HAAS SERVICE AND OPERATOR MANUAL ARCHIVE

HS-Series Series Manual 96-9010 RevC English June 2001

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

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

COMMON ABBREVIATIONS USED IN HAAS MACHINES

AC	Alternating Current
AMP	Ampere
APC	Automatic Pallet Changer
APL	Automatic Parts Loader
ASCII	American Standard Code for Information Interchange
ATC	Automatic Tool Changer
ATC FWD	Automatic Tool Change Forward
ATC REV	Automatic Tool Changer Reverse
AWG	American Wire Gauge
BHCS	Button Head Cap Screw
CAD	Computer Assisted Design
CAM	Computer Assisted Machining
CB	Circuit Breaker
CC	Cubic Centimeter
CCW	Counter Clockwise
CFM	Cubic Feet per Minute
CNC	Computerized Numeric Control
CNCR SPINDLE	Concurrent Spindle with axis motion
CRC	Cyclic Redundancy Check Digit
CRT	Cathode Ray Tube
CW	Clockwise
DB	Draw Bar
DC	Direct Current
DGNOS	Diagnostic
DIR	Directory
DNC	Direct Numerical Control
DOS	Disk Operating System
ENA CNVR	Enable Conveyor
EOB	End Of Block
EOF	End Of File
EPROM	Erasable Programmable Read Only Memory
E-Stop	Emergency Stop
FHCS	Flat Head Cap Screw
FT	Foot
FU	Fuse
FWD	Forward
GA	Gauge
HHB	Hex Head Bolts
HP	Horse Power
HS	Horizontal Series Of Machining Centers
ID	Inside Diameter
IGBT	Isolated Gate Bipolar Transistor
IN	Inch
IOPCB	Input Output Printed Circuit Board
LAN	Local Area Network
LB	Pound
LED	Light Emitting Diode
LO CLNT	Low Coolant
LOW AIR PR	Low Air Pressure
LVPS	Low Voltage Power Supply
MB	Megabyte (1 million)
MCD RLY BRD	M-Code Relay Board
MDI	Manual Data Input

MEM	Memory
M-FIN	M-Code Finished
MM	Millimeter
MOCON	Motor Control
MOTIF	Motor Interface
MSG	Message
MSHCP	Metric Socket Head Cap Screw
NC	Numerical Control
NC	Normally Closed
NO	Normally Open
OD	Outside Diameter
OPER	Operator
P	Pocket
PARAM	Parameter
PCB	PrintedCircuit Board
PGM	Program
POR	Power On Reset
POSIT	Positions
PROG	Program
PSI	Pounds Per Square Inch
PWM	Pulse Width Modulation
RAM	Random Access Memory
REPT RIG TAP	Repeat Rigid Tap
RET	Return
REV CNVR	Reverse Conveyor
RJH	Remote Jog Handle
RPDBDN	Rotary Pallet Draw Bar Down
RPDBUP	Rotary Pallet Draw Bar Up
RPM	Revolutions Per Minute
S	Spindle Speed
SDIST	Servo Distribution PCB
SFM	Surface Feet Per Minute
SHCS	Socket Head Cap Screw
SIO	Serial Input/Output
SKBIF	Serial Key Board Inter Face PCB
SMTC	Side Mount Tool Changer
SP	Spindle
T	Tool Number
TC	Tool Changer
TIR	Total Indicated Runout
TNC	Tool Nose Compensation
TRP	Tool Release Piston
TS	Tail Stock
TSC	Through The Spindle Coolant
VF	Vertical Mill (very first)
VF-E	Vertical Mill- Extended
VMC	Vertical Machining Center
WAN	Wide Area Network

1. TROUBLESHOOTING

This section is intended for use in determining the solution to a known problem. Solutions given are intended to give the individual servicing the CNC a pattern to follow in, first, determining the problem's source and, second, solving the problem.

The troubleshooting tips are organized in this section according to the area of the CNC that may be giving sign of a problem. (Ex.: Out-of round circles in drilling will be found under the heading General Machine Operation - Accuracy).

If the problem you are experiencing cannot be found under the heading you expect, please try several other possible headings. If the problem is still not found, contact Haas Automation for further details.

