code defined by this parameter. The controller must also be in RUN mode to respond to the interface. Since the controller powers-on in RUN mode, unattended remote operation is possible.

Commands are sent to the controller in ASCII code and terminated by a carriage return (CR). All commands, except for the B command, must be preceded by the axis select code (U,V,W,X,Y,Z). The B command does not require the select code, as it is used to activate all axes simultaneously. The ASCII codes used to command the controller are shown below.

## RS-232 Commands

The following are the RS-232 commands, where **X** is the selected axis:

- xSnn.nn**      Specify step size or absolute position.
- xFnn.nn**      Specify feed rate in units/second.
- xGnn**          Specify G code.
- xLnnn**          Specify loop count.
- xP**              Specify servo status or position.  
(This command causes the addressed controller to respond with the servo position if normal operation is possible or otherwise with the servo status.)
- xB**              Begin programmed step on X-axis.



- B** Begin programmed step on all axes at once.
- xH** Return to HOME position or use home offset.
- xC** Clear servo position to zero and establish zero.
- xO** Turn servo on.
- xE** Turn servo off.

## RS-232 Responses

The xP command is presently the only command that responds with data. It will return a single line consisting of:

- xnnn.nnn** (servo at standstill at position **nnn.nnn**) OR
- xnnn.nnnR** (servo in motion past position **nnn.nnn**) OR
- xOn** (servo is off with reason **n**) OR
- xLn** (servo HOME position lost with reason **n**)

### 2.4 THE REMOTE INPUT

The CNC Interface Cable provides a basic method of communication between a non-Haas mill and Haas Servo Control/Rotary Head. Since most CNC machine tools are equipped with spare M-codes, Semi-fourth axis machining can be achieved by connecting one end of the CNC Interface Cable to any one of these spare relays (switches), and the other to a Haas Servo Control unit. Indexing commands for the rotary unit are stored only in the Servo Control's memory, and each pulse of the host machine's relay triggers the control to index to its next programmed position. After finishing the index, the Servo Control signals that it has finished and is ready for the next pulse.

A remote socket is provided on the back panel of the control unit. The remote input consists of a **cycle start** line and a **cycle finish** line. To connect to the remote, you will need a connector supplied by HAAS (or one obtained from a local source) that can be used to trigger the controller from any one of several sources. The cable connector used is a male four-pin DIN connector. The Amphenol part number is 703-91-T-3300-1. The part number of the panel receptacle in the control box is 703-91-T-3303-9.



## Cycle Start

Figure 2 shows the connector as viewed from the rear panel of the control unit. When pins 3 and 4 are connected to each other for a minimum of 0.1 seconds, the control will index the head one cycle or step. To index again, pins 3 and 4 must be opened for a minimum of 0.1 seconds. Under no circumstances should power be applied to pins 3 and 4. A relay closure is the safest way to interface the control to your equipment.

When a cycle start is implemented, pin 3 supplies a positive 12 volts at 20 millamps and pin 4 is connected to the diode of an opto-isolator that grounds to chassis. Connecting pin 3 to pin 4 causes a current to flow through the diode of the opto-isolator, triggering the control.

If the control is used around high frequency equipment such as electric welders or induction heaters, you will need to use shielded wire to prevent false triggering by radiated EMI (electromagnetic interference). The shield should be attached to earth ground.

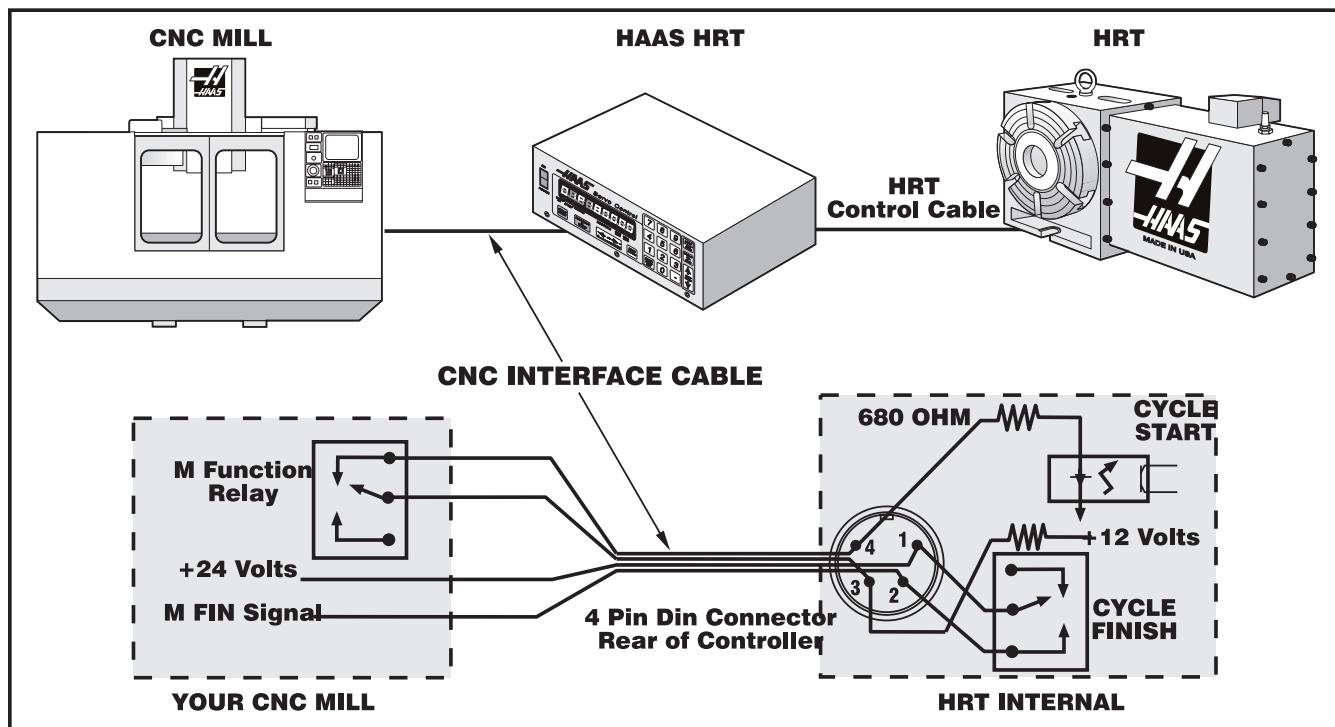
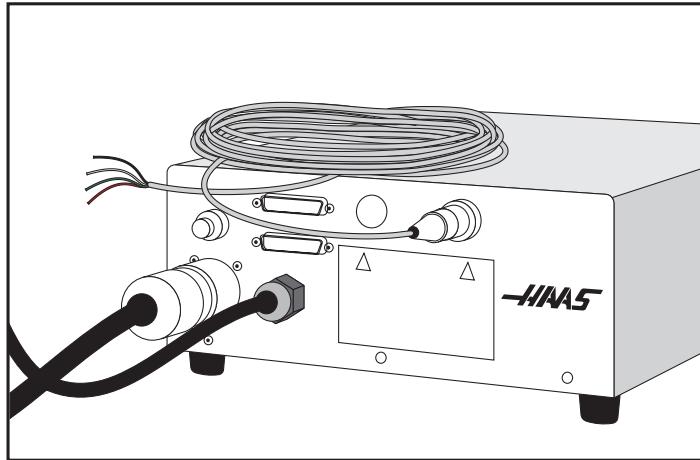


Figure 2. A Typical CNC Interface.

## Cycle Finish

If your application is in an automatic machine, such as a CNC mill, the feedback lines (pins 1 and 2) should be utilized. Pins 1 and 2 are connected to the contacts of a relay inside the control and have no polarity or power on them. They are used to synchronize the automatic equipment with the controller.

The feedback lines provide a switch closure through a relay inside the Haas control box to let your machine know when the table has finished indexing. The relay can be used to "Feed Hold" NC machine movements or it can be used to cancel the **M** function. If your machine is not equipped with such an option, another alternative may be to dwell for a period of time longer than it takes the control to index the head. The relay will trigger for all cycle start closures except a no-operation code of 97.



## 2.5 REMOTE OPERATION WITH MANUAL EQUIPMENT

The remote connection is used when you wish to index the unit other than by the START switch on the front panel. This frees the operator from having to touch the control to start indexing. For example, using our optional **remote quill switch** (Haas P/N RQS) for Bridgeport milling machines, every time the quill handle is retracted it touches a micro switch on the clamp and the indexing head will rotate automatically. This eliminates the need to remove your hand from the quill, increasing production dramatically. Using a magnetic base, an aluminum bracket, and a micro-switch you can get the unit to index almost anywhere you wish. Use the switch to index the unit when you are milling. Every time the table comes back to a certain position, a simple bolt on the table can close the switch, indexing the unit.

Refer to Figure 2. By simply connecting pins 3 and 4 together, the control will index. Be careful that you do not apply power to these lines (3 and 4 only). You do not need to hook up the feedback pins 1 and 2 unless you want the control to start another mechanism such as an automatic drilling head. The feedback pins (1 and 2) do not need to be connected for the control to operate.

Color-coded remote interface cables are available, as an option, to help the users understand the M-function hookup. They are coded as follows:

1 = red	3 = black
2 = green	4 = white

## 2.6 REMOTE OPERATION WITH CNC EQUIPMENT

**NOTE:** All Haas controls come standard with 1 CNC interface cable. Additional CNC interface cables can be ordered (Haas P/N CNC).

CNC machines have Miscellaneous functions called **M** functions. These control external switches (relays) that turn things on or off (i.e., spindle, coolant, etc.). Most CNC controls provide some degree of access to the **M** functions, with most late model machines providing several spare relays just for this purpose. The HAAS remote cycle start line is hooked into the normally open contacts of a spare **M** function relay. Our remote feedback lines are then connected to the **M** function finished line (MFIN), which is an input to the CNC control, to cancel the **M** function and proceed to the next block of information.

On late model CNC machines, interfacing the unit is relatively simple, if you know where to make the connections. Your machinery dealer is the best source for this information.

**2.7 REMOTE OPERATION WITH A FANUC CNC CONTROL****FANUC control set-up requirements**

There are several requirements that must be met before a Haas Servo Control can be interfaced with FANUC controlled mill. These are as follows:

1. FANUC control with custom macro enabled and parameter 6001, bits 1 and 4 set to "1".
2. A serial port on the FANUC control must be available for exclusive use by the Haas Servo Control while DPRNT program is running.
3. Single axis Haas Servo Control and Indexer/Rotary table. Note: A dual axis control will not work in this application as the RS-232 communications port is being used for internal communication.
4. RS-232 shielded cable 25' DB25M / DB25M (null modem not required) Radio Shack Catalogue no.RSU 10524 114 (see pinout below)
5. Shielded M-code relay cable Haas Automation Part Number : CNC

DB25 pinout:  
1-1      2-2  
3-3      4-4  
5-5      6-6\*  
7-7      8-8\*  
20-20\*

\*Not connected in the brushless control

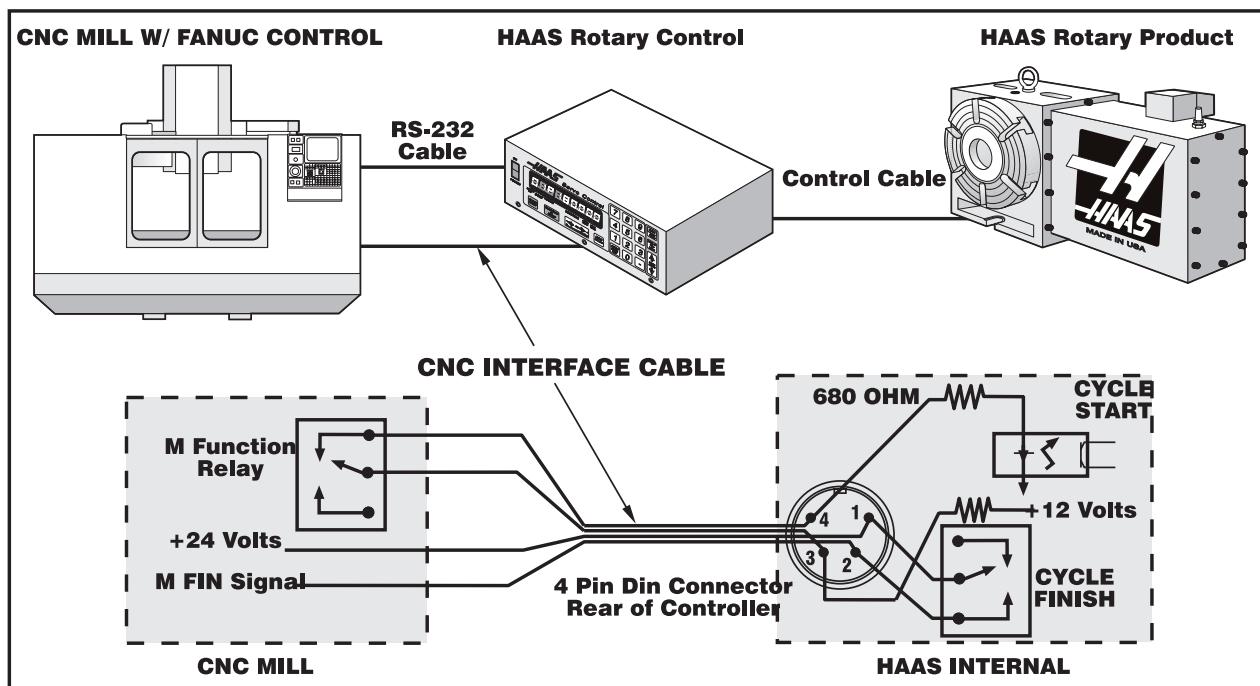


Figure 3. A Typical CNC Interface.



## Haas parameters

Once the above requirements have been met you can revise the parameters of the Haas control. Listed below are the parameters that will need to be changed.

Parameter 1 = 1	Parameter 2 = 0
Parameter 5 = 0	Parameter 8 = 0
Parameter 10 = 0	Parameter 12 = 3*
Parameter 13 = 65535	Parameter 14 = 65535
Parameter 21 = 6* (see table 1)	Parameter 26 = 3* (see table 2)
Parameter 31 = 0*	Parameter 33 = 1

**Table 1**

0= RS 232 upload / download programs	1= U
2= V	3= W
4= X	5= Y
6= Z	7,8 AND
	9 RESERVED

**Table 2**

0 = 110	1 = 300	8 = 19200
2 = 600	3 = 1200	
4 = 2400		5 = 4800
6 = 7200		7 = 9600

## Fanuc Parameters

The Fanuc control parameters must be set as follows to successfully communicate with Haas Control.

Baud Rate	1200*
Parity	Even (Required setting, do not experiment)
Data Bits	7 or ISO (If CNC control defines Data bits as word length + parity bit then set to 8)
Stop bits	2 (Required setting, do not experiment)
Flow control	XON / XOFF
Character Coding (EIA/ISO)	ISO (Required setting, EIA will not work)
DPRNT EOB	LF CR CR (CR is required, If is always ignored by Servo control)
DPRNT leading zeroes as blanks	off

\*Initial settings. Experiment with these settings only AFTER interface is functional.

### NOTES:

1. Be certain to set FANUC parameters related to actual serial port connected to Haas Servo Control.

The parameters have been set for remote operation. You can now program, or run an existing program. There are several key items you need to consider to insure your program will run successfully. First and foremost DPRNT must proceed every command sent to the Haas Control. The commands are sent to the controller in ASCII code and terminated by a carriage return (cr.). All commands must be proceeded by an axis select code (U, V, W, X, Y, Z), parameter 21 = 6. For this explanation Z will represent the axis code.



## RS 232 Command Blocks:

DPRNT[ ]	Clear / Reset receive buffer
DPRNT [ZGnn ]	Loads G-code nn into step no. 00, "0" is a place holder
DPRNT[ ZSnn.nnn ]	Loads Step Size nnn.nnn into Step no. 00
DPRNT[ ZFnn.nnn ]	Loads Feed Rate nnn.nnn into Step no. 00
DPRNT[ZLnnn]	*Loads Loop Count into Step no. 00
DPRNT[ZH]	Return home immediately without M-FIN
DPRNT [ZB]	*Activates Remote Cycle Start without M-FIN
DPRNT [B]	*Activates Remote Cycle Start without M-FIN regardless of Haas Servo Control Parameter 21 setting

\*Not for general use in this application.

**NOTES:**

1. Use of "Z" above assumes Haas Servo Control Parameter 21 = 6.
2. Leading and trailing "0" must be included (Correct: S045.000, Wrong: S45).
3. When writing your program in the FANUC format it is important **not** to have blank spaces or carriage returns (CR) in your DPRNT statement.



## DPRNT PROGRAM EXAMPLE

The following is an Example of one way to program the FANUC.

```

O0001
G00 G17 G40 G49 G80 G90 G98
T101 M06
G54 X0 Y0 S1000 M03
POpen          ( OPEN FANUC SERIAL PORT)
DPRNT [ ]      ( CLEAR /RESET HAAS)
G04 P64
DPRNT [ZG090]   ( SERVO CONTROL STEP SHOULD NOW READ "00" )
G04 P64
DPRNT [ZS000.000] ( LOADS STEP SIZE 000.000 INTO STEP 00)
G04 P64
DPRNT [ZF050.000] ( LOADS FEED RATE 50 UNITS / SEC INTO STEP 00)
G04 P64
Mnn           (REMOTE CYCLE START, MOVES TO P000.0000, SENDS M-FIN)
G04 P250        (DWELLS TO AVOID DPRNT WHILE M-FIN IS STILL HIGH)
G43 Z1. H01 M08
G81 Z-.5 F3. R.1 (DRILLS AT: X0 Y0 P000.000)
DPRNT [ ]       (MAKE CERTAIN HAAS INPUT BUFFER IS CLEAR )
G04 P64
#100 = 90.      (EXAMPLE OF CORRECT MACRO SUBSTITUTION)
DPRNT [ZS#100[33]] ( LOADS STEP SIZE 090.000 INTO STEP 00)
                  (LEADING ZERO CONVERTED TO SPACE PARAM. MUST BE OFF)
G04 P64
Mnn           (REMOTE CYCLE START MOVES TO P090.000, SENDS M-FIN)
G04 P250
X0            (DRILLS AT: X0 Y0 P090.000)
G80           (CANCELS DRILL CYCLE)
PCLOS          (CLOSE FANUC SERIAL PORT)
G00 Z0 H0
M05
M30

```

### **2.8 UPLOAD / DOWNLOAD**

The serial interface may be used to upload or download a program the same as with almost any other CNC in use today. All data is sent and received in ASCII code. Lines sent by the controller are terminated by a carriage return (CR) and line feed (LF). Lines sent to the controller may contain a LF, but it is ignored and the lines are terminated by a CR. It is important that parameter 26 be set to "0" in the Servo Control prior to attempting Uploading or Downloading programs. This parameter sets the RS-232 communication speed.

