



HAAS SERVICE AND OPERATOR MANUAL ARCHIVE

HRT Series Operators Manual 96-5047J RevJ English June 2004

- 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.



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 AC (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.

The HRT320FB uses a facegear (Hirth coupling) for extreme indexing accuracy and rigidity. It positions the platter in multiples of exactly 1° . The platter lifts .070" during indexing and the table positioning is done at full rapid speed. The HRT320FB cannot be used as a full forth axis or with a tailstock.

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 3.0HP (HA5CHD, HRT 160, HRT 210), 5.0 HP (HRT 310, HRT 450, HRT 600), 1.5 HP (HA5C)

DC SERVO DRIVE

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

VARIABLE FEED RATES*

Variable from .001 deg./sec. to 100 deg./sec (100 deg./sec. for HRT160 and HRT320FB, 75 deg./sec. for HRT210, 60 deg./sec. for HRT310, 50 deg./sec. for HRT450, 40 deg./sec for HRT600).

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.



Hrt-Series

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.

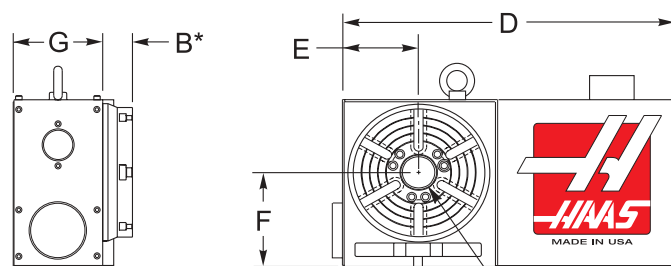
1.5 SPECIFICATIONS

MODEL:	HRT 160(SP)	HRT 210(SP)	HRT 310(SP)	HRT 450	HRT 600
SPINDLE					
Table Torque (ft./lbs) AC / DC	150/ 100	210 / 210	300 / 200	400 / 325	450 / 380
Feedrates (deg./sec.) AC / DC	AC .001 to 100 DC .001 to 80	AC .001 to 100 DC .001 to 60 DC 0.001 to 130 ¹ DC .001 to 360 ²	AC .001 to 60 DC .001 to 50	AC .001 to 50 DC .001 to 40	AC .001 to 50 DC .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 ¹	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 ²	500	1500	1500
INDEXING					
Indexing Accuracy (arc/sec.)	+/- 15	+/- 15 +/- 30 ²	+/- 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
MOTOR					
AC Servo (Brushless) DC Servo (Brush)	3.0 HP 0.5 HP	3.0 HP ¹ / 5.0 HP ² 1.5 HP	5.0 HP 1.5 HP	5.0 HP 1.5 HP	5.0 HP 1.5 HP
Drive Ratio (Timing Belt and Pulley Set)	2:1	2:1 1:1 ¹ / N/A ²	2:1	3:1	3.5:1
Worm Gear Ratio	63:1	90:1 N/A ²	72:1	72:1	72:1
Total Gear Reduction	126:1	180:1 90:1 ¹ 50:1 ²	144:1	216:1	252:1
OPERATING SPECIFICATIONS					
Max. Air Pressure	120 PSI 115V AC +/- 5% @ 15 Amps Mobil SHC-630 synthetic gear oil Mobil SHC-626 synthetic gear oil ²				
Power Requirements					
Lubrication					
OPERATING ENVIRONMENT					
Maximum Temperature	100 Degrees F				
¹ HRT210HS ² HRT210SHS					

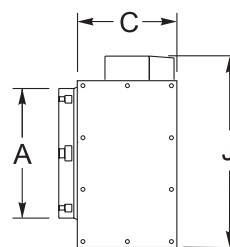


Hrt-Series

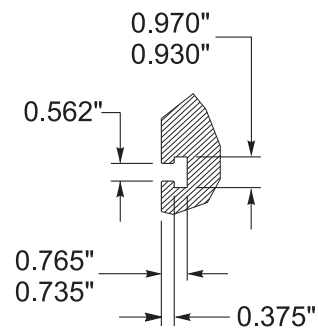
1.6 MACHINE DIMENSIONS



0.530" W x 3/4" DP
Front & Rear
Tie Down Slots



T-SLOT DETAIL

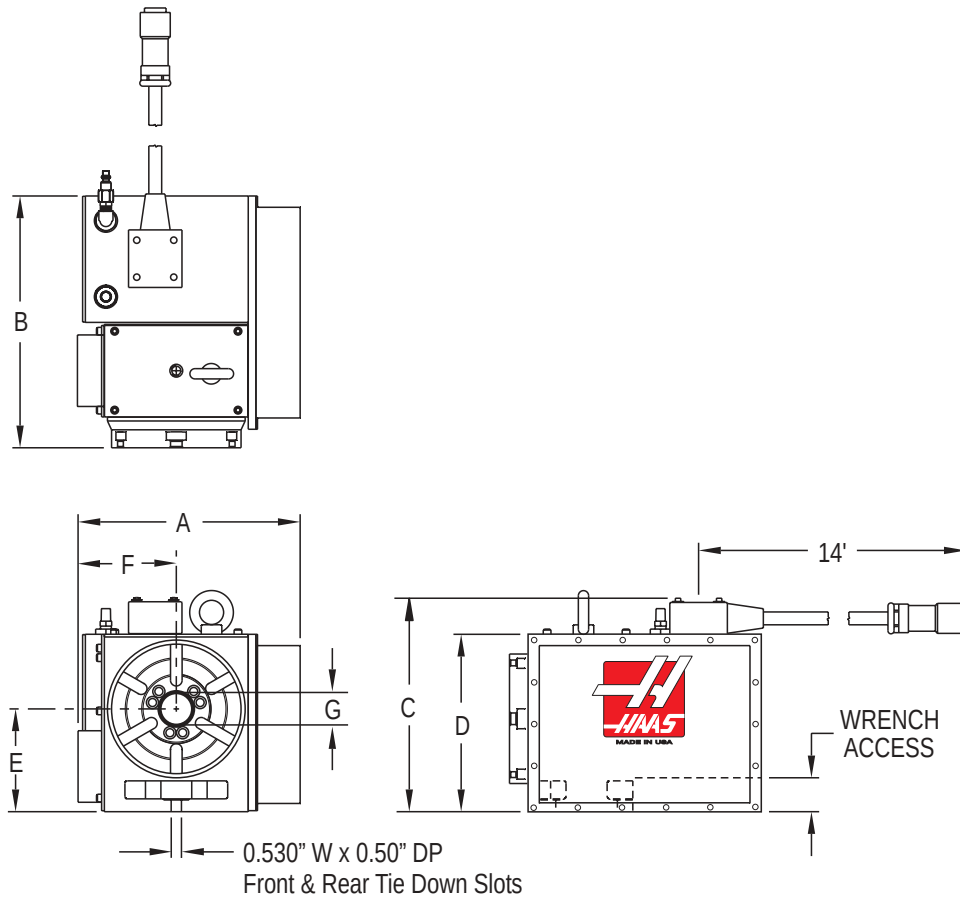


MODEL

DIMENSIONS

	A	B	C	D	E	F	G	H	J
HRT160	160 mm (6.30")	1.50	5.50	16.20	3.63	5.000 ±0.001	4.50	Ø1.50 ^{+0.0005}	10.4
HRT 210	210 mm (8.27")	1.75	5.84	17.80	4.63	6.000±0.001	5.25	Ø2.00 ^{+0.0005}	12.4
HRT210 (Brush)	210 mm (8.27")	1.75	5.84	20.00	4.63	6.000±0.001	5.25	Ø2.00 ^{+0.0005}	12.4
HRT 310	310 mm (12.20")	2.00	7.82	22.80	6.88	9.000±0.001	7.875	Ø3.25 ^{+0.0005}	17.7
HRT320FB (*The platter lifts .070" during positioning)									
HRT310 (Brush)	310 mm (12.20")	2.00	7.82	24.30	6.88	9.000±0.001	7.875	Ø3.25 ^{+0.0005}	17.7
HRT450	450 mm (17.72")	2.25	9.00	28.55	9.26	11.500±0.001	9.00	Ø7.50 ^{+0.00}	22.4
HRT600	600 mm (23.62")	2.50	9.00	34.82	12.13	14.500"±0.001	9.00	Ø7.50 ^{+0.001}	28.4

HRT SP DIMENSIONS



MODEL

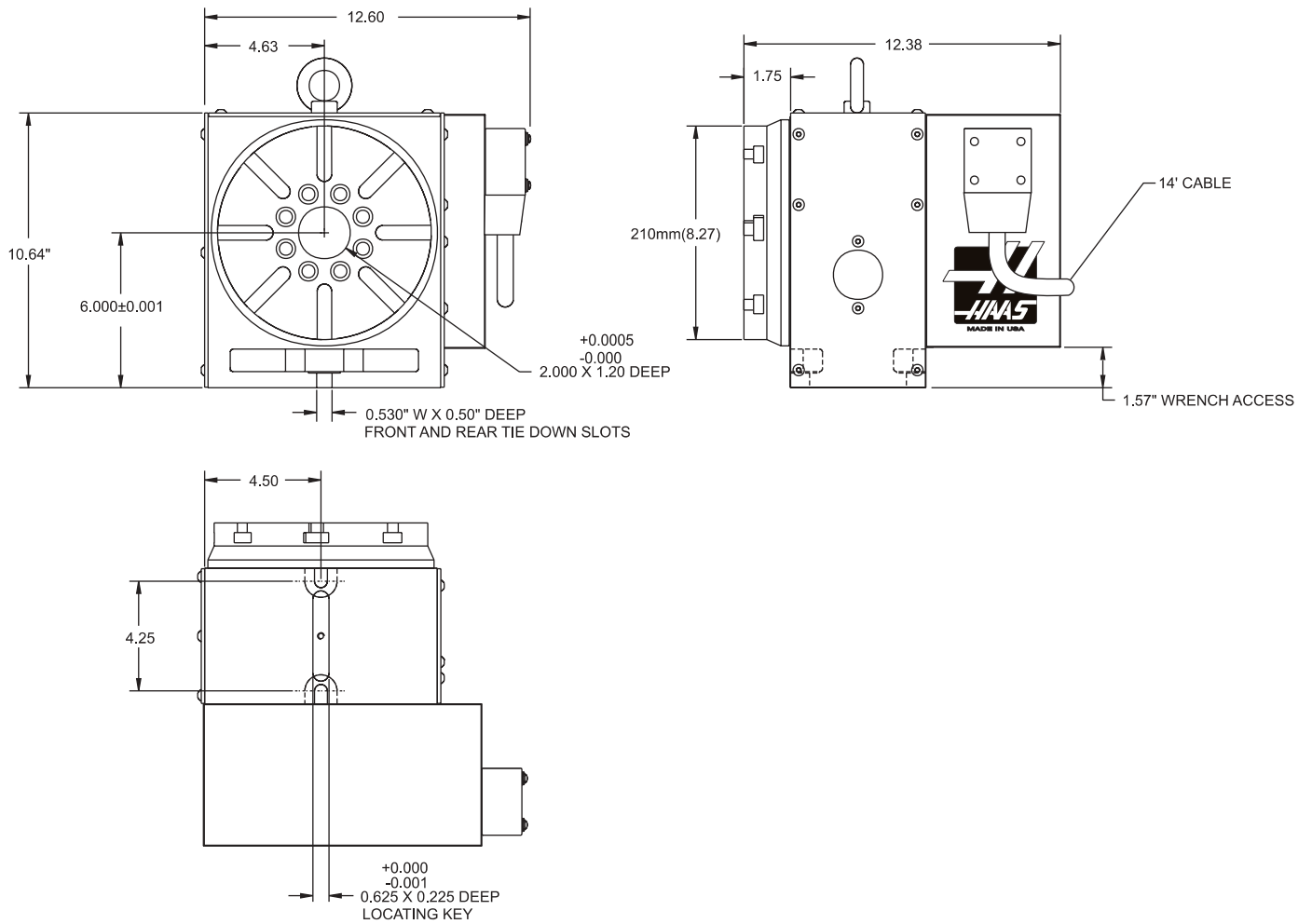
DIMENSIONS

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



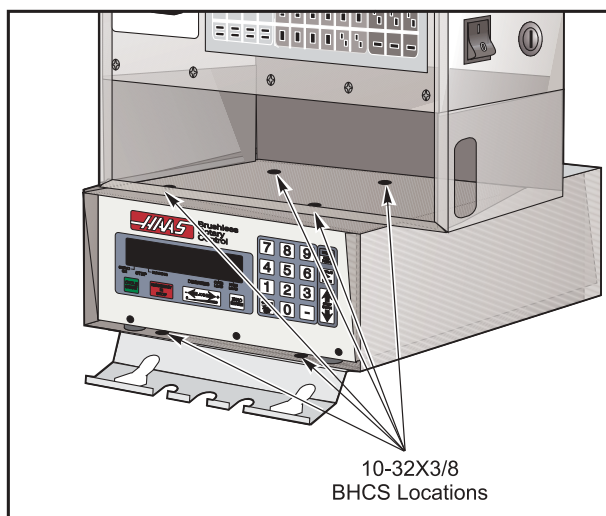
Hrt-Series

HRT210SHS MACHINE DIMENSIONS



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

1.8 HAAS TAILSTOCKS

Tailstocks must be properly aligned to the rotary table before using.

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.

See the Haas tailstock manual (96-5000) for pneumatic tailstock's operating pressure.

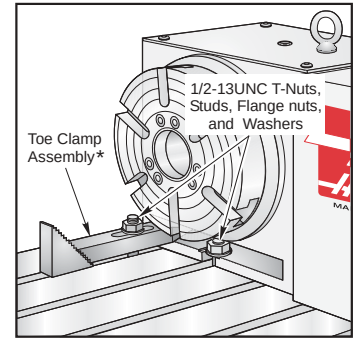
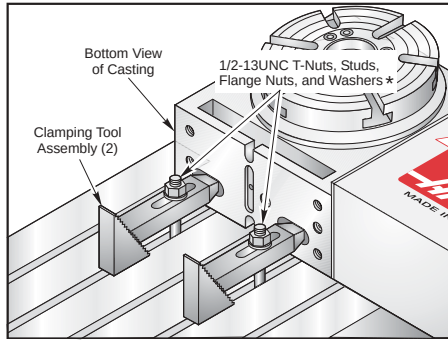
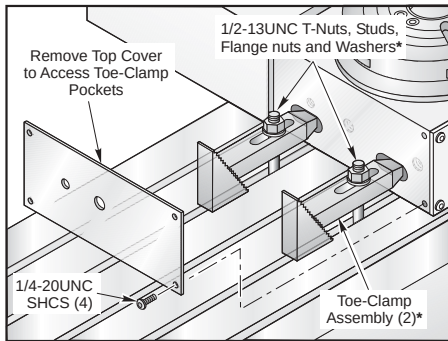
Tailstocks cannot be used with the HRT320FB table.

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.