BEFORE YOU BEGIN:

USE COMMON SENSE

Many problems are easily overcome by correctly evaluating the situation. All machine operations are composed of a program, tools, and tooling. You must look at all three before blaming one as the fault area. If a bored hole is chattering because of an overextended boring bar, don't expect the machine to correct the fault. Don't suspect machine accuracy if the vise bends the part. Don't claim hole mis-positioning if you don't first center-drill the hole.

FIND THE PROBLEM FIRST

Many mechanics tear into things before they understand the problem, hoping that it will appear as they go. We know this from the fact that more than half of all warranty returned parts are in good working order. If the spindle doesn't turn, remember that the spindle is connected to the gear box, which is connected to the spindle motor, which is driven by the spindle drive, which is connected to the I/O BOARD, which is driven by the MOCON, which is driven by the processor. The moral here is don't replace the spindle drive if the belt is broken. Find the problem first; don't just replace the easiest part to get to.

DON'T TINKER WITH THE MACHINE

There are hundreds of parameters, wires, switches, etc., that you can change in this machine. Don't start randomly changing parts and parameters. Remember, there is a good chance that if you change something, you will incorrectly install it or break something else in the process. Consider for a moment changing the processor's board. First, you have to download all parameters, remove a dozen connectors, replace the board, reconnect and reload, and if you make one mistake or bend one tiny pin it WON'T WORK. You always need to consider the risk of accidentally damaging the machine anytime you work on it. It is cheap insurance to double-check a suspect part before physically changing it. The less work you do on the machine the better.

1.1 General Machine Operation

Machine Not Running

Machine cannot be powered on

- Check input voltage to machine (see "Electrical Service").
- Check main circuit breaker at top right of electrical cabinet; switch must be at the on position.
- Check overvoltage fuses (see "Electrical Service").
- Check wiring to POWER OFF button on front control panel.
- Check wiring to AUTO OFF relay to IOPCB.
- Check connection between 24V transformer and K1 contactor.

Machine can be powered on, but turns off by itself

- Check Settings #1 and #2 for Auto Off Timer or Off at M30.
- Check AC power supply lines for intermittent supply.
- Check low voltage power supply for intermittent supply.
- Check wiring to POWER OFF button on front control panel.
- Check connection between 24V transformer and K1 contactor.
- Check Parameter 57 for Power Off at E-STOP.

Machine turns on, keyboard beeps, but no CRT display

- Check for green POWER LED at front of CRT.

• Check for power connections to CRT from IOPCB.

• Close doors and Zero Return machine (possible bad monitor).

• Check video cable (760) from VIDEO PCB to CRT.

• Check for lights on the processor.

• Replace CRT (see "Electrical Service").

Machine turns on, CRT works, but keyboard keys do not work

• Check keyboard cable (700) from VIDEO to KBIF PCB.

Constant E-Stop Condition (will not reset)

• Check Hydraulic counterbalance pressure, low pressure switches and cabling.

Vibration

Vibration is a subjective evaluation with perceptions varying among individuals, making it difficult to determine in mild cases if there is an actual problem. In obvious cases, it is a matter of determining the source - which is not easy, since all parts rotate together and sound can be transferred readily. Vibrations also need to be distinguished from noise such as a bad bearing. One crude method of measurement would be to take an indicator on a magnetic base extended 10 inches between the table and spindle housing and observe the reading of the indicator. A reading of more than .001 would indicate excessive vibration. The two common sources of noise are the spindle and axis drives. Most complaints about vibration, accuracy, and finish can be attributed to incorrect machining practices such as poor quality or damaged tooling, incorrect speeds or feeds, or poor fixturing. Before concluding that the machine is not working properly, ensure that good machining practices are being observed. These symptoms will not occur individually (Ex. A machine with backlash may vibrate heavily, yielding a bad finish.). Put all of the symptoms together to arrive at an accurate picture of the problem.

Machine vibrates while jogging the axis with the hand wheel

The HAAS control uses very high gain accelerations curves. This vibration as you jog is simply the servos quickly trying to follow the handle divisions. If this is a problem, try using a smaller division on the handle. You will notice the vibration more at individual clicks than when you are turning the handle faster. This is normal.