An upload or download is started from the PROGRAM mode with the G code displayed. To start an upload or download, press the minus (-) key while the G code is displayed and blinking. The display will then show:

**Prog n**

Where **n** is the currently selected program number. You can select a different program by pressing a number key and then START to return to PROGRAM mode or MODE to return to RUN mode. Or you can press the minus (-) key again and the display will show:

**SEnd n**



Where **n** is the currently selected program number. You can select a different program by pressing a number key and then START to begin sending that selected program. Or you can press the minus (-) key again and the display will show:

**rEcE n**

Where **n** is the currently selected program number. You can select a different program by pressing a number key and then START to begin receiving that selected program. Or you can press the minus (-) key again and the display will return to PROGRAM mode. Both uploading and downloading can be terminated by pressing the CLR button.

Programs sent or received by the controller have the following format: (Sample Only)

```
%  
N01 G91 S045.000 F080.000 L002  
N02 G90 S000.000 F080.000  
N03 G98 F050.000 L013  
N04 G96 P02  
N05 G99  
%
```

The % must be found before the controller will process any input and it will always begin output with a %. The N code and G code are found on all lines and the remaining codes are present as required by the G code. The N code is the same as the step number display in the controller. All N codes must be continuous starting from 1. The controller will insert steps and re-number all required data. The P code is the destination of a subroutine jump for G code 96. The controller will always end output with a % and input to it is terminated by a %, N99 or G99. Spaces are only allowed where shown.

The controller will display **SEnding** while sending a program, and the line number will change with information sent. The controller will display **LoAding** while a program is being loaded into the controller, and the line number will change with information received. An error message will be displayed on the controller if bad information is sent, and the display will indicate the last line received. If an error occurs, first make sure that the letter O was not inadvertently used in the program instead of a zero. If not, refer to the "Troubleshooting" section.

When using an RS-232 interface, it is recommended that the programs be written in DOS Edit, Wordstar, Notepad Editor, or other ASCII program. Word processing programs, such as Word Perfect or Word 6.0, are not recommended, as they will insert extra, unnecessary information.

Upload/Download functions do not need an axis select code as they are manually initiated by an operator at the front panel. However, if the select code (Parameter 21) is not zero, an attempt to send a program to the control will fail, as the lines do not begin with the correct axis select code.



## 2.9 HAAS A6AC AIR COLLET CLOSER

The A6AC collet closer easily bolts to the back of the HRT A6 (see Figure 1a). The drawbar and collet adapters are designed to mate with the Haas A6/5C spindle nose. The optional A6/3J and A6/16C may be obtained from your local tooling distributor.

**NOTE:** A special drawtube adaptor is required for the 16C and 3J. Make sure to supply tooling distributor with spindle/drawbar details as shown in figure 1-b.

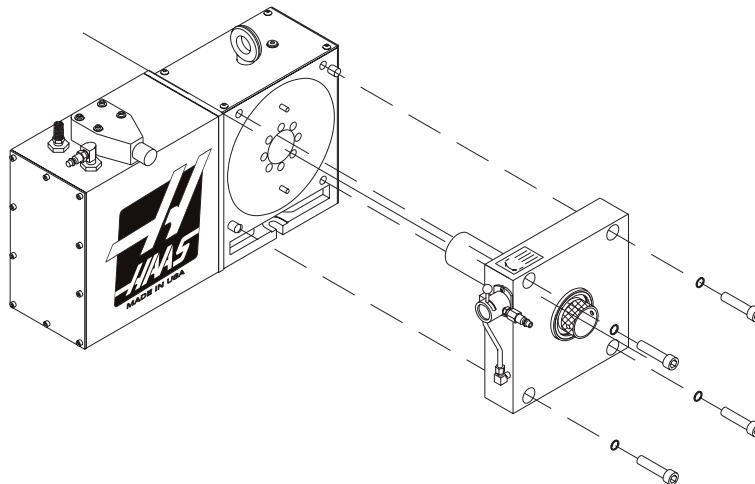


Figure 1-a. A6AC collet closer shown mounted to an HRT A6.

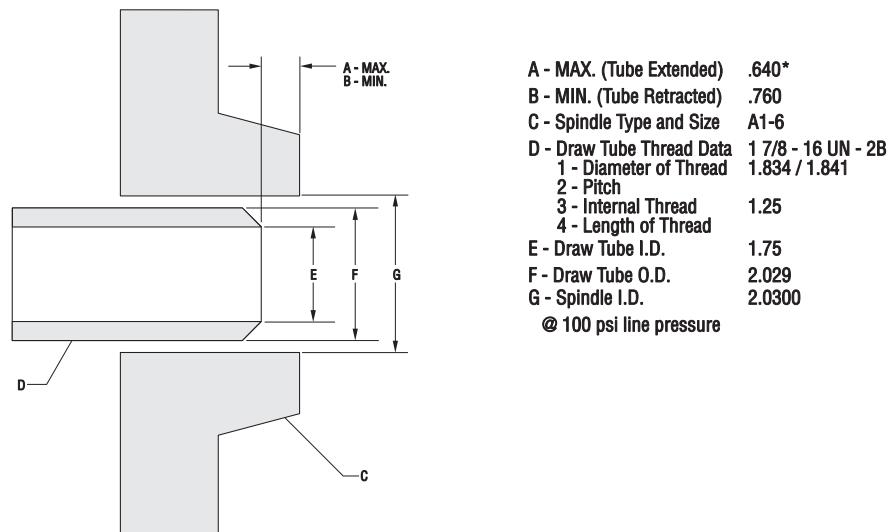


Figure 1-b. Drawtube to spindle dimensions (extended/retracted).



## Clamping Force and Air Supply

The A6AC is a 1-3/4 diameter thru-hole type closer which is adjustable from the rear. It holds parts by utilizing spring force to provide up to 0.125 of longitudinal movement and up to 5000 lbs. of draw force at 120 PSI shop air pressure.

### Adjustment

To adjust the collet closer, align a collet with the keyway, push the collet into the spindle, and turn the drawbar clockwise to pull the collet in. To make the final adjustment, place a part in the collet, turn the air valve to the UNCLAMPED position to charge the cylinder and compress the spring mechanism, then tighten the drawbar until it stops. Back off 1/4 - 1/2 turn and turn the air valve to the CLAMPED position. This will be adjusted for maximum clamping force. To reduce the clamping force, back off further on the drawbar or regulate the air pressure down before adjusting.

### Collet Sticking

---

**NOTE:** To prevent excessive wear and collet sticking, make sure collets are in good condition and free from burrs. A light coat of Molybdenum grease on the collet wear surfaces will extend the life of the spindle / collet and help prevent sticking.

When the air supply is turned on, the drawbar is kicked forward and releases the collet. Increasing the air pressure can help stop the collet sticking; however, do not exceed 200psi into the cylinder. Backing off further on the drawbar during final adjustment may also reduce collet sticking.

### **WARNING!**

**Do not index the Rotary Table while the A6AC air valve is in the ON position. This will put excessive friction on the worm gear system and cause premature wear.**



## 3. OPERATION

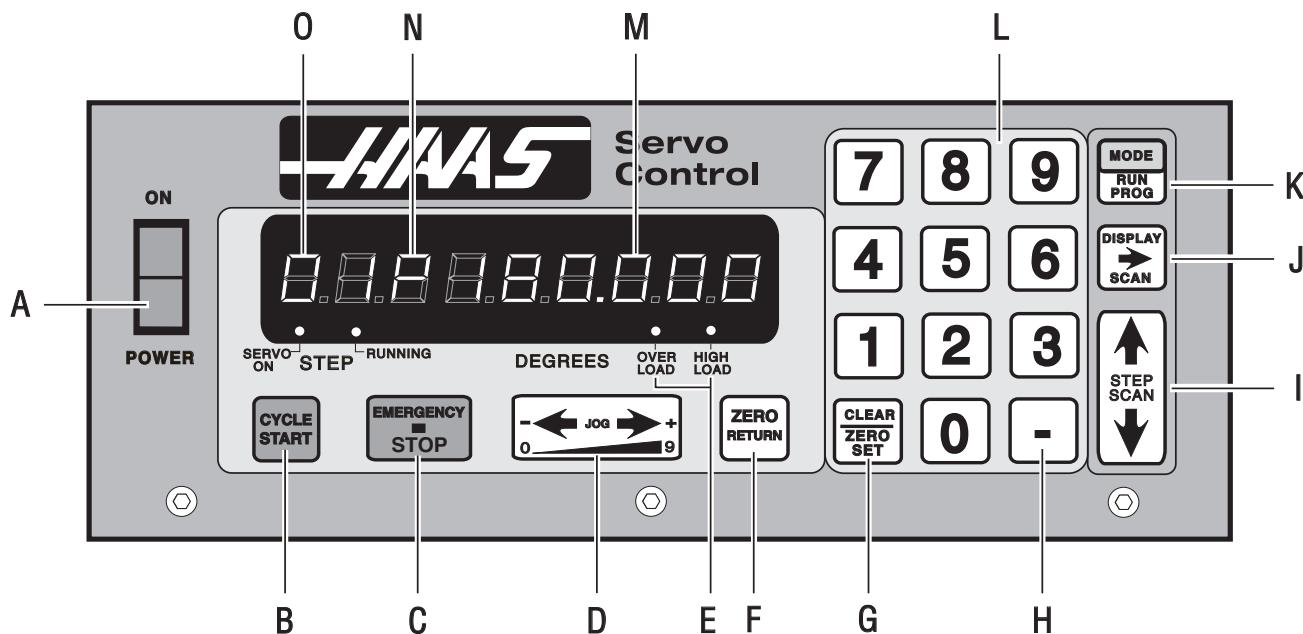
### 3.1 THE FRONT PANEL DISPLAY

The Light Emitting Diode (LED) front panel display tells you what is going on inside the controller. There are nine characters that are displayed. The left two characters are the step number and go from 1 to 99. They cannot be changed with the numeric keys and are selected by using the STEP SCAN arrow buttons. The remaining seven characters display data that is stored in memory. Every step (or block) contains several pieces of information that are necessary for your program, but they cannot be displayed simultaneously. In order to overcome this, use the DISPLAY SCAN button to view the pieces of data for each step. The data is preceded by a letter to indicate which piece of information is being displayed. For example, if an **F** precedes the number, the displayed data is for feed rates. There are five such registers. They are:

- 1) current spindle position (indicated by a letter **P**)
- 2) step size and direction (indicated by no letters),
- 3) feed rate (indicated by a letter **F**),
- 4) loop count (indicated by a letter **L**)
- 5) G code (indicated by a letter **G**)

Successive pushes of the **right** arrow button will cause the display to cycle to the next register, that is, POSITION - STEP SIZE - FEED RATE - LOOP COUNT - G CODE - POSITION - etc. In RUN mode, the **right** arrow button can select among any of these five displays. In PROGRAM mode, all of these but the position may be displayed.

Refer to the diagram on the following page. When you are in the PROGRAM mode, you are editing the numbers (or registers) inside the dotted lines. Think of the LED displays as a window that allows you to see only one number of the program at a time. The DISPLAY SCAN button allows you to scan sideways and see all the information for a single step. Pushing the DISPLAY SCAN button shifts the window one place to the right, looping from left to right at the end of the row. Pushing the **up** arrow allows you to view the previous step, while pushing the **down** arrow allows you to view the next step. Using these three keys, you can scan to anywhere in the program. If you enter a new number in that position, the number will be stored when you scan to another position or return to RUN mode.



- A) Main POWER switch to turn the unit on (For brushless units the power switch is located on the rear).
- B) CYCLE START begins a step, stops a continued operation, inserts a step, or turns the servo on.
- C) EMERGENCY STOP turns off the servo when on and aborts a step in progress.
- D) JOG causes the servo to move in either the forward or backward direction at a rate defined by the last numeric key pressed.
- E) Load meter LED. If LEDs are illuminated continuously during a low feed rate or when stationary, the following conditions apply:

**HIGH LOAD:** Indicates overload level, excessive load or workpiece support misalignment. Hi-LoAd or Hi Curr alarms may occur if not corrected. (See "Troubleshooting" section)

**OVERLOAD:** Indicates 2x overload level, excessive load or workpiece misalignment. Hi LoAd or Hi Curr alarms will occur if not corrected. Damage to motor or table may result. (See "Troubleshooting" section)

---

**NOTE:** It is normal for the LEDs to be illuminated during a rapid movement or high duty cycle.

- F) ZERO RETURN causes the servo to return to HOME position, search for mechanical HOME, delete a step, or move forward to the mechanical offset.
- G) ZERO SET clears the entered data, resets program to 0, or defines the present servo position as HOME.
- H) MINUS KEY selects negative step values or Prog/Upload/Download functions.
- I) STEP SCAN scans step numbers from 1 through 99.
- J) DISPLAY SCAN scans the display to show either Position, Step Angle, Feed Rate, Loop Counts, or G Code.
- K) MODE / RUN PROG switches from RUN mode to PROGRAM mode (blinking display).
- L) Data entry keys and jog speed selection.
- M) Displays show current data, i.e., a current spindle position of 180.
- N) Indicates what data is being displayed. Either P, F, L, blank, or G for Position, Feed Rates, Loop Count, Step Angle, or G Code.
- O) Present step number. Step numbers 1 to 99 are available. Also displays errors at turn on.



### **3.2 TURNING THE SERVO ON**

There is a single 115V AC @ 15 amp supply required by the controller. Ensure that the front panel power switch is turned off (Brushless units have the power switch on the rear) and connect the motor cable from the table and the power cord.

Turn the controller on. The display will show:

**HAAS nn**

where **nn** is the software revision number. That number should be used when describing problems to HAAS. If any other message is displayed, refer to the "**Error Codes**" section of this manual. The number only remains in the display for about one second. The front panel displays should indicate:

**Por On**

This indicates that the servo is turned off (no power is applied to the closed-loop motor).

In addition, the internal battery is checked at power-on and if the battery is low the following message is displayed:

**Lo bAt**

Pressing any key will allow you to continue operation, but the low battery may have caused loss of your program parameters.

Press the front panel START switch once. The panel should now indicate:

**01 no Ho**

This indicates that the motor is powered, but the zero position is not yet defined.

### **3.3 AUTOMATICALLY FINDING THE ZERO POSITION**

Press the ZERO RETURN button to start the automatic homing operation. When the table stops, the display will indicate:

**01 Pnnn.nnn**

**3.4 MANUALLY FINDING THE ZERO POSITION**

Use the left/right JOG switch to position the table to the position that you want to use as zero and then press and hold the CLR key for three seconds. The display should now indicate:

**01 P 000.000**

This indicates that the zero position is established and the controller is ready to begin normal operations. If a different position is to be used as zero, jog the table to the new position and press the CLR key for three seconds. The display will again indicate:

**01 P 000.000**

If you had previously cleared a new HOME position for the table, the display will show a non-zero position. In this case, press the ZERO RETURN button once more and the table will move forward to the pre-defined zero position.

**3.5 JOGGING**

Jogging of the motor can be done with the front panel JOG switch. The jog speed is selected with the front panel number keys and is a fraction of the maximum feed rate set by the parameters. The jog speeds (for the HRT 160) are:

Number pressed	Speed (% of maximum)	Jog speed (for 80 deg/sec max.)
0	0.008	0.006 Deg/sec
1	0.015	0.012 Deg/sec
2	0.031	0.024 Deg/sec
3	0.062	0.049 Deg/sec
4	0.125	0.100 Deg/sec
5	0.25 (default)	0.200 Deg/sec
6	0.5	0.400 Deg/sec
7	1.0	0.800 Deg/sec
8	4.0	3.200 Deg/sec
9	16.0	12.800 Deg/sec

If the control is set up for linear motion, positive and negative travel limits are possible. If a step is started which would have caused the control to exceed travel limits, the following message is shown:

**2 FAR**

and the control will not execute the step. (See parameter 13 and 14, travel range)



### **3.6 ERROR CODES**

When the controller is first turned on, a set of self tests is run and the results may indicate a controller fault. Any of these could result in an **En** display of one of the following codes:

<b>Blank front panel</b>	Program CRC failure (bad RAM, or cycle power if bad ROM to RAM program transfer.)
<b>E0 EProm</b>	EPROM CRC error
<b>FP Short</b>	Front panel switch closed (or PIO fault)
<b>rE Short</b>	Remote START switch closed and enabled
<b>E3 rAm</b>	RAM cannot store data
<b>E4 bAtt</b>	Saved program is in error (low battery)
<b>E5 Pio2</b>	PIO2 is bad
<b>E6 Pio3</b>	PIO3 is bad
<b>Lo Volt</b>	Power-fail interrupt (low line voltage)
<b>E8 Encod</b>	Encoder chip bad
<b>E9 intEr</b>	Interrupt problem
<b>EA no go</b>	Keep alive circuit failure
<b>Eb nmi</b>	NMI sense bad
<b>Ec Pwm</b>	PWM generation bad
<b>Ed cloc</b>	1 kHz signal missing
<b>EE Au in</b>	Auxiliary input 2 shorted
<b>Lo bAt</b>	Low battery (Get serviced)

Intermittent low voltage errors or power failures may be the result of inadequate power to the controller. Use heavy duty extension cords only and keep them as short as possible. Make sure power service is a minimum of 15 amps at the plug and that the voltage is a minimum of 115 V AC.