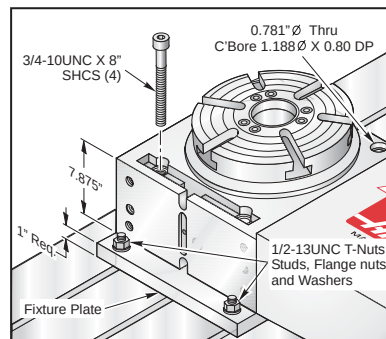
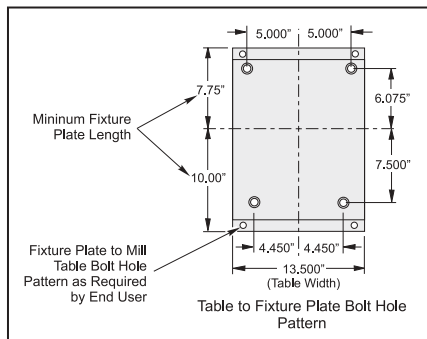
NOTE: The HRT 160, 210, 450, and 600 Rotary Tables can be secured as shown:



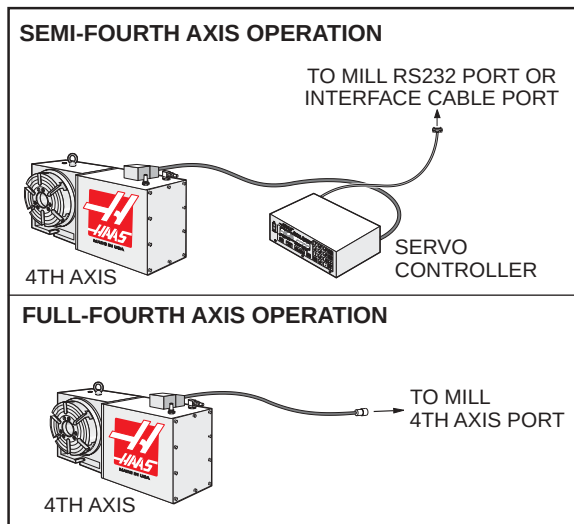
*NOTE: Toe-Clamp Fasteners are not supplied.

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

NOTE: The HRT 310 can be secured as shown:

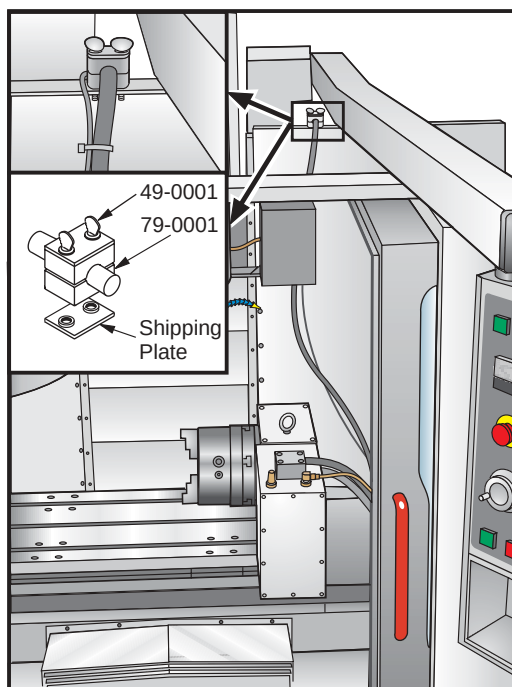


3. Connect the indexer to run as a full-fourth or semi-fourth axis. See the following figure. For full-fourth axis, the indexer is connected directly to the HAAS mill control at the connector labeled "A-Axis", and is the desired connection.



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. (HRT320FB cannot be run directly from a mill)

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 contaminants 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 by pressing the Zero Return button. 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) but it 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-9, 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-9 female on the other. Pins 1, 2, 3, 4, 5, 6, 7, 8, and 9 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 (RS-232 out) DB-25 connector is only used when more than one controller is to be used. The first controller's down (RS-232 out) line connector goes to the second controller's up (RS-232 in) 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. Parameter 12 must be set to 3 in order to coordinate mill and controller motion. This will prevent Aux. axis position mismatch alarm (355) when in handle jog mode.

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 Haas Automation part number is 74-1510 (Amphenol part number is 703-91-T-3300-1). The The Haas Automation part number is 74-1509 for the panel receptacle in the control box is (Amphenol part number 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 milliamps 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.

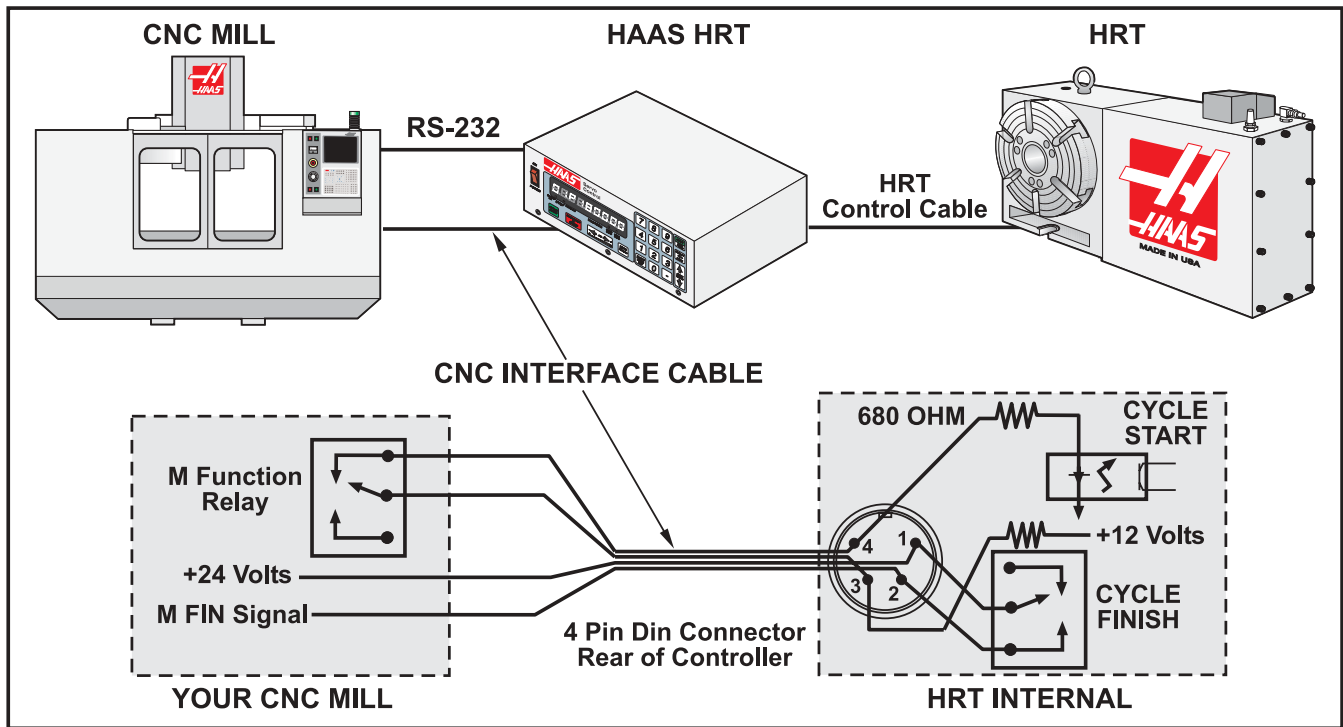
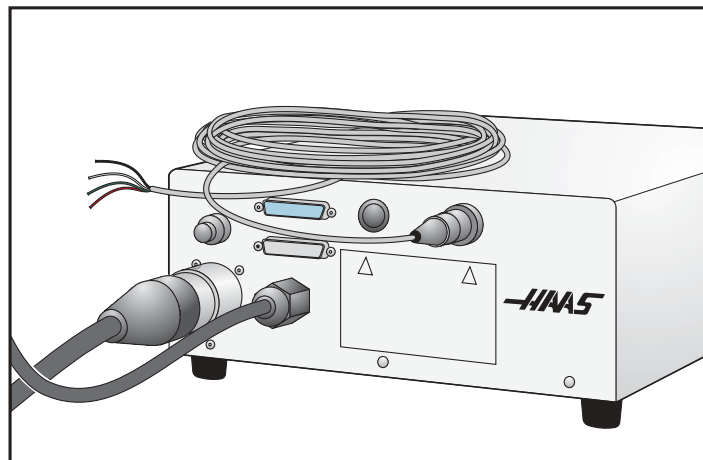


Figure 2. A Typical CNC Interface.

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

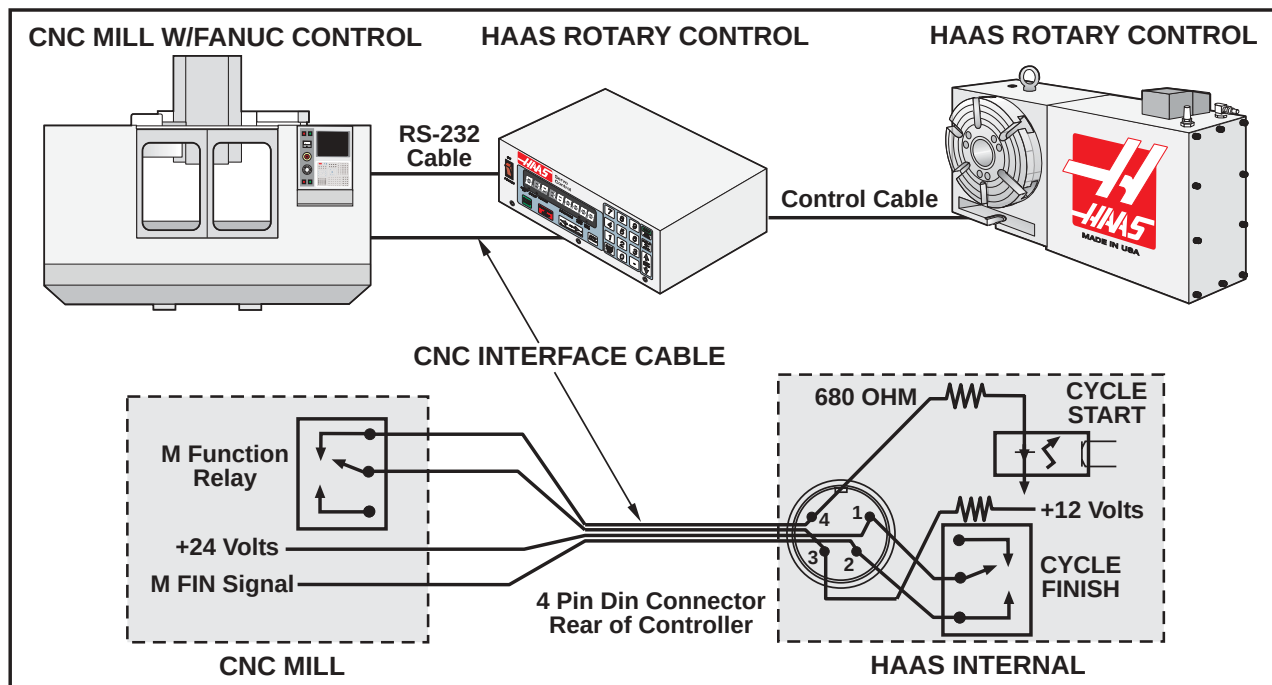


Figure 3. A Typical CNC Interface.

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
2= V
4= X
6=Z

1= U
3= W
5=Y
7,8AND
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 preceded 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 21 be set to "1" in the Servo Control prior to attempting Uploading or Downloading programs.

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 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.

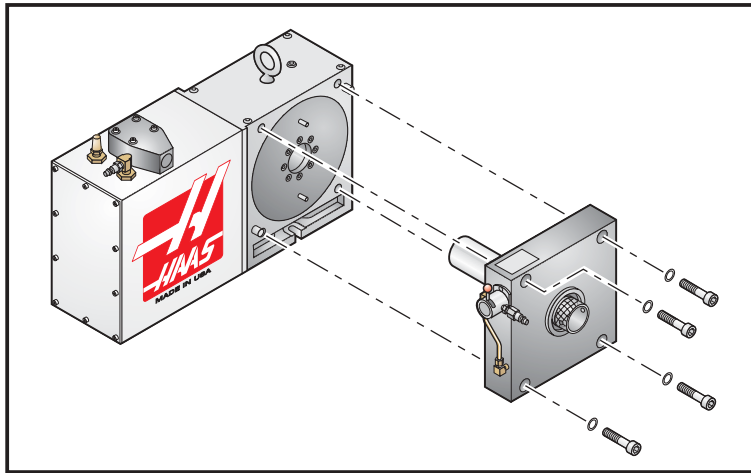


Figure 1-a. A6AC collet closer shown mounted to an HRT A6.

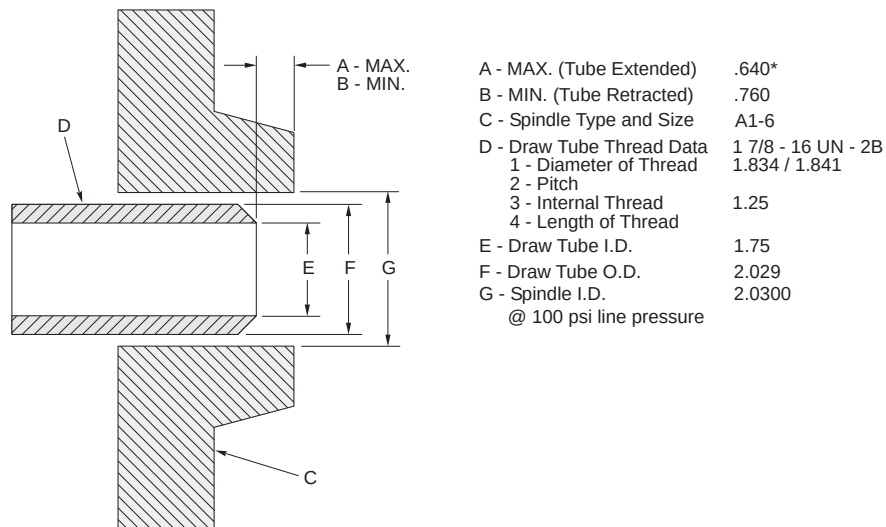


Figure 1-b. Drawtube to spindle dimensions (extended/retracted).