The machine vibrates excessively in a cut

This is a tough one to call because machining practices come into play. Generally speaking, the least rigid element of a cut is the tool because it is the smallest part. Any cutter will vibrate if pushed beyond its tensile strength. In order to eliminate the machine as the source of the problem, you need to check the spindle and the backlash of the axes as described in the following sections. Once machining practices have been eliminated as the source of vibration, observe the machine in both operation and “cutting air.” Move the axes (individually) without the spindle turning and then turn the spindle without moving the axes. Isolate whether the vibration comes from the spindle head or from an axis. Isolate the source of vibration per "Spindle", "Servo Motors/Lead Screws", and "Gearbox and Spindle Motor" sections.

ACCURACY

Before you complain of an accuracy problem, please make sure you follow these simple do’s and don’ts:

• Ensure that the machine has been sufficiently warmed up before cutting parts. This will eliminate mispositioning errors caused by thermal growth of the leadscrews (see "Thermal Growth" section).

• *Don’t* ever use a wiggler test indicator for linear dimensions. They measure in an arc and have sine/cosine errors over larger distances.

• *Don’t* use magnetic bases as accurate test stops. The high accel/decel of the axis can cause them to move.

• *Don’t* attach magnetic base to the sheet metal of the machine.

• *Don't* mount the magnetic base on the spindle dogs.

• *Don’t* check for accuracy/repeatability using an indicator with a long extension.

• Ensure that test indicators and stops are absolutely rigid and mounted to machined casting surfaces (e.g. spindle head casting, spindle nose, or the table).

• *Don't* rapid to position when checking accuracy. The indicator may get bumped and give an inaccurate reading. For best results, feed to position at 5-10 inches per minute.

• Check a suspected error with another indicator or method for verification.

• Ensure that the indicator is parallel to the axis being checked to avoid tangential reading errors.

• Center drill holes before using jobber length drills if accuracy is questioned.

• Once machining practices have been eliminated as the source of the problem, determine specifically what the machine is doing wrong.

Machine will not interpolate a round hole.

• Check that the machine is level (see "Installation" section).
• Check for backlash ("Servo Motors/Leadscrews" section).

Bored holes do not go straight through the workpiece.

• Check that the machine is level (see "Installation" section).
• Check for squareness in the Z axis.

Machine bores holes out-of-round.

• Check that the machine is level (see "Installation" section).
• Check the sweep of the machine (see "Spindle Sweep Adjustment" section).

Bored holes are out of round or out of position.

• Check for thermal growth of the leadscrew (see "Thermal Growth" section).
• The spindle is not parallel to the Z axis. Check the sweep of the machine (see "Spindle Sweep Adjustment")

Machine mis-positions holes.

• Check for thermal growth of the leadscrew (see "Thermal Growth" section).
• Check that the machine is level (see "Installation" section).
• Check for backlash (see "Servo Motors/Leadscrews" section).
• Check the squareness of the X axis to the Y axis.

Machine leaves large steps when using a shell mill.

• Check that the machine is level (see "Installation" section).
• Check the sweep of the machine (see "Spindle Sweep Adjustment" section).
• Cutter diameter too large for depth of cut.

FINISH

Machining yields a poor finish

- Check for gearbox vibration.
- Check for backlash ("Accuracy/Backlash")
- Check the condition of the tooling and the spindle.
- Check for spindle failure.
- Check the condition of the axis motors.
- Check that the machine is level (See the Installation Manual).

Poor Y-axis finish

Check the hydraulic counterbalance system pressure. If pressure is low, check for:

- abnormal noises from counterbalance system
- oil leaks (esp. at fittings and at filter at top of cylinder)
- bound cylinder

THERMAL GROWTH

A possible source of accuracy and positioning errors is thermal growth of the leadscrew. As the machine warms up, the leadscrews expand in all three linear axes, causing accuracy and positioning errors, or inaccurate boring depths. This is especially critical in jobs that require high accuracy, machining multiple parts in one setup, or machining one part with multiple setups.