<b>0 too SL</b>	(Zero margin too small) Zero margin too small is the distance between the home switch and the final stopped motor position, after seeking home, is either less than 1/8 or greater than 7/8 of a motor revolution.
-----------------	--

This alarm may occur while homing the rotary table. The distance between the home switch and the final motor position at zero is less than 1/8 of a motor revolution. To prevent this alarm, parameter 45 must be set properly. Start with the default value for parameter 45 (0) and add 1/2 of a motor revolution (1/2 motor revolution is equal to the value in parameter 28 divided by 2). Home the rotary table after the new value for parameter 45 has been entered.

There are no user-serviceable parts inside, so refer all problems to HAAS Automation for repair.

**3.7 SERVO OFF CODES**

At any time the servo is turned off, a reason code is displayed along with the following codes:

<b>Por On</b>	Power was just turned on (or failed prev.)
<b>Ser Err</b>	Servo following error too large
<b>E-StoP</b>	Emergency stop
<b>Hi LoAd</b>	Software fuse
<b>rS-232</b>	Remote RS-232 commanded off
<b>Air-Hot</b>	Motor overheat sensor
<b>EncodEr</b>	Z channel fault (bad encoder or cable)
<b>Hi Curr</b>	Over current limit (stalled or PCB fault)
<b>EncodES</b>	Z channel missing (bad encoder or cable)
<b>Hi VoLt</b>	Regen overheat (high line voltage)
<b>CABLE</b>	Break detected in encoder cable wiring
<b>PHAS Er</b>	Power up phase error (Brushless units only)
<b>dr FLt</b>	An overcurrent or drive fault.( Brushless units only)
<b>trAnS</b>	Encoder transition fault had been detected by the brushless circuitry.

**3.8 EMERGENCY STOP**

Pushing the EMERGENCY STOP button will turn the servo off and cause the spindle to decelerate and stop. Position will not be lost. If the step was not completed you will still be on that step. Push CYCLE START to turn the servo on. The remote cycle start and cycle finish will not function until the EMERGENCY STOP is removed by pushing the START button. If an EMERGENCY STOP is performed, the display will indicate an:

**E-StoP**

CE machines have an Emergency-stop switch on the top of the control. Pressing the E-stop switch will turn off the servo and aborts the step in progress.




---

## 4. PROGRAMMING THE CONTROLLER

---

### **4.1 INTRODUCTION**

Programming is done through the square 15-key keypad on the right side of the front panel. The three buttons on the right column of the keypad are used for program control. They are the:

**MODE / RUN PROG** button,  
**DISPLAY SCAN (RIGHT ARROW)** button  
**STEP SCAN (UP/DOWN ARROWS)** button

The MODE button is the most important. It selects between the RUN mode and PROGRAM mode. You can tell which mode you are in by looking at the display.

**IF THE DISPLAY IS STEADY, YOU ARE IN THE RUN MODE.  
IF IT IS FLASHING ON AND OFF, YOU ARE IN THE PROGRAM MODE.**

The RUN mode is where pre-programmed commands may be executed and the PROGRAM mode where commands are entered into memory. The servo loop can be turned on in either mode and will hold the motor to a commanded position when at standstill.

When the controller is first turned on, it is in RUN mode but the servo is turned off. This is indicated by:

#### **Por On**

Pressing any key will allow you to continue operation.

Some buttons have more than one function depending upon which mode you are in. Always release a button immediately after pressing it. Holding a button down will cause it to repeat.

---

### **4.2 How Data is STORED IN THE CONTROLLER'S MEMORY**

---

Step Number	Step Size	Feed Rate	Loop Count	G code
1	90.000	80	01	91
2	-30.000	05	01	91
3	0	80	01	99
through 99	0	80	01	99

- your program data -

window Pushing the **right** arrow key moves the window to the right.

Pushing the **up** arrow or **down** arrow keys moves the window up or down.

**4.3 ENTERING A STEP**

To enter a step into the controller's memory, press the MODE button. This will put the controller into the PROGRAM mode. The display will begin blinking and show a step size. Clear the last program by pressing and holding the CLR key for three seconds. To enter a **45 degree** ( $45^\circ$ ) step, press the following keys:

**4 5 0 0 0**

The display should now indicate:

**01 45.000**

Press the **right** arrow button. This will cause the **45 degree** ( $45^\circ$ ) step to be stored and the feed rate to be displayed. To enter a feed rate of **80 degrees** ( $80^\circ$ ) per second, press the following keys:

**8 0 0 0 0**

The display should now indicate:

**01 F 80.000**

To return the controller to the RUN mode, press the MODE button. The display should now indicate:

**01 P 000.000**

Start the **45 degree** ( $45^\circ$ ) step by pressing the CYCLE START button. The table should move to the new position and at the end of the step, the display should indicate:

**01 P045.000****4.4 PUTTING A PROGRAM INTO MEMORY**

Programming begins with ensuring that the controller is in PROGRAM mode and at step number 01. To do this, press the MODE button while the servo is NOT in motion. **The displays must be blinking.** Next, push and HOLD the clear (CLR) key for five seconds. You have now cleared the memory and are at step one and ready to begin programming. "01 000.000" should be displayed. Please note that you do not have to clear the memory each time you wish to enter or change data. Data in the program can be changed simply by writing the new data over the old.

Up to 7 programs can be stored, numbered 0 to 6. To access a different program, press the minus key while showing a G code. The display will change to:

**Prog n**

Press a number key to select a new program and then press the MODE key to return to RUN mode or the START key to continue with the PROGRAM mode.



Every one of the possible 99 steps in a program may contain the following:

1. a step size or position command (shown as a number with possible minus sign),
2. a feed rate shown with a preceding **F**,
3. a loop count shown with a preceding **L**,
4. a G code shown with a preceding **G**, and
5. a jump destination with a preceding **Loc**.

**Every step must contain at least one G code.** The following section describes the possible G codes.

To display the additional codes associated with a step, press the **right arrow key**. Possible data entry includes:

Step size (no code letter but possible minus sign),  
 Feed rate (**F**),  
 Loop count (**L**),  
 G code (**G**), and  
 Subroutine jump destination step number (**Loc**).

Some of these entries are not allowed for particular G codes and either cannot be entered or are ignored. Most steps are incremental position commands and this is the default G code (91). The G codes 86, 87, 89, 92, and 93 should be used with the CNC relay function disabled (Parameter 1 = 2).

Enter your step size in degrees to three decimal places. The decimal places must always be entered, even if they are zero. Enter a (-) minus sign for opposite rotation. If you need to edit a feed rate or loop count, push the **right arrow key** to view that register and input the data.

If you are programming for a part that does not utilize feed rates or loop counts, simply push the down arrow to go to the next step. Insert the G code and step size and move on to the next step. The step will automatically be set to the fastest feed rate and a loop count of one.

**The data you input is automatically stored in memory whenever you push one of the control buttons.**

If you enter a wrong number or one that is out of limits the control will display an error message:

### Error

To correct this, push the CLR button and re-enter the correct number. If you are entering the correct number and **Error** still appears, check Parameter 7 for memory protect.

When the last step has been entered, an end code must be present at the following step. Steps 2 through 99 are set to the end code when a clear memory is performed. This means that you usually do not need to set the last step to 99. If you are removing steps from an existing program, make sure that you have entered a (99) after the last step.

**4.5 G Codes**

The following G codes are possible:

<b>G28</b>	return to HOME position (same as G90 with step 0)
<b>G73</b>	peck cycle (linear operation only)
<b>G85</b>	fractional circle division
<b>G86</b>	turn CNC relay on
<b>G87</b>	turn CNC relay off
<b>G88</b>	return to HOME position (same as G90 with step 0)
<b>G89</b>	wait for remote input
<b>G90</b>	absolute position command
<b>G91</b>	incremental command
<b>G92</b>	pulse CNC relay and wait for remote input
<b>G93</b>	pulse CNC relay
<b>G94</b>	pulse CNC relay and run next L steps automatically
<b>G95</b>	end of program/return but more steps follow
<b>G96</b>	subroutine call/jump (destination is a step number)
<b>G97</b>	delay by L count/10 seconds (down to 0.1 second)
<b>G98</b>	circle division (circular operation only)
<b>G99</b>	end of program/return and end of steps

**4.6 ABSOLUTE / INCREMENTAL MOTION**

**G90** and **G91** are used to select absolute (**G90**) or incremental (**G91**) motion. **G90** is the only command allowing absolute positioning.

**4.7 FEED RATES**

The feed rate display ranges between 00.001 and 080.000 (Maximum 080.000 for HRT 160, 060.000 for HRT 210, 050.000 for HRT 310, and 050.000 for HRT 450), preceded by an **F**. It displays the feed rate that will be used for the selected step. The feed rate corresponds to degrees rotated per second. A feed rate of 080.000 means the platter will rotate **80 degrees** (80°) in one second.

**4.8 Loop Counts**

**Loop Counts** allow you to repeat a step up to 999 times before going on to the next step. The loop count display is three digits between 1 and 999 preceded by an **L**. In RUN mode, it displays the remaining loop counts for the selected step. It is also used in conjunction with the **Circle Division** function to enter the number of divisions in the circle from 2 to 999. Used in conjunction with G96, the **Loop Count** specifies the number of times you wish to repeat that subroutine.



#### **4.9 SUBROUTINES (G96)**

Subroutines allow you to repeat a particular step sequence up to 999 times. A subroutine is invoked by entering **G96** into the G code. After entering **G96** you must DISPLAY SCAN over to the LOC (short for location) register to enter the step you wish to jump to. The location register replaces the feed rate register and is only present on **G96** steps. After executing a **G96** step, the control will jump to the step called out in the LOC register, execute that step and the ones following until it reaches G code 95 or 99, the end of subroutine call. The program then jumps back to the step following **G96**.

A subroutine can be repeated a number of times by utilizing the loop count of the **G96** step. To end the subroutine, you must insert a G code of 95 or 99 after the last sequence step. A subroutine call is not considered a step by itself since it will always execute itself and the first step of the subroutine. Nesting of subroutine calls is not permitted.

#### **4.10 DELAY CODE (G97)**

**G97** is used to program a dwell or delay time into a program. **G97** does not pulse the CNC relay at step completion. As an example, programming a **G97** and setting L=10 will produce a 1 second dwell.

#### **4.11 CIRCLE DIVISION (G98)**

Circle division is selected with a **G98**. The **L** count defines how many equal sized parts a circle is to be divided into. After the **L** count steps, the servo will be in the same position as it started. Circle division is only available in the circular modes (i.e., Parameter 12=0, 5, or 6).

#### **4.12 AUTO CONTINUE CONTROL**

If Parameter 10 is set to 2, the controller can be run like a single axis CNC. The entire program will be executed until the last step is encountered. In all cases, the last step is the one with a **G99**. Actually, the step preceding the **G99** is the last one to be executed. Step **99** may also be the last step if all of memory is used. When running automatically, the sequence of step operation can be stopped by pressing and holding the START switch until the current step is finished. The program can then be continued by pressing START again.

#### **4.13 INSERTING A LINE**

A new step may be inserted into a program by pressing and holding the CYCLE START button for three seconds while in PROGRAM mode. It will cause the present step and all following steps' contents to be moved down and the present step to be initialized to default values. All subroutine jumps are also renumbered.

#### **4.14 DELETING A LINE**

A step may be deleted from a program by pressing and holding the ZERO RETURN button for three seconds while in PROGRAM mode. It will cause the next step and all following steps to be moved up by one. All subroutine jumps are also renumbered.

**4.15 DEFAULT VALUES**

For all steps, the default values are:

000.000	(step size zero)
F	(maximum feed rate defined by Parameters)
L	001
G	91 (incremental)

If an entry is cleared or set to 0 by the operator, the controller will be set to the default value. All entries are stored when selecting the next display function, step number, or returning to **RUN** mode.

**4.16 SELECTING A STORED PROGRAM**

There can be more than one stored program, and selection of that program is done by pressing the minus (-) key while showing a G code in PROGRAM mode. The display will change to:

Prog n

Press a number key to select a new program and then press the MODE key to return to RUN mode or the START key to continue with the PROGRAM mode. There are seven programs available, numbered 0-6.

**4.17 CLEARING A PROGRAM**

To initialize or clear a stored program (not including Parameters), go to PROGRAM mode (press the MODE button if displays are not blinking) and press and hold the CLR button for three seconds. The displays will cycle through all 99 steps and set all but the first to G99. The first step is set to G91, step size of 0, maximum feed rate, and a loop count of 1.

**4.18 OPERATING HINTS**

1. You can select another display while in the RUN mode by pushing the DISPLAY SCAN button. This way you could view the particular feed rate for a step or view the remaining loop counts left.
2. You can start your program on any step by using the UP/DOWN scan keys.
3. Make sure your CNC has the same number of **M** functions programmed as you have steps in the HAAS control.
4. DO NOT program two **M** functions one directly after another in your CNC control to index the HAAS control, as this may cause a timing hang-up in your CNC. Use a dwell of 1/4 second between them.
5. If all else fails, read the manual again.



#### **4.19 SIMULTANEOUS ROTATION AND MILLING**

**G94** can be used to perform simultaneous milling. The CNC relay is pulsed at the beginning of the step so that your NC machine will proceed to the next block. The controller then executes the following **L** steps automatically without waiting for start commands. Normally the **L** count on the **G94** is set to 1 and that step is followed by a step that is to be run simultaneously with an NC mill.

#### **4.20 SPIRAL MILLING**

The simultaneous rotation and milling feature of the controller will permit machining of certain cam forms, spiral, and angular cuts. Spiral milling is when the spindle rotates and an axis on your mill moves at the same time. Insert a **G94** into the control and the desired rotation and feed rate on the next step. The control will execute **G94** (this pulses the MFIN relay and allows your CNC to proceed) and the following step or steps as one step. If you wish to do more than one step, then insert the number into the **L** register. By selecting a rotation feed rate and varying the mill feed rate, any spiral is possible. In order to spiral mill, you will have to calculate the feed rate for your mill so that the HAAS spindle and your axis will stop at the same instant.

In order to calculate the feed rate for your mill you need to know:

1. The angular rotation of the spindle (this should come from the print)
2. A feed rate for the spindle (arbitrarily select a reasonable one, **five degrees** ( $5^\circ$ ) per second is a good starting point)
3. The distance you wish to travel on X-axis (this should come from the print)

For example, we wish to mill a spiral that is **72 degrees** ( $72^\circ$ ) of rotation and moves 1.500 inches on the X-axis at the same time.

1. Compute the amount of time it will take the HAAS index head to rotate through the angle  
 $\# \text{ of degrees} / (\text{divided by}) \text{ feed rate of spindle} = \text{time to index}$   
 $72 \text{ degrees} / \text{five degrees per sec} = 14.40 \text{ seconds for indexing head to rotate.}$
2. Now we need to compute the feed rate for the mill that will travel the X distance in 14.40 seconds.  
 $(\text{length to travel in inches} / (\text{divided by}) \# \text{ of seconds of rotation}) \times 60 \text{ seconds} = \text{feed rate for mill in inches per minute.}$   
 $1.500 \text{ inches} / 14.4 \text{ seconds} = 0.1042 \text{ inches per second} \times 60 = 6.25 \text{ inches per minute.}$

Therefore, if you set the indexer to step **72 degrees** ( $72^\circ$ ) at a feed rate of **five degrees** ( $5^\circ$ ) per second you will have to program your mill to travel 1.500 inches at a feed rate of 6.25 inches per minute for the spiral to be generated.