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

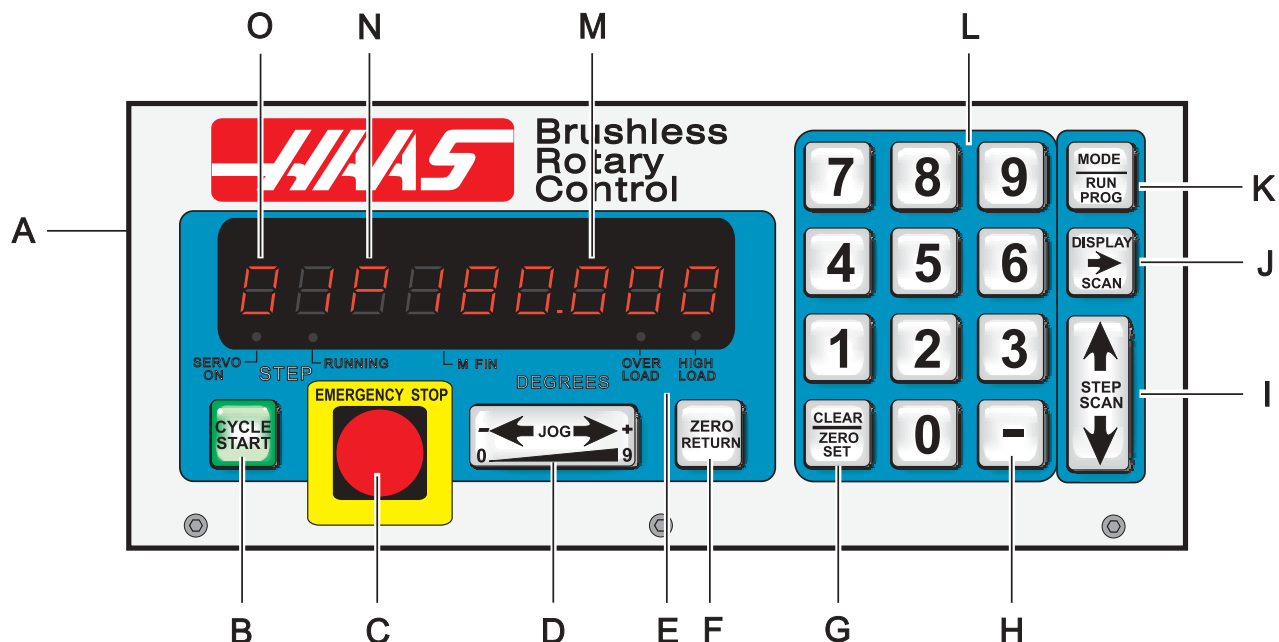
3.1 THE FRONT PANEL DISPLAY

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 (back panel).
- 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 the 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:

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

0 too SL (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:

Por On	Power was just turned on (or failed prev.)
Ser Err	Servo following error too large
E-StoP	Emergency stop
Hi LoAd	Software fuse
rS-232	Remote RS-232 commanded off
Air-Hot	Motor overheat sensor
EncodEr	Z channel fault (bad encoder or cable)
Hi Curr	Over current limit (stalled or PCB fault)
EncodES	Z channel missing (bad encoder or cable)
Hi VoLt	Regen overheat (high line voltage)
CABLE	Break detected in encoder cable wiring
PHAS Er	Power up phase error (Brushless units only)
dr FLt	An overcurrent or drive fault. (Brushless units only)
trAnS	Encoder transition fault had been detected by the brushless circuitry.
Indr dn	Platter not fully up (HRT320FB only). Can be caused by low air pressure.

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.

Feedrate will default to maximum (rapid) for HRT320FB.

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°) 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°) step to be stored and the feed rate to be displayed. To enter a feed rate of **80 degrees** (80°) 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°) 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:

G28	return to HOME position (same as G90 with step 0)
G73	peck cycle (linear operation only)
G85	fractional circle division
G86	turn CNC relay on
G87	turn CNC relay off
G88	return to HOME position (same as G90 with step 0)
G89	wait for remote input
G90	absolute position command
G91	incremental command
G92	pulse CNC relay and wait for remote input
G93	pulse CNC relay
G94	pulse CNC relay and run next L steps automatically
G95	end of program/return but more steps follow
G96	subroutine call/jump (destination is a step number)
G97	delay by L count/10 seconds (down to 0.1 second)
G98	circle division (circular operation only)
G99	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 **96** into the G code. After entering **96** 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°) 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°) 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
of degrees /(divided by) feed rate of spindle = time to index
72 degrees/ five degrees per sec = 14.40 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.
(length to travel in inches/(divided by) # of seconds of rotation) x 60 seconds = feed rate for mill in inches per minute.
1.500 inches/14.4 seconds = 0.1042 inches per second x 60 = 6.25 inches per minute.