NOTE: The leadscrew will always expand ***away*** from the motor end.

VERIFY THERMAL GROWTH

There are a number of ways to verify the problem. The following procedure will verify thermal growth of the X-axis leadscrew in a machine that has not been warmed up:

1. Home the machine. In MDI mode, press POSIT and PAGE DOWN to the OPER page.

2. Jog to an offset location on the table (example: X-15.0" Y-8.0"). Select the X axis and press the ORIGIN key to zero it. Select the Y axis and zero it.

3. Press the OFSET key, then scroll down to G110 (or any unused offset). Cursor to X and press PART ZERO SET twice. This will set X0, Y0 at this position.

4. Enter the following program. It will start at the new zero position, rapid 10 inches in the X direction, feed the final .25 inches at 10 inches/min., and then repeat the X movement.

```
G00   G110  X0  Y0;
X10.0;
G01  X10.25  F10. ;
M99;
```

5. In order to set up the indicator, run the program in SINGLE BLOCK mode, and stop it when X is at 10.25". Set the magnetic base on the table, with the indicator tip touching the spindle housing in the X-axis, and zero it.

6. Exit SINGLE BLOCK mode, and run the program for a few minutes. Enter SINGLE BLOCK mode again, stop the program when X is at 10.25", and take a final reading on the indicator. If the problem is thermal growth, the indicator will show a difference in the X position.

NOTE: Ensure the indicator setup is correct as described in "Accuracy" section. Errors in setup are common, and often incorrectly appear to be thermal growth.

7. A similar program can be written to test for thermal growth in the Y and Z axes, if necessary.

SOLUTIONS

Since there are many variables that affect thermal growth, such as the ambient temperature of the shop and program feed rates, it is difficult to give one solution for all problems.

Thermal growth problems can generally be eliminated by running a warm-up program for approximately 20 minutes before machining parts. The most effective warm-up is to run the current program, at an offset Z position above the part or table, with the spindle "cutting air". This will allow the leadscrews to warm up to the correct temperature and stabilize. Once the machine is at temperature, the leadscrews won't expand any further, unless they're allowed to cool down. A warm-up program should be run after each time the machine is left idle.

1.2 Spindle

Not Turning

Spindle not turning

- If there are any alarms, refer to "Alarms" section.
- Check that the spindle turns freely when machine is off.
- If motor turns but spindle does not, see "Spindle Drive Belts" and "Transmission" sections.
- Command spindle to turn at 1800 RPM and check spindle drive display. If display blinks “bb”, check spindle orientation switch ("Spindle Orientation"). If spindle drive does not light the RUN LED, check forward/reverse commands from IOPCB ("Electrical Service").
- Check the wiring of analog speed command from MOTIF PCB to spindle drive (cable 720).
- If spindle is still not turning, replace MOCON PCB ("Electrical Service").
- If spindle is still not turning, replace spindle drive ("Electrical Service").
- Check for rotation of the gearbox. If the gearbox operates, check the drive belts ("Spindle Drive Belts").
- Disconnect the drive belts. If the spindle will not turn, it is seized and must be replaced ("Spindle").

NOTE: Before installing a replacement spindle, the cause of the previous failure must be determined.

Noise

Most noises attributed to the spindle actually lie in the gearbox or drive belt of the machine. Isolate the sources of noise as follows:

Excessive noise coming from the spindle head area

First determine if the noise is related to the RPM of the motor or the RPM of the spindle. **For example:** If the noise appears at 2000 RPM in high gear, listen for a similar noise at 500 RPM in low gear. If the same noise persists, the problem lies within the gearbox. If the noise disappears, the problem could be either the gearbox or the spindle, and further testing is necessary.

NOTE: The gear ratio is 1:1.25 in high gear, and 3.2:1 in low gear.

- Run the gearbox with the drive belts disconnected. If the noise persists, the problem lies with the gearbox.

- Check the drive belts' tension.

  If the noise persists, turn the drive belts over on the pulleys. If the noise is significantly different, the belts are at fault. Replace the belts ("Spindle Drive Belts").

  If the noise does not change, remove the belts and go on to the next step.

