



HAAS SERVICE AND OPERATOR MANUAL ARCHIVE

TRT Series Operators Manual 96-5048J Rev J 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 tilting rotary table is a fully automatic, programmable, rotary positioning device. The unit is made up of a mechanical table that holds the workpiece, a second table that rotates the first, and an electronic unit that controls the movement of the tables. For the T5C, the table rotates an indexer. Positioning of the workpiece is accomplished by programming the angular movements into the memory of the dual control, and then pressing the CYCLE START button on the front panel.

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

TABLE

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

CONTROL

The tilting 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.

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 TRT series was designed for positioning and continuous milling of medium to large sized 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. 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.



1.4 FEATURES

RIGID DESIGN

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

CLASS 30 GRAY IRON CASTING

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

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

AIR BRAKE

On the TRT 210 and TR210, a built-in air brake with 500 ft-lb (Tilt-Axis) and 200 ft.-lb (Rotary-Axis) of holding torque @ 100 PSI. On the TRT 160, a built-in air brake with 200 ft-lbs (Tilt-Axis) and 100 ft-lbs (Rotary-Axis) of holding torque @ 100 PSI.

AC SERVO DRIVE

Closed loop 1.0 HP (HRT160, HRT210), 3.0 HP (HRT310), .75 HP (HA5C).

DC SERVO DRIVE

Closed loop 1.5 HP (A and B axes) DC servo motor on the TRT 210, and a closed loop 1.5 HP and 0.5 HP (Tilt and Rotary axes, respectively) DC servo motor on the TRT 160 and T5C.

VARIABLE FEED RATES

For the TRT 210, variable from .001 deg./sec. to 50 deg./sec for Tilt-axis and from .001 deg./sec to 60 deg. for Rotary -axis. For the TRT 160, variable from .001 deg./sec. to 60 deg./sec. for Tilt-axis and from .001 deg./sec. to 80 deg./sec. for Rotary-axis. For the T5C, variable from .001 deg./sec. to 60 deg./sec. for Tilt-axis and from .001 deg./sec. to 270 deg./sec. for rotary axis.

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.



Trt-Series

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 you to repeat sequences up to 999 times saving programming time and memory space.

AUTOMATIC CIRCLE DIVISION

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

PROGRAMMABLE PARAMETERS

You can alter many of the basic features by performing your own basic programming.

PROGRAM STORAGE

Store and recall from up to four different programs.

MEMORY

A non-volatile memory retains your 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 TRT Series quickly and easily by using a spare **M** function that provides a switch-closer as a signal between your mill and the TRT.

EMERGENCY STOP/FEED-HOLD

You can use the EMERGENCY STOP 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 $\pm 5\%$ @ 15 Amps.

*** OPTIONAL RS-232 INTERFACE** For computer control of sending and receiving programs.

*** 12-MONTH WARRANTY** Against any defects in materials or workmanship.

*** SYNTHETIC GEAR OIL** Provides greater worm gear wear protection than conventional gear oils.

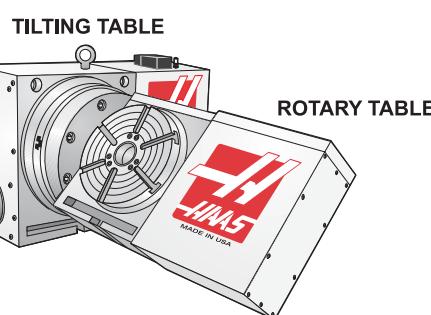


Trt-Series

1.5 SPECIFICATIONS

	TRT 210	TRT 160	T5C*	T5C2,3,4		
	Rotary B-Axis (210)	Tilt A-Axis (310)	Rotary B-Axis (160)	Tilt A-Axis (210)	Rotary B-Axis (HA5C)	Rotary B-Axis (HA5C 2,3,4)
SPINDLE						
Table Torque (Ft.-lb.) (AC / DC)	210 / 210	300 / 200	150 / 100	210 / 210	60 / 45	25 / 20
Feed Rates (Deg/Sec)	.001 to 60	.001 to 50	.001 to 80	.001 to 60	.001 to 270	.001 to 200
Platter Runout (Inch)	.0005	.0005	.0005	.0005	.0004	.004
Backlash (Arc Sec)	30	30	30	30	40	50
Center Height (Inch)	N/A	9.000+/-0.001	N/A	7.750+/-0.001	N/A	N/A
Brake Holding Torque @ 100 PSI (Ft.-lb.)	200	500	100	200	N/A	N/A
INDEXING						
Indexing Accuracy (Sec)	+/-15	+/-25	+/-15	+/-30	+/-30	+/-60
Repeatability (Sec)	within 10	within 10	within 10	within 10	within 10	within 10
Resolution (Deg)	.001	.001	.001	.001	.001	.001
Max. Resolution (Deg)	999.999	999.999	999.999	999.999	999.999	999.999
MOTOR						
Closed loop, AC Servo	1.0 HP	3.0 HP	1.0 HP	1.0 HP	.75 HP	.75HP
DC Servo	1.5 HP	1.5 HP	0.5 HP	1.5 HP	0.5 HP	.5HP
Drive		2:1 Timing Belt & Pulley Set			Direct	Direct
Worm Gear Ratio	90:1	72:1	63:1	90:1	60:1	60:1
OPERATING SPECIFICATIONS						
Air Pressure Max.(PSI)	120	120	120	120	120	120
Power Requirements		115V AC +/- 15% @ 15 AMPS				
Lubrication		Mobil SHC-630 synthetic gear oil.				
Total Weight	735 lbs	400 lbs		213 lbs	285/333/415lbs	
OPERATING ENVIRONMENT						
Maximum Temperature (Deg. F)	100					

* T5C tilt (A-axis) specifications are the same as the tilt (A-axis) of the TRT 160



ROTARY TABLE	TRT - 160	TRT - 210	T5C	T5C2,3,4
TIKLTING TABLE	210mm rotary table	160mm rotary table	HA5C	HA5C2,3,4
	310mm rotary table	210mm rotary table	210mm rotary table	210mm rotary table



Trt-Series

1.6 MACHINE DIMENSIONS

TRT-160/210 () denotes brushless models

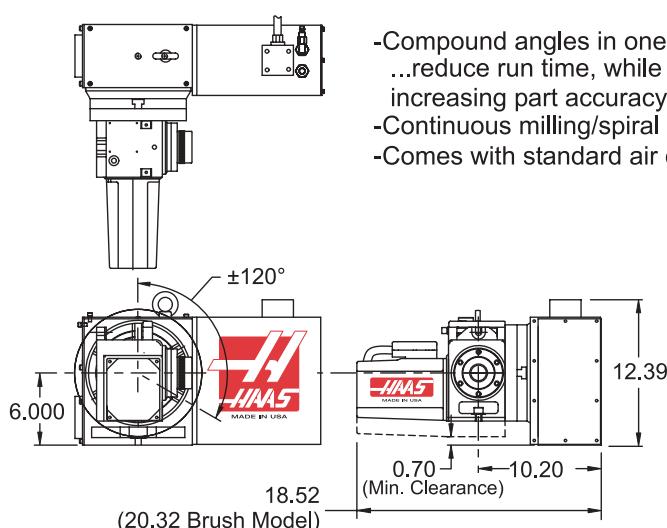
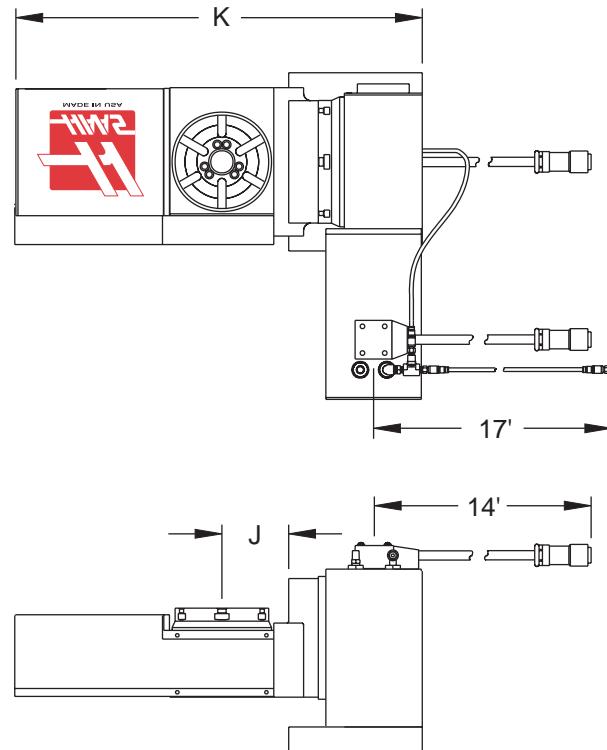
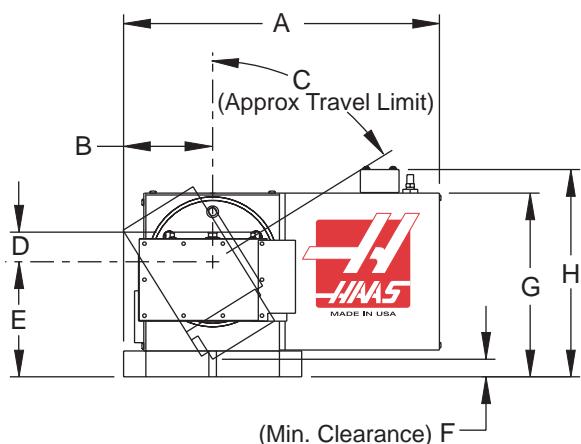
DIMENSIONS

TRT-160

A	19.08" (21.28" Brush)
B	6.00"
C	+/- 120°
D	2.000"
E	7.750"
F	1.18"
G	12.39"
H	14.14"
J	4.25"
K	26.15"

TRT-210

	24.34" (25.84" Brush)
	8.48"
	+/- 120°
	1.000"
	9.000"
	0.40"
	15.90"
	17.65"
	6.00"
	31.10" (33.36" Brush)



- Compound angles in one set-up ...reduce run time, while increasing part accuracy
- Continuous milling/spiral
- Comes with standard air collet

T5C HA5C/HRT210



Trt-Series

1.7 TR SPECIFICATIONS

TR160

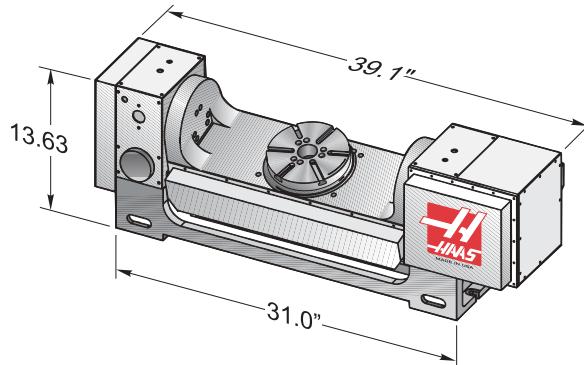
Travels: A - +/- 120° (tilt),
B - 360 (rotate).

Platter: Diameter 6.3" (160mm)
Capacity 80 pounds (36 kg)
Pilot hole 1.5" (38.1mm)
+0.0005", -0.0" x 4.79" deep
Max swing diameter for B-axis 17.5"
Max swing at 90°: 14.4" (366mm)
located 0.125" (3.1mm)
below centerline of A-axis

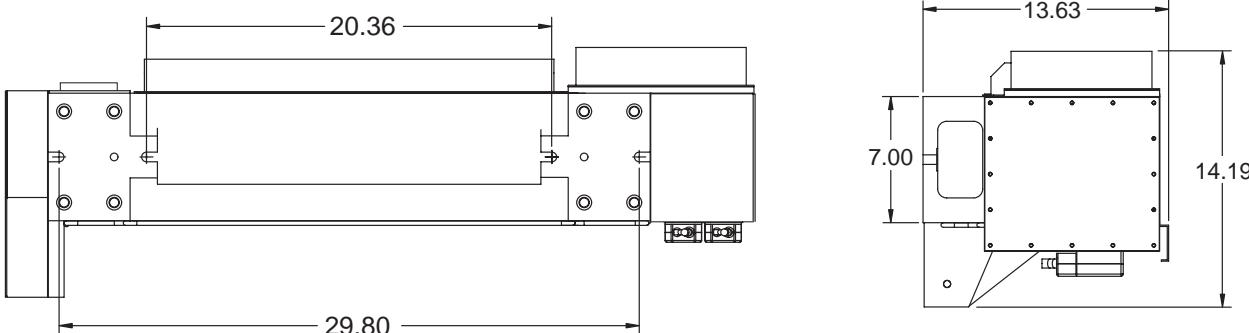
Speed: A-axis 80° per sec
B-axis 80° per sec

Spindle: Torque A-axis 150 ft. lb.
B-axis 100 ft. lb.
Brake torque A-axis 200 ft. lb.
B-axis 100 ft. lb.

T-Slots: Width - 0.625 inches
Quantity: 6, 0.625" (15.88mm) T-slots equally spaced
Diameter spaced at 60°



Trunnion Mounting (TR160)



Bottom View



Trt-Series

TR160-2

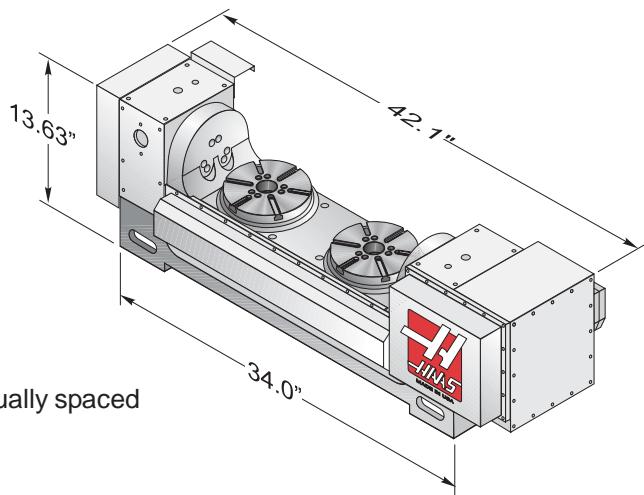
Travels: A - +/- 120° (tilt),
B - 360 (rotate).

Platter: Diameter 6.3" (160mm)
Capacity 80 pounds (36 kg)
Pilot hole 1.5" (38.1mm)
+0.0005", -0.0" x 4.79" deep
Max swing diameter for B-axis 10.45" (265mm)
Max swing at 90°: 10.45" (265mm)
located 0.125" (3.1mm)
below centerline of A-axis

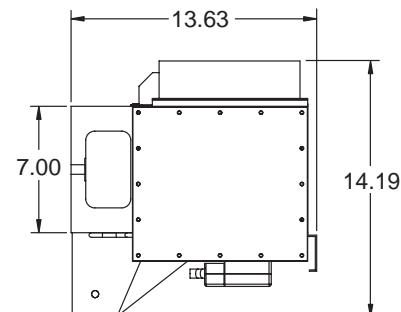
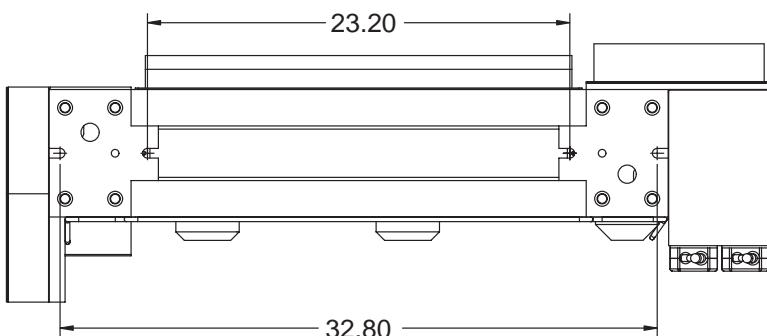
Speed: A-axis 80° per sec
B-axis 80° per sec

Spindle: Torque A-axis 150 ft. lb.
B-axis 100 ft. lb.
Brake torque A-axis 200 ft. lb.
B-axis 100 ft. lb.

T-Slots: Width - 0.625 inches
Quantity: 6, 0.625" (15.88mm) T-slots equally spaced
Diameter spaced at 60°



Trunnion Mounting (TR160-2)



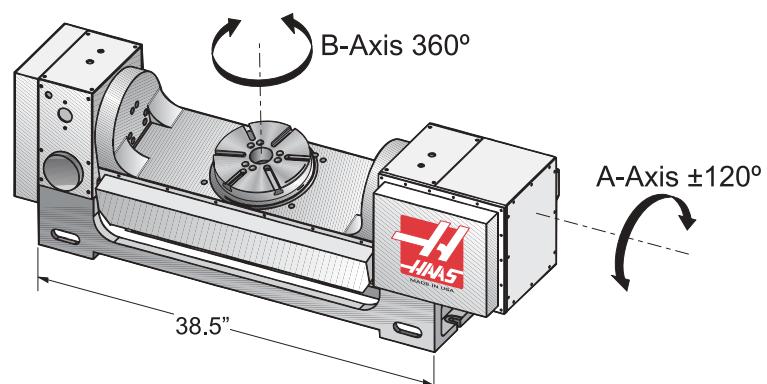
Bottom View

TR210

Travels: A - +/- 120° (tilt),
B - 360 (rotate).

Platter: Diameter 8.27" (210mm)
Capacity 200 pounds (90.7 kg)
Pilot hole 2.000" (50.8mm)
+0.0005", -0.0" x 5.1" deep
Max swing diameter for B-axis 23.5"
Max swing at 90°: 19.3" (490mm)
(596.9mm) located 0.125" (3.1mm)
below centerline of A-axis

Speed: A-axis 60° per sec
B-axis 60° per sec



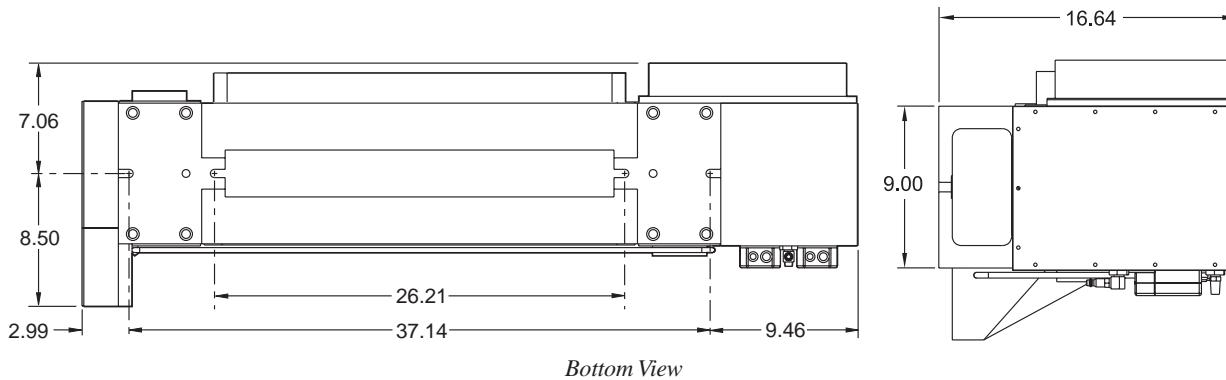


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Spindle: Torque A-axis 300 ft. lb.
B-axis 210 ft. lb.
Brake torque A-axis 400 ft. lb.
B-axis 200 ft. lb.

T-Slots: Width - 0.625 inches
Quantity: 6, 0.625" (15.88mm) T-slots equally spaced
Diameter spaced at 60°

Trunnion Mounting (TR210)



Bottom View

TR310

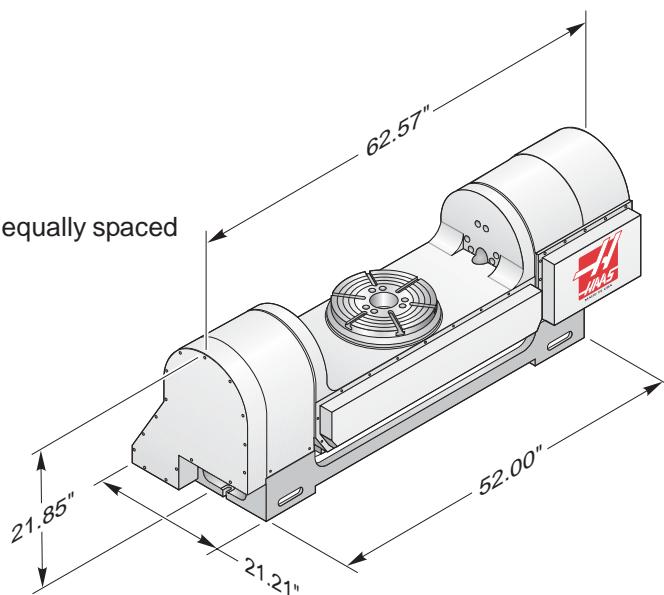
Travels: A - +/- 120° (tilt),
B - 360 (rotate).