The program for the HAAS control would be as follows:

STEP	STEP SIZE	FEED RATE	LOOP COUNT	G CODE
01	0	080.000	1	[94]
02	[72000]	[5.000]	1	[91]
03	0	080.000	1	[88]
04	0	080.000	1	[99]

The program for your mill would generally look like this:

N1 G00 G91                         (rapid in incremental mode)  
N2 G01 F10. Z-1.0                 (feed down in Z-axis)  
N3 M21                             (to start indexing program above at step one)  
N4 X-1.5 F6.25                     (index head and mill move at same time here)  
N5 G00 Z1.0                         (rapid back in Z-axis)  
N6 M21                             (return indexer HOME at step three)  
N7 M30

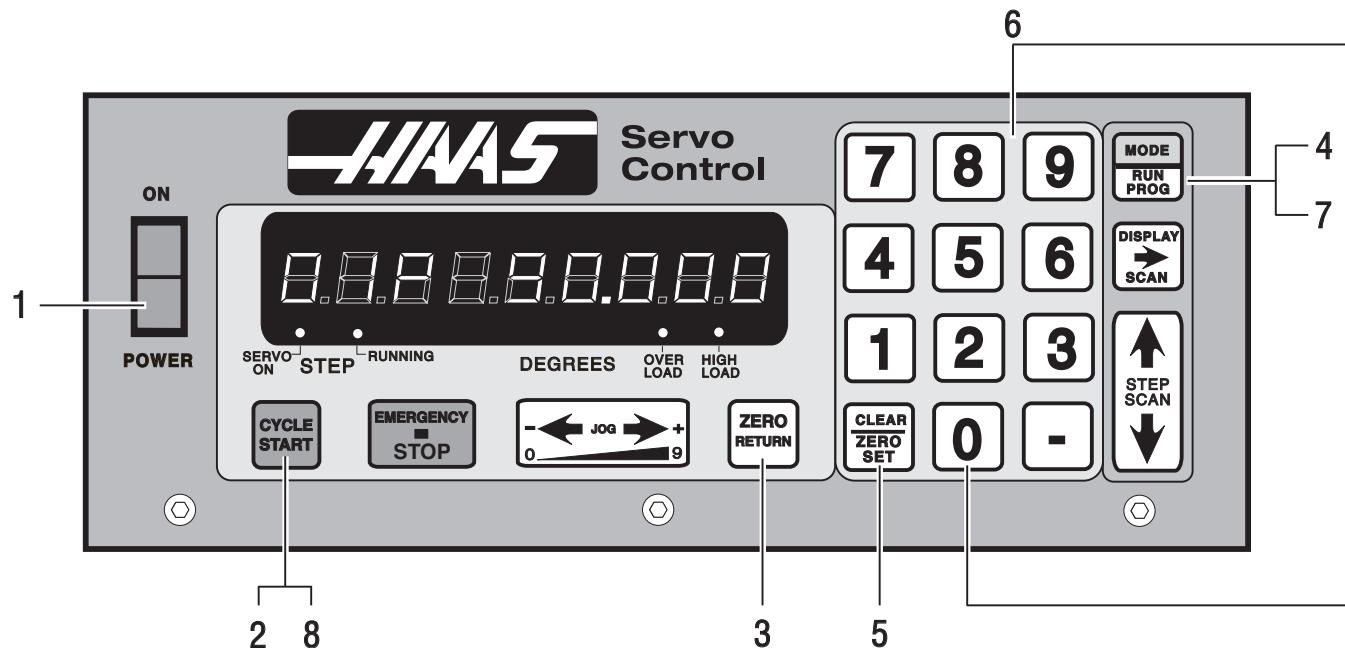
#### 4.21 POSSIBLE TIMING PROBLEMS

When the HRT executes a **G94**, a 250 millisecond delay is required before executing the following step. This may (it usually doesn't) cause your axis to move before the table rotates, leaving a flat spot in the cut. If this is a problem, a solution is to insert a G04 dwell (from 0 to 250 milliseconds) in your CNC after the M function to prevent axis movement. By selecting the right dwell, the HRT and your mill should start moving at the same instant. In the same manner, a problem may exist at the end of the spiral, but this can be eliminated by slightly altering the feed rate on your mill. Don't adjust the feed rate on the HAAS control because your mill has a much finer feed rate adjustment than the HAAS control. If the undercut appears to be in the X-axis direction, then speed up slightly (0.1 change in feed rate) your mill's feed rate. If the undercut appears in the radial direction of the spindle of the indexer, then slow down your mill's feed rate.

If the timing is off by several seconds such that your mill completes movement before the indexer completes its movement, and you have several spiral moves one right after another (such as in retracing a spiral cut), this may cause your CNC to stop for no reason. The reason for this is your CNC will send a cycle start signal (for next cut) to the HAAS control before it has completed its first move, thereby causing a timing hang-up. The HAAS control will not accept another cycle start until it is finished with the first. If you are doing multiple moves it is very important to check your timing calculations. A way to verify if this is actually the problem is to single block your control, allowing five seconds between steps. If you can single block the control but it will not successfully run in the continuous mode, then your timing is off somewhere.



## 5. PROGRAMMING EXAMPLES



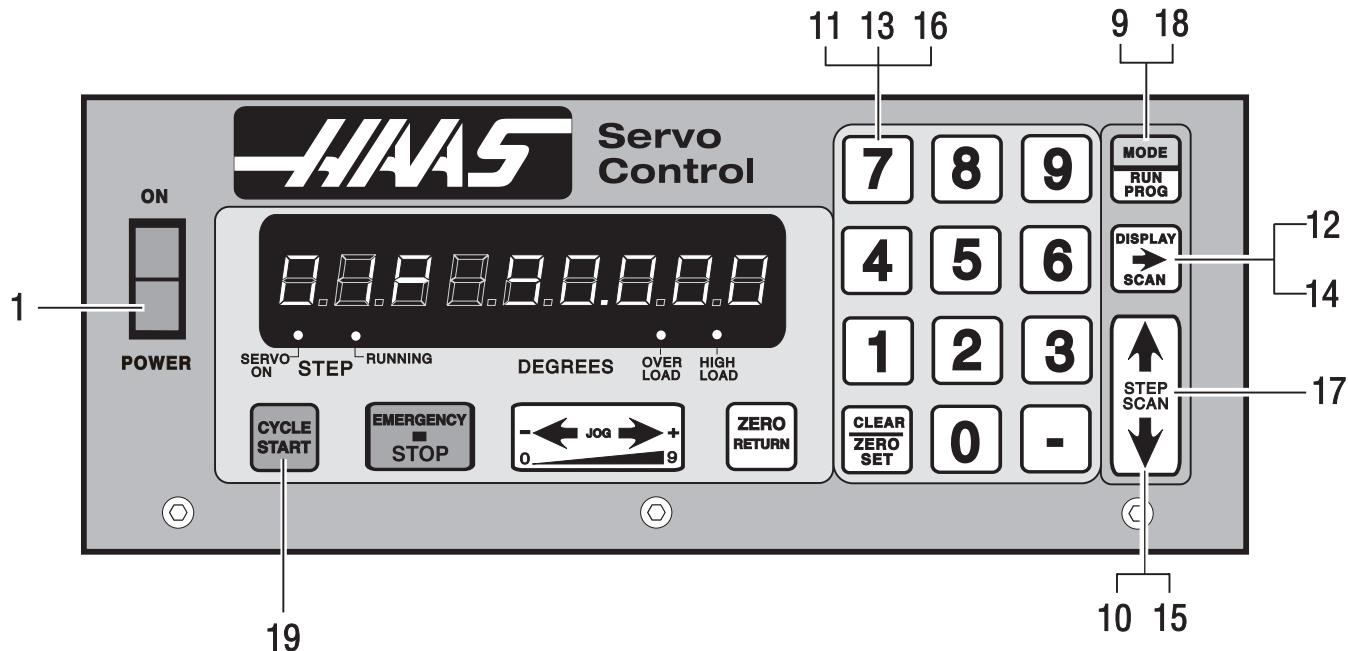
### Example #1

We want to index the platter **90 degrees** ( $90^\circ$ ).

1. Turn [**POWER**] switch on.
2. Push the [**CYCLE START**] switch.
3. Push the [**ZERO RETURN**] switch.
4. Push the [**MODE**] button and release. Displays must be blinking.
5. Push and hold [**CLR**] button for five seconds. "01 000.000" displayed.
6. Enter **[9 0 0 0 0]**
7. Push [**MODE**] button. Steady displays.
8. Push [**CYCLE START**] to index.

**Example #2**

Continuing the previous example, we want to index the platter **90 degrees** (Step 1), rotate at **five degrees/sec** (F5) in the opposite direction for **10.25 degrees** (Step 2), and then return home (Step 3).



9. Push the [MODE] button. Displays blinking.
10. Push the [DOWN ARROW] once. You should be on Step 2.
11. Enter [- 1 0 2 5 0] on the keypad. Use CLR if you make a mistake.
12. Push the [DISPLAY SCAN] button once.
13. Enter [5 0 0 0] on the keypad.
14. Push the [DISPLAY SCAN] button twice. A "G 91" will be displayed.
15. Push the [DOWN ARROW] once. You should be on Step 3.
16. Enter [8 8] on the keypad.
17. Push the [UP ARROW] twice. You should be on Step 1.
18. Push the [MODE] button. Steady displays.
19. Push the [CYCLE START] switch three times. The table should index **90 degrees** ( $90^\circ$ ), slow feed in the opposite direction for **10.25 degrees** ( $10.25^\circ$ ), and return home.

The following examples show the program as you would enter it into the control. We will assume each time that you have cleared out the memory. The bold-face type surrounded by [] indicates data that you would enter into the controller.



### Example #3

We want to drill a four-hole pattern, and then a five-hole pattern on the same part.

STEP	STEP SIZE	FEED RATE	LOOP COUNT	G CODE
01	[90.000]	080.000	[4]	[91]
02	[72.000]	080.000	[5]	[91]
03	0	080.000	1	[99]

Example #3 could have also been done using Circle Division.

STEP	FEED RATE	LOOP COUNT	G CODE
01	080.000	[4]	[98]
02	080.000	[5]	[98]
03	080.000	1	[99]

### Example #4

We want to index **90.12 degrees** ( $90.12^\circ$ ), start a seven-hole bolt pattern, and then return to the zero position.

STEP	STEP SIZE	FEED RATE	LOOP COUNT	G CODE
01	[90.120]	080.000	1	[91]
02	0	080.000	[7]	[98]
03	0	080.000	1	[88]
04	0	080.000	1	[99]

**Example #5**

We want to index **90 degrees** ( $90^\circ$ ), then slow feed for **15 degrees** ( $15^\circ$ ), repeat this pattern three times, and return home.

STEP	STEP SIZE	FEED RATE	LOOP COUNT	G CODE
01	[90.00]	080.000	1	[91]
02	[15.00]	[25.000]	1	[91]
03	[90.00]	080.000	1	[91]
04	[15.00]	[25.000]	1	[91]
05	[90.00]	080.000	1	[91]
06	[15.00]	[25.000]	1	[91]
07	0	080.000	1	[88]
08	0	080.000	1	[99]

This is the same program (Example #5) using subroutines.

STEP	STEP SIZE	FEED RATE	LOOP COUNT	G CODE
01	0	LOC [4]	[3]	[96]
02	0	080.000	1	[88]
03	0	080.000	1	[95]
04	[90.00]	080.000	1	[91]
05	[15.00]	[25.000]	1	[91]
06	0	080.000	1	[99]

**Explanation:**

Step #1 tells the control to jump to Step #4. The control will do steps #4 and #5 three times, with Step #6 marking the end of the subroutine. After finishing the subroutine, the control jumps back to the step following the "G 96" call (in this case, Step #2). Since Step #3 is not part of a subroutine, it marks the end of the program and will return the control to Step #1.

Using subroutines in Example #5 saves only two lines of programs. However, if you wanted to repeat the pattern eight times, you would save twelve program lines. In the subroutine example, only the loop count in Step #1 would be changed to increase the number of times you wish to repeat the pattern.

As an aid in programming subroutines, think of the subroutine as a separate program and write it on a piece of paper. Program the control using "G96" when you want to invoke the previously written subroutine. When finished, end the program with an End 95 code. Now enter your subroutine and note the step it begins with. Enter that step in the LOC register of the "G96" call.

**Example #6**

We want to index 15, 20, 25, 30 degrees in sequence four times and then drill a five-hole bolt pattern.

STEP	STEP SIZE	FEED RATE	LOOP COUNT	G CODE
01	0	Loc [4]	[4]	[96]
02	0	080.000	[5]	[98]
03	0	080.000	1	[95]
(main program above—subroutine below)				
04	[15.000]	<b>080.000</b>	1	[91]
05	[20.000]	080.000	1	[91]
06	[25.000]	080.000	1	[91]
07	[30.000]	080.000	1	[91]
08	0	080.000	1	[99]



## 6. PROGRAMMABLE PARAMETERS

There are 37 stored parameters (46 for brushless units) associated with each servo controller. There is a battery in the controller which will keep the parameters (and the stored program) saved for up to eight years. These parameters are used to change the way the controller and servo loop operate. To change a parameter, go to the PROGRAM mode by pressing the MODE button. Then press the **up** arrow and hold it at Step 1 for three seconds. After three seconds, the display will change to the parameter entry mode. The display will indicate:

**01 PP.nnnnn**

For brushless units the display will indicate:

**01U.nnnnnn**

Where **n** is the value of Parameter 1. Parameters are one to five digits in length and are decimal integers. If changing parameters associated with the servo loop, it is safest to do this with the servo loop off. Turn the servo loop off by pressing EMERGENCY STOP. To exit from parameter entry mode, either press the MODE button to go to RUN mode or push the **down** arrow key until you return to Step 1.

The **up** arrow key is used to select the next higher numbered parameter and the **down** arrow key is used to select the next lower numbered parameter. Pressing the **up** arrow, **down** arrow, or MODE keys will cause an entered parameter to be stored.

Most parameters have particular values to which they must be assigned to gain an intended result. There are several parameters, however, which give numbers to add, such as +1. With these parameters, start at zero and add the value for each option you would like.

Some of the parameters are protected from being changed by the user. This is because they could result in unstable or unsafe servo operation. If you need to change any of these parameters, call HAAS Automation.

### 6.1 GEAR COMPENSATION

The control has the ability to store a compensation table to correct for small errors in the worm gear. The gear compensation tables are part of the parameters. While parameters are displayed, press the **right** arrow button to select the gear compensation tables. There is a separate plus direction table from the minus direction table. Use the **right** arrow button to display the plus or minus table. The gear compensation data is displayed as:

**gP Pnnn cc** for plus table  
**G- Pnnn cc** for minus table

The **nnn** value is the machine position in degrees and the **cc** is the compensation value in encoder steps. There is a table entry every two degrees starting at 001 and going to 359. If your control has non-zero values in the gear compensation tables, it is recommended that you do not change them.

When the gear compensation tables are displayed, the **up** and **down** arrow button will select the next two degree ( $2^\circ$ ) entry and the minus (-) and numeric buttons will enter a new value. In addition to this, the JOG button may be used to adjust the compensation value. If the servo is on when changes are made, and the table is at the position corresponding to the entry changed, the servo motor will move by the adjustment amount. This is valuable in that the JOG button can be used to move the motor to a desired position.

Clearing of parameters will set all of the gear compensation tables to zero. To exit the gear compensation display, press the MODE button; this returns the control to RUN mode.

When a table is using gear compensation, the values in Parameter 11 must be set to "0".



## 6.2 PARAMETER LIST

The following is a list of the programmable parameters:  
 If the brushless software ranges are different, they will be shown in parentheses.

**Parameter 1:** CNC interface relay control, range 0 to 2

- 0: relay active during indexer motion
- 1: relay pulsed for  $\frac{1}{4}$  second at end of motion
- 2: no relay action

**Parameter 2:** CNC interface relay polarity & Aux. Relay enable, range 0 to 3

- 0: normally open
- +1: normally closed
- +2: optional relay number 2 pulsed at end of program

**Parameter 3:** servo loop proportional gain, range 0 to 255 PROTECTED!

Servo loop proportional gain.

**Parameter 4:** servo loop differential gain, range 0 to 255 (0 to 99999) PROTECTED!

Servo loop differential gain.

**Parameter 5:** double remote trigger option, range 0 to 1

When this parameter is set to 1, the remote START must be triggered twice to activate the control. When it is zero, each activation of the remote input will trigger a step.

**Parameter 6:** disable front panel START, range 0 to 1

When this parameter is set to 1, the front panel START and HOME buttons will not work.

**Parameter 7:** memory protection, range 0 to 1

When this parameter is set to 1, no changes can be made to the stored program. This does not prevent the changing of parameters.

**Parameter 8:** Disable remote start, range 0 to 1

- 1: The remote start input will not work

**Parameter 9:** encoder steps per programmed unit, range 0 to 65535 (0 to 99999)

This parameter defines the number of encoder steps required to complete one full rotation of the platter.

**For example:** An HRT with a 2000 line encoder a 72:1 gear ratio, and a final drive of 2:1 would produce:  
 $[2000 \times 4 \times (72 \times 2)] / 360 = 3200$  steps for 1 degree of motion.

**Parameter 10:** auto continue control, range 0 to 3

- 0: stop after each step
- 1: continue all looped steps and stop before next step
- 2: continue all programs until end code 99 or 95
- 3: repeat all steps until stopped manually

**Parameter 11:** reverse direction option, range 0 to 3 PROTECTED!

This parameter consists of two flags used to reverse the direction and the motor drive and encoder. Start with a zero and add the number shown for each of the following selected options:

- +1 Reverse the direction of positive motor motion
- +2 Reverse the polarity of motor power

Changing both flags to the opposite state will reverse the direction of motor motion.

Parameter 11 **must** be set to zero if the indexer is using gear compensation.

**Parameter 12:** display units and precision, range 0 to 6

0: degrees and minutes (circular)

Use this setting to program four digits of degrees up to 9999 and two digits of minutes.

1: inches to 1/10 (linear)

2: inches to 1/100 (linear)

3: inches to 1/1000 (linear)

4: inches to 1/10000 (linear)

5: degrees to 1/100 (circular)

Use this setting to program four digits of degrees up to 9999 and two digits of fractional degrees to 1/100.

6: degrees to 1/1000 (circular)

Use this setting to program three digits of degrees up to 999 and three digits of fractional degrees to 1/1000.

**Parameter 13:** maximum positive travel, range 0 to 65535 (0 to 99999)

This is the positive travel limit in **units\*10**. It applies only to linear motion (i.e. Parameter 12=1,2,3, or 4). If it is set to 1000, positive travel will be limited to 100 inches.

**Parameter 14:** maximum negative travel, range 0 to 65535 (0 to 99999)

This is the negative travel limit in **units\*10**. It applies only to linear motion (i.e. Parameter 12=1,2,3, or 4).

**Parameter 15:** backlash amount, range 0 to 99

This parameter is used to correct for backlash in the mechanical part of a system. It is in units of encoder steps.

**Parameter 16:** auto continue dwell, range 0 to 99

This parameter causes a pause at the end of a step when the automatic continuation option is used. The delay is in multiples of 1/10 second. Thus, a value of 13 will give 1.3 seconds of delay.

**Parameter 17:** servo loop integral gain, range 0 to 255 PROTECTED!

Servo integral gain. In addition to the range of 0 to 255, if the integral is to be disabled during deceleration (for less overshoot), set Parameter 24 accordingly.