Overheating

When investigating complaints of overheating, a temperature probe must be used to accurately check the temperature at the top of the spindle taper. The temperature displayed in Diagnostics is not relevant. A machine that runs at high RPM continuously will have a much warmer spindle than a machine that runs at a lower RPM. New spindles tend to run much warmer than spindles that have already been run-in. In order to run a valid test on a new spindle, ensure that it is properly run-in.

To break in a spindle, run the following program (it will take approximately 6 hours):

```
S300  M03
M97  P6G4
S1000  M03
M97  P6040
S1500  M03
M97  P6040
S2000  M03
M97  P6040
S2500  M03
M97  P6040
S3000  M03
M97  P6040
S3500  M03
M97  P6040
S4000  M03
M97  P6040
S4500  M03
M97  P6040
S5000  M03
M97  P6040*
S5500  M03
M97  P6040
S6000  M03
M97  P6040
S6500  M03
M97  P6040
S7000  M03
M97  P6040
S7500  M03
M97  P6040
M99
N6040
G04  P900.
M05
G04  P900.
G04  P900.
M99
```

*Loop here for 5K Spindles.

NOTE: This program will step the spindle speed from 300 RPM up to 7500 RPM at regular intervals of time, stop the spindle and allow it to cool to room temperature, then restart it so the temperature can be monitored. Loop at S5000 for 5K Spindles.

Alternate Spindle Run-in Program

Run program #O02021 with the air pressure to the spindle at 35 psi. Program time is approximately 2 hours. If possible run the program overnight by changing M30 to M99 so it can repeat. Adjust spindle speed override depending on maximum spindle speed of machine: Set override 50% for 5,000 RPM machines; Set at 100% for 7,500 and 10,000 RPM machines; Set at 150% for 15,000 RPM machines.

```
N100
S750M3
G04 P600.;
S2500M3;
G04 P600.;
S5000M3;
G04 P900.;
N200
M97 P1000 L15
M97 P2000 L15
M30;
```

```
N1000
S7500M3;
G04 P30.;
S500 M3;
G04 P150.;
M99;

N2000
S10000M3;
G04 P30.;
S500M3;
G04 P150.;
M99;
%
```

- If at any time during this procedure the spindle temperature rises above 150 degrees (120 degrees for 50 Taper), start the procedure over from the beginning and follow the steps below.

NOTE: Once run-in program is complete **reset** the air pressure back to **25psi**. prior to checking spindle temperature.

If the spindle fails this test for any reason, check the following:

- Check for correct amount of lubrication.

NOTE: Over lubrication is a common source of overheating. Check the oil flow carefully.

- Check the drive belt tension. Belts that are too tight will cause heating of the top bearing in the spindle housing.

- Ensure that the correct oil is being used (refer to "Maintenance Schedule").

HS-3/R Spindle Run-In Program

CAUTION! Spindle run-in program must be run before spindle can be run above 1000 RPM. Failure to run this program can result in spindle over heating and failure.

Before running the spindle, a spindle run-in **must** be performed.

Run the spindle at 400 rpm for 24 hours. This is critical. This time must not be compressed.

Next, a program has been supplied with the machine, which will slowly run the spindle up to speed (approx. 40 hours). The program is # O02500. This program will thermal cycle the spindle and stabilize the running temperature of the spindle.

```
%
O02500 (5000RPM SPINDLE RUN IN WITH AXIS MOVEMENT, HS-3, 40 HRS.)
(SET MACRO VARIABLES TO ZERO BEFORE STARTING)
(LATEST REVISION OCT. 11TH, 1999)

G103 P1
#115= 500. (RPM INCREMENT)
#116=5000. (MAX RPM)
#118= 1.0
IF [#117 GT 160] THEN M01 (OPTIONAL STOP)
IF [#117 LT 120] THEN #118= 0.8
IF [#117 LT 90] THEN #118= 0.6
IF [#117 LT 60] THEN #118= 0.4
IF [#117 LT 30] THEN #118= 0.2
S [[[#119 + 500] MOD [#116 + 1]] * #118]
M03
M97 P300 L3
S200 M03
M97 P300 L6
#119= [#119 + #115]
#117= #117 + 1
M99

N300 (AXIS MOVEMENT)
G90 G58 G1 F180.
X-150. Y-50. Z-30.
X0 Y0 Z0
M99

%
```

The spindle should be checked periodically for spindle temperature rise. If the temperature rises above 150 degrees, start the program from the beginning (refer to service manual for overheating troubleshooting).