Platter: Diameter 12.2" (310mm)
Capacity 500 pounds (90.7 kg)
Pilot hole 3.250" (82.55mm)
+0.0005", -0.0" x 5.1" deep 3.250" through
Max swing diameter for B-axis 31.0"
Max swing A-axis at 90° 23.8" (604mm)
(596.9mm) located 0.125" (3.1mm)
below centerline of A-axis

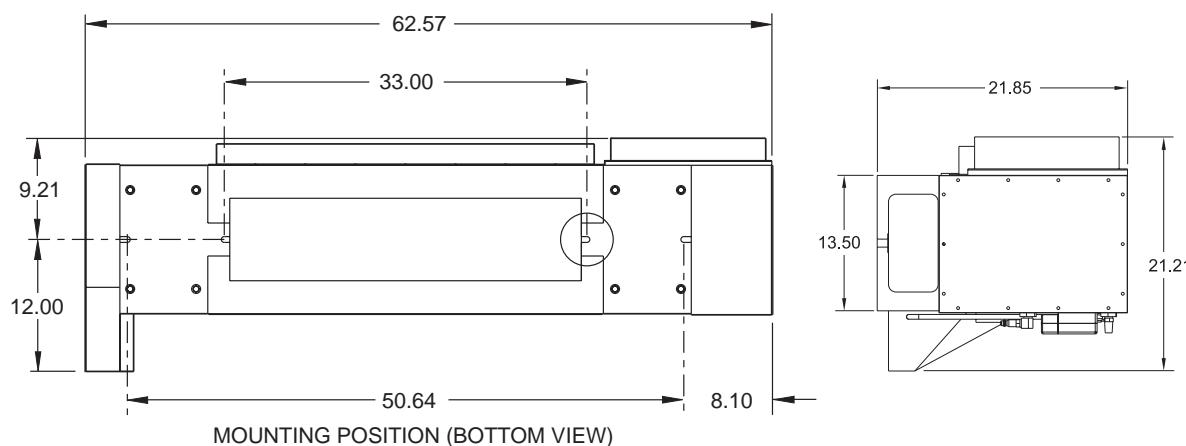
Speed: A-axis 50° per sec
B-axis 50° per sec

Spindle: Torque A-axis 300 ft. lb.
B-axis 300 ft. lb.
Brake torque A-axis 1000 ft. lb.
B-axis 500 ft. lb.

T-Slots: Width - 0.625 inches
Quantity: 6, 0.625" (15.88mm) T-slots equally spaced
Diameter spaced at 60°

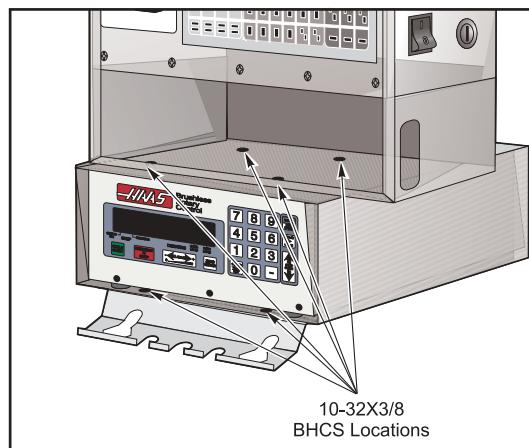


Trunnion Mounting (TR310)



1.8 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



Trt-Series

1.9 TR-SERIES SHIPPING BRACKET REMOVAL

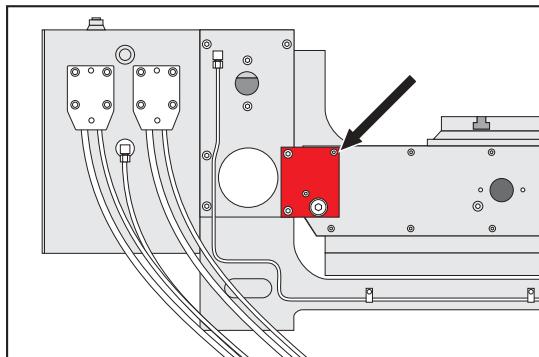
Remove the shipping bracket before using

TR160(-2) / TR210

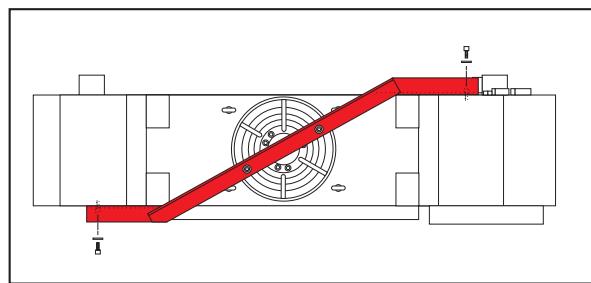
The shipping bracket is located on the right rear of the unit. Replace the (2) 10-32 and (2) 1/4-20 screws, do not replace the 1/2-13 bolt. The TR160 does not have a 1/2-13 bolt.

TR310

Remove the (4) 1/2-13 bolts and washers. Remove the (2) T-nuts from the rotary platter.



TR-210



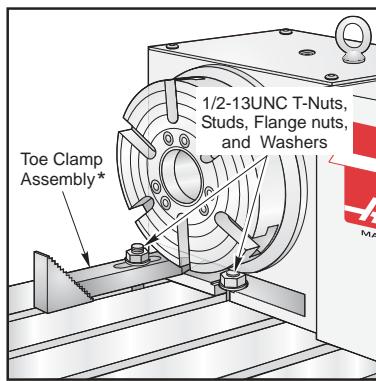
TR-310

Note: Keep all hardware and shipping brackets

2. SETTING UP THE HAAS TILTING ROTARY TABLE

2.1 GENERAL SETUP

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



Standard stud mounting front and rear. For extra rigidity, use toe clamps.

**NOTE: Toe-Clamp Fasteners are not supplied. (TRT fifth axis omitted for clarity)*

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



Figure 1. SEMI-FOURTH AND -FIFTH AXIS OPERATION
TRT160

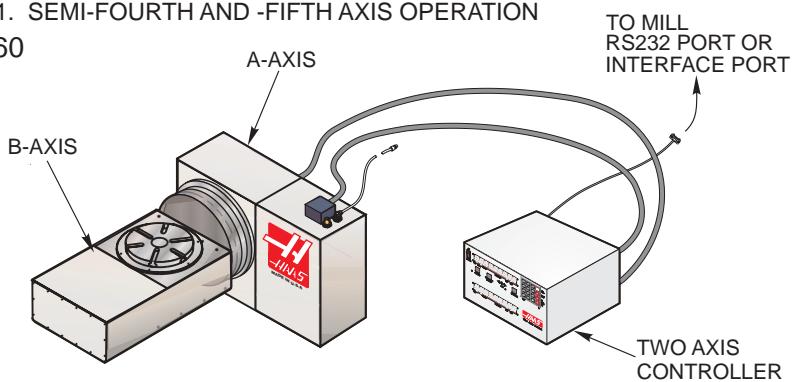


Figure 2. FULL FOURTH AND SEMI-FIFTH AXIS OPERATION
TRT160-CNC

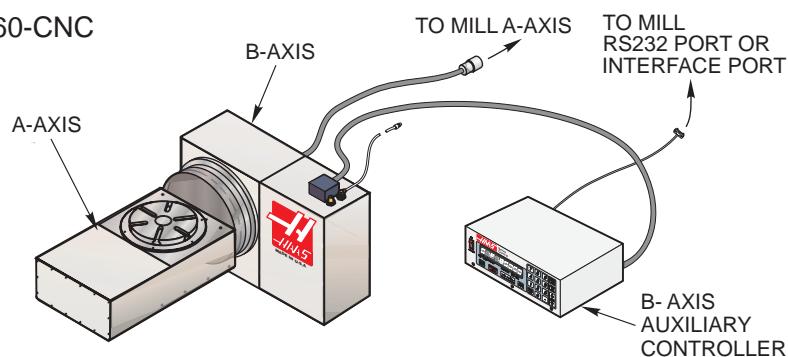
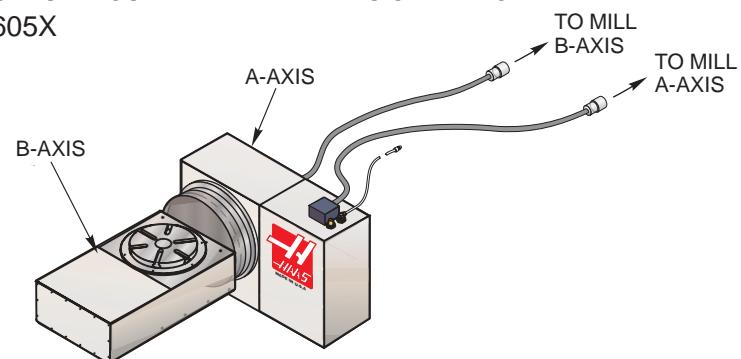


Figure 3. FULL FOURTH AND FIFTH AXIS OPERATION
TRT1605X

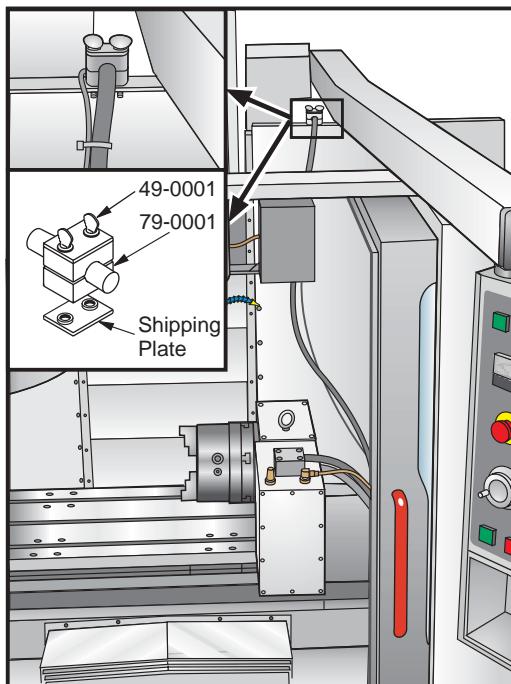


Note: Your HAAS mill must have the 4th and 5th axis options to run full-fourth and full-fifth and must be configured as brush or brushless to be compatible with your indexer. Brush uses one cable and one connection at each of the A and B axis ports on the control. Brushless uses two cables to two connectors at each of the A and B axis ports.



Trt-Series

4. Route the cables 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.

NOTE: The brushless dual axis control is 240VAC single phase with a grounded receptacle.



9. **Semi-Fourth Axis:** Connect the remote interface lines. See "Interfacing to Other equipment" section.
10. Connect the table to a standard shop air line (120 PSI Max). The line pressure to the brake is not regulated. Do not exceed the maximum pressure.

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

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

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

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

2.2 INTERFACING TO OTHER EQUIPMENT

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 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.

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.

The RS-232 connector on the back of the dual Brush control box is for up and down loading programs. On most PCs today, the RS-232 connector is a DB-9. To connect the two, a null modem cable with a female DB-9 on one end and a male DB-25 on the other end is required. Both the PC and the Dual axis controller are DTE's so a null modem cable is required. If you are building your own cable, or need to test an existing one, you must have the following connections:

PC female DB-9	connects to	Haas dual control Male DB-25
Pin 2, Receive Data	connects to	Pin 2, Transmit Data*
Pin 3, Transmit Data	connects to	Pin 3, Receive Data*
Pin 5, Logic Ground	connects to	Pin 7, Logic Ground*
Pin 4, DTR	connects to	Pin 6, DSR
Pin 6, DSR	connects to	Pin 20, DTR
Pin 7, RQS	connects to	Pin 5, CTS
Pin 8, CTS	connects to	Pin 4, RQS

*The Haas controller requires the marked signals as a minimum. Connect the remaining signals if your PC requires.

Pin 1 on the DB-9 is data carrier detect and is not commonly used. Pin 1 on the DB-25 is used for the cable shield/earth ground and should be connected at one end to minimize noise.

The Haas dual Brushless controller has 2 serial ports, both an up load port, (as described above, except it is a DCE), and down load port. The down load, or Down Line, connector is only used when one or more controller is to be used. The first controller's down line or "RS-232 OUT" connector connects to the second controller's up line or "RS-232 IN" connector, etc. The CNC control is connected to the first controller's up line or "RS-232 IN" connector.

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

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

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

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



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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.

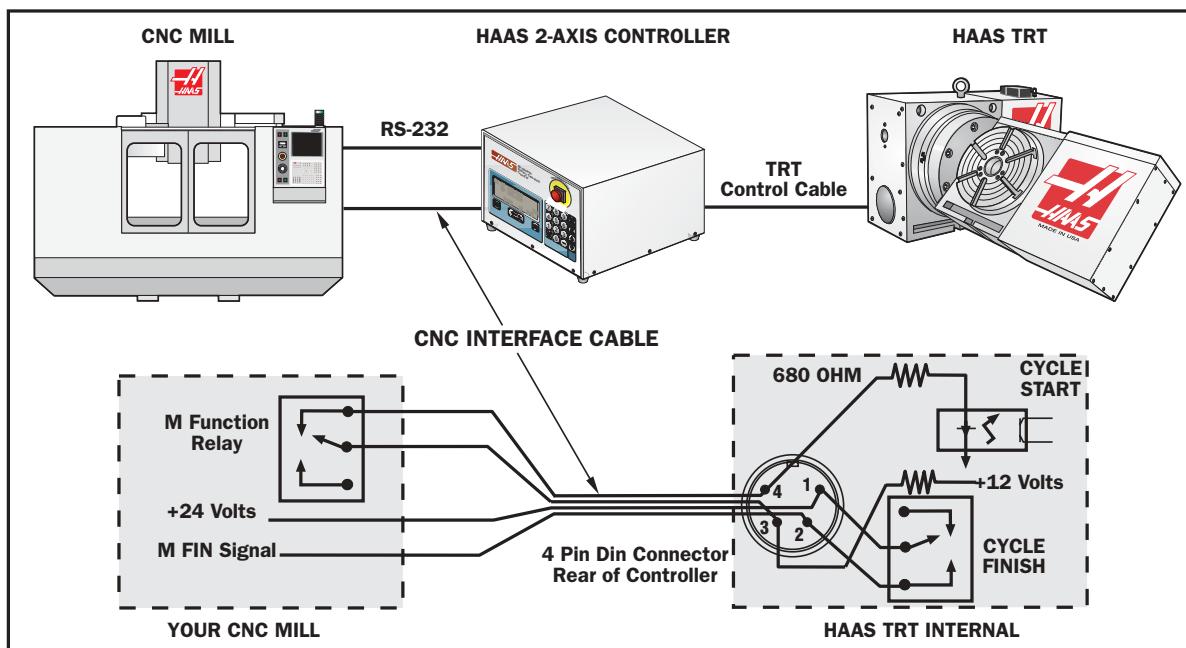
A remote socket is provided on the back panel of the control unit. The remote input consists of a ***cycle start*** line and a ***cycle finish*** line. To connect to the remote, you will need a connector supplied by HAAS (or one obtained from a local source) that can be used to trigger the controller 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 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

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

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

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



A Typical CNC Interface.

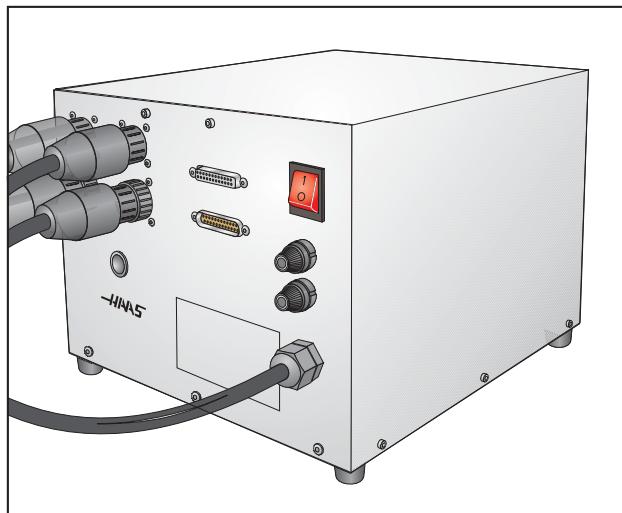


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Cycle Finish

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 the 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 G97.



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 3. 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



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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 UPLOAD / DOWNLOAD (BRUSH MOTORS)

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.

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:

```
%  
N01 G91 X045.000 F080.000 L002  
N02 G90 X000.000 Y045.000 F080.000  
N03 G98 F050.000 L013  
N04 G96 P02  
N05 G99  
%
```



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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.

2.8 UPLOAD/DOWNLOAD (BRUSHLESS MOTORS)

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 "0" 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.



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Programs sent by the controller have the following format:

```
%  
N01 G91 S000.000 F065.000 G91 S999.999 F060.000  
N02 G91 S-30.000 F025.001 G91 S-30.000 F050.000  
N03 G97 L020  
N04 G99  
%
```

Programs sent or received would have the following format and are mode dependant (M:A or M:B):

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

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

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

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

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

2.9 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. #275-247). This part should only be replaced by a qualified technician.



2.10 USE OF COLLETS, CHUCKS, AND FACE PLATES (HA5C)

The HA5C accepts standard 5C collets and step collets. When inserting the collets, align the keyway on the collet with the pin inside the spindle. Push the collet in and turn the collet drawbar clockwise until proper collet tightness is obtained. Detailed collet installation instructions for model **AC 25/125** collet closers are provided later in this section.

Chucks and face plates utilize the 2 3/16-10 threaded nose on the spindle. We recommend using chucks that are 5" diameter or smaller and weigh less than 20 pounds. Pay special attention when installing chucks. Always make sure that the thread and the outside diameter of the spindle are free of dirt and chips. Apply a thin coating of oil to the spindle. Screw the chuck on gently until it seats against the rear of the spindle. Tighten the chuck to approximately 70 ft.-lb with a strap wrench. Always use a firm, steady pressure to remove or install chucks or face plates. This is very important to prevent damage to the indexing head.

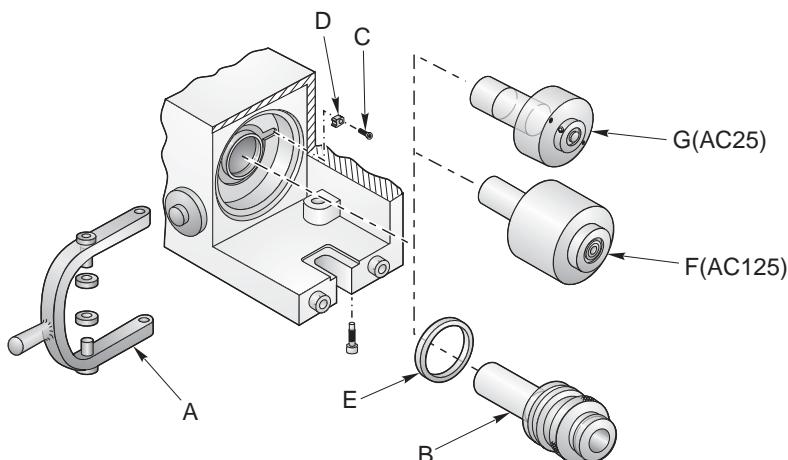
WARNING !

Never use a hammer or pry bar to tighten the chuck, as this will damage the precision bearings inside your unit.

2.11 HAAS 5C AIR COLLET CLOSERS (MODEL AC25 / AC125)

There are two types of Air Collet Closers available: Model **AC25** (Item G) may be used on the old-style indexer (S5C) or the newer model HA5C. The **AC25** is a non thru-hole type closer and holds parts by utilizing shop air pressure through a mechanical multiplier to provide between 0 and 3000 pounds of draw force, depending on air pressure supplied. The mechanical portion provides .03" of longitudinal movement so diameter variations of up to .007" can be clamped securely without readjustment.

The **AC125** (Item F) air collet closer has a 5/16" thru-hole that will allow small diameter stock to extend out the back of the unit. The **AC125** also has a large diameter counterbore in the drawtube that will allow any size stock that will pass through a standard 5C collet to protrude approximately 1.6" out the back of the collet. This also allows the use of most standard collet stops. The **AC125** uses shop air pressure through a mechanical multiplier to provide up to 10,000 lb. of draw force (adjustable through the use of an air pressure regulator supplied by the customer.) The drawtube travel of 0.060" allows the unit to accommodate part diametrical variations of up to 0.015" without readjustment.



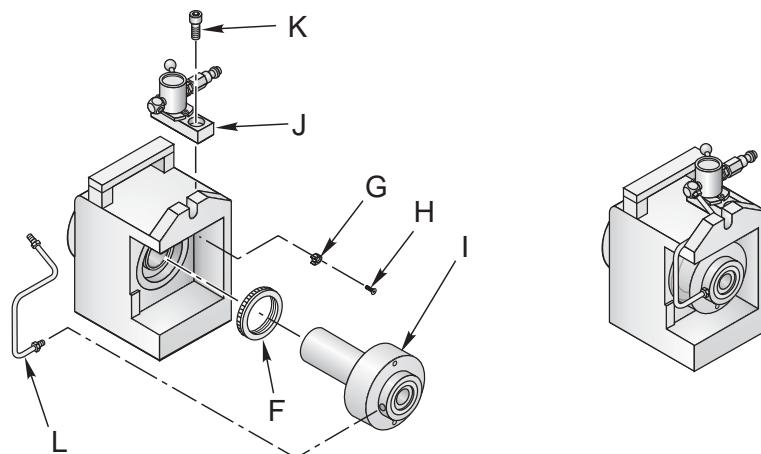
Replacing the manual collet closer with a model AC25 or AC125 Air Collet Closer.