**Parameter 18:** acceleration, range 0 to 30000 (0 to 999999x100) PROTECTED!

This parameter defines how fast the motor is accelerated up to the desired feed rate. The value used in **(par 18)\*100** in encoder steps/second/second. The highest acceleration is thus 3000000 steps per second per second. It must be greater than or equal to Parameter 19.

**Parameter 19:** maximum feed, range 0 to 10000 (0 to 999999x100)

This parameter defines the maximum feed rate. The value used is **(par 19)\*100** in encoder steps/second. The highest speed is therefore 1,000,000 steps per second. It must be less than or equal to Parameter 18. If this parameter exceeds Parameter 36, only the smaller number is used. See Parameter 36 also.

**Parameter 20:** gear ratio divider, range 0 to 100 PROTECTED!

This parameter can be used to select non-integer gear ratios for Parameter 9. If Parameter 20 is set to 2 or more, Parameter 9 is divided by Parameter 20 before it is used. **As an example**, if Parameter 9=2000 and Parameter 20=3, the number of steps per unit will be  $1000/3 = 666.667$ . This allows for fractional gear ratios. If this parameter is set to 0 or 1, no change is made to the Parameter 9 value.

**Parameter 21:** RS-232 interface axis select, range 0 to 9

When this parameter is zero, no remote RS-232 functions are available. When it is 1 to 9, that number is used to define the axis code for this controller. U is 1, V is 2, W is 3, X is 4, Y is 5, and Z is 6. 7 through 9 are other ASCII character codes.

**Parameter 22:** maximum allowed servo loop error, range 0 to 4000 (0 to 99999) PROTECTED!

When this parameter is zero, no maximum error limit test is applied to the servo. When it is non-zero, that number is the maximum allowed error before the servo loop is turned off and an alarm generated.

**Parameter 23:** fuse level in %, range 0 to 100 PROTECTED!

This parameter is used to define a fuse level for the servo control loop. The value is a percentage of maximum power level available to the controller. It has an exponential time constant of about 30 seconds. If exactly the set level is output by the driver continuously, the servo will shut off after 30 seconds. Twice the set level will shut the servo off in about 15 seconds. This parameter is factory set and is usually set from 25% to 40%, depending on the product. This auto shut-off results in a display of:

**Hi LoAd****Parameter 24:** general purpose flags, range 0 to 1023 (0 to 959) PROTECTED!

This parameter consists of five individual flags for controlling servo functions.

- +1: Interpret Parameter 9 as twice entered value
- +2: Disable integral while decelerating (see Parameter 17)
- +4: Disable integral when brake is engaged (see Parameter 17)
- +8: Protection of parameters enabled (see Parameter 30)
- +16: Serial interface disabled
- +32: Start-up "HAAS" message disabled
- +64: Lower lag in compensation
- +128: Disable Z channel encoder test
- +256: Normally closed overtemp sensor
- +512: Disable cable test

**Parameter 25:** brake release time, range 0 to 19 PROTECTED!

If this parameter is zero, the brake is not activated (i.e. always engaged); otherwise this is the delay time to release the air before the motor is started in motion. It is in units of 1/10 second. A 5 will thus delay for 5/10 second.

**Parameter 26:** RS-232 speed, range 0 to 8

This parameter is used to select data rates on the RS-232 interface. The parameter values and rates are:

0:	110	5:	4800
1:	300	6:	7200
2:	600	7:	9600
3:	1200	8:	19200
4:	2400		

**Parameter 27:** automatic home control, range 0 to 255 (0 to 512) PROTECTED!

This parameter is used to customize home control function of servo.

0:	no automatic home functions available
1:	only table zero position switch available
2:	only Z channel home available
3:	home on both Z channel and table zero switch
+4:	home if inverted Z
+8:	home in negative direction
+16:	home in positive direction
+24:	home in shortest direction
+32:	auto servo on at power on
+64:	auto home at power on
+128:	for inverted HOME switch
+256:	search for home in positive direction

**Parameter 28:** encoder steps per motor revolution, 0 to 10000 (0 to 99999) PROTECTED!

This parameter is used with the Z channel option to check the encoder accuracy. If Parameter 27 is 2 or 3, this parameter is used to check that the correct number of encoder steps are received per revolution.

**Parameter 29:** Back-EMF compensation, 0 to 999 (not used for brushless software)PROTECTED!

This parameter is used to control the adjustment of loop gain in response to motor generated back-EMF. It is **volts/Krpm times 10**.

**Parameter 30:** Protection, 0 to 65535

This parameter is used to protect some of the other parameters. Every time the controller is turned on, this parameter will have a new, random, value. If protection is selected (Parameter 24), the protected parameters cannot be changed until this parameter is set to a different value that is a function of the initial random value.

**Parameter 31:** CNC Relay Hold Time (0 to 9)

This parameter is used to specify the amount of time the CNC interface relay is held active at the end of a step. If zero, the relay time is  $\frac{1}{4}$  second. All other values give the time in multiples of 0.1 second.

**Parameter 32:** delay time for engaging brake, (0 to 9) PROTECTED!

This parameter is used to set to amount of time delay between the end of a motion and engaging the air brake. It is in units of 1/10 seconds. A '4' will thus delay for 4/10 second.

**Parameter 33:** X-on/X-off Enable, (0 or 1)

This parameter is used to enable the sending of the X-on and X-off codes via the RS-232 interface. If your computer needs these, this parameter should be set to 1. Otherwise, only the RTS and CTS lines can be used to synchronize communication.

**Parameter 34:** belt stretch adjustment, (0 to 99) PROTECTED!

This parameter is used to correct for stretching in a belt if one is used to couple the motor to the load being moved. It is a count of the number of steps of motion that are added to the motor position while it is in moving. It is always applied in the same direction as the motion. Thus, when motion stops, the motor will snap backwards to take the load off of the belt.

**Parameter 35:** dead zone compensation, (0 to 19) PROTECTED!

This parameter is used to compensate for the dead zone in the driver electronics. It is normally set to 3.

**Parameter 36:** maximum speed, range 0 to 10000 (0 to 999999x100) PROTECTED!

This parameter defines the maximum feed rate. The value used is **(par 36)\*100** in encoder steps/second. The highest speed is thus 1,000,000 steps per second. It must be less than or equal to Parameter 18. If this parameter exceeds Parameter 19, only the smaller number is used. See Parameter 19 also.

**Parameter 37:** encoder test window size, range 0 to 999

This parameter defines the tolerance window for the Z channel encoder test. This much error is allowed in the difference between the actual encoder position and the ideal value when the Z channel is encountered.

**The following parameters are for brushless motors:****Parameter 38** KDD (0 to 9999)

Servo loop second differential gain.

**Parameter 39** Phase offset (0 to 9)

Offset of encoder Z-pulse to zero degree of phasing.

**Parameter 40** Max current (0 to 2046)

Maximum peak current output to the motor. Units DAC bits.

**Parameter 41** Not used (0 to 537289)**Parameter 42** KLAG (0 to 3)

Filter coefficient for the output current.

0 is 0% of 65536

1 is 50% of 65536 or 0x8000

2 is 75% of 65536 or 0xC000

3 is 7/8 of 65536 or 0xE000

**Parameter 43** EREV PER MREV (1 to 9)

Number of electrical revolutions of the motor per one mechanical revolution.

**Parameter 44** ACCEL\_CONST (0 to 999)

Exponential acceleration time constant. Units are 1/10000 seconds.

**Parameter 45** Grid Offset (0 to 99999)

The distance between the home switch and the final stopped motor position after homing, is added by this grid-offset amount. It is modulus of parameter 28, which means if Parameter 45=32769 and Parameter 28=32768, then it is interpreted as 1.

**Parameter 46** Not used (0 to 9)



## 7. HRT TROUBLESHOOTING

### 7.1 TROUBLESHOOTING A WORKING INTERFACE ON A CNC

If you are having problems with an interface, try to isolate the problem by checking the HAAS control and your CNC separately. There are only two signals and each one can be checked separately from the other. If your unit stops indexing because of an interface problem, here are some simple checks to follow:

#### 1) Check The HAAS Control Remote Input Alone

Disconnect the remote cable from the back of the controller. Set the control to index a single step of **90 degrees** (90°). Referring to Figure 2, connect a continuity tester or a voltmeter (a digital meter may not be fast enough to sample the brief pulse) set for low ohms across pins 1 and 2. They are marked on the rear of the control as FINISH SIGNAL. Since this is a female plug, you may have to insert some small wires in the plug in order to make a connection but, in any case, it is imperative that a good connection is made. It must show open circuit, otherwise check relay Parameters #1 (should be 1) and #2 (should be 0). (With the control turned off, the relay must show open circuit, otherwise it is defective.) Now, using a wire jumper, short pins 3 and 4 together (They are marked on the rear of the control as CYCLE START.). The unit must index, and at the end of the index, the voltmeter should deflect briefly towards low ohms or continuity. If this works as described, then you know the problem is not in the HAAS control, but possibly in the interface cable or your CNC.

#### 2) Check CNC Cable Interface Alone

You can check the signals from the CNC using a voltmeter, keeping in mind that the pin orientation is reversed. Execute an **M** function from your CNC to index. The CNC cycle start light should come on and stay on. Use the meter and check continuity across the cycle start pins (pins 3 and 4). Try not to short your test leads and pins against the shield of the male plug.

**NOTE:** On rare occasions, some machine builders provide a +12 to +24 volt signal on pin 4 to activate our unit. If the continuity test fails, check and see if there is a voltage present between pin 4 and the machine ground. This is also a valid cycle start signal. If there is a voltage present on pin 4 when checked with a voltmeter; a Haas Interface Box must be used (P/N IB). Contact the Haas Service department if there are questions on how to use the interface box.

To check out the cycle finish, take one of your voltmeter test probes and short together pins 1 and 2 on your CNC cable. The cycle start light on your CNC should immediately turn off.

If the above tests (1 and 2) pass, you have valid signals coming from your CNC.

#### 3) Check The HAAS Control And CNC Together

Reset your CNC by hitting the RESET button or turning it off. With both the CNC and HAAS controls ON, connect the remote cable. Nothing should happen. If the HAAS should index, then the cycle start signal from the CNC is shorted on. If OK, execute or MDI an **M** function from your CNC to index. Don't index from the program unless you are single-blocking it. If the HAAS unit does not index, then your CNC is not outputting a signal or there is a break in the line.

If the HAAS unit indexes properly, observe that the machine's cycle start light goes out at the end of index. (Make sure that this light isn't burned out.). If the light does not go out then the cycle finish signal is not getting back to your CNC. This could be an open wire in the remote cable or a problem in the wires that connect to the CNC.

If the unit works only in single block, but not in the RUN mode, then you're probably having a timing problem involving two **M** functions or are doing simultaneous milling. Please review the section on simultaneous milling. If you have two **M** functions, separate them with a dwell of  $\frac{1}{4}$  second.

**7.2 TROUBLESHOOTING GUIDE**

SYMPTOM	PROBABLE CAUSES	REMEDY
Unit is turned on but the power switch is not illuminated.	① Control is not receiving power.	① Check power cord, line fuse, and AC supply.
Unit will not index. Display reads <b>AIR-HOT</b>	① Table is over maximum operating temperature (See HI-LOAD). ② Conduit not connected to control box.	① Allow motor to cool down. If this occurs often, consult HAAS Service Dept. ② Make sure power is OFF and attach conduit to control box.
Front panel <b>START</b> and <b>ZERO RETURN</b> buttons don't work.	① In PROGRAM mode, or Parameter 6 is set to 1.	① Change Parameter 6 to 0. Set to <b>RUN</b> mode.
<b>ERROR</b> displays when trying to program.	① Parameter 7 is set to 1.	① Change Parameter 7 to 0.
<b>Lo Volt</b> or <b>Por On</b> appears while running, or erratic operation.	① Power available to control is inadequate.	① Power source must be capable of 15 amps at 120V AC. Use shorter/ heavier gauge cord.
Indexer runs through entire program without stopping.	① Parameter 10 is set to 3.	① Change Parameter 10 to 0.
<b>High current (Hi Curr)</b>	① Brake does not release  ② Heavy work load ③ Fixture/workpiece is distorted  ④ Coolant-damaged conduit box ⑤ Shorted motor	① Examine brake solenoid valve, and replace if necessary. Air line kinked or exhaust muffler restricted.  ② Reduce feed.  ③ Ensure fixture workpiece mounting surface is flat within .001".  ④ Examine conduit box, and replace if necessary.  ⑤ Consult Haas Service Department
<b>Ser-Err</b> (Servo Error) during first home find initiation.  <b>Ser-Err</b> (Servo Error) upon indexing.	① Faulty main cable or cable connector.  ② Table driving a heavy load. ③ Table is jammed. ④ Check Parameter 25.  ⑤ Head is jammed	① Check cable and motor fuse.  ② Reduce workload weight and/or feed rates. ③ Eliminate obstruction. ④ Must be set to <b>8</b> for HRT 160, 210, 450 ( <b>19</b> for HRT 310) ⑤ Eliminate obstruction
<b>High load (Hi LoAd)</b>	① Fixture or workpiece is distorted.  ② Tailstock or workpiece support not properly aligned. ③ Heavy Workload	① Ensure fixture workpiece mounting surface is flat within .001".  ② Align tailstock or support to table within .003 TIR.  ③ Reduce Feed
<b>Workpiece Chatter</b> during index cutting operation.  <b>Workpiece Chatter</b> during continuous cutting operation.	① Brake not operative.  ① Excessive backlash. ② Excessive wormshaft play.	① Consult HAAS Service Dept.  ① Consult HAAS Service Dept. ② Consult HAAS Service Dept.



SYMPTOM	PROBABLE CAUSES	REMEDY
<b>HRT (A6)</b> Dead length collets sticking, and/or insufficient clamping force.	① Excessive spindle/collet friction.	① Lubricate spindle and collet with a Molybdenum disulfide grease.
Air leaking around rear brake disc.	① Chips blown in between O-ring and brake disc.	① Contact HAAS Service Dept. (Do Not use air gun around rear brake disc). See section 8.5.



## 8. ROUTINE MAINTENANCE

The HAAS rotary tables require very little routine servicing. However, it is very important to perform these services to ensure reliability and long operating life.

### 8.1 INSPECTION OF THE TABLE

To ensure that the table will perform accurately, there are a few points of inspection that should be performed occasionally. There are basically two points of interest when inspecting the table: the platter runout and backlash.

**Platter Runout:** To check the platter runout, mount an indicator to the body of the table. Position the indicator on the platter face. Index the table **360 degrees** ( $360^\circ$ ). The runout should be .0005 or less.

**Worm Play:** Worm play will show up as backlash at the platter. Therefore, worm play must be measured before meaningful backlash measurements can be made. Remove the air supply to the table. First drain the oil, then remove the worm housing cover from the side of the table. Mount a tenths indicator to the table body with the sensing arm on the exposed end of the worm. Use an aluminum bar to rock the platter back and forth. There should be no detectable reading. Not applicable for the HRT210SHS.

**Backlash Between Worm And Gear:** After the worm play near the outside edge of the platter is checked, the backlash can be measured. The air must be disconnected from the table for this. Mount a magnet on the platter of the table. Use a tenths indicator to measure the backlash. Take your reading off the magnet at a 4" radius. Use the aluminum bar to rock the platter back and forth. Read the amount of backlash from the indicator; it should be between .0002 and .0006. Not applicable for the HRT210SHS.

**Backlash In The System:** Connect the air to the table. Index the table in the negative direction **360 degrees** ( $360^\circ$ ). Place the indicator at the edge of the platter. Program a .001 degree (.001°) move into the controller. Cycle the rotary table at this .001 degree (.001°) move until you detect movement with the indicator. Read the amount of backlash in the system from the readout. Not applicable for the HRT210SHS.

### 8.2 ADJUSTMENTS TO THE TABLE

The platter runout and worm play are set at the factory and should not need to be readjusted. If the platter runout or worm play are out of adjustment, contact HAAS for information.

**Backlash Between Worm And Gear:** Contact HAAS Service department for details.

**Backlash In The System:** The backlash in the system can be compensated for by the use of Parameter 15. Contact HAAS service department for details.

**8.3 USE OF OIL- AND WATER-SOLUBLE COOLANTS**

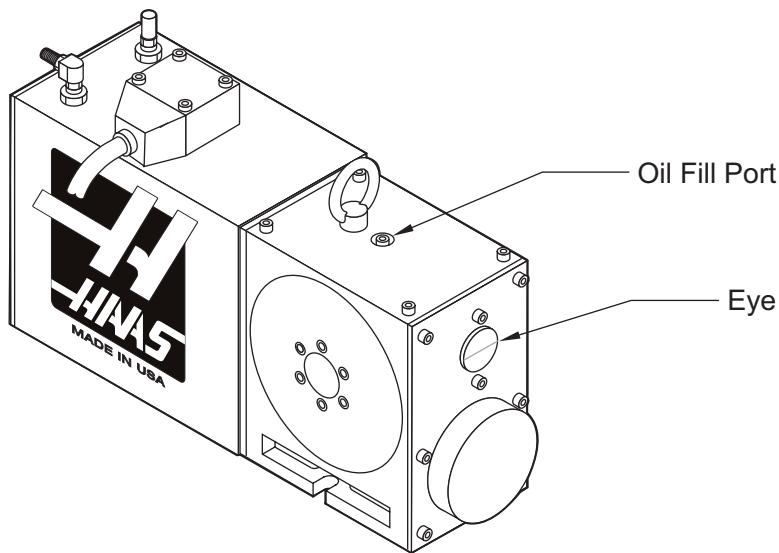
For the use of oil- and water-soluble coolants the following guidelines should be observed:

- **DO NOT SUBMERGE THE UNIT IN COOLANT.** Keep the coolant lines on the work piece spraying away from the rotary table. Tool spraying and spatter will not be detrimental to the unit.
- Inspect the cables and gaskets for cuts or swelling. Damage must be repaired immediately.