Therefore, if you set the indexer to step **72 degrees** (72°) at a feed rate of **five degrees** (5°) 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

```

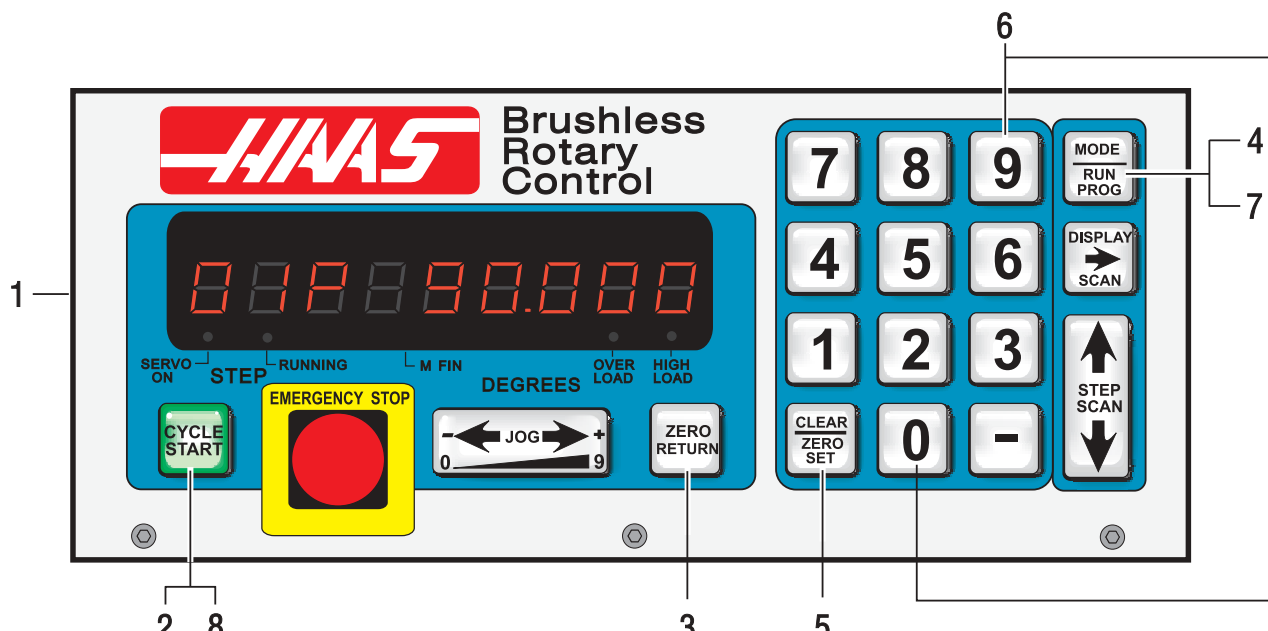
4.21 POSSIBLE TIMING PROBLEMS

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



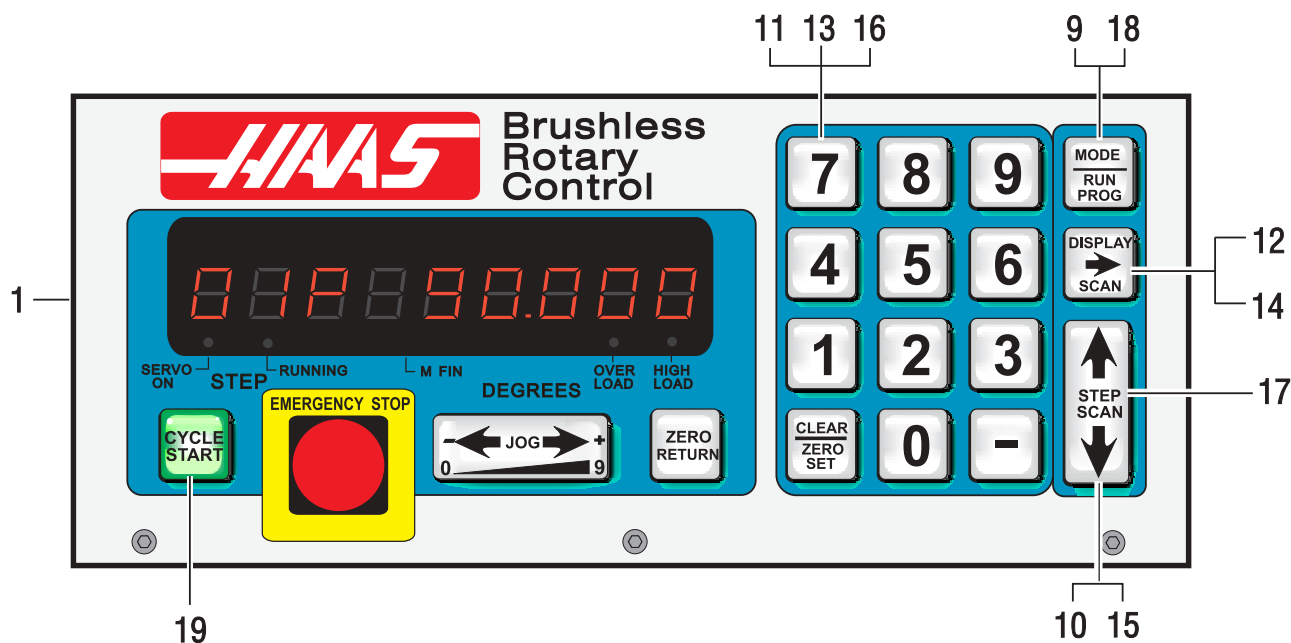
Example #1

We want to index the platter **90 degrees** (90°).

1. Turn **[POWER]** switch on. (The power switch is located on the rear panel.)
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 key pad. 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°), slow feed in the opposite direction for **10.25 degrees** (10.25°), 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°), 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°), then slow feed for **15 degrees** (15°), 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]	080.000	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.nnnnnn

For brushless units the display will indicate:

01U.nnnnnnn

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 SC 4.0, 5.0 AND 9.0 PARAMETER SETUP

The SC 4.0, 5.0 and 9.0 may require the following parameters to be recalculated for your application to enable coordinated display feedback during operation. The default parameter list should be used as a starting point for initial parameter settings.

1. **Parameter 9 (and 20 if required)** – is the calibration ratio between encoder pulses (encoder lines X4) and your unit of measurement (degrees or inches) in steps per unit. Several examples follow:

Linear Example (6mm pitch ballscrew):

32768 (brushless) encoder pulses per revolution X 25.4 millimeters per inch / 6mm per revolution = 138718

Rotary Examples:

8000 (brush) encoder pulses per revolution X 90:1 gear ratio X 2:1 belt ratio / 360 degrees per revolution = 4000

32768 (brushless) encoder pulses per revolution X 90:1 gear ratio X 3:1 belt ratio / 360 degrees per revolution = 24576

Rotary Example with a gear ratio divider (parameter 20) needed:

32768 (brushless) encoder pulses per revolution X 72:1 gear ratio X 2:1 belt ratio / 360 degrees per revolution = 13107.2 since 13107.2 is non-integer we require a ratio divider (parameter 20) set to 5 then:
13107.2 ratio = 65536 (parameter 9) encoder steps / 5 (parameter 20) ratio divider.

2. **Parameter 12, 13, 14** – give optimum display precision (decimal location). See parameter 12 description for your setting. If travel limits are required, linear settings of 1,2,3 or 4 must be entered in parameter 12 and parameter 13&14 must be calculated and set as follows: (Entered value loses last digit.)
Linear Example (6mm pitch ballscrew):
 20.0 inch travel X 138718 ratio = 2774360 (entered value: 277436)
Rotary Example (must also use “linear” settings of 1,2,3 or 4 entered in parameter 12):
 120.0 degrees of travel X 4000 ratio = 480000 (entered value: 48000)
3. **Parameter 3, 4, 17** – These parameters may have to be changed due to different motor load conditions. Use standard values as a baseline and revise parameters based on the following:
 - A. Proportional gain – increases current in proportion to the proximity to the target position. The farther from the target, the greater the current up to the maximum value in parameter 40. A mechanical analogy is a spring that will oscillate past the target unless dampened by the derivative gain.
 - B. Derivative gain – resists motion effectively braking oscillations. This parameter is increased in proportion to the p gain.
 - C. Integral gain – provides larger increases of current to achieve target. This parameter, set too high, will often cause a hum.
4. **Parameter 27** – options for home switch usage (required for repeatability after control shutdown). All HAAS Indexers use a home switch used in conjunction with the Z pulse on the motor encoder (one for each revolution of the motor) for repeatability. The home switch consists of a magnet (Haas PN 69-18101) and proximity switch (Haas PN 36-3002), which is of the magnetically sensitive transistor type. When the control is shut down and restarted, it will give a “no home” display, requiring the user to press the “zero return” button. The motor then operates slowly in a clockwise direction (as viewed from the platter of a rotary table) until the proximity switch is magnetically tripped and then backs up to the first Z pulse. (See parameter code options in parameter section for actual options.) Note: to reverse direction when seeking a home switch (if it currently moves away from the home switch during the home sequence), add 256 to the value in parameter 27. Note: A home switch is not required for parameter 27. Setting Parameter 27 to 2 will home at first Z pulse. To repeat home position when set to 2, the system must be jogged by using the arrow keys to be manually moved within one revolution of the motor before homing the unit.
5. **Summary of additionally useful parameters to SC 4.0, 5.0 and 9.0 users:**
 - A. Parameter 7 – protect a program that won’t be changed often.
 - B. Parameter 10 – continuous cycle repetition.
 - C. Parameter 11 – reverse the sign (+ or –) on the control display to match your positive direction convention.
 - D. Parameter 15 – to enable precise positioning for reversed motion (compensating for mechanical backlash).
 - E. Parameter 16 – dwell time between programmed steps. Also functions to cool motor for long motor life.
 - F. Parameter 18 – lower number allows for gentler acceleration (this value must be greater than parameter 19, usually 2X).
 - G. Parameter 19 – lower number reduces speed (RPM of motor).
 Formula: degrees (or inches) per sec X ratio (parameter 9) / 100 = entered value in parameter 19.
 - H. Parameters 25,32 – if your system has a brake, it must be timed to avoid motor overheat.

Motor Parameters 23, 28, 29, 36-45 should not be changed! This can damage the motor and will void the warranty!



6.2 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°) 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".

6.3 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 ¼ 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 increases current in proportion to the proximity to the target position. The farther from the target, the greater the current up to the maximum value in parameter 40. A mechanical analogy is a spring that will oscillate past the target unless dampened by the Derivative gain.

Parameter 4: Servo Loop Derivative Gain, range 0 to 255 (0 to 99999) PROTECTED!

Servo loop derivative gain resists motion effectively braking oscillations. This parameter is increased in proportion to the p 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 unit (degree, inch, millimeter, etc).

Example 1: A Brush HRT with a 2000 line encoder (with four pulses per line, or quadrature), a 72:1 gear ratio, and a final drive of 2:1 would produce:

$$[8000 \times (72 \times 2)] / 360 = 3200 \text{ steps for 1 degree of motion.}$$

Example 2: A Brushless HRT with 8192 line encoder (with quadrature), a 90:1 gear ratio and a final drive of 3:1 would produce:

$$[32768 \times (90 \times 3)] / 360 = 24576 \text{ steps for 1 degree of motion.}$$

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 12: Display Units and Precision (decimal location), range 0 to 6. Must be set to 1,2,3, or 4 if travel limits are to be used (including circular motion with travel limits).

- 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** (entered value loses last digit). 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. The entered value is also affected by the gear ratio divider (parameter 20).

Linear example (6mm pitch ballscrew): 20.0 inch travel X 138718 ratio = 2774360 (entered value: 277436)

Rotary example (must also use "linear" settings of 1,2,3 or 4 entered in parameter 12): 120.0 degrees of travel X 4000 ratio = 480000 (entered value: 48000)

Rotary Example (with a parameter 20 value of 3): 120.0 degrees of travel x 4000 ratio/3 = 160000 (entered value: 16000).

Parameter 14: Maximum Negative Travel, range 0 to 65535 (0 to 99999)

This is the negative travel limit in **units*10** (entered value loses last digit). It applies only to linear motion (i.e. Parameter 12=1,2,3, or 4). For examples see parameter 13.

Parameter 15: Backlash Amount, range 0 to 99