Collet Closer Installation (Model AC25 / AC125)

Before installing the **AC25/125** on the HA5C, you must first remove the manual collet closer assembly (Item B). Remove the top and bottom mounting bolts for the handle (Item A) and slide the handle off the collet closer assembly. With the collet removed, slide the collet closer assembly out the back of the spindle. Remove the flathead screw (Item C) and locking pawl (Item D) and unscrew the spindle nut (Item E). (It may be necessary to use two 1/8" pins and a screwdriver to break the spindle nut loose.)

AC25 Collet Closer

To install the AC25, install new spindle nut (Item F), locking pawl (Item G) and FHCS (Item H) Insert drawtube of assembled AC25 (Item I) into back of HA5C spindle and screw the main body onto the back of the spindle. Tighten with strap wrench to approximately 30 ft-lb. Mount valve assembly (Item J) to top of HA5C as shown using 1/2-13 SHCS (Item K) . Assemble fittings of copper tube (Item L) between valve and fitting on back of collet closure and tighten.



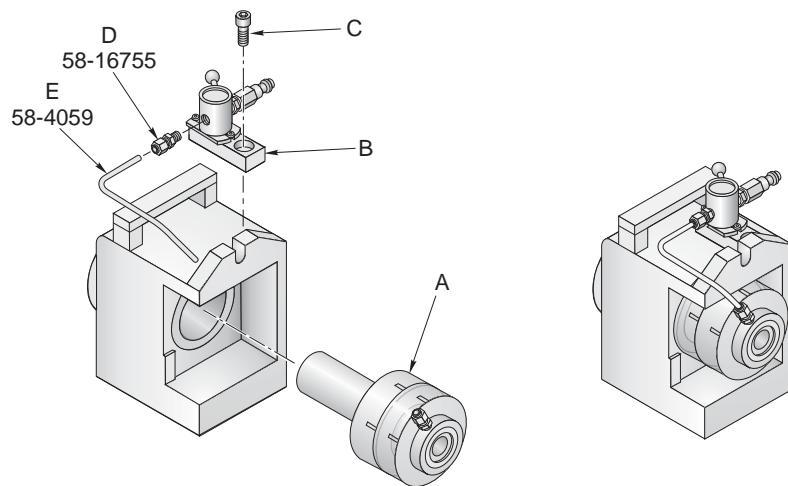
CAUTION! The Model **AC25** Collet Closer relies on your air pressure to maintain clamping force and will release if the air supply is accidentally removed. If this presents a fail-safe problem, then an air switch should be installed in-line to stop machining operations if the air supply should fail.

AC125 Collet Closer

To install the **AC125**, remove the snap ring that retains the pneumatic slip ring (as shown in the figure). Remove the slip ring together with the copper tube and the valve. Insert the front of the drawtube into the back of the HA5C spindle, and screw the main body onto the back of the spindle. Tighten with a woven strap wrench to approximately 30 ft-lb. Maneuver the plumbing assembly into position, without bending the copper tube, so that the valve sits on top of the HA5C casting and the sliring fits over the input diameter on the back of the **AC125** body. Install the snap ring and screw the valve to the top of the HA5C body using the 1/2-13 cap screw provided.

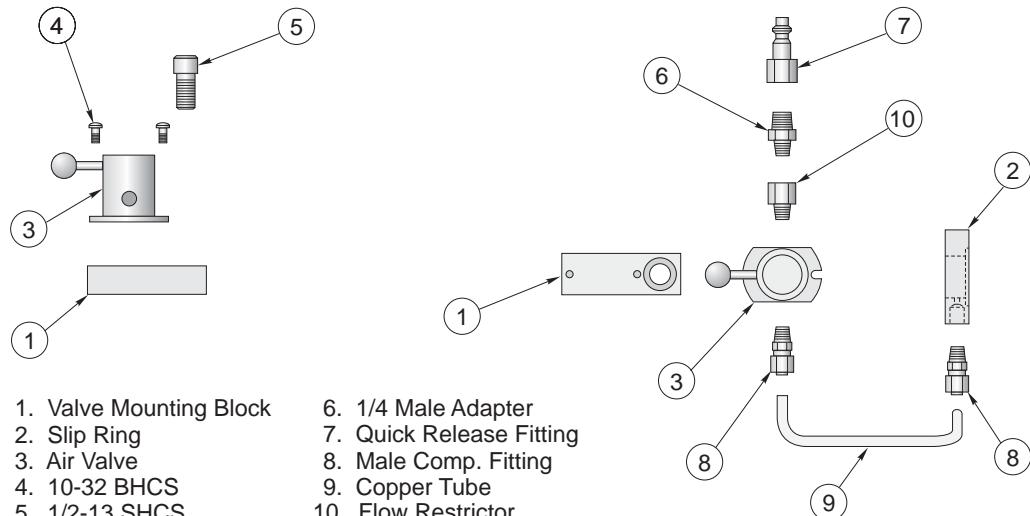


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Replacing the manual collet closer with a model AC125 Air Collet Closer.

Never use hammer blows to remove or install these items. The shock will damage the precision bearings and gears inside your HA5C.



* The flow restrictor does not exist on the AC25.

Assembly of valve and slip ring (AC 25/ 125).

Collet Closer Removal (Model AC25 / AC125)

The air collet closer is fitted at the factory and is not intended to be removed. If you do remove it, use a woven strap wrench. A special spindle nut is used and must be replaced before you can use the manual lever. When re-installing the air collet closer, it must be tightened securely or it may come loose during indexing.



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2.12 USE OF COLLETS WITH HAAS COLLET CLOSERS

Collet Installation (AC25)

To install a collet, line the collet keyway up with the spindle key and insert the collet. There are two ways to turn the draw tube to adjust the collet:

1. If you are using a collet with an 11/64" or larger opening, you can insert a 9/64" hex wrench through the collet to turn the draw tube.
2. If you are using a collet with an opening smaller than 11/64", you can adjust the collet by turning the draw tube with a pin through a slot. Look between the back face of the worm gear and collet closer and you will see some holes in the draw tube. If they are not visible, jog the spindle until they come into position. Use a 9/64 diameter pin to rotate the draw tube and tighten the collet in position. There are 15 adjustment holes, so it will take 15 steps to turn the draw tube one full revolution. Put a part in the collet and tighten until it grips the part then back the draw tube off 1/4 to 1/2 turn.

WARNING!!

Multi-spindle and HA5C units require a minimum collet of 11/64" (Option #2 not possible due to lack of clearance.)

Collet Installation (Model AC125)

All collets used with the **AC125** must be clean and in good condition. To install a collet in the **AC125**, align the collet keyway with the spindle key and insert the collet. Insert a 5/16" hex wrench into the hex in the back of the drawtube, and turn the drawtube to engage the collet. Turn the drawtube until it grips the part, and then back off approximately 1/4 turn. This will be a good starting point for fine-tuning the grip range.

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 using the **AC25**, releasing a collet is accomplished by removing the air supply. It is then pushed out by a heavy spring inside the air collet.

The **AC125** uses shop air to pull the drawtube in, and a heavy internal spring to push the drawtube out and release the collet. If, after repeated use, the spring will not push the collet out, use one of the following methods to remove the collet and lubricate the outside of the collet with a light grease before re-inserting:

1. If the three-way air valve provided with the unit becomes clogged with contaminants, the exhaust airflow may be restricted, which may cause the collet to stick in the taper. If this situation arises, leave the valve in the clamped position, and connect and disconnect the air supply several times in rapid succession.
2. If the above procedure does not free the collet, switch the valve to the unclamped position, then gently tap the back end of the drawtube with a plastic faced mallet.

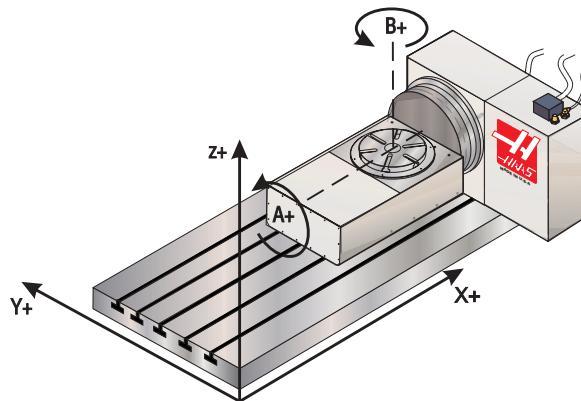


3. OPERATION (BRUSHLESS MOTORS)

The TRT is available in two configurations, Brush and Brushless motors. The Servo Controller and the Software is different between the two. The following steps are for TRTs with **Brushless** motors. If you have the Brush version go to section 4.

3.1 THE COORDINATE SYSTEM

The layout of the **A** and **B** axes on the HAAS five-axis control are depicted below. The **A** axis is rotary motion about the **X** axis, while the **B** axis determines rotary motion about the **Y** axis. The right hand rule can be used to determine axis rotation for the **A** and **B** axes. When placing the thumb of the right hand along the positive **X** axis, the fingers of the right hand will point in the direction of tool movement for a positive **A** axis command. Likewise, when placing the thumb of the right hand along the positive **Y** axis, the fingers of the right hand will point in the direction of tool movement for a positive **B** axis command. It is important to remember that the right hand rule determines direction of tool movement and not the table movement direction. For the right hand rule, the fingers will point opposite of the positive rotary table movement. Refer to the following figures.



Work coordinates (Positive direction).

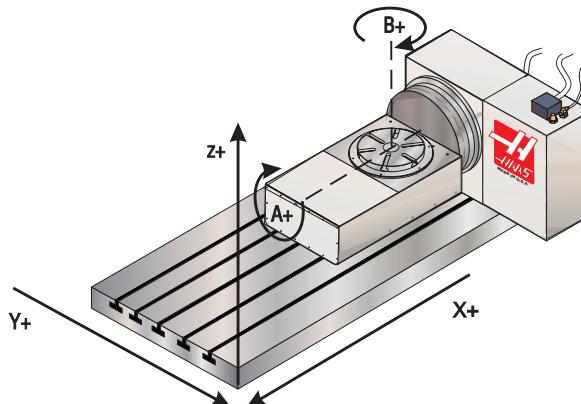


Table movement (Positive command).

NOTE: The previous figures represent one of many possible machine tool and table configurations. You may have different table movements for positive directions, depending on the equipment, parameter settings, or five-axis software being used.



3.2 THE FRONT PANEL DISPLAY

There are twenty characters that can be displayed on each line of the four lines in the display. 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. 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 10 different displays in the dual axis control; 5 for the A-axis and 5 for the B-axis. The "Display Scan" key is used to move from one display to the next. 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 of the same axis, that is, POSITION - STEP SIZE - FEED RATE - LOOP COUNT - G CODE - (for the A axis); continuing to push the right arrow button steps the control through the same registers for the B-axis. The control then repeats the A axis registers. In RUN mode, the **right** arrow button can select among any of these five displays, for each axis. In PROGRAM mode, all of these but the positions may be displayed.

Three variables at the bottom of the display represent the operation the dual control is in. The "S:" means servo on. The "R:" means running, and the "M:" means the axis mode. Each is followed by an axis letter A or B. When the servo is on and both axis are enabled, the control will show "S:AB R: M:A". When both axes are running the control will show "S:AB R:AB M:A". An example of the display is as follows:

```
01 A 123.456  
B 654.321  
  
S:AB R:AB M:A
```

Display Examples

The following displays when the control is powered up and "Cycle Start" is pressed.

```
01 A no Ho  
B no Ho  
  
S: AB M:A
```

The display indicates that the A and B axes have not been homed. The display shows that both A and B axes are enabled (parameter 47 = 0). The "S:" on the fourth line is short for SERVO ON, and AB represents the axis that have its servo on. The "M:" represents the axis mode the control is in and the following letter(s) represent the axis available for operation.

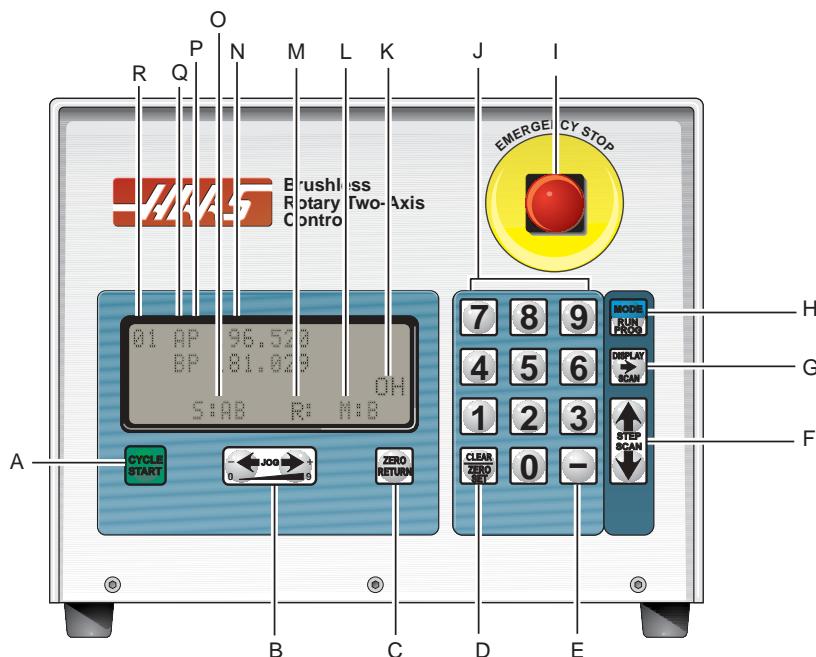
Both A and B axes are enabled when parameter 47 is set to 0. The A axis is disabled when parameter 47 is set to 1 and B-axis is disable when parameter 47 is set to 2. The following is and example of parameter 47 set to 2:

```
01 A no Ho  
B disabled  
  
S:A M:A
```



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Refer to the diagram on the following page. When you are in the PROGRAM mode, you are editing the numbers (or registers) that are blinking. Think of the LCD 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) CYCLE START begins a step, stops a continued operation, inserts a step, or turns the servo on.
- B) JOG causes the servo to move in either the forward or backward direction at a rate defined by the last numeric key pressed.
- C) ZERO RETURN causes the servo to return to HOME position, search for mechanical HOME, delete a step, or move forward to the mechanical offset. It is axis mode dependant.
- D) ZERO SET clears the entered data, resets program to 0, or defines the present servo position as HOME.
- E) MINUS KEY selects negative step values or Prog/Upload/Download functions.
- F) STEP SCAN scans step numbers from 1 through 99.
- G) DISPLAY SCAN scans the display to show either Position, Step Angle, Feed Rate, Loop Counts, or G Code.
- H) RUN/PROG switches from RUN mode to PROGRAM mode (blinking display).
- I) EMERGENCY STOP turns off the servo when on and aborts a step in progress.
- J) Data entry keys and jog speed selection.
- K) Load meter. If an **O** or **H** is displayed in this area during a low feed rate or when stationary, the following conditions apply:
 - H - 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)
 - O - 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 **O** or **H** to be displayed during a rapid movement or high duty cycle.



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- L) Indicates axis Mode
- M) Indicates which axis is running
- N) Displays show current data, i.e., a current spindle position of 180.
- O) Indicates which axis servo is on.
- P) Indicates what data is being displayed. Either **P**, **F**, **L**, blank, or **G** for Position, Feed Rates, Loop Count, Step Angle, or G Code.
- Q) Indicates the active axis.
- R) Present step number. Step numbers 1 to 99 are available. Also displays errors at turn on.

3.3 TURNING THE SERVO ON

There is a single 220V AC supply required by the controller. Ensure that the front panel power switch is turned off and connect the motor cables from the indexer and the power cord.

Turn the controller on. Within a few seconds, the displays will show:

HAAS DUAL nn

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

Por On

This indicates that the servos are 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	A no Ho
	B no Ho
S:AB	
	M:AB

This indicates that the motors are now powered but the zero position is not yet defined (there is no home position).

WARNING!

The operator should only shut off power to the controller if the tilt axis is in the normal operation zone. If this is not possible, contact Haas Automation for assistance.



3.4 FINDING THE ZERO POSITION

Press the ZERO RETURN button to start the automatic homing operation. The indexer will move slowly slightly to the right and then move to the left until it senses the home position. When the indexer stops, the display will indicate:

01	A Pnnn.nnn
	B no Ho
S:AB	M:A

Zero Return function depends on the selected axis (use the **right** arrow key to select the desired axis). The LCD indicates the selected axis with either M:A or M:B.

3.5 OFFSETTING THE ZERO POSITION

Use the left/right JOG switch to position the tilt indexer to the position which you want to use as zero and then press and hold the CLR key for 3 seconds. Press the **right** arrow key to select the **B** (rotary) axis and repeat for that axis. The displays will now show:

01	P000.000
	P000.000
S:AB	M:B

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 indexer to the new position and press the CLR key for 3 seconds. The displays will again indicate:

01	P000.000
	P000.000
S:AB	M:B

If there is a zero offset defined for the indexer, the display will show a non-zero number. In this case, press the ZERO RETURN button once more and the indexer will move forward to the predefined zero position. Press the **right** arrow key to select the **B** (rotary) axis and repeat for that axis and the lower display.

Note: Tilt units that use a Dual axis Servo control, will zero return at a slower speed than our regular single axis units. To save time during the zero return sequence, Haas recommends that prior to turning the unit off, handle jog the rotary table to a position close to zero.

3.6 JOGGING

Jogging of the motors can be done with the front panel JOG switch. Select which axis you wish to jog using the **right arrow** button. The selected axis, **A** or **B**, (M:A or M:B) is displayed at the bottom of the screen. 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 are:

# pressed	Speed % of max.	TRT 210		TRT 160	
		Jog speed (deg./sec.)		Jog speed (deg./sec.)	
		Tilt	Rotary	Tilt	Rotary
0	0.008	0.004	0.005	0.005	0.006
1	0.015	0.007	0.009	0.009	0.012
2	0.031	0.015	0.019	0.019	0.025
3	0.062	0.031	0.038	0.038	0.050
4	0.125	0.062	0.075	0.075	0.100
5	0.25 (default)	0.125	0.150	0.150	0.200
6	0.5	0.250	0.300	0.300	0.400
7	1.0	0.500	0.600	0.600	0.800
8	4.0*	2.000	2.400	2.400	3.200
9	16.0*	8.000	9.600	9.600	12.800

* Feed rates listed are for single axis servo controls.

Last two feed rates for dual axis controls are 2% and 4% respectively.

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

2 FAr

and the control will not execute the step (See parameter 13 and 14 for the A-axis, parameter 59 and 60 for the B-axis travel range).

3.7 ERROR CODES

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

E0 EProm	EPROM CRC error (Get serviced)
FP Short	Front panel button shorted (take hand off button)
rE Short	Remote CNC input shorted (remove CNC cable to test)
E3 rAm	RAM fault (Get serviced)
E4 bAtt	Stored program fault (but corrected, check battery)
E5 Pio2	PIO 2 fault (Get serviced)
E6 Pio3	PIO 3 fault (Get serviced)
Lo VoLt	Power failure (check that getting at least 110V AC or 220 V for SCO2-AC)
E8 Encod	PIO 1 fault (Get serviced)
E9 intEr	Timer/interrupt fault (Get serviced)
EA no go	Internal power supply failure (Get serviced)
Eb nmi	Non-maskable interrupt failure (Get serviced)
Ec Pwm	PWM generation logic failure (Get serviced)
Ed cloc	Clock generation logic failure (Get serviced)
EE Au in	Auxiliary input shorted at power-on
Lo bAt	Low battery voltage (Get serviced)



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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 220V 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, for the A axis or parameter 91 for the B axis must be set properly. Start with the default value (0) for the axis parameter (45 or 91) and add 1/2 of a motor revolution (1/2 motor revolution is equal to the value in A-axis parameter 28 divided by 2, or B-axis parameter 74). Home the rotary table after the new value for parameter has been entered.

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

3.8 SERVO OFF CODES

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

Por On	Power just applied (or failed previously).
Ser Err	Following error was too large (see Parameter 22 or 68).
E-StoP	Turned off with EMERGENCY STOP.
Hi Load	Turned off due to overload condition (see Parameter 23 or 69).
rS-232	Turned off from RS-232 due to communication problem between the upper and lower controls.
Air-Hot	Motor overheat sensor
EncodEr	Servo turned off because of encoder/Z channel fault (bad encoder or fault).
EncodeS	Encoder Z channel missing (bad encoder or cable).
Hi VoLt	Line voltage is too high causing regen overheat.
CAbLE	Break detected in encoder cable wiring.
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.

An **A** or **B** may precede the code. This is the reference to the axis that caused the fault.

3.9 EMERGENCY STOP

Pressing 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. Push the CYCLE START again to restart the step. 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

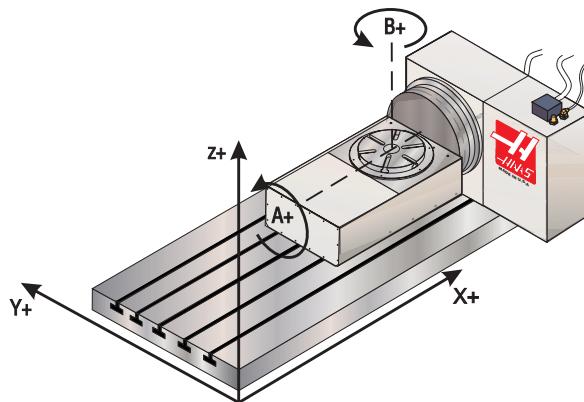
CE machines have an Emergency-stop switch on the top of the control. Pressing the E-stop switch will turn off the servo and aborts the step in progress.