Stalling / Low Torque

Generally, complaints of stalling or low torque relate to incorrect tooling or machining practices. A spindle that is tending to seize will yield a poor finish, and run very hot and very loud. Investigate machining problems before concluding that the problem exists with the spindle or spindle drive.

Spindle Drive

Non Vector Drive

Low line voltage may prevent the spindle from accelerating properly. If the spindle takes a long time to accelerate, slows down or stays at a speed below the commanded speed with the load meter at full load, the spindle drive and motor are overloaded. High load, low voltage, or too fast accel/decel can cause this problem.

If the spindle is accelerated and decelerated frequently, the regenerative load resistor inside the control may heat up. If this resistor heats beyond 100°C, a thermostat will generate an “overheat” alarm.

If the regen load resistors are not connected or open, this could then result in an overvoltage alarm. The overvoltage occurs because the regenerative energy being absorbed from the motor while decelerating is turned into voltage by the spindle drive. If this problem occurs, the possible fixes are to slow the deceleration rate or reduce the frequency of spindle speed changes.

Vector Drive

To properly troubleshoot the Vector Drive, use the following questions as a guide:

- What alarms are generated?
- When does the alarm occur?
- Is the Vector Drive top fault light on?
- Is there a fault light on any of the servo amplifiers?
- Does the alarm reset?
- Does the spindle motor turn at all?
- Does the spindle turn freely by hand?
- Have the C-axis parameters been confirmed?
- What is the input voltage to the vector drive unit?
- What does the DC Bus voltage measure? (320 VDC to 345 VDC)
- Does the DC Bus voltage displayed on the diagnostic page match the measured DC Bus voltage?

All of the questions above must be answered. The DC Bus voltage should be between 320 VDC to 345 VDC with the machine powered up but not running. If the voltage is not in this range, adjust the taps on the main line transformer until this voltage range is achieved. There is a possibility the drive is faulty, but low Bus voltage can also be caused by a shorted REGEN load or a shorted amplifier.

If the DC Bus voltage is below 50 VDC and never goes any higher, perform Steps 1-6.

1. With the machine powered up, is the green “POWER-ON” L.E.D. lit? If not, replace the Vector Drive unit.

2. Power down the machine. Disconnect the REGEN load (terminals 1 and 2 on the Vector Drive unit) and measure the resistance from each wire-to-chassis ground (open) and between the wire leads. The resistance should be 8.6 ohms for machines with 20/15 Vector drives and HT10K mills equipped with 40/30 drives. All other machines with 40/30 drives should measure 6 ohms. If not, replace the REGEN load or cabling.

3. Disconnect cable 490 at terminals 2 and 3 of the Vector Drive and from the servo amplifiers. With a multimeter in the diode mode, place the red meter lead to the +HV terminal and the black meter lead to the -HV terminal of each amplifier. The meter should read open.

4. Reverse the leads: Place the red meter lead on the -HV terminal and the black lead on the +HV terminal. The meter should read .7 ohms in both instances. If not, replace the faulty amplifier.

5. Measure the resistance between terminals 1 and 3 of the Vector Drive. The meter should read greater than 100K ohms. If not, the Vector Drive is faulty.

6. If the green “POWER-ON” L.E.D. was lit (from Step 2), leave both 490 cables (2 and 3) disconnected from the drive and power up the machine.
   a. Does the DC Bus voltage come up? If not, the Vector Drive is faulty.
   b. Measure the voltage between terminals 1 and 3. The voltage should be 300 VDC or more. If not, the Vector Drive is faulty.

   If both ‘a’ and ‘b’ check out okay, there is a problem with either the amplifiers or the REGEN load.