This parameter is used to compensate electronically for mechanical gear backlash. It is in units of encoder steps. Note: this parameter cannot correct mechanical backlash.

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.

Used primarily for continuous duty, allowing for motor cool down time and longer motor life.

Parameter 17: Servo Loop Integral Gain, range 0 to 255 PROTECTED!

Servo loop 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. Integral gain provides larger increases of current to achieve target. This parameter, set too high, will often cause a hum.

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

This parameter defines how fast the motor is accelerated up to the desired speed. 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, usually 2X. Lowering this value results in gentler acceleration.

Parameter 19: Maximum Speed, range 0 to 10000 (0 to 999999x100)

This parameter defines the maximum speed (RPM of motor). 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. The entered value = the desired value/parameter 20 if a gear ratio divider is used. Lowering this value results in reduced maximum speed (maximum motor RPM).

Standard Formula: degrees (or inches) per sec X ratio (parameter 9) / 100 = entered value in parameter 19.

Formula with Gear Ratio Divider (parameter 20): degrees (or inches) per second X ratio (parameter 9) / [ratio divider (parameter 20) x 100] = entered value in parameter 19.

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. If this parameter is set to 0 or 1, no change is made to the Parameter 9 value.

Example 1: Parameter 9=2000 and Parameter 20=3, the number of steps per unit will be 2000/3 = 666.667.

Example 2 (with a gear ratio divider parameter 20 needed):

32768 (brushless) encoder pulses per revolution X 72:1 gear ratio X 2:1 belt ratio / 360 degrees per revolution = 13107.2 since 13107.2 is non-integer we require a ratio divider (parameter 20) set to 5 then: 13107.2 ratio = 65536 (parameter 9) encoder steps / 5 (parameter 20) ratio divider.

Parameter 21: RS-232 Interface Axis Select, range 0 to 9

When this parameter is zero, no remote RS-232 functions are available. Must be set to zero when uploading or downloading programs. 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. This auto shut-off results in a display of: **Ser Err**

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**.

Warning! Changes from HAAS recommended values will damage the motor.

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 over temp 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!

All HAAS Indexers use a home switch used in conjunction with the Z pulse on the motor encoder (one for each revolution of the motor) for repeatability. The home switch consists of a magnet (Haas PN 69-18101) and proximity switch (Haas PN 36-3002), which is of the magnetically sensitive transistor type. When the control is shut down and restarted, it will give a "no home" display, requiring the user to press the "zero return" button. The motor then operates slowly in a clockwise direction (as viewed from the platter of a rotary table) until the proximity switch is magnetically tripped and then backs up to the first Z pulse. (See parameter code options in parameter section for actual options.) Note: to reverse direction when seeking a home switch (if it currently moves away from the home switch during the home sequence), add 256 to the value in parameter 27.



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

- 0: no automatic home functions available (no home switch)
- 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 (determined by encoder used)
- +8: home to zero position in negative direction
- +16: home to zero position in positive direction
- +24: home to zero position in shortest direction
- +32: auto servo on at power on
- +64: auto search for home at power on (have "auto servo on at power up" selected)
- +128: for inverted HOME switch (determined by home switch used)
- +256: search for home in positive direction (Brushless Only)

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.

Only two numbers are used here: **32768** for all brushless motors (8192 line encoder x quadrature)
8000 for all brush motors (2000 line encoder x quadrature)

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**. Thus if the motor has 24.6 volts per KRPM this parameter is set to 246.

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 ¼ 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. (See section 2.3 on RS-232 Interface.)

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 speed. 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, 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 do not apply to brush 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 2047)

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

Warning! Changes to this parameter from HAAS recommended values will damage the motor.

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: Beeper Timing (0 to 999)

Length of beeper tone in milliseconds. 0-35 no tone. Default 150 milliseconds.

Parameter 47: Zero Offset (0-9999) For HRT320FB.

Angular value to offset zero position. Units are 1/1000 of a degree.

Parameter 48: Indexer Increment (0-1000) HRT320FB only

Angular value to control indexer increments. Units are 1/1000 of a degree



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 ¼ second.

7.2 TROUBLESHOOTING GUIDE

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



SYMPTOM	PROBABLE CAUSES	REMEDY
HRT (A6) Dead length collets sticking, and/or insufficient clamping force.	❶ Excessive spindle/collet friction.	❶ Lubricate spindle and collet with a Molybdenum disulfide grease.
Air leaking around rear brake disc.	❶ Chips blown in between O-ring and brake disc.	❶ Contact HAAS Service Dept. (Do Not use air gun around rear brake disc). See section 8.5.
Display reads: Indr dn	❶ Insufficient Air Pressure. ❷ Platter face prevented from lifting	❶ Check Air Pressure (60psi min.) ❷ Check for platter clearance or excessive weight of workpiece.

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°). 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°). 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.



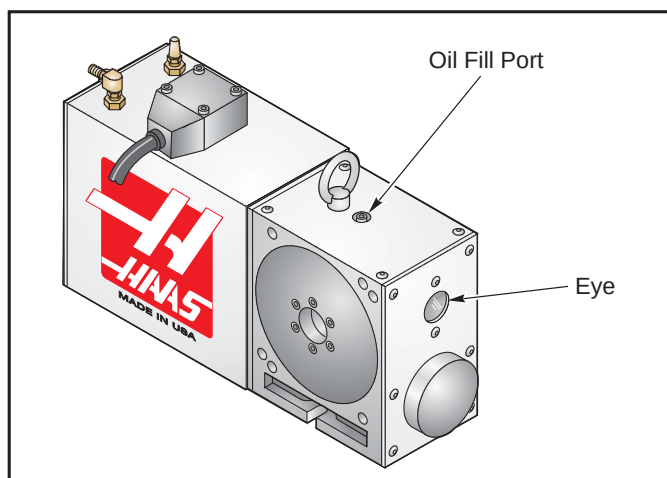
8.4 LUBRICATION

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 sight glass*.

*HRT210SHS - The lube level should not show more than 1/3 on the sight glass. The oil level must be to the bottom of the sight glass at a minimum.

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 Mobil SHC-630 oil until the proper level is reached. Replace the fill port bolt and tighten.

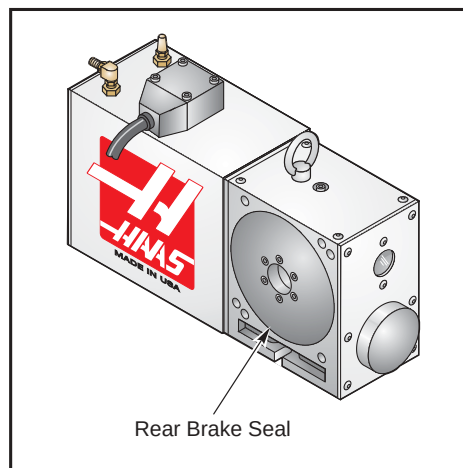
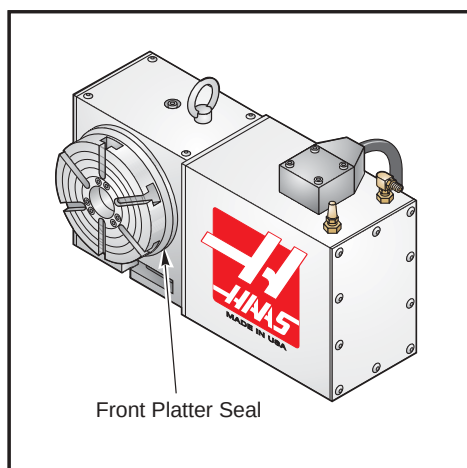
Replace the oil every 2 years.



Fill Port location for Rotary Table

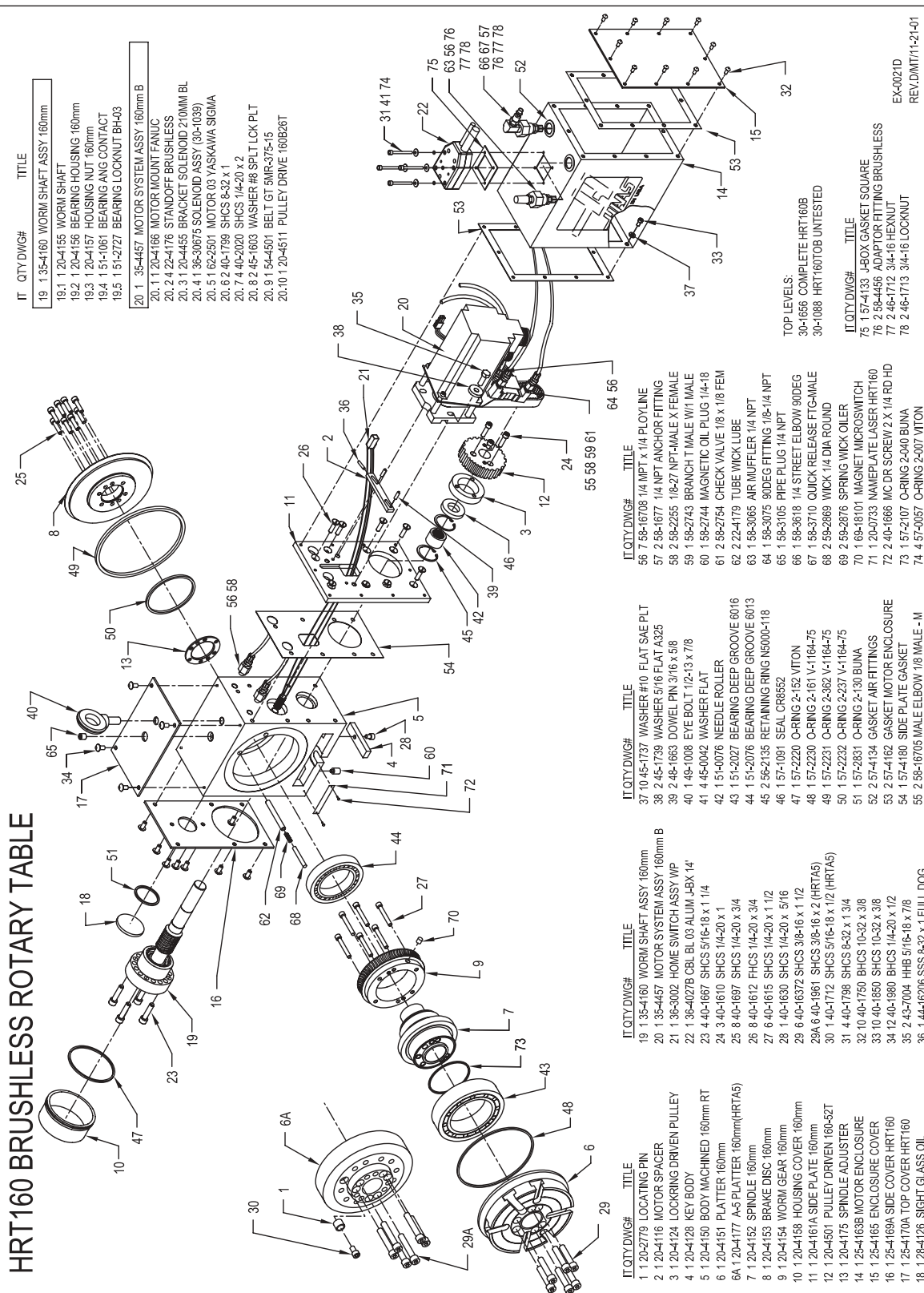
8.5 CLEAN UP

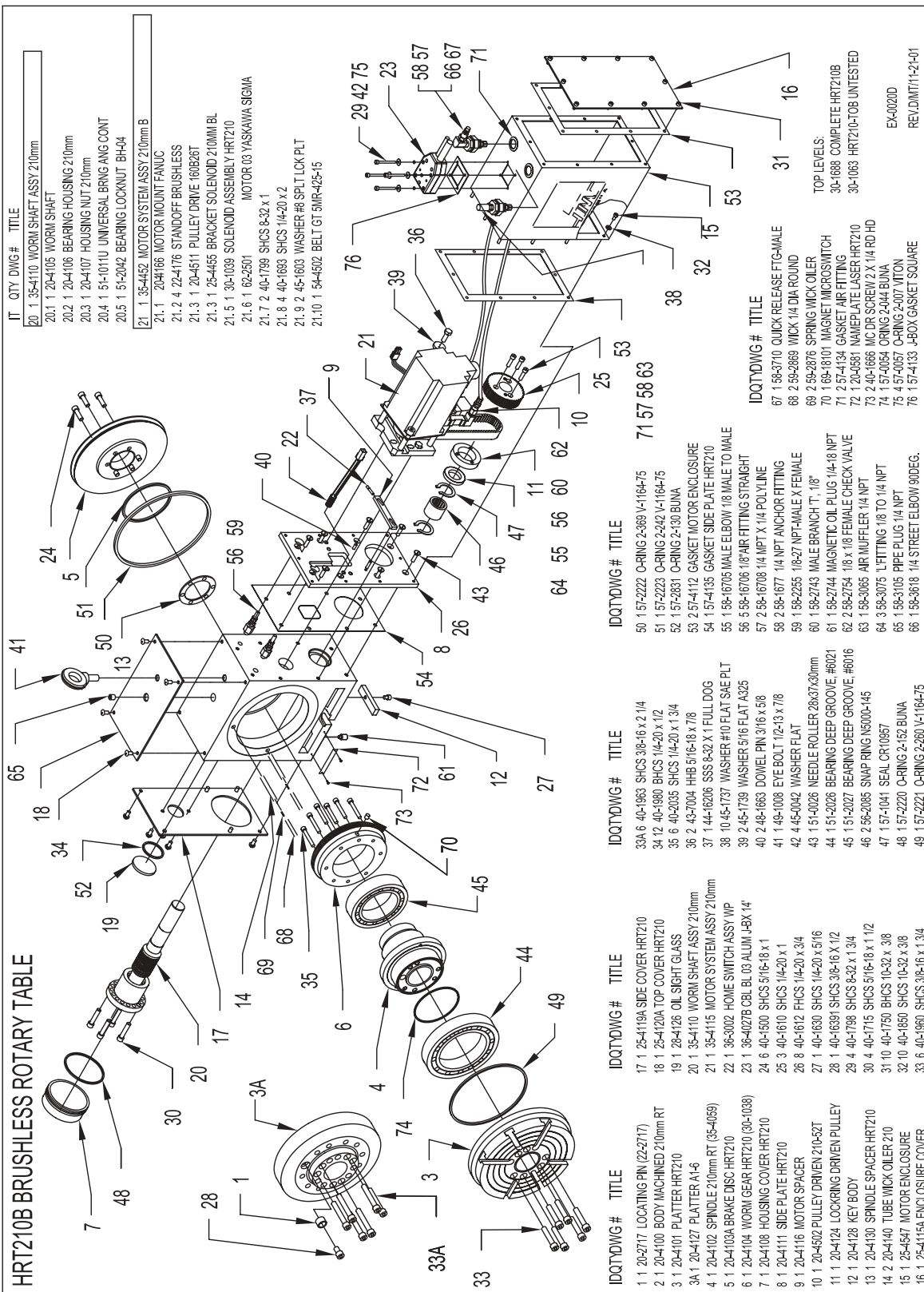
At the end of the workday or shift, it is important to clean the rotary table. The table should be free of any chips or grime. Clean with a chip brush and apply a coat of a rust preventative. **Do not use air gun around front or rear seals.** Chips may damage seal if blown in with an airgun.



Front and Rear Seals for HRT.

9. HRT ASSEMBLY DRAWINGS

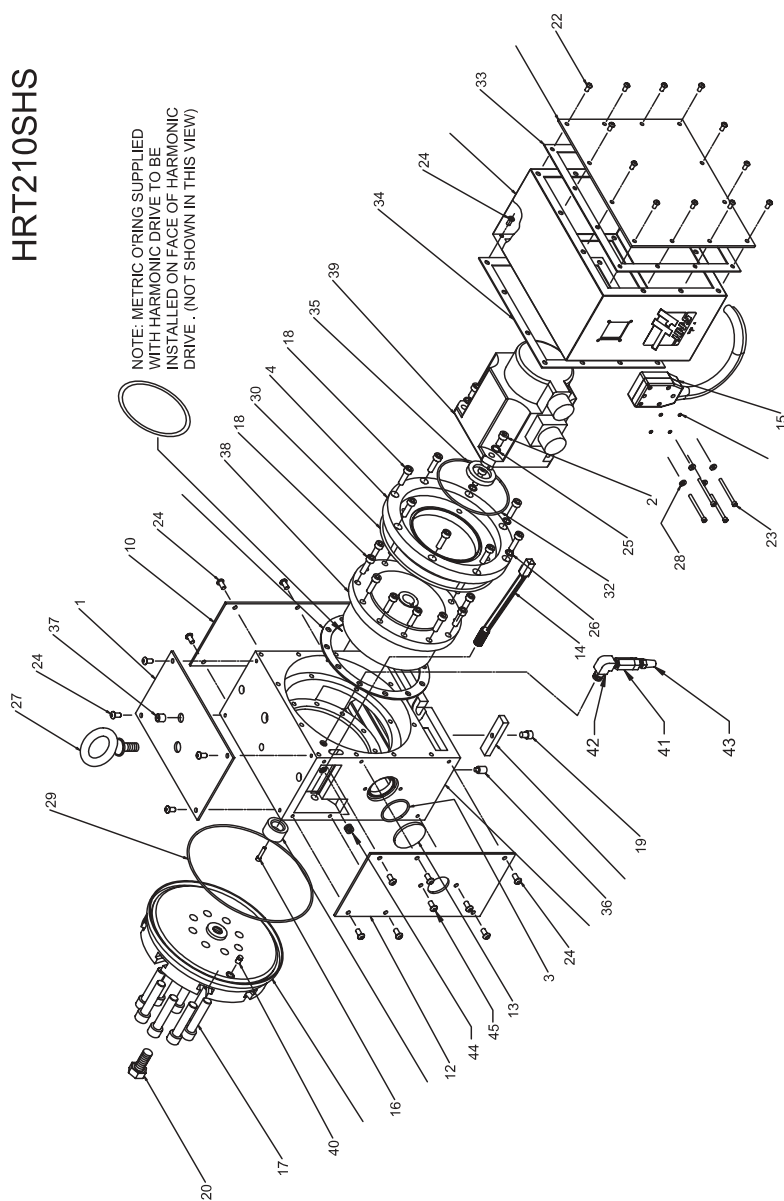




Note: All rotary tables use Polyurethane tubing for all air lines. Specifications are: 1/4 O.D. x .160 I.D. 95A Durometer.



HRT210SHS



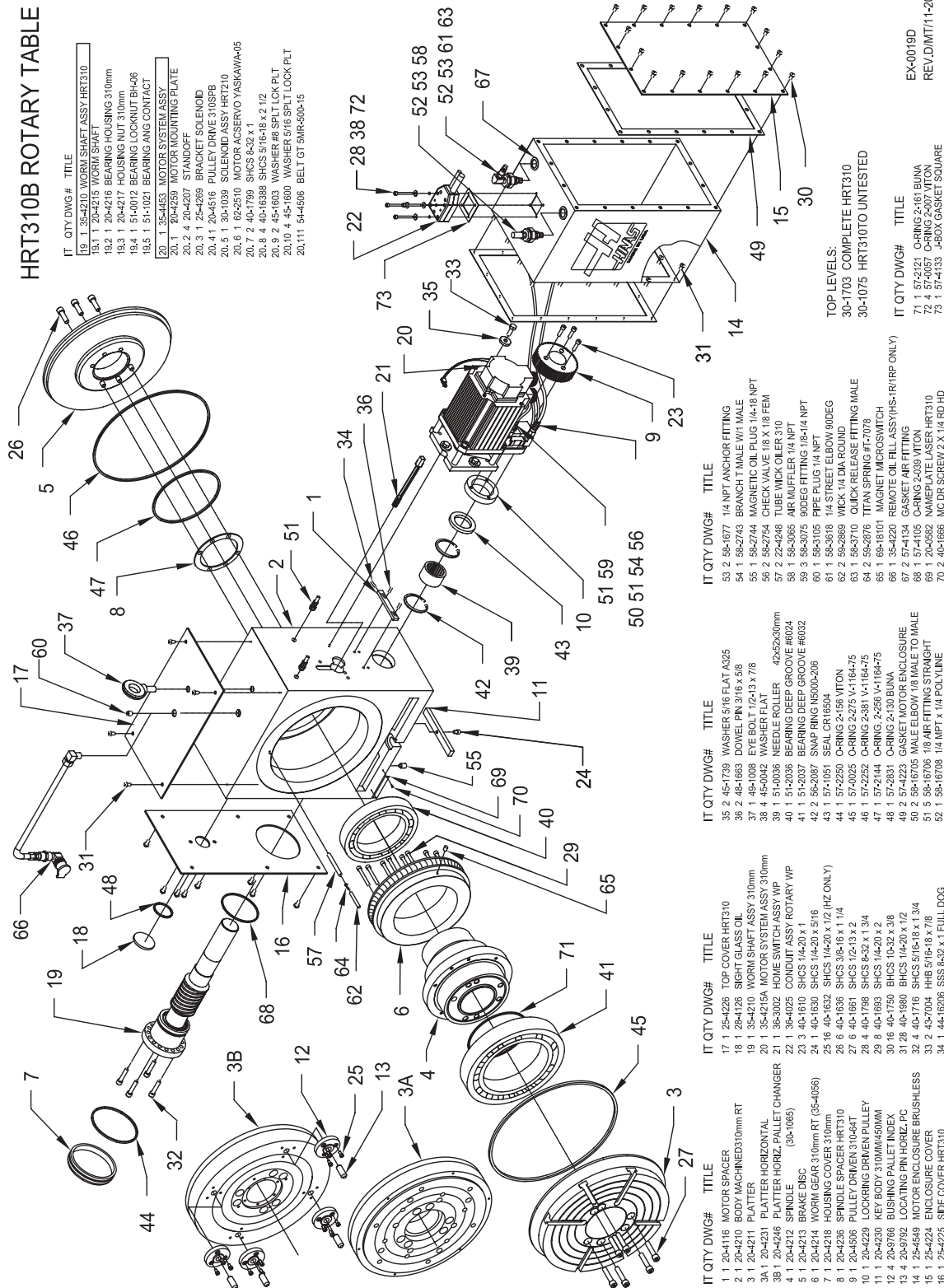
NOTE: METRIC O-RING SUPPLIED
WITH HARMONIC DRIVE TO BE
INSTALLED ON FACE OF HARMONIC
DRIVE. (NOT SHOWN IN THIS VIEW)

ID	QTY	DWG#	TITLE	ID	QTY	DWG#	TITLE	ID	QTY	DWG#	TITLE
1	1	20-4128	KEY, BODY	16	1	43-1651	MSHCS, M5 X 16	31	1	57-2831	O-RING, 2-130 BUNA
2	1	20-4520	BODY MACHINING	17	8	40-0010	MSHCS, M12 X 45	32	1	57-2875	O-RING, 2-157 BUNA
3	1	20-4521	PLATTER, HRT210SHS	18	24	40-1500	SHCS, 5/16-18 X 1	33	1	57-4529	GASKET, ENCLOSURE COVER
4	1	20-4522	MOTOR MOUNT, HRT210SHS	19	1	40-1630	SHCS, 1/2-20 X 5/16	34	1	57-4530	GASKET, MOTOR ENCLOSURE
5	1	20-4523	DRIVE SPACER	20	1	43-0015	HHB 1/2-13 X 1 SELF SEALING	35	1	57-4533	SEAL CR11615
6	1	20-4531	RETENTION CAP	21	4	40-16385	SHCS, 5/16-18 X 3/4	36	1	58-2744	MAGNETIC OIL PLUG 1/4-18
7	4	57-0057	O-RING 2-007 VITON	22	12	40-1750	BHCS, 10-32 X 3/8	37	1	58-3105	PIPE PLUG 1/4 NPT
8	1	25-4524	MOTOR ENCLOSURE	23	4	40-1798	SHCS, 8-32 X 1 3/4	38	1	59-4532	HARMONIC DRIVE, 50:1