4. OPERATION (BRUSH MOTORS)

The TRT is available in two configurations, Brush and Brushless motors. The Servo Controller and the Software is different between the two. The following steps are for TRTs with **Brush** motors. If you have the Brushless version go to section 3.

4.1 THE COORDINATE SYSTEM

The layout of the **A** and **B** axes on the HAAS five-axis control are depicted below. The **A** axis is rotary motion about the **X** axis, while the **B** axis determines rotary motion about the **Y** axis. The right hand rule can be used to determine axis rotation for the **A** and **B** axes. When placing the thumb of the right hand along the positive **X** axis, the fingers of the right hand will point in the direction of tool movement for a positive **A** axis command. Likewise, when placing the thumb of the right hand along the positive **Y** axis, the fingers of the right hand will point in the direction of tool movement for a positive **B** axis command. It is important to remember that the right hand rule determines direction of tool movement and not the table movement direction. For the right hand rule, the fingers will point opposite of the positive rotary table movement. Refer to the following figures.



Work coordinates (Positive direction).

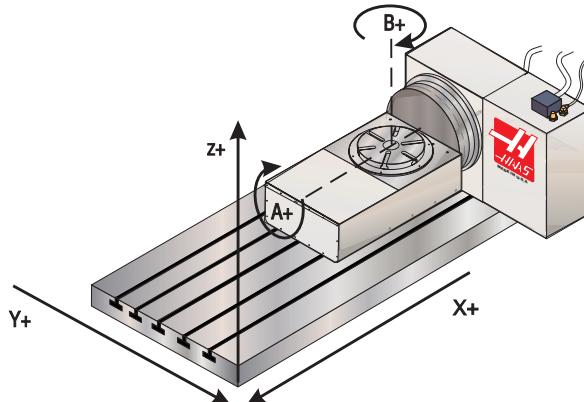


Table movement (Positive command).

NOTE: The previous figures represent one of many possible machine tool and table configurations. You may have different table movements for positive directions, depending on the equipment, parameter settings, or five-axis software being used.



4.2 THE FRONT PANEL DISPLAY

The two Light Emitting Diode (LED) front panel displays tell you what is going on inside the controller. There are nine characters that are displayed on each. 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:

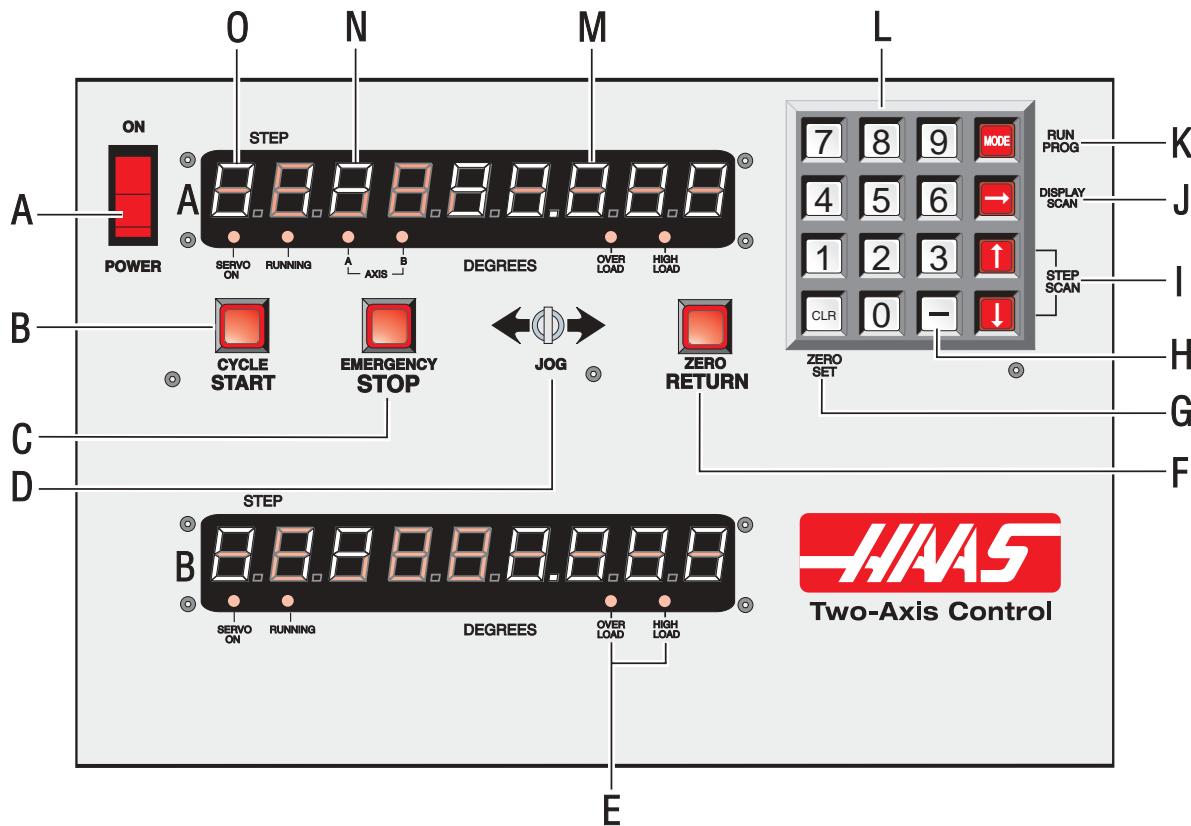
- 1) current spindle position (indicated by a letter **P**)
- 2) step size and direction (indicated by no letters),
- 3) feed rate (indicated by a letter **F**),
- 4) loop count (indicated by a letter **L**)
- 5) G code (indicated by a letter **G**)

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.



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- A) Main POWER switch to turn the unit on.
- B) CYCLE START begins a step, stops a continued operation, inserts a step, or turns the servo on.
- C) EMERGENCY STOP turns off the servo when on and aborts a step in progress.
- D) JOG causes the servo to move in either the forward or backward direction at a rate defined by the last numeric key pressed.
- E) Load meter LED. If LED's 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.



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- 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) 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.

4.3 TURNING THE SERVO ON

There is a single 115V AC supply required by the controller. Ensure that the front panel power switch is turned off and connect the motor cables from the indexer and the power cord.

Turn the controller on. Within one half second, the displays will show:

HAAS dnn

HAAS Snn

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

01 Por On
Por On

This indicates that the servos are 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
no Ho

This indicates that the motors are now powered but the zero position is not yet defined (there is no home position).

WARNING!

The operator should only shut off power to the controller if the tilt axis is in the normal operation zone. If this is not possible, contact Haas Automation for assistance.



Trt-Series

4.4 FINDING THE ZERO POSITION

Press the ZERO RETURN button to start the automatic homing operation. The indexer will move slowly slightly to the right and then move to the left until it senses the home position. When the indexer stops, the top display will indicate:

01 Pnnn.nnn

4.5 OFFSETTING THE ZERO POSITION

Use the left/right JOG switch to position the tilt indexer to the position which you want to use as zero and then press and hold the CLR key for 3 seconds. Press the **right** arrow key to select the **B** (rotary) axis and repeat for that axis. The displays will now show:

**01 P000.000
P000.000**

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 indexer to the new position and press the CLR key for 3 seconds. The displays will again indicate:

**01 P000.000
P000.000**

If there is a zero offset defined for the indexer, the display will show a non-zero number. In this case, press the ZERO RETURN button once more and the indexer will move forward to the predefined zero position. Press the **right** arrow key to select the **B** (rotary) axis and repeat for that axis and the lower display.

4.6 JOGGING

Jogging of the motors can be done with the front panel JOG switch. Select which axis you wish to jog using the **right** arrow button. The selected axis, **A** or **B**, is shown by the two LED's on the front panel. 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 are:

# pressed	Speed % of max.	TRT 210		TRT 160	
		Tilt	Rotary	Tilt	Rotary
0	0.008	0.004	0.005	0.005	0.006
1	0.015	0.007	0.009	0.009	0.012
2	0.031	0.015	0.019	0.019	0.025
3	0.062	0.031	0.038	0.038	0.050
4	0.125	0.062	0.075	0.075	0.100
5	0.25 (default)	0.125	0.150	0.150	0.200
6	0.5	0.250	0.300	0.300	0.400
7	1.0	0.500	0.600	0.600	0.800
8	4.0*	2.000	2.400	2.400	3.200
9	16.0*	8.000	9.600	9.600	12.800

* Feed rates listed are for single axis servo controls.

Last two feed rates for dual axis controls are 2% and 4% respectively.



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

2 FAr

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

4.7 ERROR CODES

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

E0 EProm	EPROM CRC error (Get serviced)
FP Short	Front panel button shorted (take hand off button)
rE Short	Remote CNC input shorted (remove CNC cable to test)
E3 rAm	RAM fault (Get serviced)
E4 bAtt	Stored program fault (but corrected, check battery)
E5 Pio2	PIO 2 fault (Get serviced)
E6 Pio3	PIO 3 fault (Get serviced)
Lo VoLt	Power failure (check that getting at least 110V AC)
E8 Encod	PIO 1 fault (Get serviced)
E9 intEr	Timer/interrupt fault (Get serviced)
EA no go	Internal power supply failure (Get serviced)
Eb nmi	Non-maskable interrupt failure (Get serviced)
Ec Pwm	PWM generation logic failure (Get serviced)
Ed cloc	Clock generation logic failure (Get serviced)
EE Au in	Auxiliary input shorted at power-on
Lo bAt	Low battery voltage (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 115V 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.



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4.8 SERVO OFF CODES

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

Por On	Power just applied (or failed previously).
Ser Err	Following error was too large (see Parameter 22).
E-StoP	Turned off with EMERGENCY STOP.
Hi Load	Turned off due to overload condition (see Parameter 23).
rS-232	Turned off from RS-232 due to communication problem between the upper and lower controls.
Air-Hot	Motor overheat sensor
Encoder	Servo turned off because of encoder/Z channel fault (bad encoder or fault).
Hi Curr	Motor current exceeded safety limit (stalled or PCB fault).
EncodeS	Encoder Z channel missing (bad encoder or cable).
Hi VoLt	Line voltage is too high causing regen overheat.
FAiLEd	Indicates communication problem between upper and lower controls. This flashes up for only two seconds.
CAbLE	Break detected in encoder cable wiring.
trAnS	Encoder transition fault had been detected by the brushless circuitry.

4.9 EMERGENCY STOP

Pressing 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. Push the CYCLE START again to restart the step. 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.



5. PROGRAMMING THE CONTROLLER

5.1 INTRODUCTION

Programming is done through the square 16-key keypad on the right side of the front panel. The four **RED BUTTONS** on the right column of the keypad are used for program control. They are the:

MODE button (or RUN PROG),
RIGHT ARROW button (or DISPLAY SCAN)
UP ARROW button (or STEP SCAN BACK)
DOWN ARROW button (or STEP SCAN FORWARD)

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.

Always press and immediately release a button. Pushing and holding a button down will cause the button to repeat, which is useful when scanning a long program. Some buttons have more than one function depending upon which mode you are in.

5.2 How DATA IS STORED IN THE CONTROLLER'S MEMORY

Brushless Motor

Step Number	Step Size	Feed Rate	Loop Count	G code
1 (A-axis) (B-axis)	90.000	80	01	91
2 (A-axis) (B-axis)	-30.000	05	01	91
3 (A-axis) (B-axis) through 99 (A-axis)	0	80	01	99
(B-axis)	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.



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Brush Motor

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.

5.3 ENTERING A STEP

Brushless Motors

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 3 seconds. The display will scan through 99 steps and finish with a G91 showing. To enter a tilt **45 degree** (45°) step and a simultaneous rotary **90 degree** (90°) step, press the **right** arrow and then the following keys:

A 45000

The display should now indicate:

01 A 45.000 (with the M:A display)

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 **right** arrow again and the following keys:

80000

The display should now indicate:

01 A F 80.000

Then press the right key twice and enter the following:

90000

The display should now indicate:

01 B 90.000 (with the M:B display)

To enter a feed rate of **80 degrees** (80°) per second, press **right** arrow again and the following keys:

80000



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The display should now indicate:

01 B F 80.000

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

**01 A P000.000
B P000.000**

S:AB M:A

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

**01 A P045.000
B P090.000**

For more details on operating and programming the controller, see the following section.

Brush Motor

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 3 seconds. The display will scan through 99 steps and finish with a G91 showing. To enter a tilt **45 degree** (45°) step and a simultaneous rotary **90 degree** (90°) step, press the **right** arrow and then the following keys:

4 5 0 0 0

The top display should now indicate:

01 45.000 (with the A axis light on)

Press the **right** arrow button. This will cause the **45 degree** (45°) step to be stored and the feed rate to be displayed. Then press the following keys:

9 0 0 0 0

The top display should now indicate:

01 90.000 (with the B axis light on)

To enter a feed rate of **80 degrees** (80°) per second, press **right** arrow again and 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 P000.000
P000.000**

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

**01 P045.000
P090.000**

For more details on operating and programming the controller, see the following section.



5.4 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 CLR key for five seconds. You have now cleared the memory and are at step one and ready to begin programming. "01 000.000" (01 A 000.000 if a brushless unit) 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 four programs can be stored, numbered 0 to 3. To gain 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 contains 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 press 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.



5.5 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

Note for **Brushless** motors: An axis with G95, G96, or G99 will be run regardless of the other axis' G-code commands. If both axes contain one of these G-codes, the A-axis G-code will be the only one running. Each step will wait for the slower axis G-code to finish all its loops before proceeding to the next step. When G97 is programmed into both axes, the amount of delay is the sum of both axis G97 delays.

5.6 ABSOLUTE / INCREMENTAL Motion

G90 and **G91** can be used for absolute (**G90**) or incremental (**G91**) positioning. G90 is the only command allowing absolute positioning. Note that G91 is the default value and provides incremental motion.

G28 and G88 both provide for a programmed home command. The entered feed rate is used to return to the zero position.

5.7 FEED RATES

The feed rate display ranges between 00.001 and 270.000 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 270.000 means the spindle will rotate 270 degrees (270°) in one second.

5.8 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.



5.9 SUBROUTINES (G96)

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

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

5.10 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.

5.11 CIRCLE DIVISION

Circle division is selected with a **G98** or **G85**. 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). **G85** selects division of an angle other than 360 degrees (360°). The steps size is divided into **L** parts. The axis with a non-zero stop mode is moved. The other axis must have a zero stop.

5.12 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 G code of 99. 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.

5.13 INSERTING A LINE

A new step may be inserted into a program by pressing and holding the 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. Subroutine jumps must be renumbered.

5.14 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. Subroutine jumps must be renumbered.



5.15 DEFAULT VALUES

For all steps, the default values are:

G 91 (incremental)
A 000.000 (step size zero)
B 000.000 (step size zero)
F (defined by parameters, 5C=300.000, R. tables=60.000)
L 001

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

5.16 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 PROGRAM mode. There are four available programs, numbered 0 through 3.

5.17 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.

5.18 OPERATING HINTS

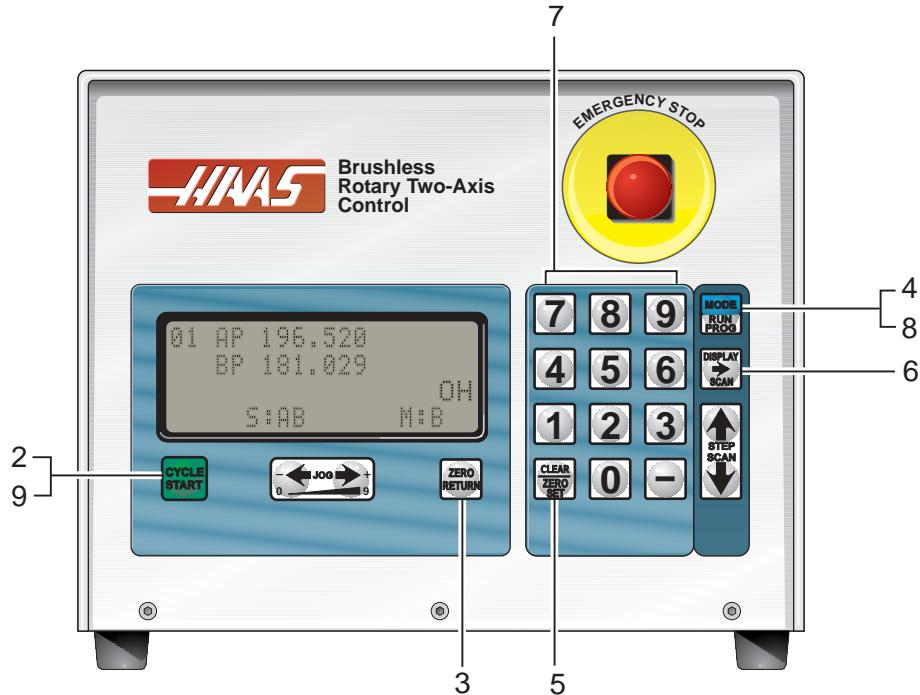
- A. You can select another display while in the RUN mode by pushing the DISPLAY SCAN button. This way you could view the particular feed rate for a step or view the remaining loop counts left.
- B. You can start your program on any step by using the UP/DOWN scan keys.
- C. Make sure your CNC has the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

5.19 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 which is to be run simultaneous with a NC mill.

6. PROGRAMMING EXAMPLES

6.1 BRUSHLESS MOTORS



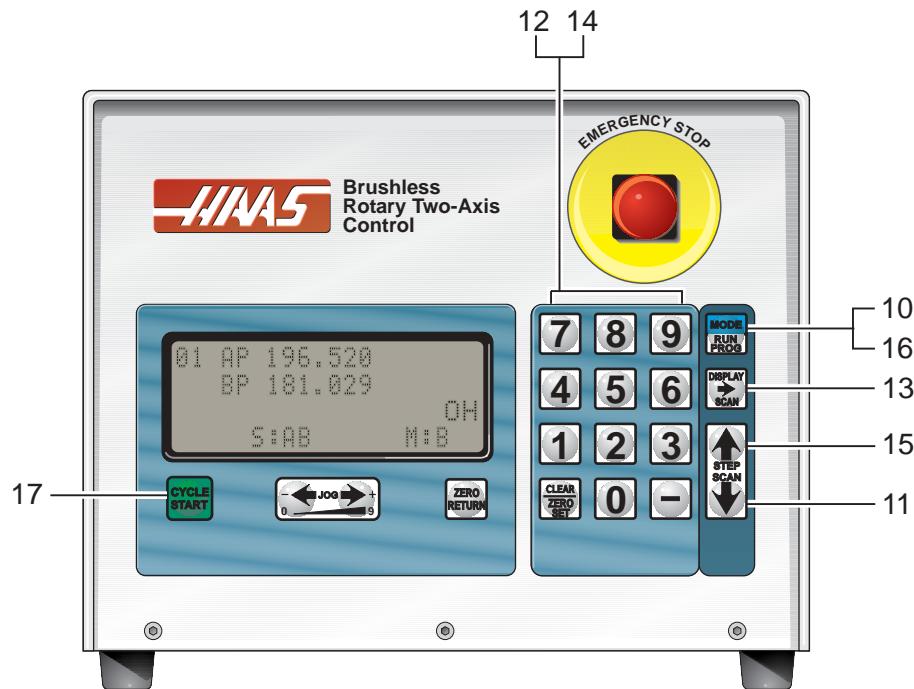
Example #1

You want the rotary table (not the tilt axis) to index **90 degrees** (90°).

1. Turn [**POWER**] switch on.
2. Push the [**CYCLE START**] switch.
3. Push the [**ZERO RETURN**] switch.
4. Push the [**MODE**] button and release. Displays must be blinking.
5. Push and hold [**CLR**] button for five seconds. "g 91" displayed.
6. Push the [**DISPLAY SCAN**] button until M:A is displayed (this is the "Steps" display).
7. Enter [**9 0 0 0 0**].
8. Push [**MODE**] button. Steady displays.
9. Push [**CYCLE START**] to index.



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Example #2

Continuing the previous example, we want to index the rotary axis **90 degrees** (90°) and then index the tilt axis **45 degrees** (45°).

10. Push the [MODE] button. Displays blinking.
11. Push the [DOWN ARROW] once. You should be on step 2.
12. Enter [9 1] on the key pad.
13. Push the [DISPLAY SCAN] button until M:B is displayed.
14. Enter [4 5 0 0 0] on the key pad. Use [CLR] if you make a mistake.
15. Push the [UP ARROW] button once. You should be on step 1.
16. Push the [MODE] button. Steady displays.
17. Push the [CYCLE START] switch. The table should index **90 degrees** (90°). Push [CYCLE START] again. The tilt axis should index **45 degrees** (45°).

Assuming you have successfully completed the previous two examples, the following examples will show the program as you would enter it into the control. The visual aid of the front panel will not be used. 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.



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Example #3

We want to tilt the rotary table **30 degrees** (30°), then drill a four-hole pattern, and then drill a five-hole pattern on the same part.