**8.4 LUBRICATION**

To check the lube level of the Rotary Table, view the level of lube visible in the eye with the Table stopped. The eye is located on the side panel of the Table. The lube level should reach the middle of the eye. If necessary, add lube until the level reaches the mid-point of the eye.

To add lube to the Rotary Indexer, locate and remove the pipe plug from the lube fill port. This is located on the top plate above the eye (see Figure below). Add Mobile SHC-630 oil until the proper level is reached. Replace the fill port bolt and tighten.



*Fill Port location for Rotary Table*

**8.5 CLEAN UP**

At the end of the workday or shift, it is important to clean the rotary table. The table should be free of any chips or grime. Clean with a chip brush and apply a coat of a rust preventative. **Do not use air gun around front or rear seals.** Chips may damage seal if blown in with an airgun.

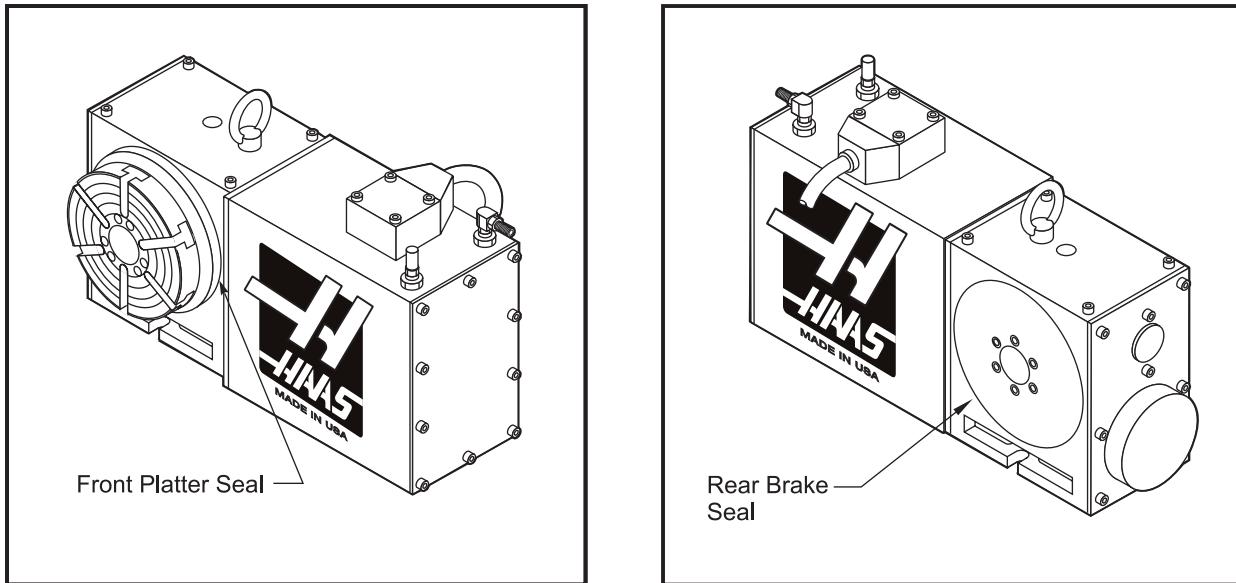
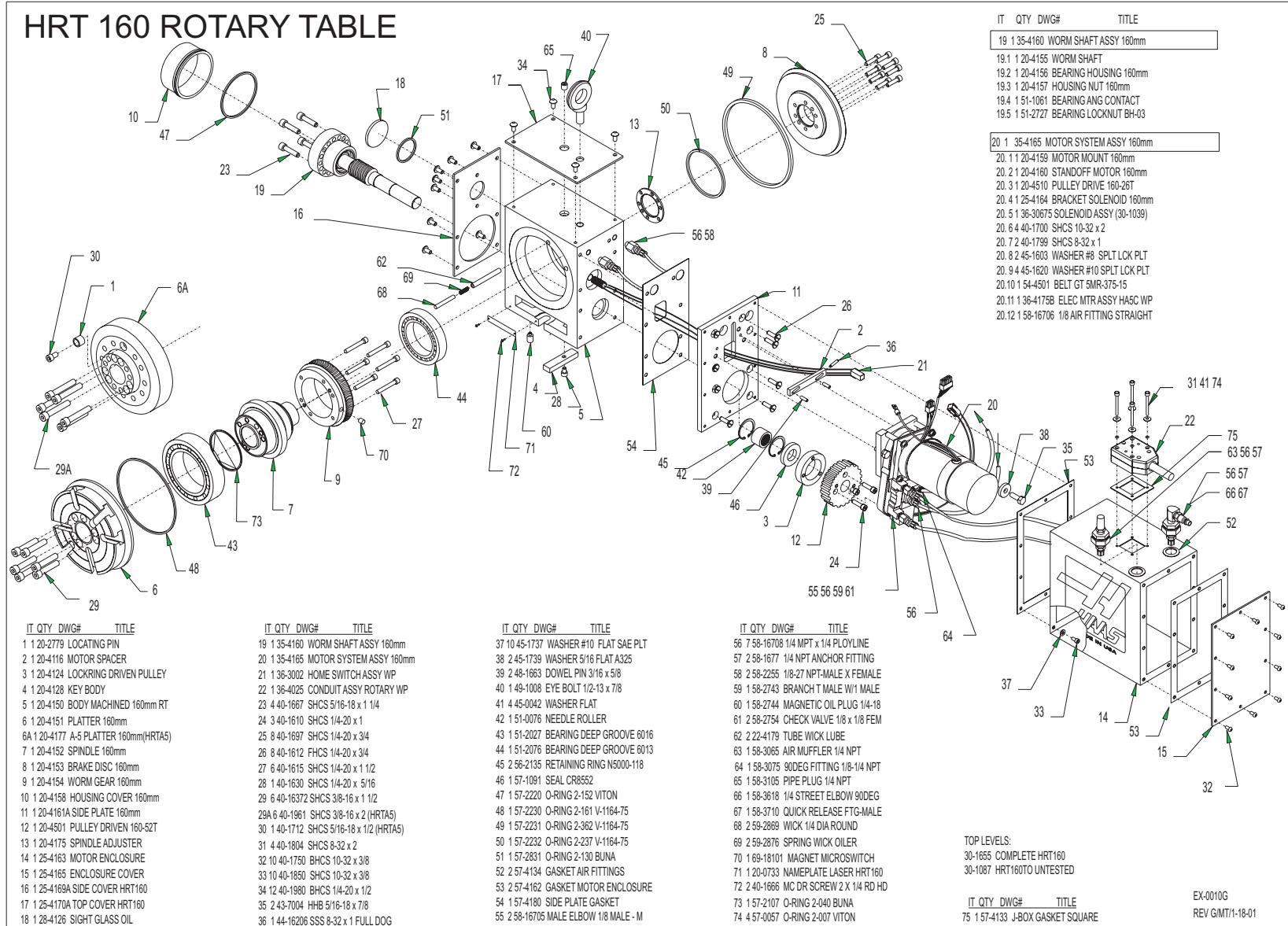


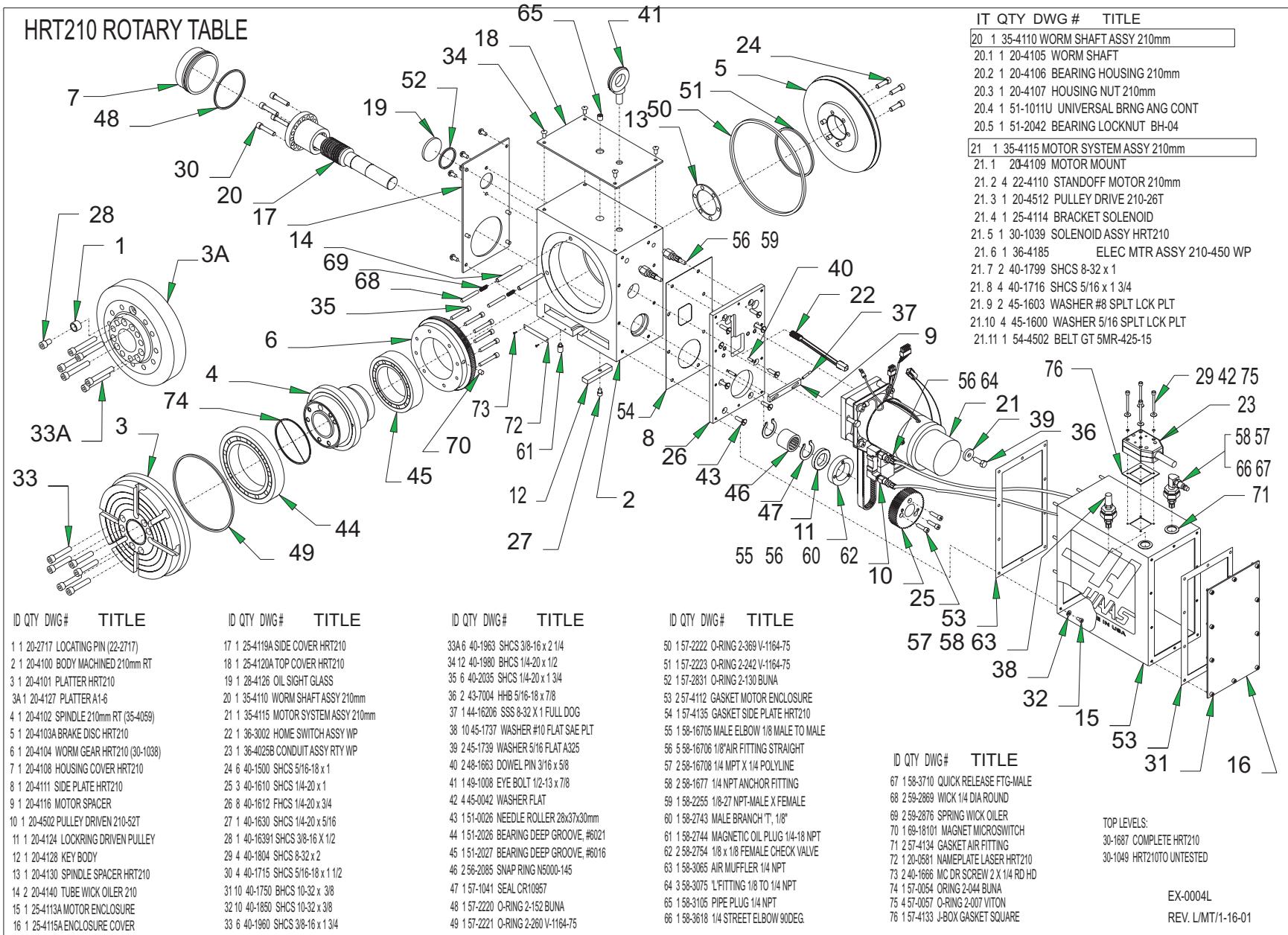
Figure 8.1. Front and Rear Seals for HRT.



Note: All rotary tables use Polyurethane tubing for all air lines. Specifications are: 1/4 O.D. x .160 I.D. 95A Durometer.

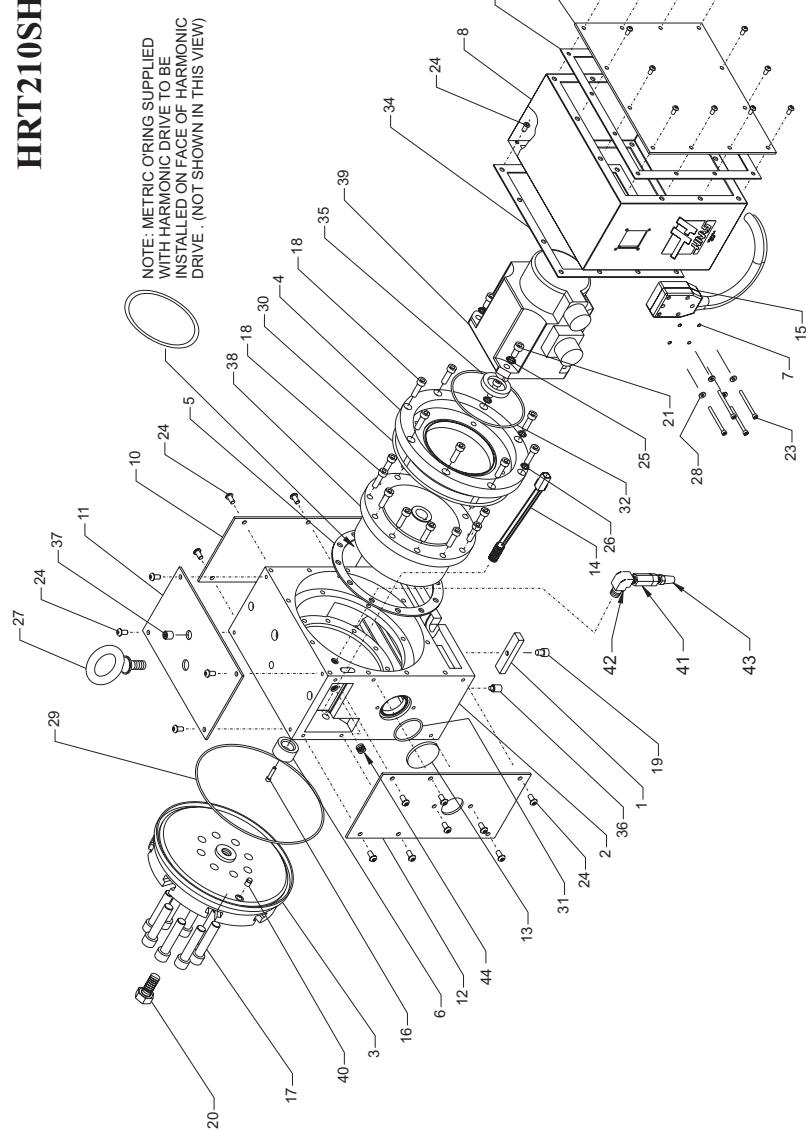
# HRT HAS ROTARY TABLE

**OPERATOR'S MANUAL**

**HMS**

Note: All rotary tables use Polyurethane tubing for all air lines. Specifications are: 1/4 O.D. x .160 I.D. 95A Durometer.



**HRT210SHS**

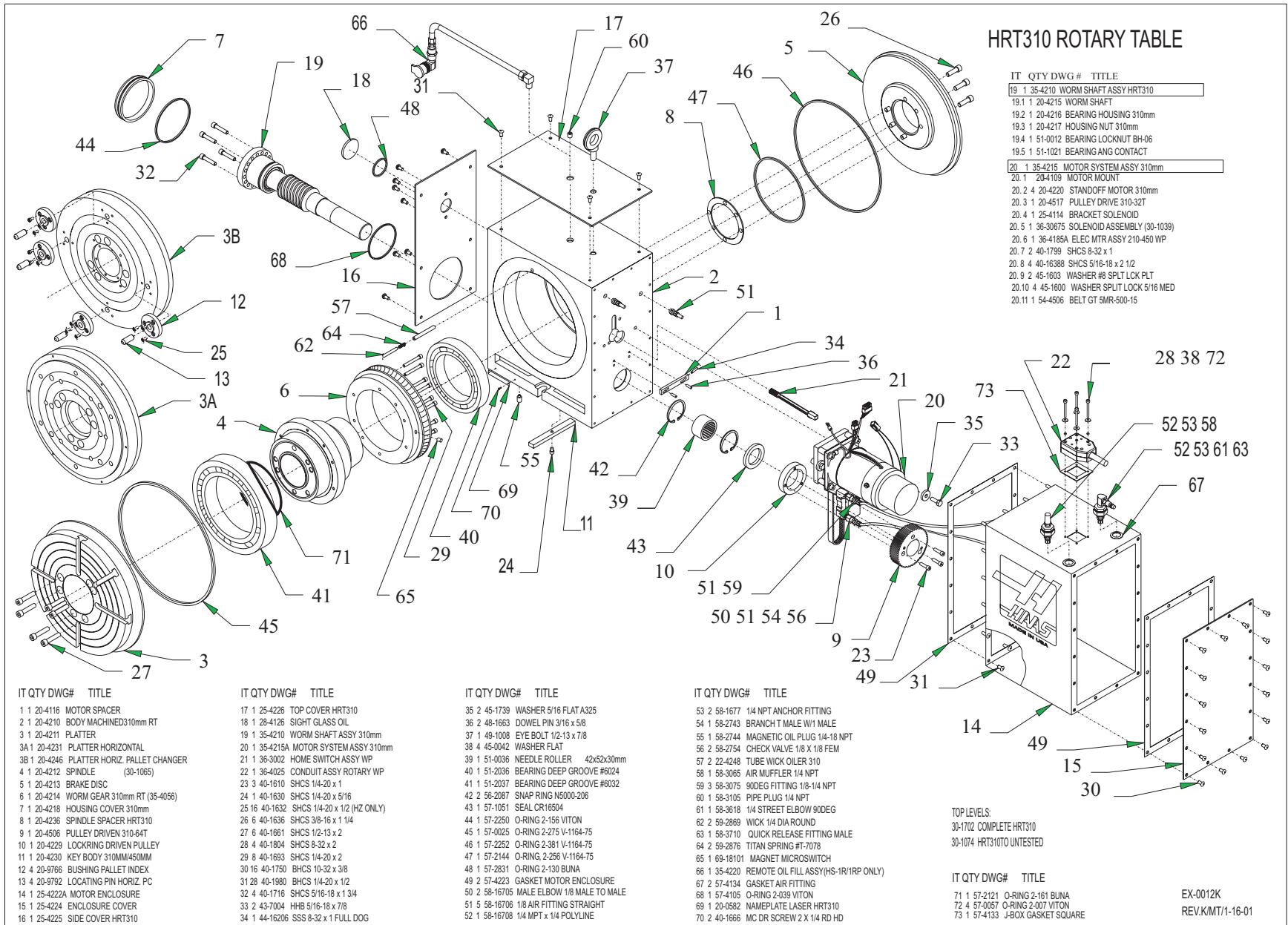
ID	QTY	DWG#	TITLE
1	1	204128	KEY, BODY
2	1	20-4520	BODY MACHINING
3	1	20-4521	PLATTER, HRT210SHS
4	1	20-4522	MOTOR MOUNT, HRT210SHS
5	1	20-4523	DRIVE SPACER
6	1	20-4531	RETENTION CAP
7	4	57-0057	O-RING 2-007 VITON
8	1	25-4524	MOTOR ENCLOSURE
9	1	25-4525	ENCLOSURE COVER
10	1	25-4526	SIDE COVER-A
11	1	25-4528	TOP COVER
12	1	25-4527	SIDE COVER-B
13	1	28-4126	OIL SIGHT GLASS
14	1	36-3002	MICRO SWITCH ASSY
15	1	36-4029B	BL 05 CABLE WP 14'
16	1	43-1651	MSHCS, M5 X 16
17	8	40-0100	MSHCS, M12 X 45
18	24	40-1500	SHCS, 5/16-18 X 1
19	1	40-1630	SHCS, 1/4-20 X 5/16
20	1	43-0015	HHB 1/2-13 X 1 SELF SEALING
21	4	40-16385	SHCS, 5/16-18 X 3/4
22	12	40-1750	BHCS, 10-32 X 3/8
23	4	40-1804	SHCS, 32 X 2
24	30	40-1980	BHCS, 1/4-20 X 1/2
25	4	45-0039	WASHER BRASS .328 ID X WASHER BRASS .562 O.D.
26	3	45-0047	WASHER BRASS 0.314 I.D. X WASHER BRASS 0.420 O.D.
27	1	49-1008	EYE BOLT, 1/2-13 X 7/8
28	4	45-0042	WASHER, #8 SEALING S.S.
29	1	57-2221	O-RING 2-260 VITON
30	1	57-2127	O-RING, 2-166