9	1	25-4525	ENCLOSURE COVER	24	28	40-1980	BHCS, 1/2-20 X 1/2	39	1	62-0014	YASKAWA SIGMA MOTOR 09
10	1	25-4526	SIDE COVER-A	25	4	45-0039	WASHER BRASS 0.328 I.D. X 0.562 O.D.	40	1	69-18101	MAGNET, MICRO SWITCH
11	1	25-4528	TOP COVER	26	3	45-0047	WASHER BRASS 0.314 I.D. X 0.420 O.D.	41	1	58-2754	1/8 X 1/8 FEMALE CHECK VALVE
12	1	25-4527	SIDE COVER-B	27	1	49-1008	EYE BOLT, 1/2-13 X 7/8	42	1	58-16705	MALE ELBOW, 1/8
13	1	28-4126	OIL SIGHT GLASS	28	4	45-0042	WASHER, #8 SEALING S.S.	43	1	58-2262	AIR MUFFLER, CENTERED
14	1	36-3002	MICRO SWITCH ASSY	29	1	57-2221	O-RING, 2-260 VITON	44	1	58-1627	1/8-27 PIPE PLUG
15	1	36-4029B	BL 05 CABLE WP 14'	30	1	57-2127	O-RING, 2-166	45	2	40-1633	BHCS 1/4 X 3/8 ZINC

EX-0028D
REV.DMT/11-25-2

HRT310B ROTARY TABLE

IT	QTY	DWG #	TITLE
19.1	1	35-4210	WORM SHAFT ASSY HRT310
19.2	1	20-4216	BEARING HOUSING 310mm
19.3	1	20-4217	BEARING NUT 310mm
19.4	1	51-0012	BEARING LOCKNUT BH-06
19.5	1	51-1021	BEARING ANG CONTACT
20.1	1	35-4453	MOTOR SYSTEM ASSY
20.2	1	20-4259	MOTOR MOUNTING PLATE
20.3	1	20-4207	STANDOFF
20.4	1	25-4269	BRACKET SOLENOID
20.5	1	30-1039	PULLEY DRIVE 310SPB
20.6	1	62-2510	SOLENOID ASSY HRT210
20.7	2	40-1799	SHCS 8-32 x 1
20.8	4	40-1638	SHCS 5/16-18 x 2 1/2
20.9	2	45-1603	WASHER #8 SPLT LCK PLT
20.10	4	45-1600	WASHER 5/16 SPLT LCK PLT
20.11	1	54-4506	BELT GT 5MR-500-15



IT	QTY	DWG #	TITLE
1	1	20-4116	MOTOR SPACER
2	1	20-4210	TOP COVER HRT310
3	1	20-4211	PLATTER
3A	1	20-4231	PLATTER HORIZONTAL
3B	1	20-4246	PLATTER HORIZ. PALLET CHANGER
4	1	20-4212	SPINDLE (30-1085)
5	1	20-4213	BRAKE DISC
6	1	20-4214	WORM GEAR 310mm RT (35-4096)
7	1	20-4218	HOUSING COVER 310mm
8	1	20-4236	SPINDLE SPACER HRT310
9	1	20-4506	PULLEY DRIVEN PULLEY
10	1	20-4230	KEY BODY 310MM-450MM
11	1	20-4230	LOCKING DRIVEN PULLEY
12	4	20-4236	KEY BODY 310MM-450MM
13	4	20-4236	LOCKING DRIVEN PULLEY
14	1	25-4569	MOTOR ENCLOSURE BRUSHLESS
15	1	25-4224	ENCLOSURE COVER
16	1	25-4225	SIDE COVER HRT310
17	1	25-4226	TOP COVER HRT310
18	1	28-4128	SIGHT GLASS OIL
19	1	35-4210	WORM SHAFT ASSY 310mm
20	1	35-4215A	MOTOR SYSTEM ASSY 310mm
21	1	35-4215A	MOTOR SYSTEM ASSY WP
22	1	35-4025	HOME SWITCH ASSY ROTARY WP
23	3	40-1610	SHCS 1/4-20 x 1/2 (HZ ONLY)
24	1	40-1630	SHCS 1/4-20 x 5/16
25	16	40-1632	SHCS 3/8-16 x 1 1/4
26	6	40-1636	SHCS 1/2-13 x 2
27	6	40-1661	SHCS 1/2-13 x 3/4
28	4	40-1798	SHCS 5/32 x 1 3/4
29	1	40-1632	SHCS 1/4-20 x 1/2
30	1	40-1632	SHCS 1/4-20 x 1/2
31	2	40-1632	SHCS 1/4-20 x 1/2
32	4	40-1716	SHCS 5/16-18 x 1 3/4
33	2	45-1704	HHB 5/16-18 x 7/8
34	1	44-16206	SSS 6-32 x 1 FULL DOG
35	2	45-1739	WASHER 5/16 FLAT A325
36	2	48-1683	DOWEL PIN 3/16 x 5/8
37	1	49-1008	EYE BOLT 1/2-13 x 7/8
38	4	45-0042	WASHER FLAT
39	1	51-0036	NEEDLE ROLLER 42-52x30mm
40	1	51-2036	BEARING DEEP GROOVE #6024
41	1	51-2037	BEARING DEEP GROOVE #6032
42	2	56-2087	SNAP RING N5000-206
43	1	57-1051	SEAL CRT1609A
44	1	57-2250	ORING 2 1/2x5x7
45	1	57-0025	ORING 2 1/2x5x7
46	1	57-2252	ORING 2 1/2x5x7
47	1	57-2252	ORING 2 1/2x5x7
48	1	57-2931	ORING 2 1/2x5x7
49	2	57-4231	GASKET MOTOR ENCLOSURE
50	2	58-1708	1/8 AIR FITTING STRAIGHT
51	5	58-1708	1/8 AIR FITTING STRAIGHT
52	1	58-1708	1/8 AIR FITTING STRAIGHT
53	2	58-1677	1/4 NPT ANCHOR FITTING
54	1	58-2743	BRANCH T MALE W1 MALE
55	1	58-2744	MAGNETIC OIL PLUG 1/4-18 NPT
56	2	58-2754	CHECK VALVE 1/8 X 1/8 FEM
57	2	22-4248	TUBE WICK OILER 310
58	1	58-3065	AIR MUFFLER 1/4 NPT
59	3	58-3075	90DEG FITTING 1/8-1/4 NPT
60	1	58-3105	PIPE PLUG 1/4 NPT
61	1	58-3618	1/4 STREET ELBOW 90DEG
62	2	58-2869	WICK 1/4 DIA ROUND
63	1	58-3710	QUICK RELEASE FITTING MALE
64	2	58-2876	TITAN SPRING #17-078
65	1	68-16101	MAGNET MICROSWITCH
66	1	35-4220	REMOTE OIL FILL ASSY (HS-16/16P ONLY)
67	2	57-4134	GASKET AIR FITTING
68	1	57-4134	GASKET AIR FITTING
69	1	20-4262	NAMEPLATE ASER HRT310
70	2	40-1666	MC DR SCREW 2 X 1/4 RD
71	1	52-2121	ORING 2-1/2x5x7
72	4	52-0567	ORING 2-207 VITON
73	1	57-4133	J-BOX GASKET SQUARE

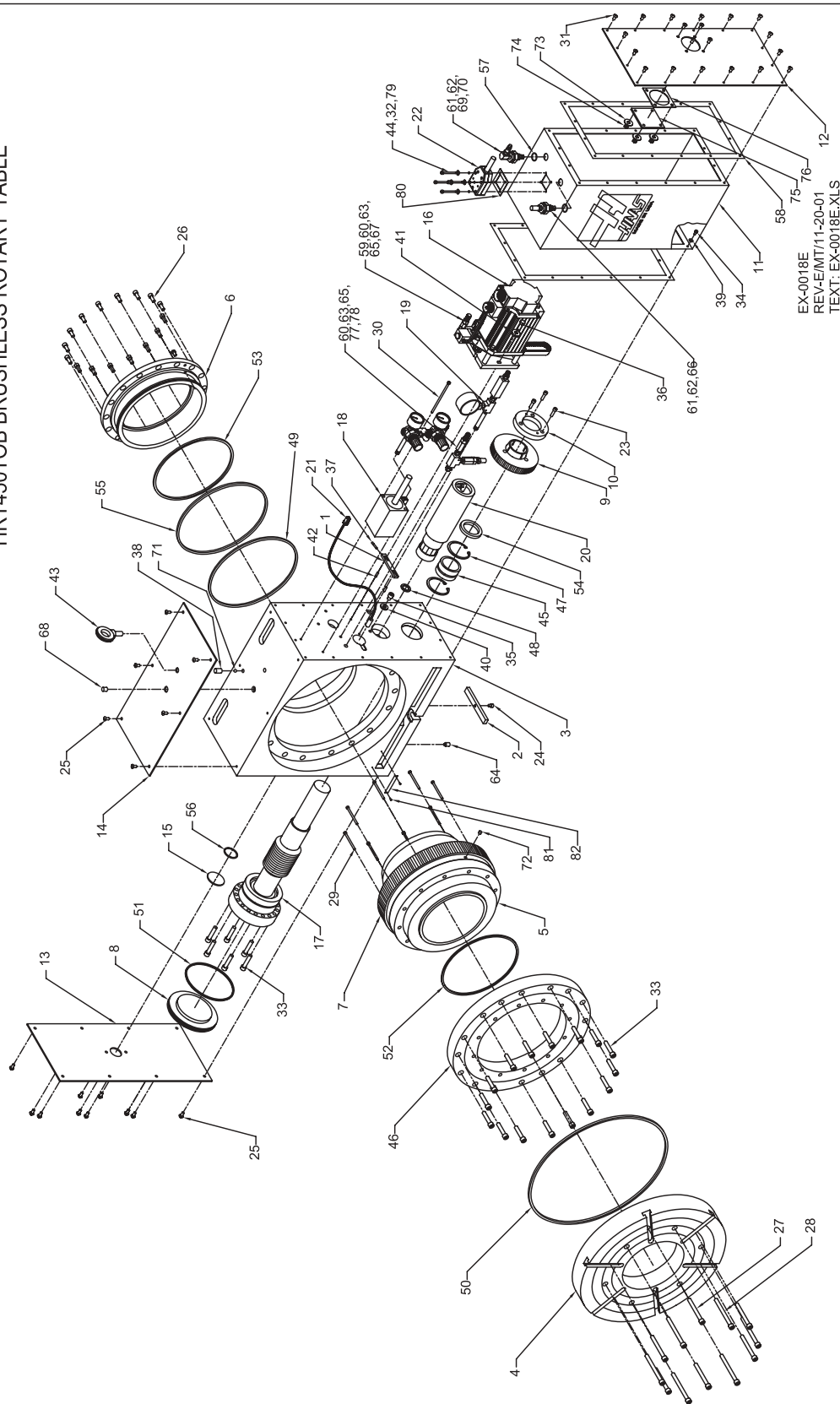
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30-1703 COMPLETE HRT310
30-1075 HRT310TO UNTESTED

IT	QTY	DWG #	TITLE
71	1	52-2121	ORING 2-1/2x5x7
72	4	52-0567	ORING 2-207 VITON
73	1	57-4133	J-BOX GASKET SQUARE

EX-0019D

REV.DIMT/11-20-01

HRT450TOB BRUSHLESS ROTARY TABLE



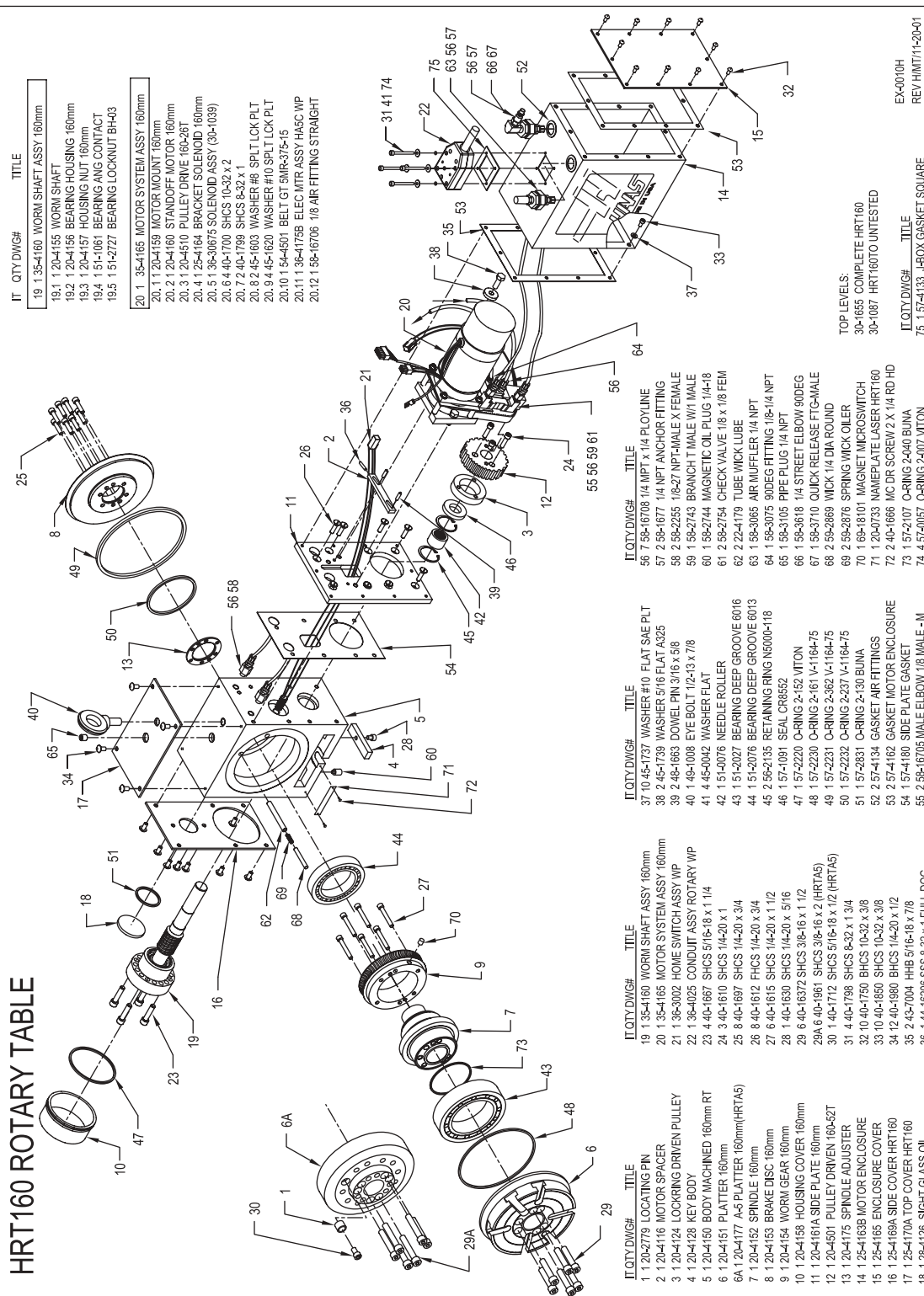
EX-0018E
REV-E/MT/11-20-01
TEXT: EX-0018E.XLS



Hrt-Series

D	QTY	DWG #	DESCRIPTION	D	QTY	DWG #	DESCRIPTION
1	1	20-4116	MOTOR SPACER	70	1	58-3710	QUICK RELEASE FTG-MALE
2	1	20-4230	KEY BODY 310MM/450MM	71	1	59-2055	3/8" STEEL BALLS
3	1	20-4250	BODY MACHINED 450mm RT	72	1	69-18101	MAGNET MICROSWITCH
4	1	20-4251	PLATTER	73	4	45-1850	WASHER 1/4 FENDER PLT
5	1	20-4252	SPINDLE	74	4	46-1625	NUT 1/4-20 HEX BLK
6	1	20-4253A	FLEX BRAKE	75	1	28-4278	SIGHT GLASS PRESS GUAGE
7	1	20-4254	WORM GEAR	76	1	57-4279	GASKET, SIGHT GLASS
8	1	20-4258	HOUSING COVER	77	1	58-2262	AIR MUFFLER CENTERED BRO
9	1	20-4508	PULLEY DIVEN 450-78T	78	2	58-16732	1/8X1/8 MALE HEX JOINT
10	1	20-4264	LOCKRING	79	4	57-0057	O-RING 2-007 VITON
11	1	25-4265	MOTOR ENCLOSURE	80	1	57-4133	J-BOX GASKET SQUARE
12	1	25-4266	ENCLOSURE COVER	81	2	40-1666	MC DR SCREW 2 X 1/4 RD HD
13	1	25-4267A	SIDE COVER	82	1	20-0733	NAMEPLATE LASER HRT160
14	1	25-4268	TOP COVER	35-4245			WORM SHAFT ASSY
15	1	28-4126	OIL SIGHT GLASS	D	QTY		DWG # DESCRIPTION
16	1	35-4454	MOTOR SYSTEM ASSY 450MM B	17.1	1	20-4255	WORM SHAFT
17	1	35-4245	WORM SHAFT ASSY	17.2	1	20-4256	BEARING HOUSING
18	1	35-4250	ACCUMULATOR ASSY	17.3	1	20-4257	HOUSING NUT
19	1	35-4255	CHECK VALVE ASSY	17.4	1	51-1013	BEARING ANG CONTACT
20	1	35-4260	HYDRAULIC CYLINDER ASSY	17.5	1	51-2043	BEARHUG LOCKNUT BH-09
21	1	36-3002	HOME SWITCH ASSY WP	35-4245			CHECK VALVE ASSY
22	1	36-4030B	CBL BL ALUM J-BOX 18.5'	D	QTY		DWG # DESCRIPTION
23	3	40-1610	SHCS 1/4-20 X 1	19.1	1	58-16708	1/4 NPT X 1/4 POLYLINE
24	1	40-1630	SHCS 1/4-20 X 5/16	19.2	1	58-1734	HYD HEX NIPPLE 1/4 NPT
25	16	40-1980	BHCS 1/4-20 X 1/2	19.3	1	58-27396	DRY GUAGE 2000PSI 1/4NPT
26	16	40-16385	SHCS 5/16-18 X 3/4	19.4	1	58-2753	HYDRAULIC CHECK VALVE
27	6	40-16437	SHCS 3/8-16 X 3 1/4	19.5	1	58-3695	1/4 NPT FEMALE T
28	6	40-16438	SHCS 3/8-16 X 4	19.6	1	58-1682	NIPPLE 1/4 NPT X 2 SST
29	8	40-1679	SHCS 1/4-20 X 2 1/2	35-4250			ACCUMULATOR ASSY
30	2	40-1696	SHCS 1/4-20 X 4 1/2	D	QTY		DWG # DESCRIPTION
31	16	40-1750	BHCS 10-32 X 3/8	18.1	2	58-1627	1/8-27 PIPE PLUG
32	4	40-1804	SHCS 8-32 X 2	18.2	2	58-16732	1/8X1/8 MALE HEX JOINT
33	20	40-1960	SHCS 3/8-16 X 1 3/4	18.3	1	58-16700	STREET ELBOW 1/8 INCH
34	16	40-1632	SHCS 1/4-20 X 1/2	18.4	1	58-1683	LONG NIPPLE 1/8-27 X 3 BRASS
35	1	40-16391	SHCS 3/8-16 X 1/2	18.5	2	58-27395	AIR PRESSURE GUAGE
36	3	43-7004	HHB 5/16-18 X 7/8	18.6	2	58-2740	AIR REGULATOR
37	1	44-16205	SSS 8-32 X 1 FULL DOG	18.7	3	58-3075	90DEG FITTING 1/8-1/4 NPT
38	1	44-1696	SSS 1/2-13 X 3/4 FULL DOG	18.8	1	58-3100	FEMALE BRANCH T 1/8NPT
39	16	45-16390	WASHER 1/4 FLAT SAE PLT	18.9	1	59-2736	AIR CYLINDER QJ92-1673
40	1	45-1730	WASHER 3/8 HARD	35-4454			MTR SYSTEM ASSY 450MMB
41	3	45-1739	WASHER 5/16 FLAT A325	D	QTY		DWG # DESCRIPTION
42	2	48-1663	DOWEL PIN 3/16 X 5/8	16.1	4	22-4207	STANDOFF
43	1	49-1008	EYE BOLT 1/2-13 X 7/8	16.2	1	20-4259	MOTOR MOUNTING PLATE
44	4	45-0042	WASHER FLAT	16.3	1	20-4519	PULLEY DRIVE 45600B
45	1	51-0077	NEEDLE ROLLER	16.4	1	25-4269	BRACKET SOLENOID
46	1	51-2038	BRNG CROSS ROLLER	16.5	1	36-30675	SOLENOID ASSY WP
47	2	56-2083	RETAINING RING N5000-244	16.6	1	62-0014	MOTOR 09 YASKAWA SIGMA
48	1	57-0020	O-RING 2-210 VITON	16.7	4	40-1629	SHCS 5/16-18 X 2 3/4
49	1	57-0025	O-RING 2-275 V-1164-75	16.8	2	40-1799	SHCS 8-32 X 1
50	1	57-0094	O-RING 2-384 V-1164-75	16.9	4	45-1600	WASHER 5/16 SPLT LCK PLT
51	1	57-0097	O-RING 2-162 VITON	16.10	2	45-1603	WASHER #8 SPLT LCK PLT
52	1	57-0098	O-RING 2-270 VITON	16.11	1	54-4508	BELT GT 5MR-800-15
53	1	57-0101	O-RING 2-373 V-1164-75	16.12	1	62-0027	NOK SEAL SIGMA 9 SERIES
54	1	57-2086	SEAL CR19606	35-4260			HYDRAULIC CYLINDER ASSY
55	1	57-2251	O-RING 2-276 V-1164-75	D	QTY		DWG # DESCRIPTION
56	1	57-2831	O-RING 2-130 BUNA	20.1	1	20-4270	PRIMARY CYLINDER
57	2	57-4134	GASKET AIR FITTINGS	20.2	1	20-4271	PRIMARY PISTON 450MM
58	2	57-4261	GASKET ENCLOSURE COVER	20.3	1	20-4272	CAP PRIMARY CYLINDER
59	2	58-16705	MALE ELBOW 1/8 MALE TO MALE	20.4	1	20-4273A	SECONDARY CYLINDER
60	4	58-16706	1/8 AIR FITTING STRAIGHT	20.5	1	20-4274	SECONDARY PISTON
61	2	58-16708	1/4 MPT X 1/4 POLYLINE	20.6	1	56-2084	RETAINING RING N5000-200
62	2	58-1677	1/4 NPT ANCHOR FITTING	20.7	1	57-1036	POLYSEAL 1870-16250