STEP	MODE (M:)	G CODE	STEP SIZE	FEED RATE	LOOP COUNT
01	A	[91]	000.000	080.000	1
	B	[91]	[30.000]	080.000	1
02	A	[91]	[90.000]	080.000	[4]
	B	[91]	000.000	000.000	[4]
03	A	[91]	[72.000]	080.000	[5]
	B	[91]	000.000	080.000	[5]
04	A	[99]	000.000	080.000	1
	B	[99]	000.000	080.000	1

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

STEP	MODE (M:)	G CODE	STEP SIZE	FEED RATE	LOOP COUNT
01	A	[91]	000.000	080.000	1
	B	[91]	[30.000]	080.000	1
02	A	[98]	000.000	080.000	[4]
	B	[98]	000.000	080.000	[4]
03	A	[98]	000.000	080.000	[5]
	B	[98]	000.000	080.000	[5]
04	A	[99]	000.000	080.000	1
	B	[99]	000.000	080.000	1

Example #4

We want to tilt the rotary table **37.9 degrees** (37.9°), index the rotary table **90.12 degrees** (90.12°), start a seven-hole bolt pattern, and then return to our zero position.

STEP	MODE (M:)	G CODE	STEP SIZE	FEED RATE	LOOP COUNT
01	A	[91]	000.000	080.000	1
	B	[91]	[37.900]	080.000	1
02	A	[91]	[90.120]	080.000	1
	B	[91]	000.000	080.000	1
03	A	[98]	000.000	080.000	[7]
	B	[98]	000.000	080.000	[7]
04	A	[88]	000.000	080.000	1
	B	[88]	000.000	080.000	1
05	A	[99]	000.000	080.000	1
	B	[99]	000.000	080.000	1



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Example #5

We want to first tilt the table **22 degrees** (22°), then index it **90 degrees** (90°) and slow feed for it **15 degrees** (15°), repeating the pattern three times and then returning home.

STEP	MODE (M:)	G CODE	STEP SIZE	FEED RATE	LOOP COUNT
01	A	[91]	000.000	080.000	1
	B	[91]	[22.000]	080.000	1
02	A	[91]	[90.00]	080.000	1
	B	[91]	000.000	080.000	1
03	A	[91]	[15.00]	[25.000]	1
	B	[91]	000.000	080.000	1
04	A	[91]	[90.00]	080.000	1
	B	[91]	000.000	080.000	1
05	A	[91]	[15.00]	[25.000]	1
	B	[91]	000.000	080.000	1
06	A	[91]	[90.00]	080.000	1
	B	[91]	000.000	080.000	1
07	A	[91]	[15.00]	[25.000]	1
	B	[91]	000.000	080.000	1
08	A	[88]	000.000	080.000	1
	B	[88]	000.000	080.000	1
09	A	[99]	END 99	080.000	1
	B	[99]	000.000	080.000	1

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

STEP	MODE (M:)	G CODE	STEP SIZE	FEED RATE	LOOP COUNT
01	A	[91]	000.000	080.000	1
	B	[91]	[22.000]	080.000	1
02	A	[91]	[90.00]	080.000	1
	B	[91]	000.000	080.000	1
03	A	[98]	[15.00]	[25.000]	1
	B	[98]	000.000	080.000	1
04	A	[88]	[90.00]	080.000	1
	B	[88]	000.000	080.000	1
05	A	[99]	[15.00]	[25.000]	1
	B	[99]	000.000	080.000	1
06	A	[91]	[90.00]	080.000	1
	B	[91]	000.000	080.000	1
07	A	[98]	[15.00]	[25.000]	1
	B	[98]	000.000	080.000	1



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Explanation:

Step #2 tells the control to jump to step #5. The control will do steps #5 and #6 three times with step #7 marking the end of the subroutine. After finishing the subroutine the control jumps back to the step following the "g 96" call or step #3. Since step #4 is not part of a subroutine, it marks the end of program and will return the control to step #3

As you can see, the difference in using subroutines in example #5 only saves 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 #2 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 separate piece of paper. Program the control using "g 96" 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 "g 96" call.

Example #6

You wish to tilt the table **-10 degrees** (-10°), then index **15, 20, 25, 30 degrees** in sequence four times and then drill a five-hole bolt pattern.

STEP	MODE (M:)	G CODE	STEP SIZE	FEED RATE	LOOP COUNT
01	A	[91]	000.000	080.000	1
	B	[91]	[-10.000]	080.000	1
01	A	[96]	000.000	LOC [4]	[4]
	B	[96]	000.000	080.000	1
02	A	[98]	000.000	080.000	[5]
	B	[98]	000.000	080.000	1
03	A	[95]	000.000	080.000	1
	B	[95]	000.000	080.000	1
(Main Program Previous page-----subroutine below)					
04	A	[91]	[15.000]	080.000	1
	B	[91]	000.000	080.000	1
05	A	[91]	[20.000]	080.000	1
	B	[91]	000.000	080.000	1
06	A	[91]	[25.000]	080.000	1
	B	[91]	000.000	080.000	1
07	A	[91]	[30.000]	080.000	1
	B	[91]	000.000	080.000	1
08	A	[99]	000.000	080.000	1
	B	[99]	000.000	080.000	1

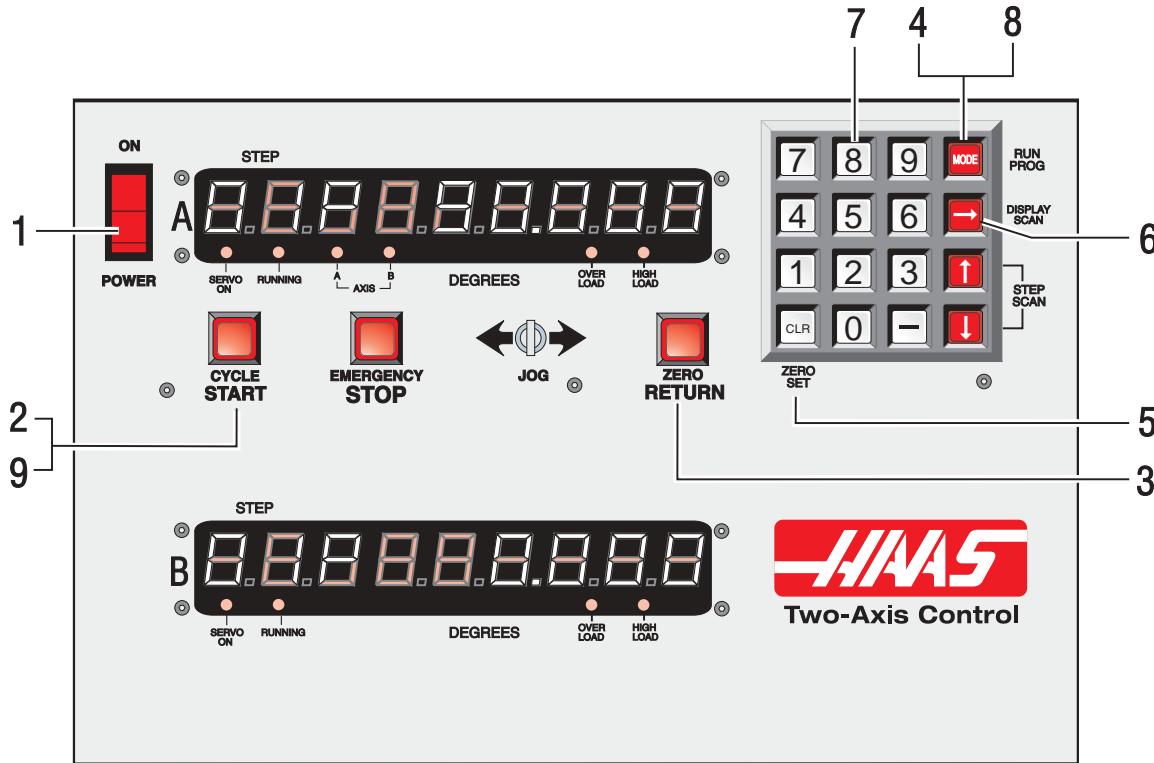
01	A	[91]	000.000	080.000	1
	B	[91]	[-10.000]	080.000	1
01	A	[96]	000.000	LOC [4]	[4]
	B	[96]	000.000	080.000	1
02	A	[98]	000.000	080.000	[5]
	B	[98]	000.000	080.000	1
03	A	[95]	000.000	080.000	1
	B	[95]	000.000	080.000	1

04	A	[91]	[15.000]	080.000	1
	B	[91]	000.000	080.000	1
05	A	[91]	[20.000]	080.000	1
	B	[91]	000.000	080.000	1
06	A	[91]	[25.000]	080.000	1
	B	[91]	000.000	080.000	1
07	A	[91]	[30.000]	080.000	1
	B	[91]	000.000	080.000	1
08	A	[99]	000.000	080.000	1
	B	[99]	000.000	080.000	1



Trt-Series

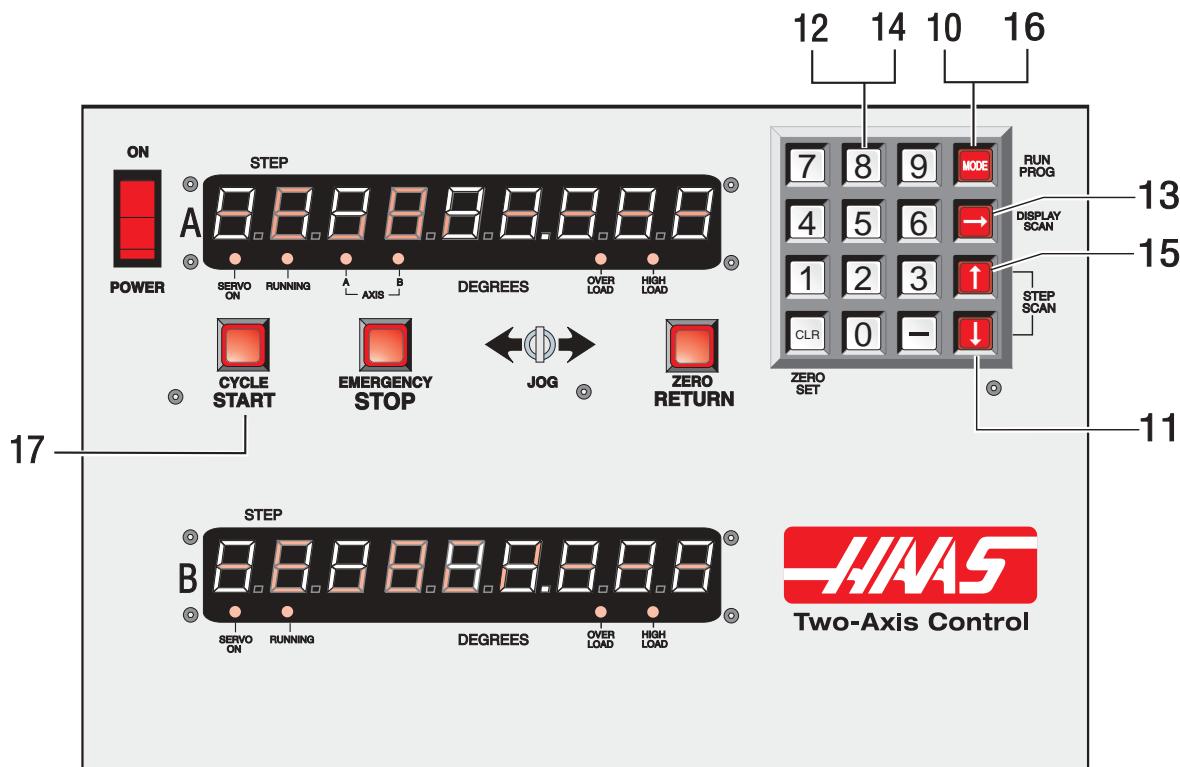
6.2 BRUSH MOTORS



Example #1

You want the rotary table (not the tilt axis) to index **90 degrees** (90°).

1. Turn [**POWER**] switch on.
2. Push the [**CYCLE START**] switch.
3. Push the [**ZERO RETURN**] switch.
4. Push the [**MODE**] button and release. Displays must be blinking.
5. Push and hold [**CLR**] button for five seconds. "g 91" displayed.
6. Push the [**DISPLAY SCAN**] button twice. (The A LED will light up.)
7. Enter [**9 0 0 0 0**].
8. Push [**MODE**] button. Steady displays.
9. Push [**CYCLE START**] to index.



Example #2

Continuing the previous example, we want to index the rotary axis **90 degrees** (90°) and then index the tilt axis **45 degrees** (45°).

10. Push the [MODE] button. Displays blinking.
11. Push the [DOWN ARROW] once. You should be on step 2.
12. Enter **[9 1]** on the key pad.
13. Push the [DISPLAY SCAN] button. (The **B** LED will light up.)
14. Enter **[4 5 0 0 0]** on the key pad. Use [CLR] if you make a mistake.
15. Push the [UP ARROW] button once. You should be on step 1.
16. Push the [MODE] button. Steady displays.
17. Push the [CYCLE START] switch. The table should index **90 degrees** (90°). Push [CYCLE START] again. The tilt axis should index **45 degrees** (45°).

Assuming you have successfully completed the previous two examples, the following examples will show the program as you would enter it into the control. The visual aid of the front panel will not be used. 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.



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Example #3

We want to tilt the rotary table **30 degrees** (30°), then drill a four-hole pattern, and then drill a five-hole pattern on the same part.

STEP	G CODE	STEP A SIZE	STEP B SIZE	FEED RATE	LOOP COUNT
01	[91]	000.000	[30.000]	080.000	1
02	[91]	[90.000]	000.000	080.000	[4]
03	[91]	[72.000]	000.000	080.000	[5]
04	[99]	000.000	000.000	080.000	1

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

STEP	G CODE	STEP A SIZE	STEP B SIZE	FEED RATE	LOOP COUNT
01	[91]	000.000	[30.000]	080.000	1
02	[98]	000.000	000.000	080.000	[4]
03	[98]	000.000	000.000	080.000	[5]
04	[99]	000.000	000.000	080.000	1

Example #4

We want to tilt the rotary table **37.9 degrees** (37.9°), index the rotary table **90.12 degrees** (90.12°), start a seven-hole bolt pattern, and then return to our zero position.

STEP	G CODE	STEP A SIZE	STEP B SIZE	FEED RATE	LOOP COUNT
01	[91]	000.000	[37.900]	080.000	1
02	[91]	[90.120]	000.000	080.000	1
03	[98]	000.000	000.000	080.000	[7]
04	[88]	000.000	000.000	080.000	1
05	[99]	000.000	000.000	080.000	1

Example #5

We want to first tilt the table **22 degrees** (22°), then index it **90 degrees** (90°) and slow feed for it **15 degrees** (15°), repeating the pattern three times and then returning home.

STEP	G CODE	STEP A SIZE	STEP B SIZE	FEED RATE	LOOP COUNT
01	[91]	000.000	[22.000]	080.000	1
02	[91]	[90.00]	000.000	080.000	1
03	[91]	[15.00]	000.000	[25.000]	1
04	[91]	[90.00]	000.000	080.000	1
05	[91]	[15.00]	000.000	[25.000]	1
06	[91]	[90.00]	000.000	080.000	1
07	[91]	[15.00]	000.000	[25.000]	1
08	[88]	000.000	000.000	080.000	1
09	[99]	END 99	000.000	080.000	1



Trt-Series

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

STEP	G CODE	STEP A SIZE	STEP B SIZE	FEED RATE	LOOP COUNT
01	[91]	000.000	[22.000]	080.000	1
02	[96]	000.000	000.000	Loc [5]	[3]
03	[88]	000.000	000.000	080.000	1
04	[95]	000.000	000.000	080.000	1
05	[91]	[90.00]	000.000	080.000	1
06	[91]	[15.00]	000.000	[25.000]	1
07	[99]	000.000	000.000	080.000	1

Explanation:

Step #2 tells the control to jump to step #5. The control will do steps #5 and #6 three times with step #7 marking the end of the subroutine. After finishing the subroutine the control jumps back to the step following the "g 96" call or step #3. Since step #4 is not part of a subroutine, it marks the end of program and will return the control to step #3

As you can see, the difference in using subroutines in example #5 only saves 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 #2 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 separate piece of paper. Program the control using "g 96" 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 "g 96" call.

Example #6

You wish to tilt the table **-10 degrees** (-10°), then index **15, 20, 25, 30 degrees** in sequence four times and then drill a five-hole bolt pattern.

STEP	G CODE	STEP A SIZE	STEP B SIZE	FEED RATE	LOOP COUNT
01	[91]	000.000	[-10.000]	080.000	1
01	[96]	000.000	000.000	Loc [4]	[4]
02	[98]	000.000	000.000	080.000	[5]
03	[95]	000.000	000.000	080.000	1
		(main program previous page)	—subroutine below—		
04	[91]	[15.000]	000.000	080.000	1
05	[91]	[20.000]	000.000	080.000	1
06	[91]	[25.000]	000.000	080.000	1
07	[91]	[30.000]	000.000	080.000	1
08	[99]	000.000	000.000	080.000	1



7. PROGRAMMABLE PARAMETERS

There are 38 stored parameters associated with each servo axis. 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 if not already in PROGRAM mode. 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 n

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. The **right** arrow key is used to alternate between parameters for the **A** and **B** axes. Pressing the **up** arrow, **down** arrow, **right** arrow, or MODE keys will cause an entered parameter to be stored.

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.

7.1 GEAR COMPENSATION

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

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

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

When the gear compensation tables are displayed, the **up** and **down** arrow button will select the next two degree (2°) 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, for the A axis, or parameter 57, for the B-axis, must be set to "0".



7.2 TRAVEL LIMITS

Travel limits are defined by Parameters 13 and 14, for the A axis (parameter 59 and 60 for the B axis). If the operator should change parameter 13 or 14, for the A axis (parameter 59 and 60 for the B axis), allowing the tilt axis to rotate beyond the normal operational limits, the conduit and air supply line for the rotary axis may become twisted. If this occurs, the tilt axis must be returned to the normal operational zone in the direction opposite to the way it was travelling when it left the zone, otherwise damage may occur. Alternatively, if the rotary axis conduit and air supply line should ever become tangled, the operator can shut off power to the controller, disconnect the conduit and air line, and untangle them manually.

It is never advisable to change the values of Parameters 13 and 14 for the A axis (parameter 59 and 60 for the B axis). If these values have been lost, contact Haas Automation for assistance.

7.3 PARAMETER LIST

A-axis parameters are in **bold**; Brushless B-axis parameters are in parenthesis ()

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 cycle finish relay
- +2: to pulse optional second relay at end of program.

Parameter 3 (49): 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 damped by the Derivative gain.

Parameter 4 (50): 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 (55): 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.)



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Example 1: A Brush TRT 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 TRT 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 (57): reverse direction option, range 0 to 3 PROTECTED!

This parameter consists of two flags used to reverse the direction of 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 (58): display units and precision (decimal location), range 0 to 6

- 0 : degrees and minutes (circular)

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

- 1 : inches to 1/10 (linear)
- 2 : inches to 1/100 (linear)
- 3 : inches to 1/1000 (linear)
- 4 : inches to 1/10000 (linear)
- 5 : degrees to 1/100 (circular)

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

- 6 : degrees to 1/1000 (circular)

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

Parameter 13 (59): maximum positive travel, range 0 to 65535

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 (60): maximum negative travel, range 0 to 65535

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 (61): backlash amount, range 0 to 99 PROTECTED!

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.



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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 (63): servo loop integral gain, range 0 to 255 PROTECTED!

Servo integral gain. 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 (64): acceleration, range 0 to 65535 (0 TO 999999) PROTECTED!

This parameter defines how fast the motor is accelerated up to the desired speed. The value used is (Par 18)*10 in encoder steps/second/second. The highest acceleration is thus 655350 steps per second per second. It must be greater than or equal to twice Parameter 19, usually 2X. The entered value = the desired value/parameter 20 if a gear ratio divider is used. Lowering this value results in gentler acceleration.

Parameter 19 (65): maximum speed, range 0 to 25000

This parameter defines the maximum speed (RPM of motor). The value used is (Par 19)*10 in encoder steps/second. The highest speed is thus 250000 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 (66): 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. 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 (68): maximum allowed servo loop error, range 0 to 3999 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 (69): 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 35% 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.



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Parameter 24 (70): general purpose flags, range 0 to 511 PROTECTED!

This parameter consists of five individual flags for controlling servo functions Start with a zero and add the number shown for each of the following selected options:

- +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 : Elapsed time display allowed
- +128 : Disable Z channel encoder test
- +256 : NC overheat and pressure sensor

Parameter 25 (71): 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 always set to 5, a data rate of 4800.

Parameter 27 (73): 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 (74): 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)



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Parameter 29 (75): back-EMF compensation, range 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 set to 10 times the back EMF per 1000 RPM. Thus if the motor has 24.6 volts per KRPM this parameter is set to 246.

Parameter 30: protection, range 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, range 0 to 9

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

Parameter 32 (78): delay time for engaging brake, range 0 to 19 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 a unit 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 (80): belt stretch adjustment, range 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 the belt.

Parameter 35 (81): dead zone compensation, range 0 to 19 PROTECTED!

This parameter is used to compensate for the dead zone in the driver electronics. It is normally set to 0 or 1.

Parameter 36 (82): maximum speed, range 0 to 25000 PROTECTED!