ID	QTY	DWG#	TITLE
31	1	57-2831	O-RING, 2-130 BUNA
32	1	57-2875	O-RING, 2-157 BUNA
33	1	57-4529	GASKET, ENCLOSURE COVER
34	1	57-4530	GASKET, MOTOR ENCLOSURE
35	1	57-4533	SEAL CR11615
36	1	58-2744	MAGNETIC OIL PLUG 1/4-18
37	1	58-3105	PIPE PLUG 1/4 NPT
38	1	59-4532	HARMONIC DRIVE, 50:1
39	1	62-0014	YASKAWA SIGMA MOTOR 09
40	1	69-18101	MAGNET, MICRO SWITCH
41	1	58-2754	1/8 X 1/8 FEMALE CHECK VALVE
42	1	58-16705	MALE ELBOW, 1/8
43	1	58-2262	AIR MUFFLER, CENTERED
44	1	58-16277	1/8-27 PIPE PLUG

EX-0028  
REV B 4-4-00

# HRT HAS ROTARY TABLE

## ASSEMBLY DRAWINGS



Note: All rotary tables use Polyurethane tubing for all air lines. Specifications are: 1/4 O.D. x .160 I.D. 95A Durometer.



ASSEMBLY DRAWINGS

# HRT HAS ROTARY TABLE

## OPERATOR'S MANUAL

June 2001

HRT450 ROTARY TABLE															
ITEM HRT450TO 450MM ROTARY TABLE ONLY QTY															
1	20-4116	MOTOR SPACER	1	22	36-4026B	CONDUIT ASSY RTV WP 18.5'	1	43	49-1663	DOWEL PIN 3/16 X 5/8	2	64	58-16706	1/8 AIR FITTING STRAIGHT	9
2	20-4230	KET BODY 310MM/450MM	1	23	40-180	SHCS 1/4-20 X 1	3	44	49-1608	EYE BOLT 1/2-13 X 7/8	1	65	58-16707	LOCK WASHER 1/2-13 NPT	1
3	20-4250	BODYSKINNED 450MM RT	1	24	40-180	SHCS 1/4-20 X 1/2	1	45	49-1616	NEEDLE BEARING 1/2-13	4	66	58-16708	14 NPT ANCHOR FLANGE	1
4	20-4251	PLATTER	1	25	40-1632	SHCS 1/4-20 X 1/2	16	51-0077	NEEDLE ROLLER 450MM WORM	4	67	57-4133	J-BOX GASKET SQUARE	1	
5	20-4253A	FLEX BRAKE 450MM RT	1	26	40-16385	SHCS 1/16-18 X 3/4	10	47	51-2038	BRNG CROSS ROLLER RB345	1	68	58-2255	1/8-27 NPT MALE X FEMALE	1
6	20-4508	PULLEY DRIVEN 450-787	1	27	40-16391	SHCS 3/8-16 X 1/2	1	48	56-2026	RETAINING RING N5000-244	1	69	58-2262	AIR MUFFLER CENTERED BRO	1
7	20-4504	LEADERSHIP 450MM/450MM	1	28	40-1639	SHCS 3/8-16 X 1/4	6	49	50-1600	SHCS 3/8-16 X 1/4	1	70	58-2263	AIR REGULATOR CENTERED BRO	2
8	25-4258	BEARING HOUSING CVR 450MM	1	29	40-1638	SHCS 3/8-16 X 4	6	50	57-0025	O-RING 2-275 V164-75	1	71	58-2743	MALE BRANCH T 1/8 INCH	1
9	25-4265	MOTOR ENCLOSURE	1	30	40-1679	SHCS 1/4-20 X 2 1/2	8	51	57-0094	O-RING 2-384 VITON	1	72	58-2744	MAGNETIC OIL PLUG 1/4-18	1
10	25-4266	ENCLOSURE COVER	1	31	40-1696	SHCS 1/4-20 X 4 1/2	2	52	57-0097	O-RING 2-162 VITON	1	73	58-2754	CHECK VALVE 1/8 X 18 FEM	4
11	25-4267	SIDE PLATE	1	32	40-1800	BUSHING 1/2-13 X 3/8	2	53	58-16709	O-RING 2-162 VITON	1	74	58-2755	AIR FILTER 1/4 NPT	1
12	25-4268A	TOP COVER HRT450	1	33	40-1804	SHCS 8-32 X 2	4	54	57-0101	O-RING 2-273 V164-75	1	75	58-3105	PIPE PLUG 1/4 NPT	1
13	25-4126	SIGHT GLASS OIL	1	34	40-1969	SHCS 3/8-16 X 1 3/4	22	55	57-2086	SEAL CR19066	1	76	58-3616	1/4 STREET ELBOW 90DEG	1
14	26-4278	SIGHT GLASS PRESSURE GAUGE	1	35	40-1980	SHCS 1/4-20 X 1/2	4	56	57-2211	O-RING 2-012 VITON	1	77	58-3670	1/4 NPT 1/8 F REDUCER	2
15	35-4254	SPINDLE GEAR ASSY 450	1	36	40-1980	SHCS 1/4-20 X 1/2	3	57	58-16705	O-RING 2-164-75	1	78	58-2055	QUICK RELEASE PLATE-TG-MALE	1
16	35-4200	MOTOR SYSTEM ASSY 450MM	1	37	44-1620	SSS 8-32 X 3/4 FULL DOG	1	58	57-2831	O-RING 2-130 BUNA	1	79	59-2055	3/8 STEEL BALLS	1
17	35-4245	MOTOR SHAFT ASSY 450MM	1	38	44-1696	SSS 1/2-13 X 3/4 FULL DOG	1	59	57-4134	GASKET AIR FITTINGS	2	80	59-2058	BALL 1/4 STEEL	1
18	35-4250	ACOUSTIC BODY	1	39	45-1700	WASHER 1/4-20 FLAT SAE PLT	16	60	57-4250	GASKET 1/4-20 FLAT SAE PLT	2	81	59-2059	SPRING 1/4 X 4 7/16	1
19	35-4260	CHECK VALVE ASSY	1	40	45-1730	WASHER 3/8-16	1	61	58-1779	GASKET SIGHT GLASS	1	82	69-18101	MAGNET MICROSWITCH	1
20	35-4260	HYDRAULIC CYLINDER ASSY	1	41	45-1850	WASHER 1/4 FENDER PLT	4	62	58-0058	O-RING 2-014 VITON	1	83	78-1993	SPIRALLY-CUT CBL WRAP 1/4	3
21	36-3002	HOME SWITCH ASSY WP	1	42	46-1625	NUT 1/4-20 HEX BLK	4	63	58-16705	MALE ELBOW 1/8 MALE - M	1	84	40-1666	MC DR SCREW 2 X 1/4 RD HD	2
ITEM 16 PART NO. DESCRIPTION QTY															
35-4200	MOTOR SYSTEM ASSY 450mm														
ITEM 16	PART NO.	DESCRIPTION	QTY												
25-4114	BRACKET SOLENOID	1													
36-3010	GROUND WIRE ROTARY	1													
40-1799	SHCS 3/2 X 1	2													
22-4110	STANDOFF MOUNT FOR 210mm	4													
20-4512	MOTOR MOUNTING PLATE	1													
20-4512	PULLEY DRIVE 210-267	1													
36-30675	SOLENOID ASSY WP	1													
36-4185A	ELEC MOTOR ASSY 210-450 WP	1													
40-1770	SPRING 1/4 X 4 7/16	4													
45-1603	WASHER #8 SPLIT LCK PLT	2													
54-5058	BELT GT 5MR-800-15	1													
ITEM 17 PART NO. DESCRIPTION QTY															
35-4245	WORM SHAFT ASSY 450MM														
ITEM 17	PART NO.	DESCRIPTION	QTY												
20-4245	WORM SHAFT	1													
20-4255	BEARING HOUSING	1													
20-4257	HOUSING NUT	1													
51-1013	BEARING ANG CONTACT	1													
51-2043	BEARING LOCKNUT BH-09	1													
ITEM 18 PART NO. DESCRIPTION QTY															
35-4250	ACCUMULATOR ASSY														
ITEM 18	PART NO.	DESCRIPTION	QTY												
58-1627	1/8-27 PIPE PLUG	2													
58-16700	STREET ELBOW 1/8 INCH	1													
58-16732	1/8 X 1/8 MALE HEX JOINT	5													
58-1671	LONG NUT 1/8-27 X 1/2	1													
58-27905	AIR PRESSURE ADAPTER 1/8	2													
58-3075	90DEG FITTING 1/8-1/4 NPT	2													
58-3100	FEMALE BRANCH 1/8 NPT	1													
59-2736	AIR CYLINDER Q902-1673	1													
ITEM 19 PART NO. DESCRIPTION QTY															
58-16708	CHECK VALVE ASSY														
ITEM 19	PART NO.	DESCRIPTION	QTY												
58-16708	1/4 MPT 1/4 POLYLINE	3													
58-1682	NIPPLE 1/4 NPT 2 SST	1													
58-1734	HYD NIPPLE 1/4 NPT	1													
58-27906	PIPSER 1/4-20 0-2000 2IN	1													
58-2753	HYDRAULIC CHECK VALVE	1													
58-3695	1/4 NPT FEMALE 1	1													
ITEM 20 PART NO. DESCRIPTION QTY															
35-4260	CYL ASSY HYDRAULIC														
ITEM 20	PART NO.	DESCRIPTION	QTY												
20-4270	PRIMARY CYLINDER	1													
20-4271	PRIMARY CYLINDER 450MM	1													
20-4272	CAP ASSEMBLY	1													
20-4273	SECONDARY CYL 450MM RT	1													
20-4274	SECONDARY PISTON	1													
56-2084	RETAINING RING N5000-200	2													
56-2085	SHIM 0.005	1													
57-1036	POLYSEAL 1870-16250	1													
57-1037	WEARBOARD W2-2000-0375	1													
57-1038	POLYSEAL 12500250	1													
58-3075	90 DEGREE BEND 1/8-1/4 NPT	2													
59-2058	BALL 1/4 STEEL	1													
59-2083	SPRING 31/64 X 4 7/16	1													
ITEM HRT450TO 450MM ROTARY TABLE ONLY QTY															
1	58-16706	TOP LEVELS													
1	30-1708	COMPLETE HRT450													
1	30-1105	HRT450TO UNTESTED													
EX-0007K REV-K/MT/1-19-01															

Note: All rotary tables use Polyurethane tubing for all air lines. Specifications are: 1/4 O.D. x .160 I.D. 95A Durometer.



## 10. TAILSTOCK

### 10.1 SETUP PROCEDURES

**IMPORTANT! Warranty card should be filled out prior to operation.**

When using Servo 5c Indexers, Haas Automation recommends using **LIVE CENTERS ONLY!**

- Clean bottom surface of tailstock casting before mounting to mill table. If there are any noticeable burrs or nicks on the mounting surface, clean them with a deburring stone.

#### Tailstock Alignment

- Mount the supplied 0.625 dia. locating pins to bottom of tailstock using **1/4-20 x 1/2" SHCS**.
- Mount tailstock to **clean** mill table.
- Fasten lightly to mill table using 1/2-13 HHB, hardened tooling washers and **1/2 - 13 T-Nuts**.
- Extend the tailstock spindle from the body. Use the spindle surface to sweep the spindle center line to rotary product center line, align to within 0.003 TIR. Once aligned, tighten the two 1/2-13 hex head bolts (HHB).

#### Installation / Removal of Morse Taper Accessories

- Inspect and clean tailstock taper and tapered surface of live center.
- Apply a light coat of oil on the center before inserting into the spindle. This aids in removing the center and also prevents corrosion buildup.

#### Manual Tailstock

- Live or dead centers:** Retract the spindle into the body and the leadscrew will force the center out.

#### Pneumatic Tailstock

- Live centers:** Wedge an aluminum bar between the face of the spindle and the rear surface of the live centers' flange.
- Dead centers:** Threaded dead centers are recommended (often called N/C Dead Centers). Use a wrench to hold the center in place and turn the nut until it backs the center out from the spindle.

**10.2 TAILSTOCK OPERATION****Manual Tailstock**

1. After completing "Setup Procedures" section, the tailstock should be positioned so that after approximately 1" of spindle travel, the center comes into contact with the workpiece/fixture.
2. Once in contact, apply only enough force on the handwheel to hold the workpiece / fixture securely.

---

**NOTE:** The force required on the handwheel is similar to the force used in closing a typical garden faucet.

3. Tighten the spindle lock at this time.

**Pneumatic Tailstock**

1. Complete "Setup Procedures" section.
2. The tailstock should be positioned so that after approximately 1" of spindle travel, the center comes into contact with the work piece / fixture.
3. Use of the spindle lock is optional when using pneumatic tailstock models. Use the following guidelines to determine tailstock air pressure:

**Rotary Tables:** Normal operating range = 10-60 psi; Maximum = 100 psi  
**Servo 5c indexers\*:** Normal operation range = 5-40 psi; Maximum = 60psi

**\*LIVE CENTERS ONLY!**

**General Reference**

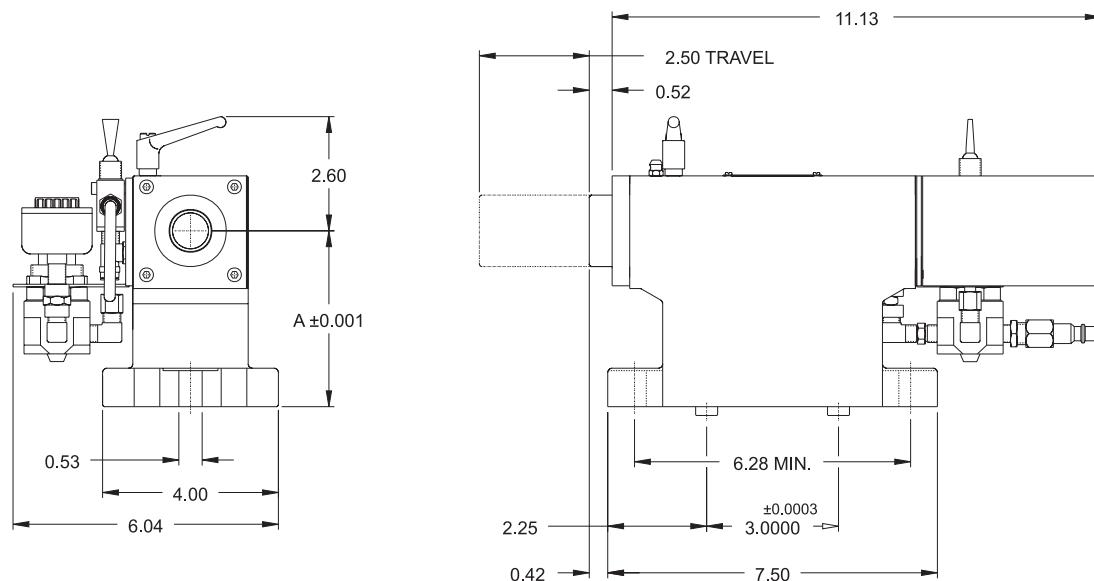
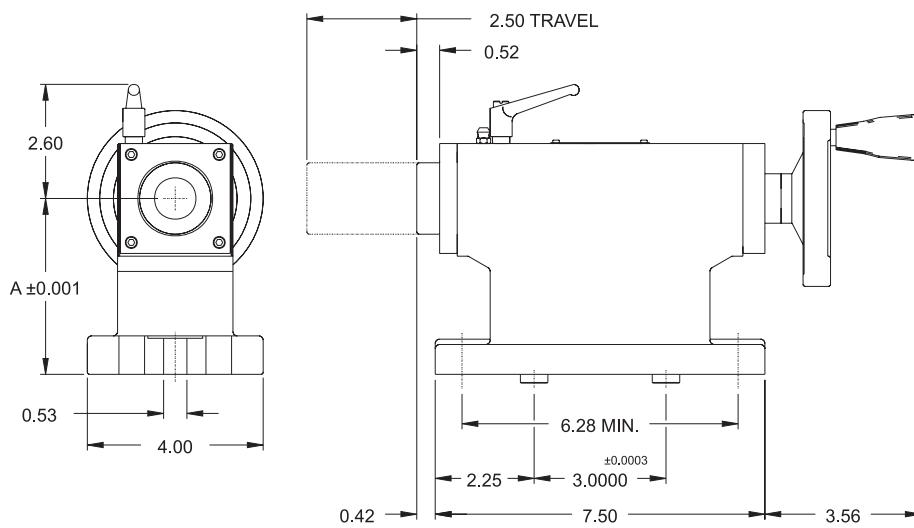
Max. Air pressure = 150 psi (lbs/sq. in.) - results in 450 lbs tailstock force  
Min. Air pressure = 5 psi (lbs/sq. in.) - results in 15 lbs tailstock force

---

**NOTE:** Excessive tailstock force and misalignment greater than 0.003 TIR will cause premature wear on the gear train and motor.