63	2	58-2743	BRANCH T MALE W/1 MALE	20.8	1	57-1037	WEARBAND W2-2000-375
64	1	58-2744	MAGNETIC OIL PLUG 1/4-18	20.9	2	58-3075	90 DEG FITTING 1/8-1/4 NPT
65	4	58-2754	CHECK VALVE 1/8 X 1/8 FEM	20.10	1	59-2058	BALL 1/4 STEEL
66	1	58-3065	AIR MUFFLER 1/4 NPT	20.11	1	59-2083	SPRING 31/64 X 4 7/16
67	1	58-3075	90DEG FITTING 1/8-1/4 NPT	20.12	1	58-0058	O-RING 2-014 V-1164-75
68	1	58-3105	PIPE PLUG 1/4 NPT	20.13	1	57-0096	O-RING 2-133 VITON
69	1	58-3618	1/4 STREET ELBOW 90DEG	20.14	1	57-1038	POLYSEAL 12500250

HRT160 ROTARY TABLE



IT QTY/DWG#	TITLE
19 1 35-4160	WORM SHAFT ASSY 160mm
19.1 1 20-4155	WORM SHAFT
19.2 1 20-4156	BEARING HOUSING 160mm
19.3 1 20-4157	HOUSING NUT 160mm
19.4 1 51-1061	BEARING ANG CONTACT
19.5 1 51-2727	BEARING LOCKNUT BH-403
20 1 35-4165	MOTOR SYSTEM ASSY 160mm
20.1 1 20-4159	MOTOR MOUNT 160mm
20.2 1 20-4160	STANDOFF MOTOR 160mm
20.3 1 20-41510	PULLEY DRIVE 160-261
20.4 1 25-4164	BRACKET SOLENOID 160mm
20.5 1 35-30675	SOLENOID ASSY (35-1039)
20.6 4 40-1700	SHCS 10-32 x 2
20.7 2 40-1799	SHCS 8-32 x 1
20.8 2 45-1603	WASHER #8 SPLIT LOCK PLT
20.9 4 45-1620	WASHER #10 SPLIT LOCK PLT
20.10 1 54-1501	BELT GT 5MR-375-15
20.11 1 35-4175B	ELEC MTR ASSY HA5C WP
20.12 1 58-16706	1/8 AIR FITTING STRAIGHT

IT QTY/DWG#	TITLE
30 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.1 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.2 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.3 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.4 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.5 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.6 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.7 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.8 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.9 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.10 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.11 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.12 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.13 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.14 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.15 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.16 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.17 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.18 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.19 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.20 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.21 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.22 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.23 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.24 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.25 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.26 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.27 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.28 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.29 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.30 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.31 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.32 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.33 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.34 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.35 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.36 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.37 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.38 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.39 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.40 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.41 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.42 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.43 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.44 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.45 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.46 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.47 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.48 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.49 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.50 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.51 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.52 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.53 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.54 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.55 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.56 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.57 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.58 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.59 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.60 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.61 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.62 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.63 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.64 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.65 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.66 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.67 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.68 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.69 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.70 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.71 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.72 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.73 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.74 1 20-4177	A-3 PLATTER 160mm(HRTA5)
30.75 1 20-4177	A-3 PLATTER 160mm(HRTA5)

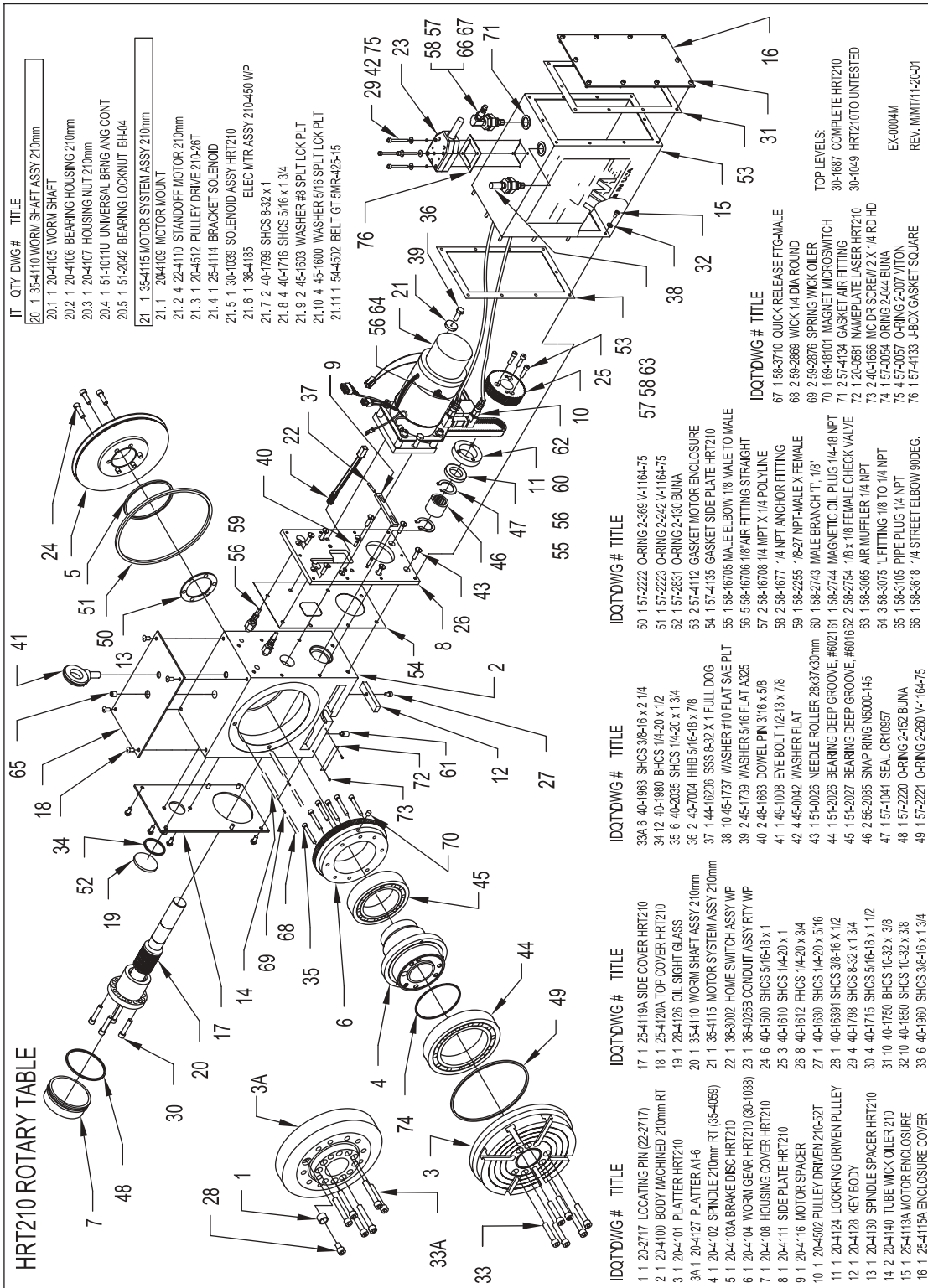
IT QTY/DWG#	TITLE
37 10 45-7737	WASHER #10 FLAT SAE PLT
38 2 45-7739	WASHER #16 FLAT A325
39 2 48-1663	DOWEL PIN 3/16 x 5/8
40 1 49-1008	EYE BOLT 1/2-13 x 7/8
41 4 45-0042	WASHER FLAT
42 1 51-2076	NEEDLE ROLLER
43 1 51-2078	BEARING DEEP GROOVE 6016
44 1 51-2079	BEARING DEEP GROOVE 6013
45 2 56-2135	RETAINING RING N6000-118
46 1 57-1091	SEAL CR8552
47 1 57-2220	O-RING 2-1/2 x 1/2 VITON
48 1 57-2230	O-RING 2-1/2 x 1/2 V-1164-75
49 1 57-2231	O-RING 2-3/8 x 1/2 V-1164-75
50 1 57-2233	O-RING 2-237 V-1164-75
51 1 57-2234	O-RING 2-130 BUNA
52 2 57-4134	GASKET MOTOR ENCLOSURE
53 2 57-4162	GASKET MOTOR ENCLOSURE
54 1 57-4180	SIDE PLATE GASKET
55 2 58-16705	MALE ELBOW 1/8 MALE - M

IT QTY/DWG#	TITLE
19 1 35-4160	WORM SHAFT ASSY 160mm
20 1 35-4165	MOTOR SYSTEM ASSY 160mm
21 1 35-3002	HOME SWITCH ASSY WP
22 1 35-4025	CONDUIT ASSY ROTARY WP
23 4 40-1667	SHCS 5/16-18 x 1 1/4
24 3 40-1610	SHCS 1/4-20 x 1
25 8 40-1697	SHCS 1/4-20 x 3/4
26 8 40-1612	FLGS 1/4-20 x 1 1/2
27 6 40-1615	SHCS 1/4-20 x 5/16
28 1 40-1630	SHCS 1/4-20 x 1 1/2
29 6 40-1632	SHCS 3/8-16 x 1 1/2
29A 6 40-1961	SHCS 3/8-16 x 2 (HRTA5)
30 1 40-1772	SHCS 5/16-18 x 1 1/2 (HRTA5)
31 4 40-1798	SHCS 8-32 x 1 3/4
32 10 40-1750	SHCS 10-32 x 3/8
33 10 40-1850	SHCS 10-32 x 3/8
34 12 40-1980	BHCS 1/4-20 x 1/2
35 2 43-7004	HHB 5/16-18 x 7/8
36 1 44-16206	SSS 8-32 x 1 FULL DOG

IT QTY/DWG#	TITLE
1 1 20-2779	LOCATING PIN
2 1 20-4116	MOTOR SPACER
3 1 20-4124	LOCKRING DRIVEN PULLEY
4 1 20-4128	KEY BODY
5 1 20-4150	BODY MACHINED 160mm RT
6 1 20-4151	PLATTER 160mm
6A 1 20-4177	A-3 PLATTER 160mm(HRTA5)
7 1 20-4152	SPINDLE 160mm
8 1 20-4153	BRAKE DISC 160mm
9 1 20-4154	WORM GEAR 160mm
10 1 20-4158	HOUSING COVER 160mm
11 1 20-4161A	SIDE PLATE 160mm
12 1 20-4501	PULLEY DRIVEN 160-52T
13 1 20-4175	SPINDLE ADJUSTER
14 1 20-4163B	MOTOR ENCLOSURE
15 1 25-4165A	ENCLOSURE COVER
16 1 25-4165A	SIDE COVER HRT160
17 1 25-4170A	TOP COVER HRT160
18 1 28-4126	SIGHT GLASS OIL

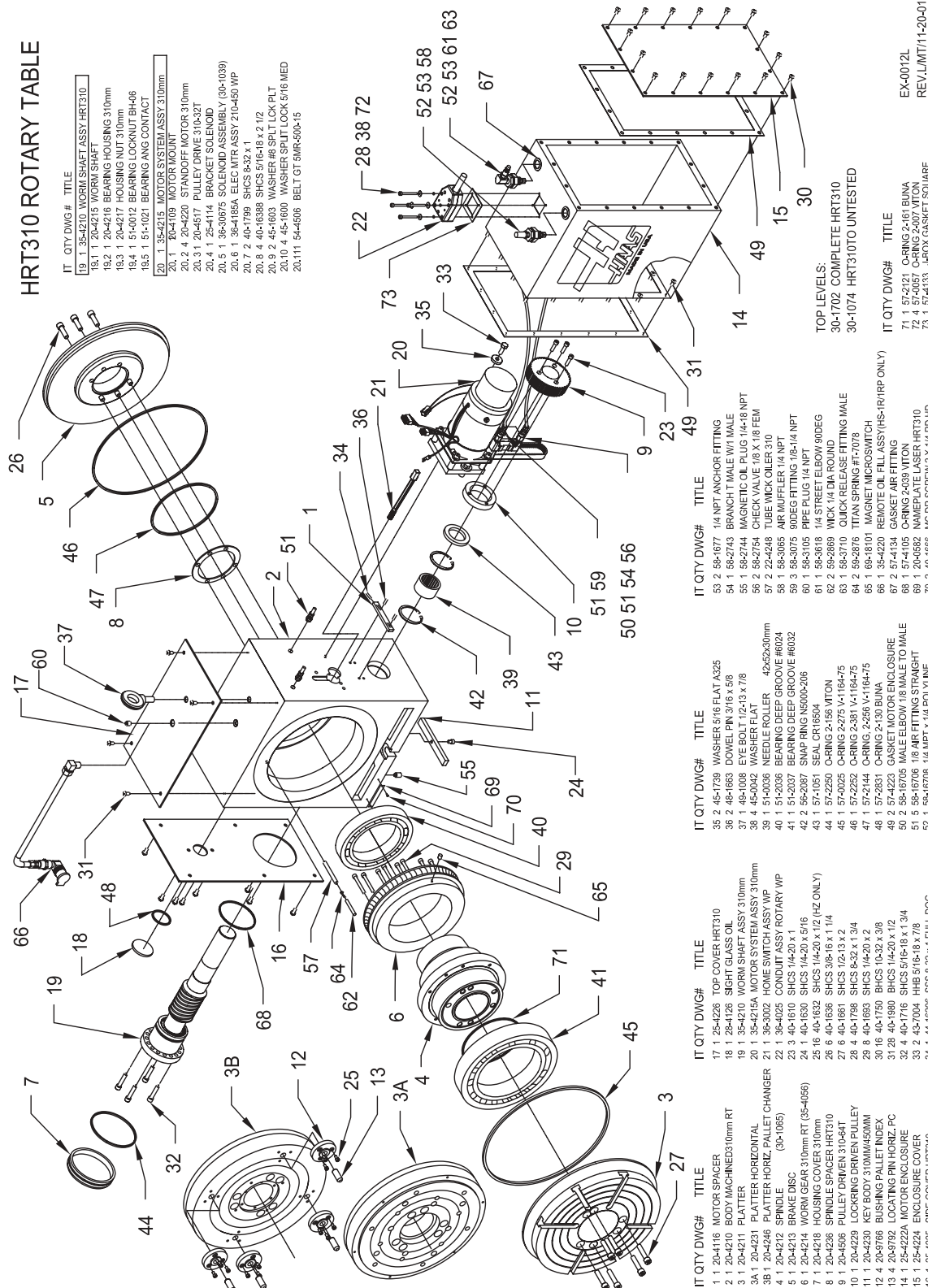
TOP LEVELS:
 30-1655 COMPLETE HRT160
 30-087 HRT160UO UNTESTED
 75 1 57-4133 J-BOX GASKET SQUARE
 75 1 57-4133 J-BOX GASKET SQUARE

EX-0010H
 REV HMT/11-20-01



HRT310 ROTARY TABLE

IT	QTY	DWG#	TITLE
19.1	1	35-4210	WORM SHAFT ASSY HRT310
19.2	1	20-4216	BEARING HOUSING 310mm
19.3	1	20-4217	HOUSING NUT 310mm
19.4	1	51-0012	BEARING LOCKNUT BH-46
19.5	1	51-1021	BEARING ANG CONTACT
20.1	1	35-4215	MOTOR SYSTEM ASSY 310mm
20.2	1	20-4109	MOTOR MOUNT
20.3	1	20-4220	STANDOFF MOTOR 310mm
20.4	1	20-4517	PULLEY DRIVE 310-32T
20.5	1	25-4114	BRACKET SOLENOID
20.6	1	36-00675	SOLENOID ASSEMBLY (30-1039)
20.7	2	36-4185A	ELEC MTR ASSY 210-450 WP
20.8	4	40-1799	SHCS 8-32 x 1
20.9	4	40-1838	SHCS 5/16-18 x 2 1/2
20.10	4	45-1003	WASHER #8 SPLIT LOCK PLT
20.11	4	45-1000	WASHER SPLIT LOCK 5/16 MED
20.111	54	4536	BELT GT 5MR-500-15



IT	QTY	DWG#	TITLE