This parameter defines the maximum feed rate. The value used is (Par 36)*10 in encoder steps/second. The highest speed is thus 250000 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 (83): encoder test window size, range 0 to 999

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

Parameter 38 (Dual Control Brush Type Only) secondary axis, range 0 to 1

This parameter normally states whether or not there is a secondary axis, and is set to one if there is. Normally, it is set to 1 for the tilting rotary table.

The following parameters are for brushless motors:

Parameter 38 (84): KDD (0 to 9999)

Servo loop second differential gain.

Parameter 39 (85): phase offset (0 to 9)

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



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Parameter 40 (86): 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 (88): 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 (89): EREV PER MREV (1 to 9)

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

Parameter 44 (90): ACCEL_CONST (0 to 999)

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

Parameter 45 (91): 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.



Trt-Series

8. TRT / T5C TROUBLESHOOTING

8.1 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 Fig. #1, 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 the relay 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 may be in the interface cable or your CNC.

2) Check The CNC Cable Interface Alone

You can check the signals from the CNC using your voltmeter and 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 may provide a +12 to +24 volts 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 (Part # 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 The 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 wires that connect to the CNC.

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



8.2 TROUBLESHOOTING GUIDE

SYMPTOM	PROBABLE CAUSES	REMEDY
Unit is turned on but the power switch is not illuminated.	① Control is not receiving power.	① Check power cord, line fuse, and AC supply.
Unit will not index. Display reads AIR-HOT . Axis dependant	① Table is over maximum operating temperature (See HI-LOAD). ② Conduit not connected to control box	① Allow motor to cool down. If this occurs often, consult HAAS Service Dept. ② Make sure power is OFF and attach conduit to control box.
Front panel START and ZERO RETURN buttons don't work.	① In PROGRAM mode, or Parameter 6 is set to 1.	① Change Parameter 6 to 0. Set to RUN mode.
ERROR displays when trying to program.	① Parameter 7 is set to 1.	① Change Parameter 7 to 0.
Lo Volt or Por On appears while running, or erratic operation.	① Power available to control is inadequate.	① Power source must be capable of 15 amps at 120V AC. Use shorter/heavier gauge cord.
Indexer runs through entire program without stopping.	① Parameter 10 is set to 3.	① Change Parameter 10 to 0.
High current (Hi Curr)	① Brake does not release. ② Heavy work load. ③ Fixture/workpiece is distorted. ④ Coolant-damaged conduit box. ⑤ Shorted motor	① Examine brake solenoid valve, replace if necessary. Air line kinked or exhaust muffler restricted. ② Reduce feed. ③ Ensure fixture workpiece mounting surface is flat within .001". ④ Examine conduit box, and replace if necessary. ⑤ Consult Haas Service Dept.
SERVO ERROR: Ser-Err during first home find Ser-Err upon indexing.	① Faulty main cable or cable connector. ② Table driving a heavy load. ③ Table is jammed. ④ Check Parameter 25. ⑤ Head is jammed	① Check cable and motor fuse. ② Reduce workload weight and/or feed rates. ③ Eliminate obstruction. ④ Must be set to 8 for HRT160 and 210, 19 for HRT310, and 0 for HA5C. ⑤ Eliminate obstruction
High load (Hi LoAd) Axis dependant	① Fixture / workpiece is distorted. ② Heavy work load	① Ensure fixture workpiece mounting surface is flat within .001". ② Reduce feed
Workpiece chatter during index cutting operation.	① Brake not operative.	① Consult HAAS Service Dept.
Workpiece chatter during continuous cutting operation.	① Excessive backlash. ② Excessive wormshaft play.	① Consult HAAS Service Dept. ② Consult HAAS Service Dept.
(TRT) A6 - Dead length collet sticking, and/or insufficient clamping force.	① Excessive spindle/collet friction.	① Lubricate spindle and collet with a Molybdenum disulfide grease.
Air leaking around rear brake disc.	① Chips blown in between O-ring and brake disc.	① Contact HAAS Service Department. Do not use air gun around rear brake disc. See section 8.5.



Trt-Series

9. ROUTINE MAINTENANCE

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

9.1 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 four points of interest when inspecting the table: the platter face and I.D., runout, backlash and popout.

Platter Face Runout: To check the platter runout, mount an indicator to the body of the table. Position the stylus on the face of the platter and index the table **360 degrees** (360°). The runout should be 0.0005" or less.

Platter I.D. Runout: To check the platter I.D. runnout, mount the indicator to the body of the table. Position the stylus on the through-hole in the platter and index the table **360 degrees** (360°). The runout should be 0.0005" or less.

Backlash Between Worm And Gear: To check the backlash between the worm and gear, the air supply must first be disconnected. Place a magnet on the face of the platter at a radius of 4". Mount an indicator on the body of the table and position the stylus on the magnet. Use an aluminum bar to rock the platter back and forth (apply approximately 10 ft-lb while testing). Backlash should be between 0.0001" and 0.0006".

Popout: To check popout, first disconnect the air supply from the unit. Then, index the table 360 degrees. Mount an indicator to the body of the table. Position the stylus on the face of the platter and zero the dial. Connect the air supply and read the popout from the indicator dial. Popout should be between 0.0001" and 0.0005"

9.2 ADJUSTMENTS TO THE TILTING ROTARY TABLE

The platter face, I.D. runout, backlash between worm and gear, and the popout are set at the factory and are not field serviceable. If any of these specifications are out of tolerance, contact your HAAS dealer for more information.

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.

9.3 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.



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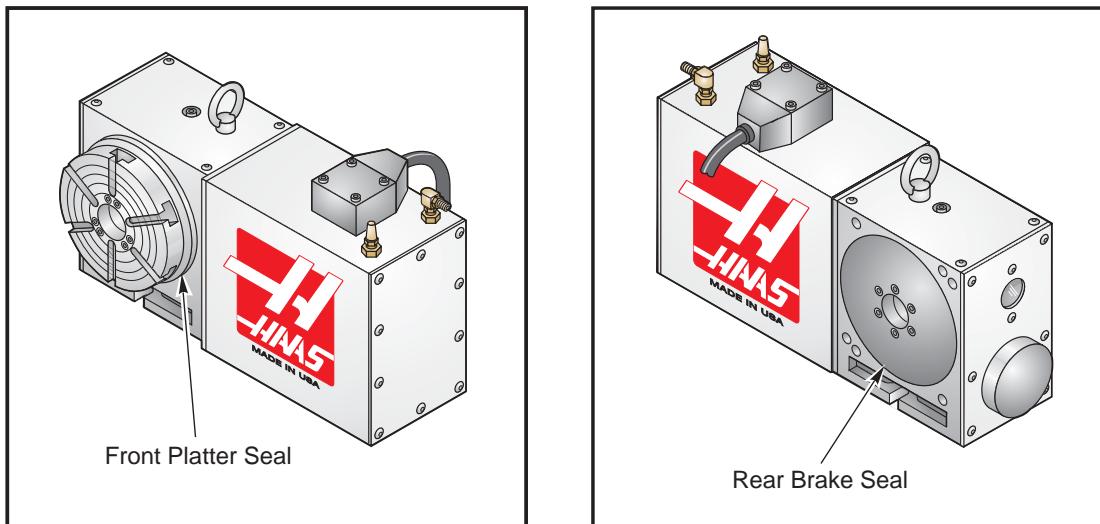
9.4 LUBRICATION

The table is lubricated with MOBIL SHC 630. The oil level must not drop below the sight glass level. If the level is low, fill the table through the pipe plug in the middle-top of the body. Fill to the top of the sight glass. Do not over fill! If the oil is dirty, drain and refill with fresh oil (Mobil SHC-630).

Replace the oil every 2 years.

9.5 CLEAN UP

After use, it is important to clean the rotary table. Remove all metal chips from the unit since the surfaces of the unit are precisely ground for accurate positioning and metal chips could damage those surfaces. Apply a coat of rust preventative.

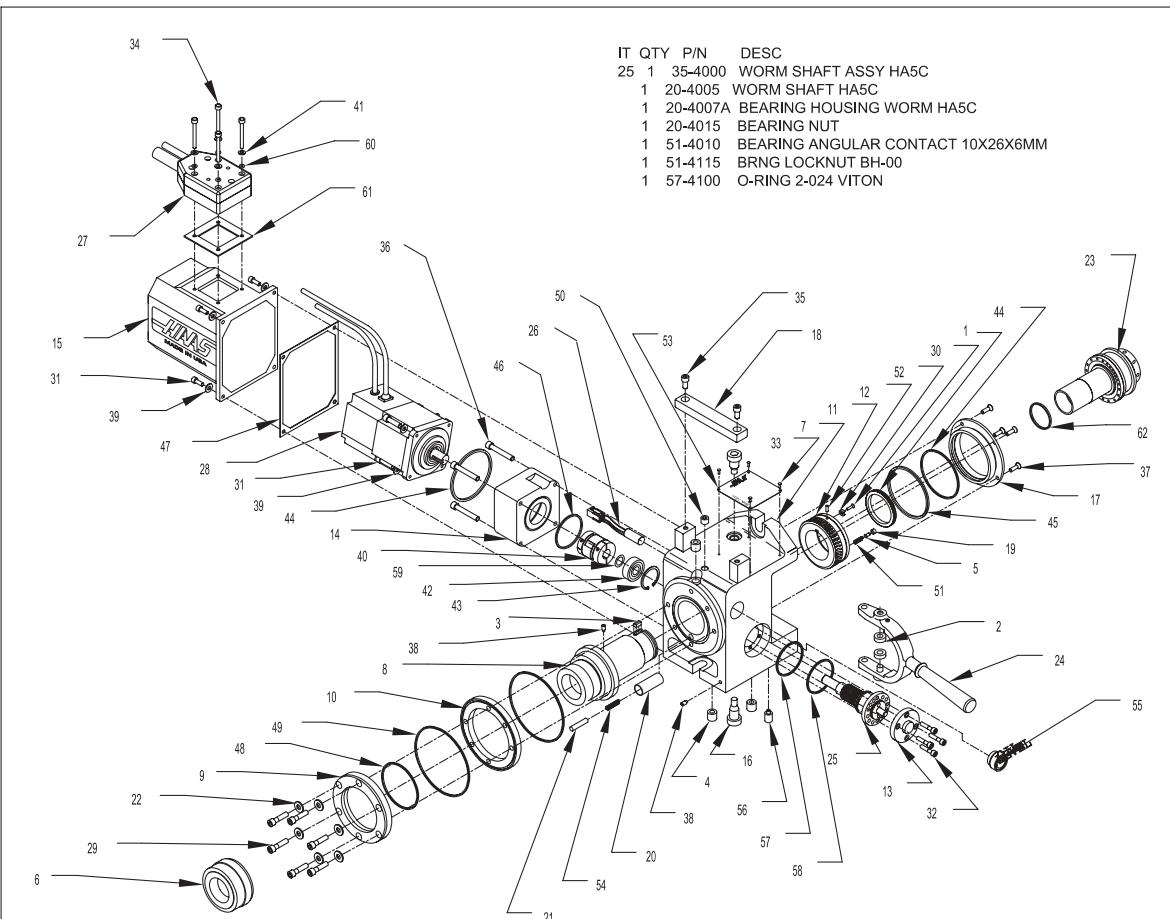


Front and Rear Brake Seals for TRT.



Trt-Series

10. TRT ASSEMBLY DRAWINGS



IT	QTY	P/N	DESC
1	1	20-2052	SPINDLE NUT (MANCCA)
2	2	22-2060	BUSHING HANDLE (MANCCA)
3	1	22-4019	KEY SPINDLE
4	2	22-5017	LOCATING PIN
5	1	22-2069	DETENT PIN S5C (30-1122)
6	1	20-2072	SPINDLE COVER S5C
7	1	20-4000A	BODY MACHINED INDEX
1	35-4057	SPINDLE/SPACER ASSY HA5C	
8	1	20-4001A	SPINDLE 5CV
9	1	20-4002A	SPINDLE LOCK
10	1	20-4003	SPINDLE SPACER
11	1	20-4004	WORM GEAR (30-1122)
12	1	69-18103	MAGNET #89 F 1405 (30-1122)
13	1	20-4008	BEARING END CAP
14	1	20-4451	MOTOR MOUNT
15	1	20-4042	BL MOTOR ENCLOSURE
16	2	20-4012	HANDLE BOLT (MANCCA)
17	1	20-4013A	REAR OIL SHIELD 5CV
18	1	20-4014	REMOVABLE HANDLE
19	1	22-4018	DETENT PLUG (30-1122)
20	1	20-4020	TUBE WICK OILER
21	1	59-2869	WICK 1/4 DIA ROUND
22	6	49-4101	WASHER 1/4 COPPER
23	1	35-3050	COLLET HOLDER ASSMBLY (MANCCA)
24	1	35-3073	INDEXER HANDLE ASSY (MANCCA)
1	20-2059	HANDLE COLLET CLOSER	
1	48-1664	PIN ROLL 3/16 X 5/8	
2	48-1665	PIN DOWEL 5/16 X 3/4	
26	1	36-3002	HOME SWITCH ASSY WP
27	1	36-4031B	BRUSHLESS 04 CABLE WP 14
28	1	62-2495	MOTOR AC SERVO YASKAWA 04
29	6	40-1610	SHCS 1/4-20 X 1
30	1	40-1613	FHCS 4-40 X 3/8
31	8	40-1645	SHCS 10-32 X 5/8

IT	QTY	P/N	DESC
32	4	40-16455	SHCS 10-32 X 7/8
33	4	40-1666	MC DR SCRW 2X 1/4 RD HD
34	4	40-1798	SHCS 8-32 X 1 3/4
35	2	40-1632	SHCS 1/4-20 X 1/2
36	4	40-16205	SHCS 10-32 X 1 3/4
37	4	40-1703	FHCS 10-32 X 1/2
38	2	22-4052	COLLET KEY HA5C
39	8	45-1735	WASHER #10 FLAT SAE T18-8
40	1	52-4478	14mm X 12mm CURVED JAW COUPLING
41	4	45-1601	WASHER FLAT
42	1	51-4000	BEARING RADIAL 12X32X10MM
43	1	56-0010	SNAP RING N5000-125
44	2	57-2022	O-RING 2-150 V- 1164-75
45	1	57-2105	O-RING 2-143 V- 1164-75
46	1	57-2235	O-RING 2-032 VITON
47	1	57-4011	MOTOR ENCLOSURE GASKET
48	1	57-4102	O-RING 2-035 V- 1164-75
49	2	57-4110	O-RING 2-045 V- 1164-75
50	2	58-1627	1/8-27 PIPE PLUG
51	1	59-2070	SPRING DETENT (30-1122)
52	1	59-2071	LOCKING PAWL
53	1	20-0732	NAMEPLATE LASER HA5C
54	1	59-2876	SPRING WICK OILER
55	1	59-4110	SIGHT GLASS LSP501-O8RGL
56	2	58-2745	MAGNETIC OIL PLUG
57	1	57-4100	O-RING 2-024 VITON
58	1	57-4130	O-RING 2-138 VITON
59	1	55-4484	WAVE WASHER SSR-0062
60	4	57-0057	O-RING 2-007 VITON
61	1	57-4133	J-BOX GASKET SQUARE
62	1	57-4114	O-RING 2-127 V-1164-75

EX-0017E REV.E MT 11-20-01



HRT160 BRUSHLESS ROTARY TABLE

HRT160 BRUSHLESS ROTARY TABLE

This technical drawing provides an exploded view of the HRT160 BRUSHLESS ROTARY TABLE assembly. The diagram illustrates the following components and their part numbers:

- IT QTY DWG# TITLE**
 - 19 1-354-160 WORM SHAFT ASSY 160mm B
 - 19.1 204-155 WORM SHAFT
 - 19.2 204-156 BEARING 160mm
 - 19.3 204-147 HOUSING NUT 160mm
 - 19.4 151-016 BEARING ANG CONTACT
 - 19.5 151-272 BEARING LOCKNUT BH-Q3
 - 20 1 35-445 MOTOR SYSTEM ASSY 160mm B
 - 20.1 11.2 224-176 STANDOFF BRUSHLESS
 - 20.3 31.2 204-055 BRACKET SOLID 210MM BL
 - 20.4 35-0675 SOLENOID ASSY (36-039)
 - 20.5 162-2501 MOTOR 03 YASAKAWA SIGMA
 - 20.6 140-789 SHCS 8-32 x 1
 - 20.7 44C-2020 SHCS 14-20 x 2
 - 20.8 45-1603 WASHER #8 SPIT LCK PLT
 - 20.9 54-4601 BELT F MFR-375-15
 - 20.10 124-511 PULLEY DRIVE 160B26T



Trt-Series

HRT210B BRUSHLESS ROTARY TABLE

HRT210B BRUSHLESS ROTARY TABLE

This technical drawing provides an exploded view of the HRT210B BRUSHLESS ROTARY TABLE. The diagram illustrates the assembly of various mechanical parts, including the worm gear, motor, bearing housing, and other structural components. Each part is labeled with a reference number, which corresponds to a detailed description in the tables below.

The tables list the part number, title, and description for each component. The drawings show the spatial relationship between the parts, such as the worm gear being mounted on the motor shaft and the bearing housing enclosing the motor assembly.

IDQT DWG # TITLE

17 1 25-2717 LOCATING PIN [22/2717]
18 1 25-4100 BODY MACHINED 210mm RT
3 1 25-4101 PLATTER HRT210
3A 1 25-4102 PLATTER PLATE A-G
4 1 25-4102 SPINDE 210mm RT (35-4059)
5 1 25-4103 BRAKE DISC HRT210
6 1 25-4104 WORM GEAR HRT210 (20-0388)
7 1 25-4108 HOUSING COVER HRT210
8 1 25-4111 SPINDE SPACER HRT210
9 1 25-4116 MOTOR SPACER
10 1 25-4502 PULLEY DRIVEN 210-50T
11 1 25-4124 LOCKING DRIVEN PULLEY
12 1 25-4125 KEY BODY
13 1 25-4130 SPINDE SPACER HRT210
14 1 25-4140 TUBE WICK OILER 210
15 1 25-5457 MOTOR ENCLOSURE
16 1 25-5458 ENCLOSURE COVER

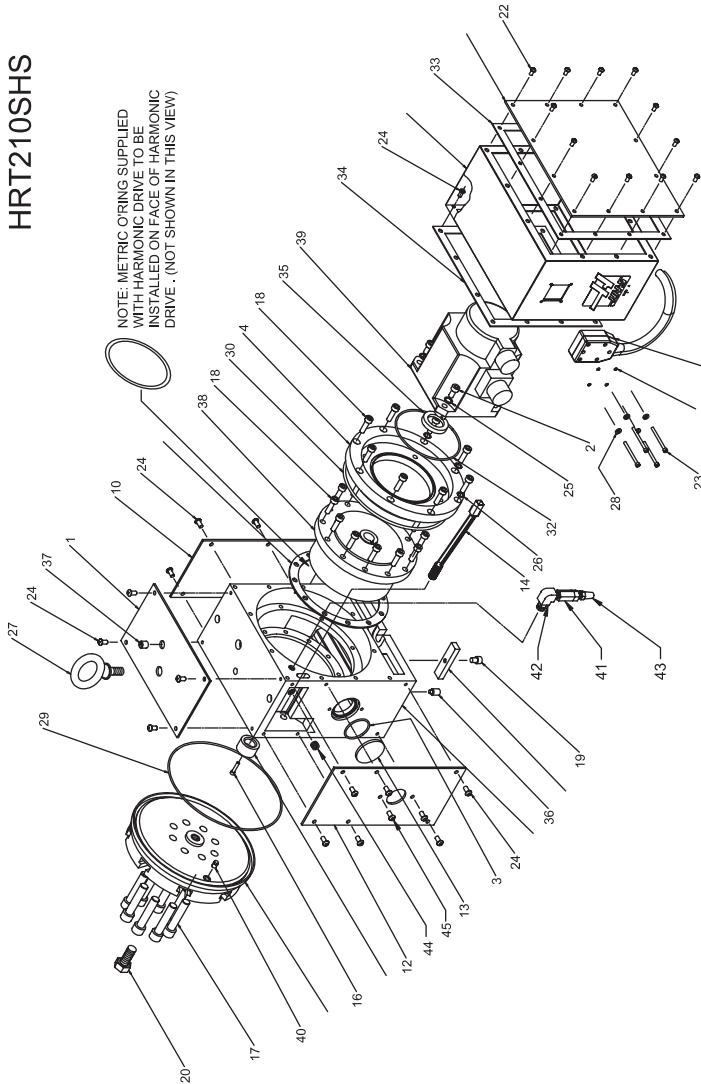
IDQT DWG # TITLE

17 1 25-4119 SIDE COVER HRT210
18 1 25-4120 TOP COVER HRT210
19 1 28-4126 OIL SIGHT GLASS
20 1 25-4127 WORM SHAFT ASSY 210mm
21 1 35-4115 MOTOR SYSTEM ASSY 210mm
22 1 38-3012 HOME SWITCH ASSY WP
23 1 38-4027 CBL 03 ALUM .LBX 14'
24 1 40-1050 SHCS 516-18 x 11
25 3 40-1610 SHCS 114-20 x 1
26 8 40-1612 FHCS 114-20 x 3/4
27 1 40-1630 SHCS 114-20 x 5/16
28 1 40-1631 SHCS 114-20 x 1/2
29 4 40-1738 SHCS 832-16 x 14
30 4 40-1739 WASHER 516 FLAT A325
31 4 40-1763 DOME FLN 316/18 x 58
32 4 40-1764 EYE BOLT 12-13 x 7/8
33 4 40-1765 WASHER FLAT
34 4 45-0024 WASHER FLAT
35 6 40-2035 SHCS 114-20 x 1/2
36 2 43-7004 HBK 516-18 x 7/8
37 1 44-1620 SSS 832-16 x 100
38 10-45-1737 WASHER #10 FLAT 34E PLT
39 2 45-1739 WASHER 516 FLAT A325
40 2 45-1763 DOME FLN 316/18 x 58
41 4 48-1004 EYE BOLT 12-13 x 7/8
42 4 45-0024 WASHER FLAT
43 15-0026 BEARING SIDE ROLLER 28x37x30mm
44 1 51-0026 BEARING DEEP GROOVE, #621
45 1 51-0027 BEARING DEEP GROOVE, #621
46 2 55-2754 18x18x10 FEMALE CHECK VALVE
47 1 58-3710 QUICK RELEASE FITTING
48 1 58-3711 14MM X 14MM FEMALE
49 1 58-3712 14MM X 14MM ANCHOR FITTING
50 1 58-3713 18x27 NPT-FEMALE
51 1 58-3714 18x27 NPT-MALE
52 1 58-3715 18x27 NPT-MALE
53 2 55-2745 MAGNETIC BRANCH, 18"
54 1 57-4135 GASKET SIDE PLATE HRT210
55 16-1675 WIRE ELBOW 18 MALE TO MALE
56 16-1707 AIR FITTING STRAIGHT
57 16-1708 AIR FITTING STRAIGHT
58 2 55-1677 1/4 NPT-MALE X 1/4 NPT-FEMALE
59 1 58-2555 18x27 NPT-MALE X FEMALE
60 2 55-2745 MAGNETIC SWITCH
61 1 58-2554 MAGNETIC OIL PLUG, 14x18 NPT
62 2 55-2754 18x18x10 FEMALE CHECK VALVE
63 1 58-3065 ARM FITTER (14 NPT)
64 3 56-3075 LIFTING PLUG (14 NPT)
65 1 56-3105 PLUG PLUG (14 NPT)
66 1 56-3116 14 STREET ELBOW 90DEG.
67 1 58-3710 14MM X 14MM NUT
68 2 55-2869 WICK 1/4 DIA ROUND
69 2 55-2876 SPRING WICK OILER
70 16-1810 MAGNETIC SWITCH
71 16-1814 GASKET AIR FITTING
72 12-02581 NAMEPLATE HRT210
73 12-02666 NC DR SCREW 2X 1/4 RD
74 12-02667 WICK 1/4 DIA ROUND
75 15-54705 O-RING 24x44 UNA
76 15-54713 GASKET SQUARE
77 30-1063 HRT210-TOB TESTED
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410 30-1063 HRT210-TOB TESTED
411 30-1063 HRT210-TOB TESTED
412 30-1063 HRT210-TOB TESTED
413 30-1063 HRT210-TOB TESTED
414 30-10