**10.3 TAILSTOCK MAINTENANCE**

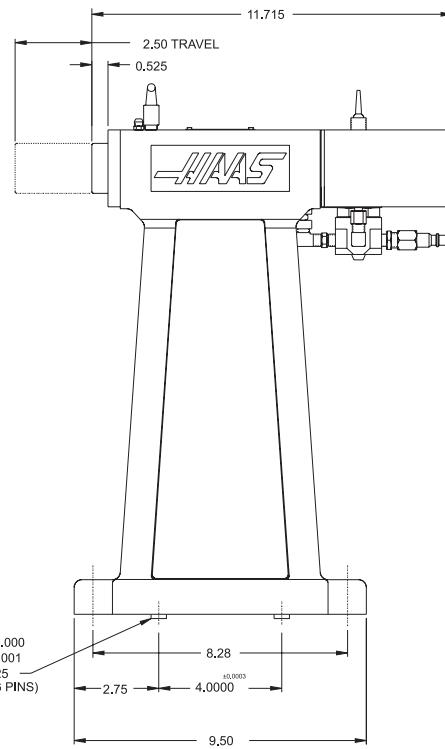
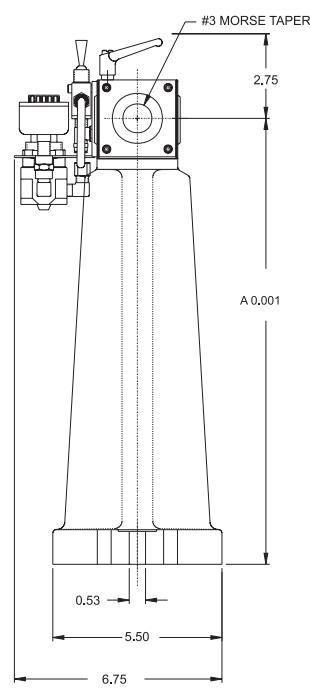
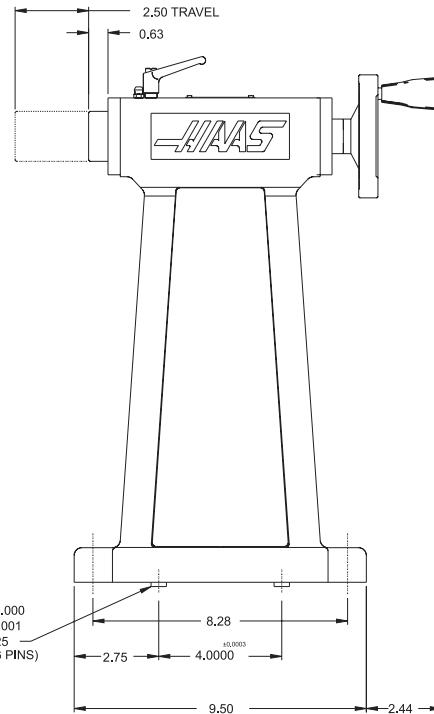
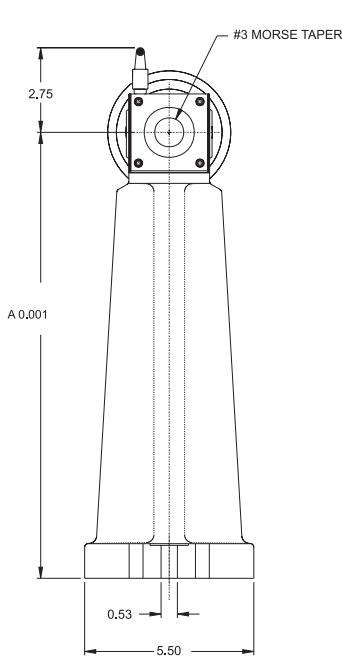
- Monthly** Use a standard grease gun and apply 1-2 full strokes to the top mount zerk fitting, for a manual tailstock.
- Weekly** Use a standard grease gun and apply 1 full stroke to the top mount zerk fitting, for a pneumatic tailstock.
- Daily** Use a shop rag to thoroughly clean the unit free of chips and apply a rust preventative, such as WD-40.
- Lubrication** Use MOBIL multi-purpose grease with MOLY (Molybdenum disulfide) or equivalent.

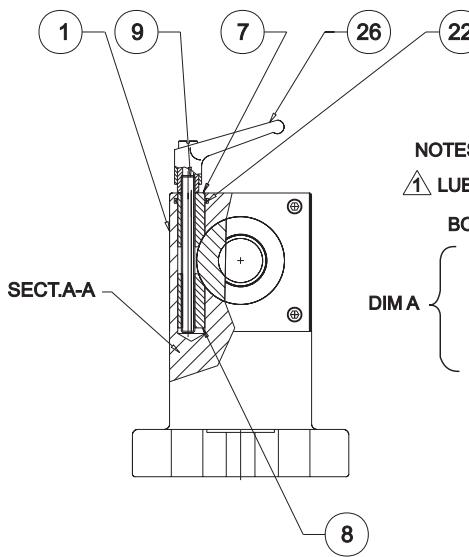
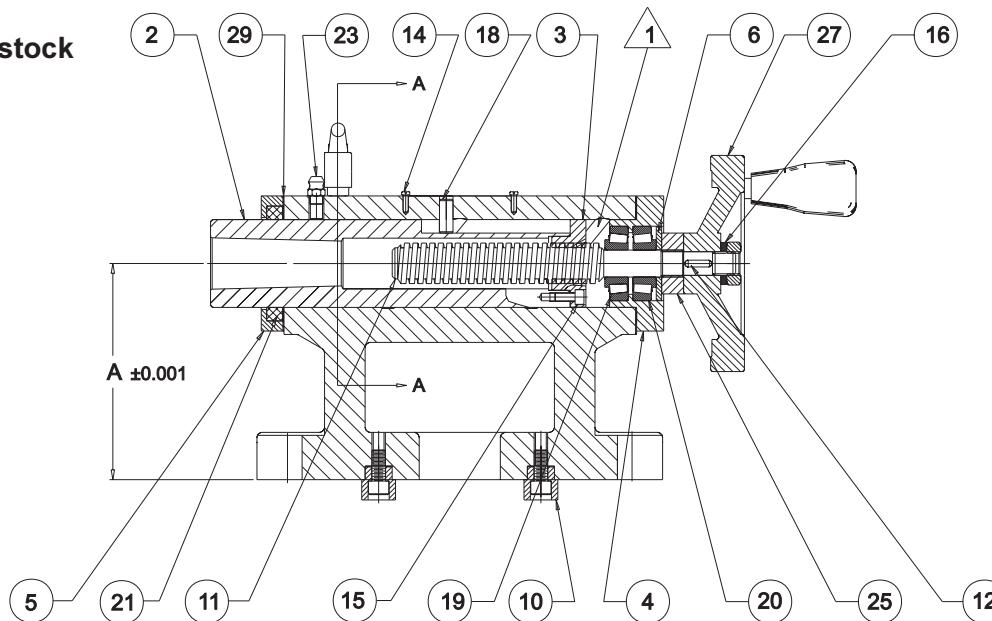
**10.4 TAILSTOCK DIMENSIONS****PNEUMATIC TAILSTOCK****MANUAL TAILSTOCK**

NOTES: UNLESS OTHERWISE SPECIFIED

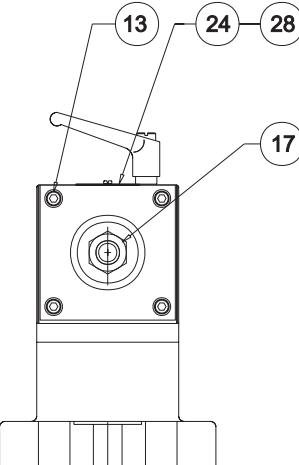
## BODY - TAILSTOCK

- DIM A {  
20-5000 (4.000)  
20-5001 (5.000)  
20-5002 (6.000)  
20-5013 (9.000 WITH SPACER)}

**HTS 11.5 AND HTS 14.5 MANUAL TAILSTOCKS**

**10.5 TAILSTOCK ASSEMBLY DRAWINGS****Manual Tailstock**

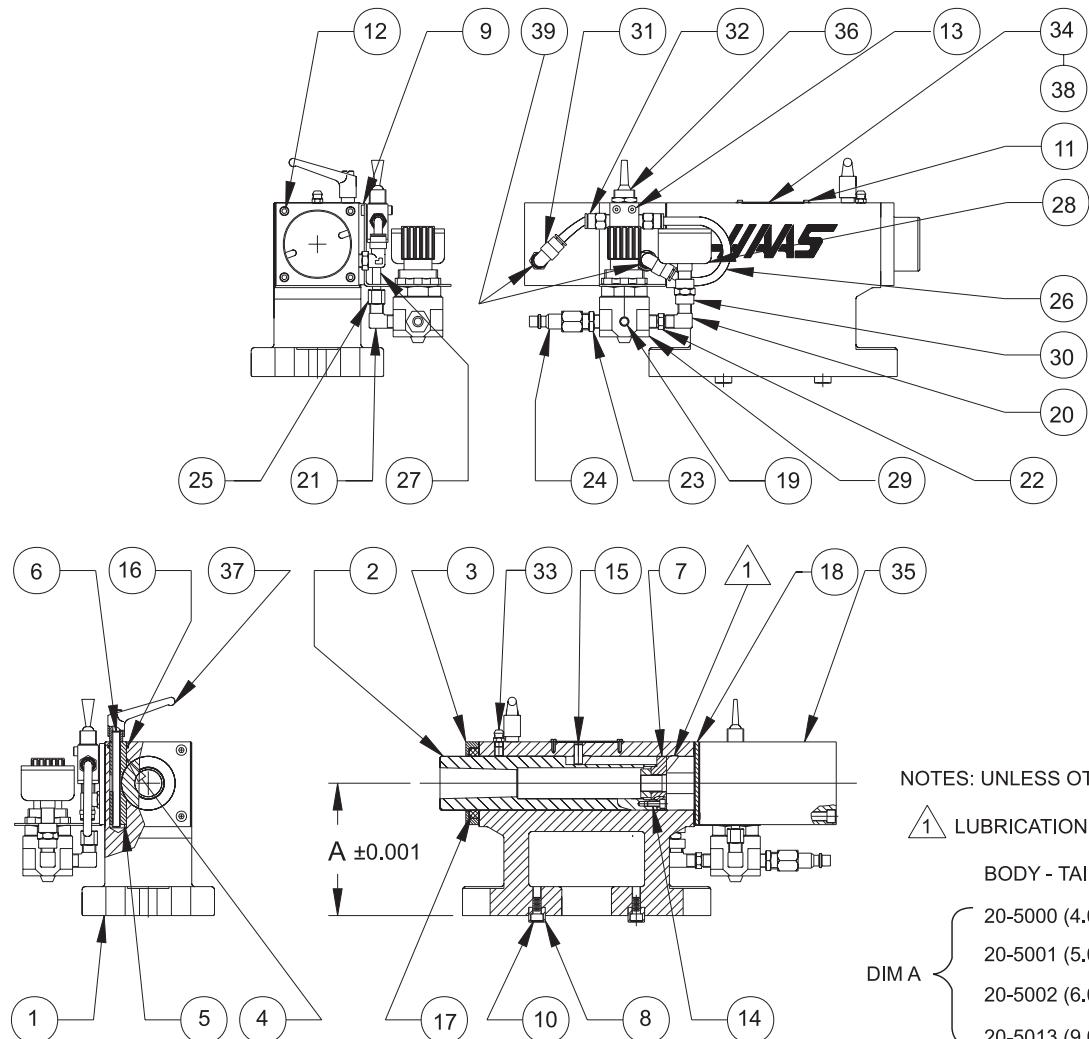
NOTES: UNLESS OTHERWISE SPECIFIED  
 ▲ LUBRICATION PATH  
 DIMA {  
 BODY - TAILSTOCK  
 20-5000 (4.000)  
 20-5001 (5.000)  
 20-5002 (6.000)  
 20-5013 (9.000 WITH SPACER)



NOTE: HANDWHEEL OMITTED IN THIS VIEW

## 30-50000 TAILSTOCK ASSEMBLY DWG.

1 1 20-5000	BODY - TAILSTOCK 4"	14 2 40-1666	MC.DR.SCREW #2 x 1/4"RD.HEAD
1 1 20-5001	BODY - TAILSTOCK 5"	15 4 40-1801	SHCS,8-32 x 3/8"
1 1 20-5002	BODY - TAILSTOCK 6"	16 1 45-1680	FLAT WASHER,7/16 SAE
1 1 20-5013	BODY - TAILSTOCK 7.25"	17 1 46-1660	HEX. JAM NUT,7/16-20
2 1 20-5003	SPINDLE	18 1 48-0060	PULL PIN 1/4 x 5/8 LG.
3 1 20-5005	NUT, LEAD SCREW	19 2 51-5000	BEARING CAP,TIMKEN #A 4138
4 1 20-5006	BEARING HOUSING	20 2 51-5010	BEARING CONE,TIMKEN #A 4050
5 1 20-5007	SEAL CAP	21 1 57-5012	WIPER,1/4"THICK
6 1 20-5008	THRUST WASHER	22 1 57-0058	O'RING,2-014
7 1 20-5009	UPPER CLAMP	23 1 59-2016	GREASE FITTING
8 1 20-5010	LOWER CLAMP	24 1 59-2091	NAME PLATE, GENERAL PURPOSE
9 1 20-5011	CLAMP STUD	25 1 59-6010	SHAFT COLLAR,#TCL8-20F
10 2 22-5017	LOCATING PIN	26 1 59-6700	CLAMPING HANDLE
11 1 22-5004	LEAD SCREW	27 1 59-6800	HANDWHEEL,GN 321-100-B1OD
12 1 22-5014	SQUARE KEY, 1/8"	28 1 29-5022	TAILSTOCK LABEL
13 10 40-1632	SHCS,1/4-20 x 1/2"	29 2 57-5020	GASKET, AIR CYLINDER

**PNEUMATIC TAILSTOCK**

1 LUBRICATION PATH

BODY - TAILSTOCK

20-5000 (4.000)

20-5001 (5.000)

20-5002 (6.000)

20-5013 (9.000 WITH SPACER)

DIM A {

IT	QTY	HAAS P/N	TITLE	IT	QTY	HAAS P/N	TITLE
1	1	20 - { 5013 5002 5001 5000}	7.25" 6" 5" 4"	19	1	58 - 1627	1/8 - 27 PIPE PLUG
2	1	20 - 5003	SPINDLE	20	1	58 - 16700	STREET ELBOW 1/8"
3	1	20 - 5007	SEAL CAP	21	1	58 - 16705	MALE ELBOW 1/8 M TO 1/8 M
4	1	20 - 5009	UPPER CLAMP	22	1	58 - 16732	1/1 x 1/8 MALE HEX.JOINT
5	1	20 - 5010	LOWER CLAMP	23	1	58 - 1674	ADAPTER MALE 1/4 NPT
6	1	20 - 5011	CLAMP STUD	24	1	58 - 1675	QUIK RELEASE FITTING, FEMALE
7	1	20 - 5016	NUT, AIR CYLINDER	25	2	58 - 16755	MALE AIR FITTING
8	2	22 - 5017	LOCATING PIN	26	2 Ft.	58 - 1981	TUBING, AIR LINE, 1/4 O.D.
9	1	25 - 5021	VALVE, BRACKET	27	2"	58 - 19900	COPPER TUBING
10	6	40 - 1632	SHCS, 1/4-20 x 1/2"	28	1	58 - 27395	AIR PRESSURE GAUGE
11	2	40 - 1666	MC.DR.SCREW #2 x 1/4" RD.HEAD	29	1	58 - 2740	AIR REGULATOR
12	4	40 - 1696	SHCS, 1/4-20 x 4 1/2"	30	1	58 - 2746	1/8 TO 1/8 FEMALE COUPLER
13	2	40 - 1800	SHCS, 8 - 32 x 3/4"	31	2	58 - 3050	ELBOW 1/8 NPT - 1/4
14	4	40 - 1801	SHCS, 8 - 32 x 3/8"	32	2	58 - 3070	FITTING, 1/8 NPT - 1/4
15	1	48 - 0060	PULL PIN 1/4 x 5/8"	33	1	59 - 2016	GREASE FITTING
16	1	57 - 0058	O'RING, 2 - 014	34	1	59 - 2091	NAME PLATE, GENERAL PURPOSE
17	1	57 - 5012	WIPER, 1/4" THICK	35	1	59 - 2736	AIR CYLINDER, #QJ 92-1673
18	2	57 - 5020	GASKET, AIR CYLINDER	36	1	59 - 2746	4 WAY VALVE, CLIPPARD, #TV-4DP
				37	1	59 - 6700	CLAMPING HANDLE
				38	1	29 - 5022	TAILSTOCK LABEL
				39	2	58-4040	AIR CHOKE DISK