53	2	58-1677	1/4 NPT ANCHOR FITTING
54	1	58-2743	BRANCH T MALE W/1 MALE
55	1	58-2744	MAGNETIC OIL PLUG 1/4-18 NPT
56	2	58-2754	CHECK VALVE 1/8 x 1/8 FEM
57	2	22-4248	TUBE WICK OILER 310
58	1	58-3065	AIR MUFFLER 1/4 NPT
59	3	58-3075	90DEG FITTING 1/8-1/4 NPT
60	1	58-3105	PIPE PLUG 1/4 NPT
61	1	58-3618	1/4 STREET ELBOW 90DEG
62	2	58-2869	WICK 1/4 DIA ROUND
63	1	58-3710	QUICK RELEASE FITTING MALE
64	2	58-2876	TITAN SPRING #15075
65	1	58-1001	1/4 STREET ELBOW 90DEG
66	1	58-4221	REMOVE OIL FITTING
67	1	58-4222	REMOVE OIL FITTING
68	1	58-4105	GASKET AIR FITTING
69	1	20-5682	NAMEPLATE LASER HRT310
70	2	40-1686	MC DR SCREW 2 X 1/4 RD HD

IT	QTY	DWG#	TITLE
35	2	45-1739	WASHER 5/16 FLAT A325
36	2	48-1663	DOWEL PIN 3/16 x 5/8
37	1	49-1008	EYE BOLT 1/2-13 x 7/8
38	4	45-0042	WASHER FLAT
39	1	51-0036	NEEDLE ROLLER 42x52x30mm
40	1	51-2037	BEARING DEEP GROOVE #6024
41	1	51-2037	BEARING DEEP GROOVE #6032
42	1	51-2037	BEARING DEEP GROOVE #6026
43	1	51-2037	BEARING DEEP GROOVE #6024
44	1	51-2037	BEARING DEEP GROOVE #6026
45	1	51-2037	BEARING DEEP GROOVE #6024
46	1	51-2037	BEARING DEEP GROOVE #6026
47	1	51-2144	O-RING 2-256 1/4 1184-25
48	1	51-2144	O-RING 2-256 1/4 1184-25
49	2	51-2144	O-RING 2-256 1/4 1184-25
50	2	51-2144	O-RING 2-256 1/4 1184-25
51	5	58-16705	MALE ELBOW 1/8 MALE TO MALE
52	1	58-16706	1/8 AIR FITTING STRAIGHT
53	1	58-16708	1/4 MPT x 1/4 POLYLINE

IT	QTY	DWG#	TITLE
17	1	25-4226	TOP COVER HRT310
18	1	28-4126	SIGHT GLASS OIL
19	1	35-4210	WORM SHAFT ASSY 310mm
20	1	35-4215A	MOTOR SYSTEM ASSY 310mm
21	1	36-0002	HOMIE SWITCH ASSY WP
22	1	36-0025	CONDUIT ASSY ROTARY WP
23	3	40-1610	SHCS 1/4-20 x 1
24	1	40-1630	SHCS 1/4-20 x 1/2 (RZ ONLY)
25	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
26	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
27	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
28	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
29	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
30	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
31	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
32	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
33	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
34	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
35	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
36	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
37	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
38	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
39	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
40	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
41	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
42	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
43	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
44	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
45	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
46	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
47	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
48	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
49	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
50	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
51	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)
52	1	40-1632	SHCS 1/4-20 x 1/2 (RZ ONLY)

IT	QTY	DWG#	TITLE
1	1	20-4116	MOTOR SPACER
2	1	20-4210	BODY MACHINED 310mm RT
3	1	20-4211	PLATTER
3A	1	20-4231	PLATTER HORIZONTAL
3B	1	20-4246	PLATTER HORIZ PALLET CHANGER
4	1	20-4212	SPINDLE (30-1065)
5	1	20-4213	BRAKE DISC
6	1	20-4214	WORM GEAR 310mm RT (35-4056)
7	1	20-4215	HOUSING COVER 310mm
8	1	20-4216	BEARING HOUSING 310mm
9	1	20-4217	HOUSING NUT 310mm
10	1	20-4218	LOCKING DRIVEN PULLEY
11	1	20-4219	KEY BODY 310MM/45MM
12	4	20-4220	LOCATING PIN HORIZ PC
13	4	20-4221	LOCATING PIN HORIZ PC
14	1	25-4222	MOTOR ENCLOSURE
15	1	25-4224	ENCLOSURE COVER
16	1	25-4225	SIDE COVER HRT310

TOP LEVELS:
30-1702 COMPLETE HRT310
30-1074 HRT310 TO UNTESTED

IT	QTY	DWG#	TITLE
71	1	52-2121	O-RING 2-161 BUNA
72	4	57-0057	O-RING 2-407 VITON
73	1	57-4133	J-BOX GASKET SQUARE

EX-0012L
REV.LMT/11-20-01

HRT450 ROTARY TABLE

ITEM	PART NO.	DESCRIPTION	QTY
ITEM 16	35-4200	MOTOR SYSTEM ASSY 450mm	
	35-4110	GROUND WIRE	1
	35-4110	GROUND WIRE	1
	40-1799	SHCS 8-32 X 1	2
	40-1799	SHCS 8-32 X 1	1
	40-1799	SHCS 8-32 X 1	1
	40-1799	MOTOR MOUNTING PLATE	1
	35-4012	SLEEVY DRIVE 210-28T	1
	35-4012	SLEEVY DRIVE 210-28T	1
	35-4185A	ELEC MOTOR ASSY 210-450 WP	1
	40-1799	SHCS 8-32 X 1	1
	45-1003	WASHER 8/32 PLT LOCK PLT	2
	45-1003	WASHER 8/32 PLT LOCK PLT	1
	45-1008	BELT GT 5MR-400-15	2
	35-4245	WORM SHAFT ASSY 450MM	
	35-4245	WORM SHAFT ASSY 450MM	
ITEM 17	35-4255	HOUSING SHAFT	QTY
	24-2557	HOUSING NUT	1
	24-2557	HOUSING NUT	1
	51-2043	BEARING LOGANUT BH-99	1
ITEM 18	35-4250	ACCUMULATOR ASSY	QTY
	58-1027	1/8-27 PIPE PLUG	5
	58-1027	1/8-27 PIPE PLUG	5
	58-1672	1/8 X 1/8 M6 HEX JON	2
	58-1672	1/8 X 1/8 M6 HEX JON	5
	58-2075	ANALOG PRESSURE GAUGE 1/2	1
	58-2075	ANALOG PRESSURE GAUGE 1/2	1
	58-3075	90DEG FITTING 1/8-1/4 NPT	3
	58-3075	90DEG FITTING 1/8-1/4 NPT	3
	58-3075	90DEG FITTING 1/8-1/4 NPT	1
	58-2736	AIR CYLINDER QJ32-1673	1
ITEM 19	35-4300	CHECK VALVE ASSY	QTY
	58-1376B	1/4 NPT V L VALVE LINE	1
	58-1376	NIPPLE 1/4 NPT X 2 ST	1
	58-1734	HYD HEX NIPPLE 1/4 NPT	1
	58-1734	HYD HEX NIPPLE 1/4 NPT	2
	58-3655	HYDRAULIC CHECK VALVE 1/4 NPT FEMALE T	1
ITEM 20	35-4350	CYL ASSY HYDRAULIC	QTY
	20-2270	PRIMARY CYLINDER	1
	20-2270	CAP PRIMARY CYLINDER	1
	20-2272	SECONDARY CYLINDER	1
	20-2272	SECONDARY PISTON	2
	58-2084	RETAINING RING N500-200	1
	58-2084	RETAINING RING N500-200	1
	57-1038	POL VESAL 1871-10280	1
	57-1038	POL VESAL 1871-10280	1
	57-1038	POL VESAL 1871-10280	1
	58-3075	90 DEG FITTING 1/8-1/4 NPT	1
	58-3075	90 DEG FITTING 1/8-1/4 NPT	1
	58-3075	90 DEG FITTING 1/8-1/4 NPT	2
	58-3075	90 DEG FITTING 1/8-1/4 NPT	2
	58-3075	90 DEG FITTING 1/8-1/4 NPT	2
	58-3075	90 DEG FITTING 1/8-1/4 NPT	2
	58-3075	90 DEG FITTING 1/8-1/4 NPT	2

ITEM	DESCRIPTION	QTY
E-HRT-650	50MM ROTARY TABLE ONLY	1
UNTESTED	AMPELATE LASER HRT-160	4
	RING 2-307 VITON	
	EX-0027L	
	RES-AMT/1-20-01	

[illegible]

3	44	48-1008	NEEDLE 1/2-13 X 7/8	1
16	45	48-1009	NEEDLE 1/2-13 X 7/8	1
10	46	48-1007	NEEDLE ROLLER 4X10X WORM	1
1	47	48-1006	NEEDLE ROLLER 4X10X WORM	1
6	48	56-2033	RETAINING RING 1650-244	1
6	49	56-2033	RETAINING RING 1650-244	1
2	50	45-0020	CRANK 2-210 VITON	1
2	51	45-0020	CRANK 2-210 VITON	1
2	52	45-0020	CRANK 2-210 VITON	1
2	53	45-0084	CRANK 2-384 VITON	1
2	54	45-0084	CRANK 2-384 VITON	1
2	55	45-0086	CRANK 2-270 VITON	1
2	56	45-0101	CRANK 2-375 V-1164-75	1
22	57	45-0101	CRANK 2-375 V-1164-75	1
4	58	45-0111	CRANK 2-210 VITON	1
4	59	45-0111	CRANK 2-210 VITON	1
1	60	52-2031	CRANK 2-138 BUNA	1
1	61	52-2031	CRANK 2-138 BUNA	1
1	62	52-2031	CRANK 2-138 BUNA	1
16	63	57-2181	ENGLISH ARMS CO FORTRESS	1
1	64	57-2181	ENGLISH ARMS CO FORTRESS	1
1	65	54-4279	GASKET RIGHT GLASS	1
1	66	54-4279	GASKET RIGHT GLASS	1
1	67	54-4279	GASKET RIGHT GLASS	1
1	68	54-4279	GASKET RIGHT GLASS	1
1	69	54-4279	GASKET RIGHT GLASS	1
1	70	54-4279	GASKET RIGHT GLASS	1
1	71	54-4279	GASKET RIGHT GLASS	1
1	72	54-4279	GASKET RIGHT GLASS	1
1	73	54-4279	GASKET RIGHT GLASS	1
1	74	54-4279	GASKET RIGHT GLASS	1
1	75	54-4279	GASKET RIGHT GLASS	1
1	76	54-4279	GASKET RIGHT GLASS	1
1	77	54-4279	GASKET RIGHT GLASS	1
1	78	54-4279	GASKET RIGHT GLASS	1
1	79	54-4279	GASKET RIGHT GLASS	1
1	80	54-4279	GASKET RIGHT GLASS	1
1	81	54-4279	GASKET RIGHT GLASS	1
1	82	54-4279	GASKET RIGHT GLASS	1
1	83	54-4279	GASKET RIGHT GLASS	1
1	84	54-4279	GASKET RIGHT GLASS	1
1	85	54-4279	GASKET RIGHT GLASS	1
1	86	54-4279	GASKET RIGHT GLASS	1
1	87	54-4279	GASKET RIGHT GLASS	1
1	88	54-4279	GASKET RIGHT GLASS	1
1	89	54-4279	GASKET RIGHT GLASS	1
1	90	54-4279	GASKET RIGHT GLASS	1
1	91	54-4279	GASKET RIGHT GLASS	1
1	92	54-4279	GASKET RIGHT GLASS	1
1	93	54-4279	GASKET RIGHT GLASS	1
1	94	54-4279	GASKET RIGHT GLASS	1
1	95	54-4279	GASKET RIGHT GLASS	1
1	96	54-4279	GASKET RIGHT GLASS	1
1	97	54-4279	GASKET RIGHT GLASS	1
1	98	54-4279	GASKET RIGHT GLASS	1
1	99	54-4279	GASKET RIGHT GLASS	1
1	100	54-4279	GASKET RIGHT GLASS	1

[illegible]

KEY BODY	2	20-4230
BODY MACH	2	20-4250
PLATTER	4	20-4251
FLEX BRACKET	5	20-4253A
LOCKING DISC	6	20-4258
BEARING H	7	22-4258
MOTOR ENCL	9	25-4265A
ENCLOSURE	10	25-4266A
SIDE COVER	11	25-4267
TOP COVER	12	25-4268A
SIGHT GLASS	13	28-4128
SIGHT GLASS	14	28-4278
SPYGLASS	15	35-4054
WORM SHAFT	16	35-4245
ACCUMULATOR	18	35-4250
CHECK VALVE	19	35-4260
HYDRAULIC	20	36-3002
HOME SWITCH	21	