Trt-Series

HRT210SHS



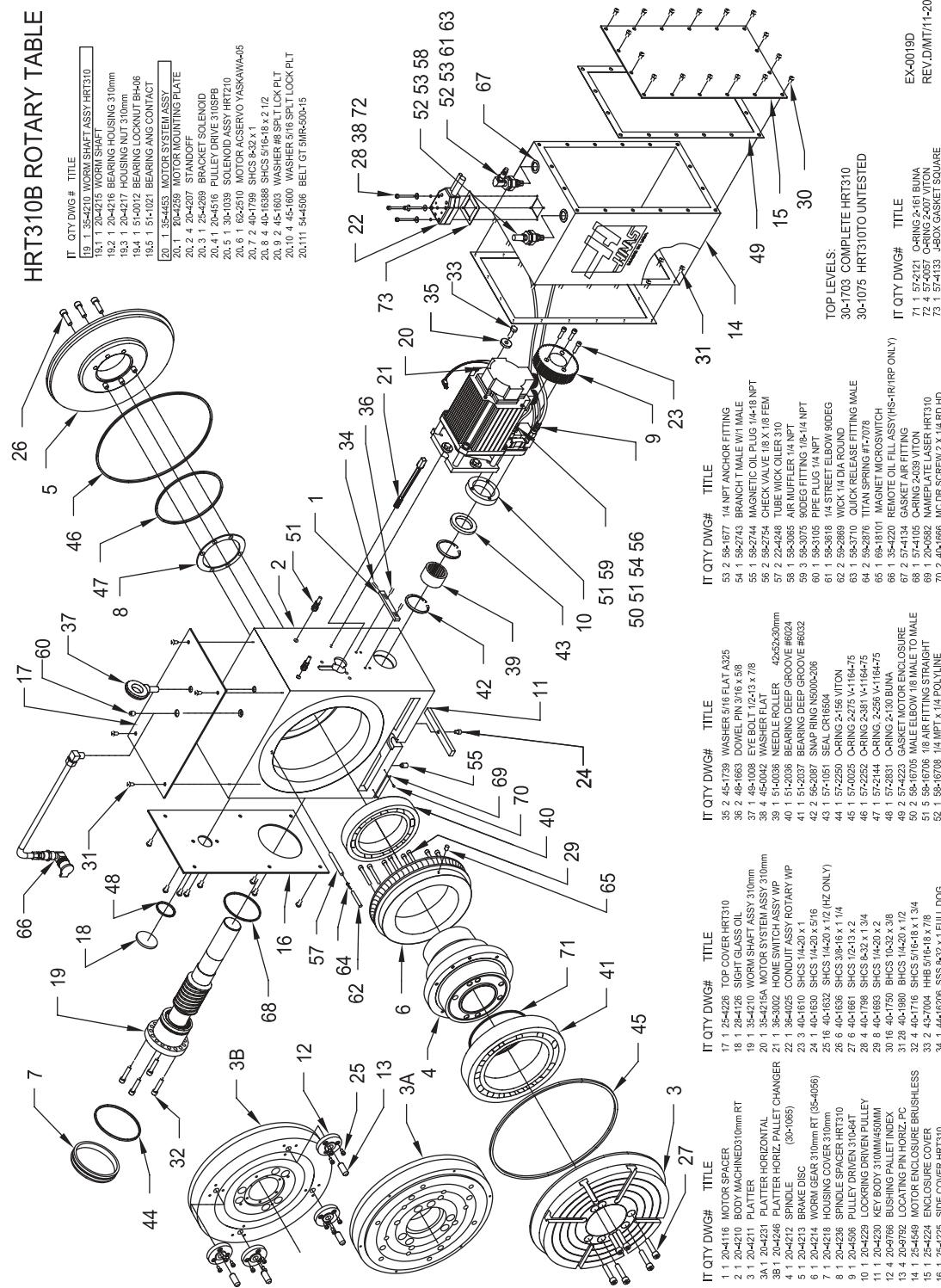
ID	QTY	DWG#	TITLE
1	1	20-4128	KEY, BODY
2	1	20-4520	BODY MACHINING
3	1	20-4521	PLATTER, HRT210SHS
4	1	20-4522	MOTOR MOUNT, HRT210SHS
5	1	20-4523	DRIVE SPACER
6	1	20-4531	RETENTION CAP
7	4	57-4057	O-RING 2-007 VITON
8	1	25-4524	MOTOR ENCLOSURE
9	1	25-4525	ENCLOSURE COVER
10	1	25-4526	SIDE COVER-A
11	1	25-4528	TOP COVER
12	1	25-4527	SIDE COVER-B
13	1	28-4126	OIL SIGHT GLASS
14	1	36-3002	MICRO SWITCH ASSY
15	1	36-4029B	BL05 CABLE WP 14'
16	1	43-1651	MSHCS, M5 X 16
17	8	40-0010	MSHCS, M12 X 45
18	24	40-1500	SHCS, 5/16-18 X 1
19	1	40-1630	SHCS, 1/2-20 X 5/16
20	1	43-0015	HHB 1/2-13 X 1 SELF SEALING
21	4	40-1635	SHCS, 5/16-18 X 3/4
22	12	40-1750	BHCS 10-32 X 3/8
23	4	40-1798	SHCS, 8-32 X 1/4
24	28	40-1980	BHCS, 1/2-20 X 1/2
25	4	45-0039	WASHER BRASS Ø0.328 ID X Ø0.562 O.D.
26	3	45-0047	WASHER BRASS Ø0.314 ID X Ø0.420 O.D.
27	1	49-1008	EYE BOLT, 1/2-13 X 7/8
28	4	45-0042	WASHER, #8 SEALING S.S.
29	1	57-2221	O-RING, 2-280 VITON
30	1	57-2127	O-RING, 2-166
31	1	57-2831	O-RING, 2-130 BUNA
32	1	57-2875	O-RING, 2-157 BUNA
33	1	57-4529	GASKET, ENCLOSURE COVER
34	1	57-4530	GASKET, MOTOR ENCLOSURE
35	1	57-4533	SEAL CR1615
36	1	58-2744	MAGNETIC OIL PLUG 1/4-18
37	1	58-3105	PIPE PLUG 1/4 NPT
38	1	59-4532	HARMONIC DRIVE, 50-1
39	1	62-0014	YASKAWA SIGMA MOTOR 09
40	1	69-18101	MAGNET, MICRO SWITCH
41	1	58-2754	1/8 X 1/8 FEMALE CHECK VALVE
42	1	58-16705	MALE EL BOW, 1/8
43	1	58-2262	AIR MUFFLER, CENTERED
44	1	58-1627	1/8-27 PIPE PLUG
45	2	40-1633	BHCS 1/4 X 3/8 ZINC

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



Trt-Series

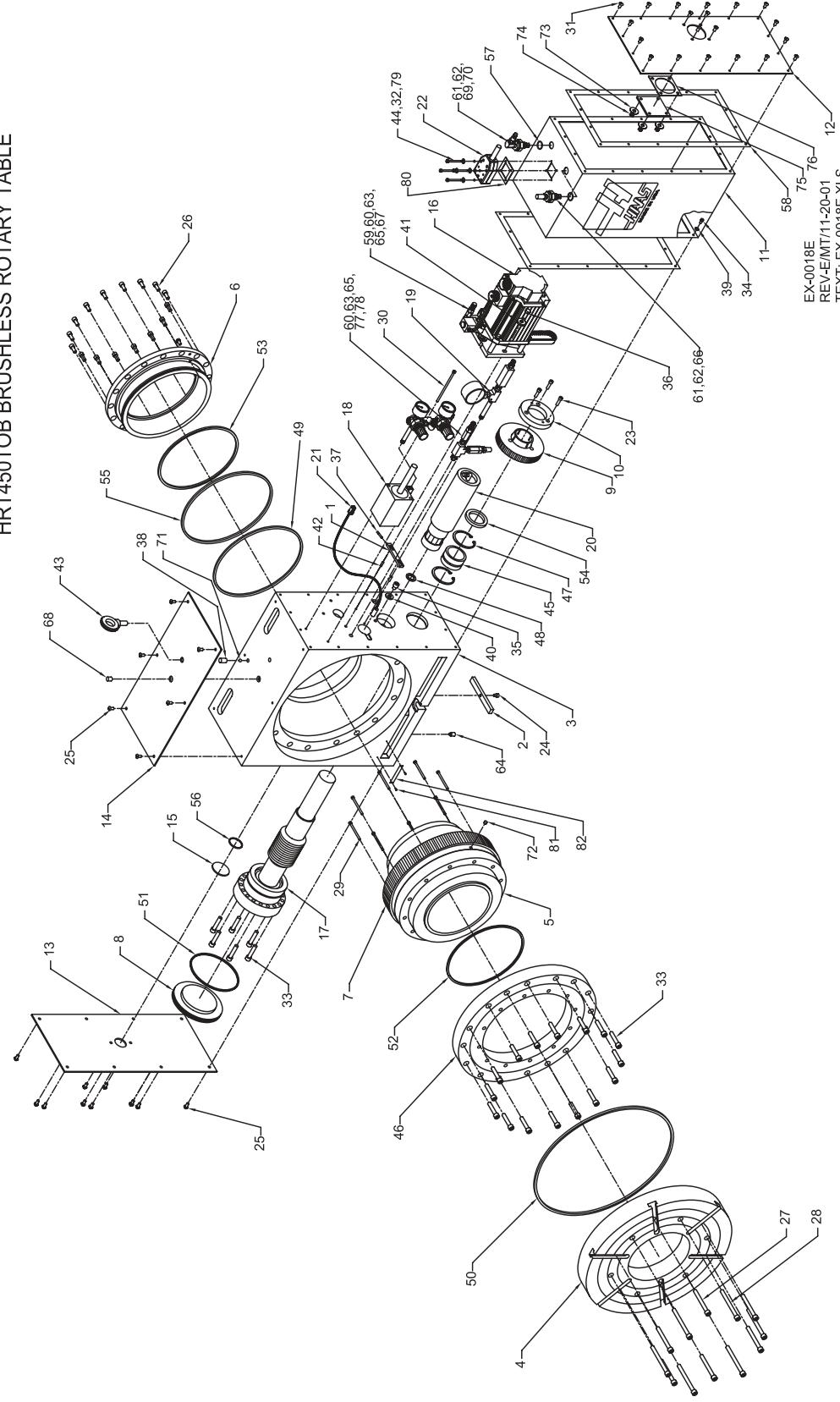
HRT310B ROTARY TABLE





Trt-Series

HRT450TOB BRUSHLESS ROTARY TABLE



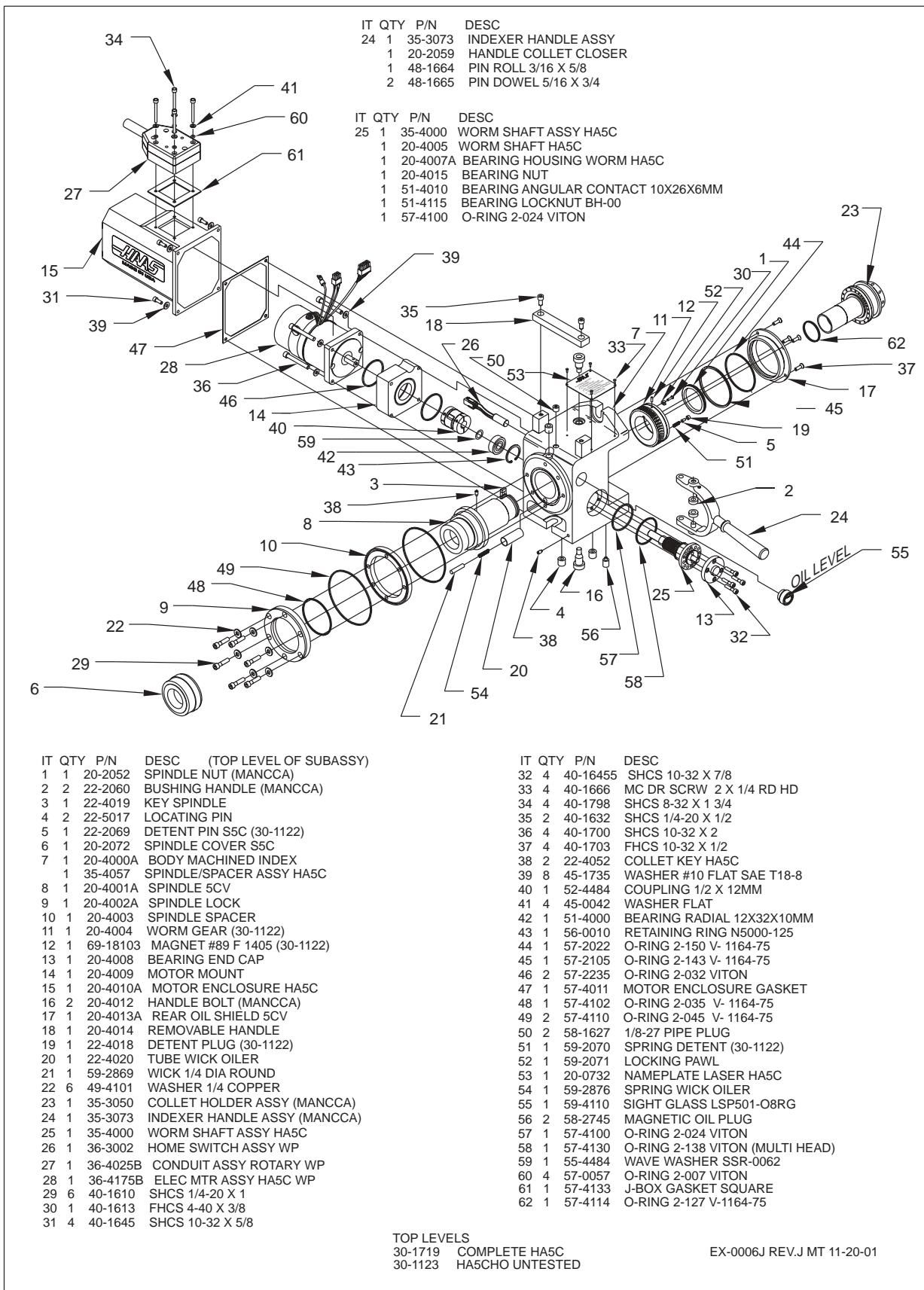


Trt-Series

ID	QTY	DWG #	DESCRIPTION	ID	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	ID	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'	ID	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	ID	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	ID	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	ID	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



Trt-Series

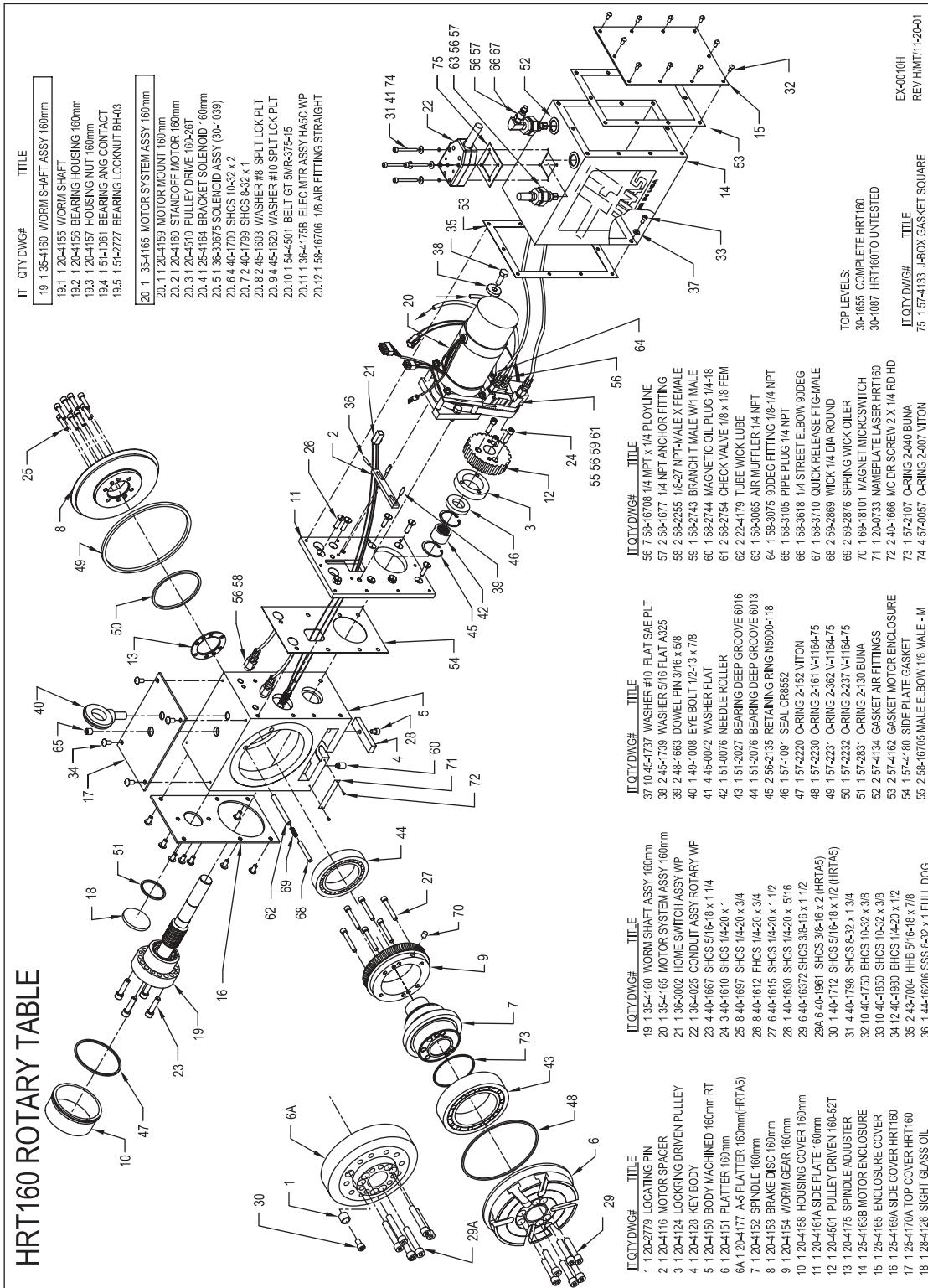


Note: All rotary tables use Polyurethane tubing for all air lines. Specifications are: 1/4 O.D. x .160 I.D. 95A Durometer.



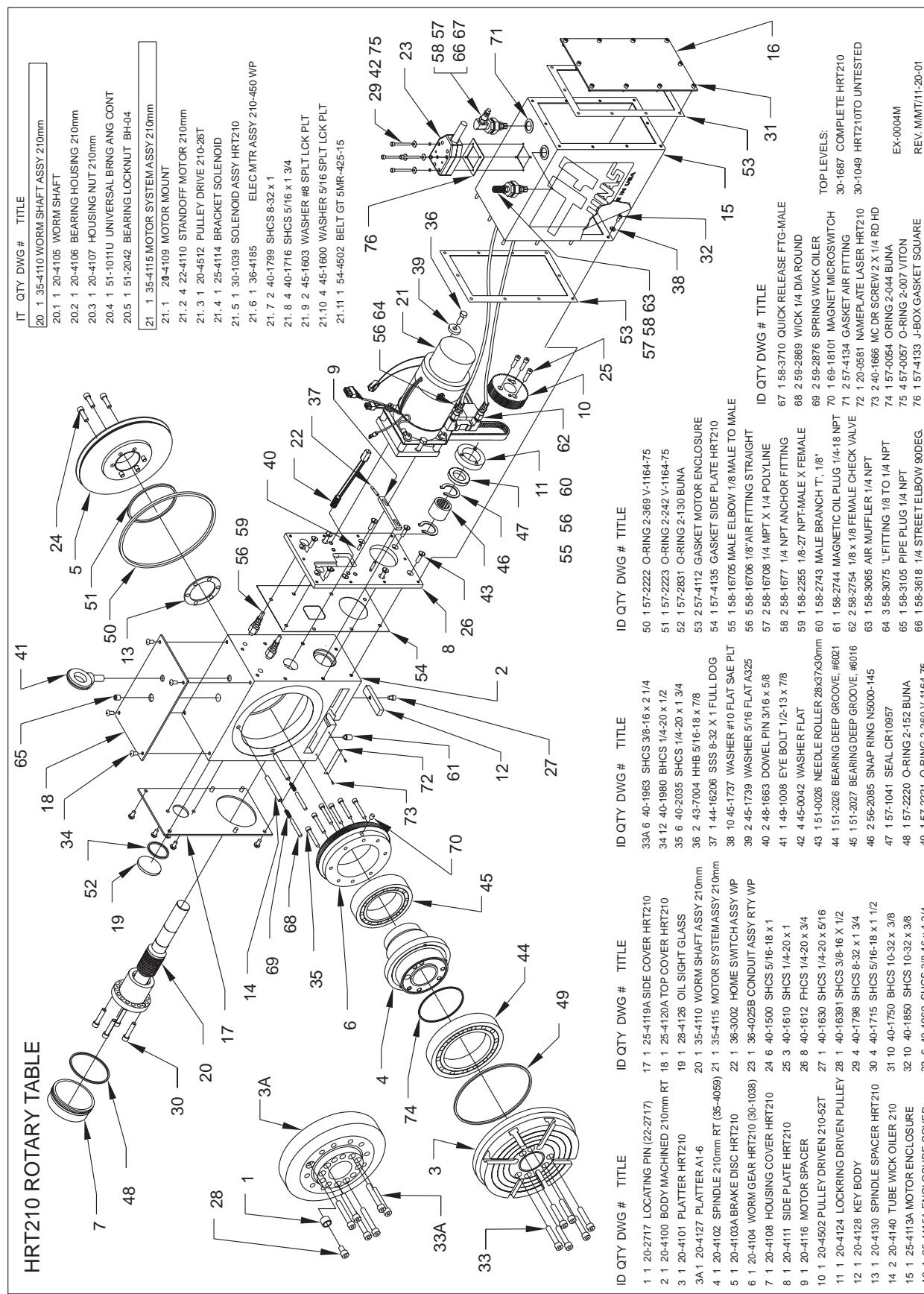
Trt-Series

HRT160 ROTARY TABLE



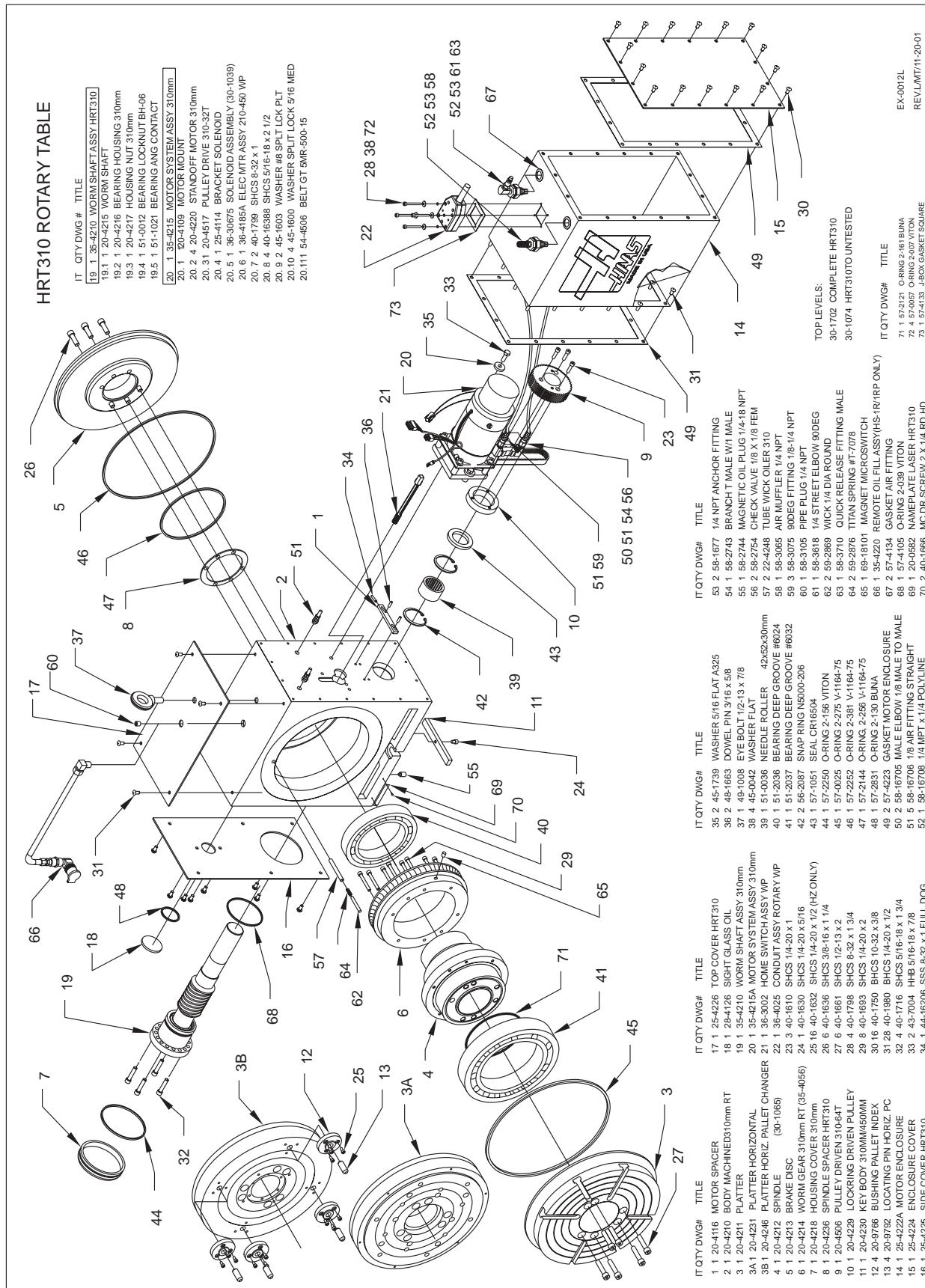


Trt-Series





Trt-Series



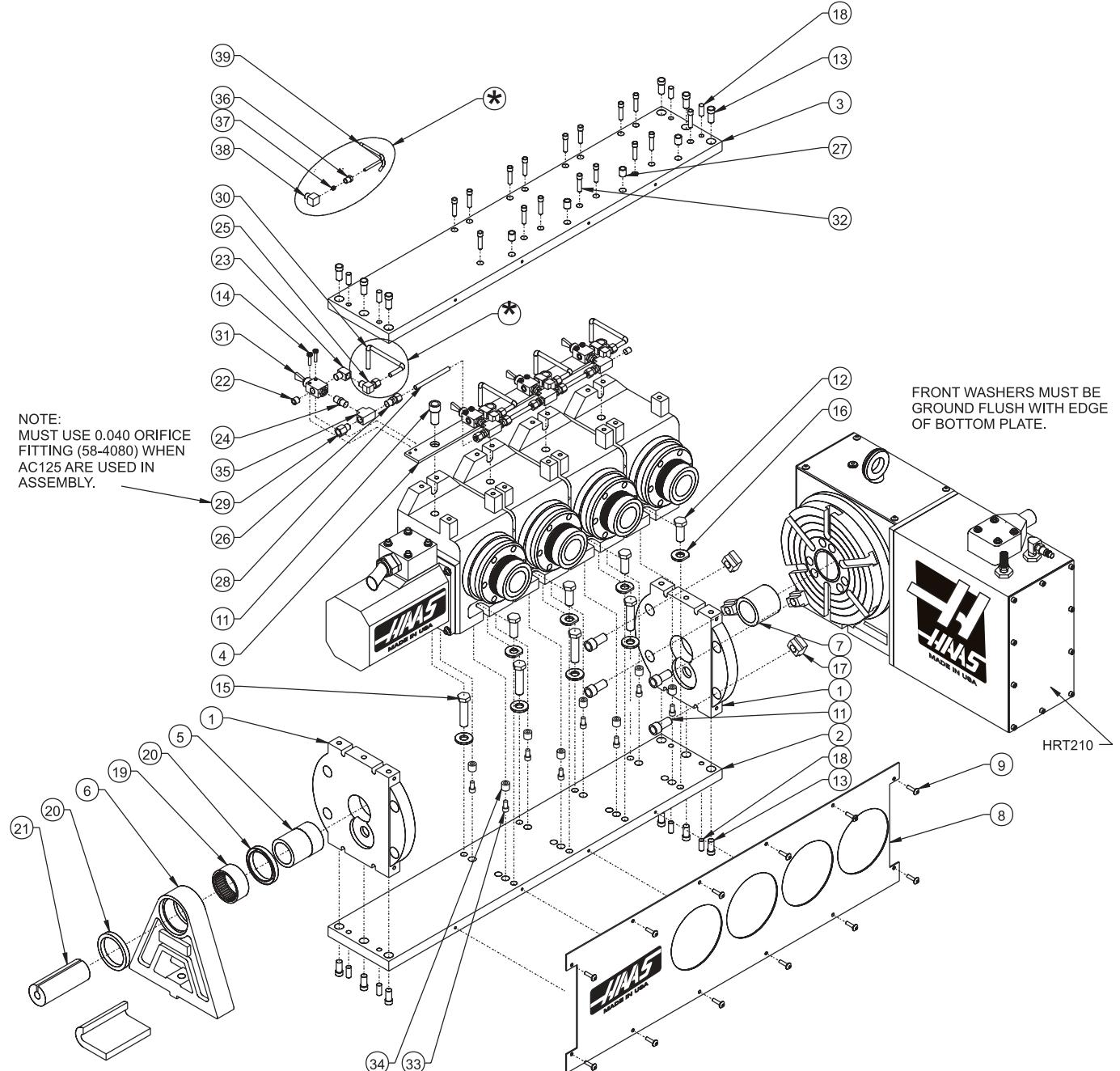
Note: All rotary tables use Polyurethane tubing for all air lines. Specifications are: 1/4 O.D. x 160 I.D. 95A Durometer.



Trt-Series

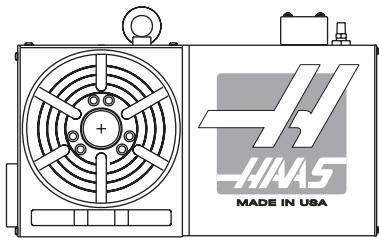
HA5C ASSEMBLY DRAWING

HA5C2.3.4

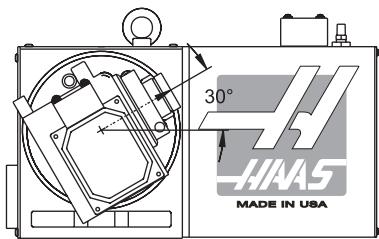




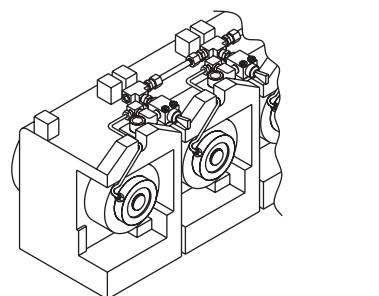
Trt-Series



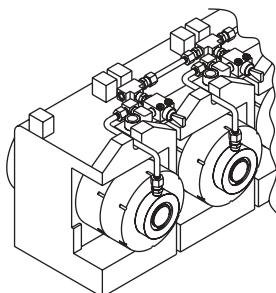
NOTE:
MUST USE AN HRT210
WITH SHORT T-SLOT
UP WHEN PLATTER
IS IN HOME POSITION.



POSITION OF SPINDLES
WHEN ASSEMBLED T5C2,3,4
IS IN HOME POSITION.



BACK VIEW OF AC25



BACK VIEW OF AC125

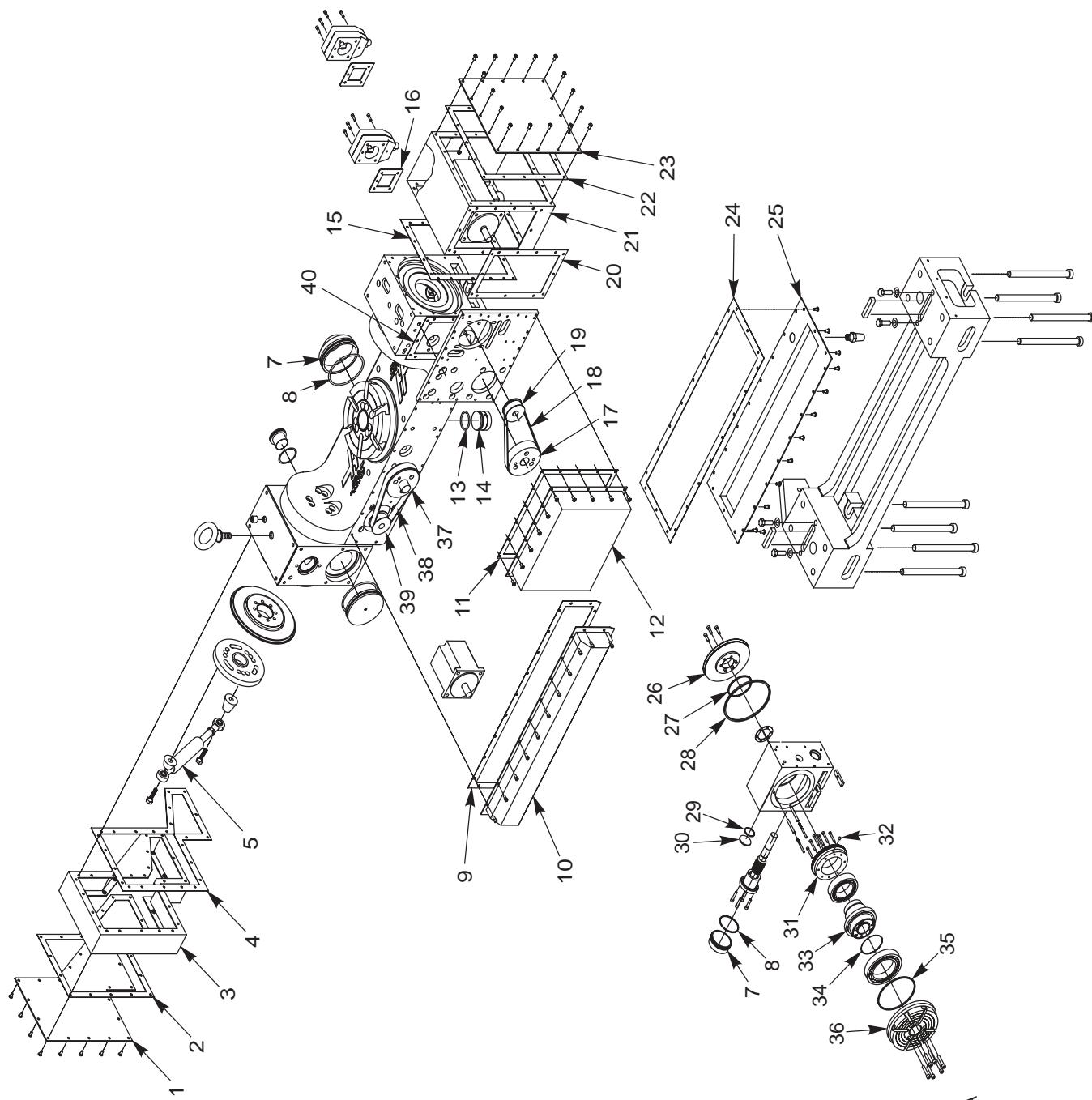
ID	PART/NO	DESCRIPTION
1.	20-4072A	SIDE PLATE
2.	20-4073	BOTTOM PLATE (T5C3)
2.	{ 20-4082	BOTTOM PLATE (T5C4)
2.	20-4085	BOTTOM PLATE (T5C2)
3.	{ 20-4074	TOP PLATE (T5C3)
3.	20-4083	TOP PLATE (T5C4)
3.	20-4086	TOP PLATE (T5C2)
4.	{ 20-4088	VALVE MOUNT STRIP (T5C2)
4.	20-4089	VALVE MOUNT STRIP (T5C4)
4.	20-4090	VALVE MOUNT STRIP (T5C3)
5.	20-4093	BEARING SUPPORT
6.	20-4319	A-FRAME SUPPORT
7.	22-4183	PILOTING PLUG
8.	{ 25-4081A	CHIP GUARD (T5C3)
8.	25-4084A	CHIP GUARD (T5C4)
8.	25-4087A	CHIP GUARD (T5C2)
9.	40-16093	BHCS, 10-32 X 3/4"
10.	40-1610	SHCS, 1/4-20 X 1"
11.	40-1654	SHCS, 1/2-13 X 1"
12.	40-1678	HHB, 1/2-13 X 1 1/4"
13.	40-2030	SHCS, 3/8-16 X 3/4"
14.	41-1604	PPHS, 8-32 X 3/4"
15.	43-16012	HHB, 1/2-13 X 2"
16.	45-1740	WASHER, BLACK HARD 1/2"
17.	46-3000	NUT "T" 1/2-13
18.	48-1665	PIN, DOWEL 5/16 X 3/4"
19.	51-0006	NEEDLE ROLLER, 50 X 58 X 25mm
20.	57-2086	OIL SEAL, CRW1 19606
21.	57-4094	CONDUIT STRAIN RELIEF GASKET
22.	58-1627	1/8-27 PIPE PLUG
23.	58-16700	STEET ELBOW, 1/8"
24.	58-16732	1/8 X 1/8 MALE HEX JOINT
25.	58-16752	90 COMPRESSION TILT
26.	58-16755	MALE AIR FITTING, 1/8"
27.	58-3105	PIPE PLUG, 1/4 NPT
28.	58-4055	COPPER TUBE, BET. VALVES
29.	58-4080	.040 ORIFICE FITTING 1/8"
30.	58-4091	COPPER TUBE (T5CN)
31.	59-2746	REVERSE ACTING, TV-4DMP
32.	40-1697	SHCS 1/4-20 X 3/4
33.	22-2065	LOCATING PIN
34.	40-1632	SHCS, 1/4-20 X 1/2
35.	58-3100	FEMALE BRANCH T 1/8 NPT

★ FOR USE WITH AC25

36.	58-2110	SLEEVE NUT
37.	58-2130	SLEEVE COMP NYLON TUBING
38.	59-3058	5/32 TUBE ELBOW
39.	58-4096	COPPER TUBE (T5CN AC25)



Trt-Series

**TR160****TR210****TR160****TR210****TR160**

1. 25-4715

2. 57-4726

3. 25-4714

4. 57-4725

5. 59-4700

6. 20-4153

7. 20-4158

8. 57-2220

9. 57-4724

10. 25-4713

11. 57-4730

12. 25-4718

13. 57-2125

14. 20-4710

15. 57-4728

16. 57-4728

17. 57-4133

18. 20-4501

19. 54-4505

20. 20-4507

21. 57-4727

22. 25-4716A

23. 57-4729

24. 25-4717

25. 57-4723

26. 57-2232

27. 57-2231

28. 20-4175

29. 57-2831

30. 28-4126

31. 20-4154

32. 69-18101

33. 20-4152

34. 57-2107

35. 57-2230

36. 20-4151

37. 20-4501

38. 54-4700

39. 20-4511

40. 57-4180

Cable
MotorTilt
36-4122
62-2508Rotary
36-4121
62-2495ACable
MotorTilt
36-4030B
62-0014Rotary
36-4122
62-2508