If the fault occurs upon acceleration -or- the spindle accelerates slowly -or- the spindle makes noise, do the following:

7. Disconnect the output cables to the spindle motor. Turn on the machine and press <**RESET**>. Do not command the spindle to turn. With a volt meter, measure the DC voltage between each output phase (terminals 9, 10, and 11) to the 320V RTN (terminal 3). The meter should read 165 VDC in each case, else one phase is faulty.

8. Measure the resistance across the motor wires from phase to phase and from each phase to chassis. The meter should read .1 ohms phase-to-phase and open phase-to-chassis.

If the fault occurs upon deceleration or acceleration just as the spindle reaches its specified speed, or if an overvoltage alarm (119) occurred, do the following:

9. Disconnect the REGEN load resistors (terminals 1 and 2) and measure the resistance from each wire lead-to-chassis ground and between the wire leads. The meter should read open lead-to-ground, and 6 ohms between the leads for machines with 40/30 Vector drives and 8.6 ohms between the leads on machines with 20/15 Vector drives and HT10K mills.

10. Measure the resistance from terminal 1 to terminal 3. If the resistance is less than 100K, the drive is faulty.

11. With the REGEN load left disconnected, power-up the machine and command a spindle speed of 700 RPM (300 RPM for lathes in high gear). Press <**RESET**> while monitoring the DC voltage between terminal 1 and terminal 3. The voltage should read 330 VDC and then drop to less than 50 VDC momentarily. If not, that drive is faulty. If the voltage at RESET was okay and the alarm was resettable, the REGEN load should be replaced even if the resistance appears to be

ORIENTATION

Spindle loses correct orientation

Non Vector Drive

- Check alarm history, looking for spindle overload and axis overcurrent alarms. These alarms mean the machine is not being properly operated.
- Check the orientation ring for tightness. Ensure the shaft on which the ring mounts is clean and is free of grease and oil.
- Check the orientation ring for cracks near the bolt holes or near the balancing holes. If there are cracks, replace the ring.
- Check the shot pin on the gearbox for binding, damage, and proper operation. Replace it if it is damaged.

Vector Drive

- Check alarm history. Look for Spindle Z Fault, or Spindle Reference Missing alarms. If these alarms exist, there may be a defective spindle encoder, or a broken ground or shield connection.
- Check parameters.
- Check for a mechanical slip at the contact points of all components between the spindle encoder.

TOOLS STICKING IN TAPER

Tool sticking in the taper causes ATC to be pulled up; accompanied by a popping noise as the tool holder pops out of the spindle taper.

NOTE: This problem may occur after loading a cold tool into a hot spindle (a result of thermal expansion of the tool holder inside the spindle taper). It may also occur due to heavy milling, milling with long tooling, or cuts with heavy vibration. This also is the result of thermal expansion.

If sticking only occurs during these situations, check your application to ensure proper machining techniques are being used; check the feeds and speeds for the tools and material being used. If a tool is pulled out of the extractors due to a tool stuck in the taper then the unclamp switch is not adjusted correctly or the switch could be bad.

NOTE: In a proper working system the spindle will pop slightly during a tool change. This popping does not create flex in the carousel or the need to remove the tool with a mallet.

- Check the condition of the tooling, verifying the taper on the tooling is ground and not turned. Look for damage to the taper caused by chips in the taper or rough handling. If the tooling is suspected, try to duplicate the symptoms with known-to-be-good tooling.
- Check the condition of the spindle taper. Look for damage caused by chips or damaged tooling. Also, look for damage such as deep gouges in the spindle taper caused by tool crashing.
- Duplicate the cutting conditions under which the deflection occurs, but do not execute an automatic tool change. Try to release the tool using the tool release button on the front of the spindle head. If sticking is observed, the deflection is not caused by improper ATC adjustment, but is a problem in the spindle head on the machine.
- Ensure the spindle is not running too hot (140° or above).
- Check air supply. Max air pressure drop of 10 psi. during a tool change is allowed.
- Are the correct pull studs being used?

Tool Holder / Spindle Fretting

Is fretting present on the tool holder or spindle?

Fretting is the result of sideways movement of a tool holder in the spindle. Fretting can leave a wave pattern on the mating surfaces and will affect the fit and finish of both the tool holder and the spindle.

- If light fretting is present, check the application to ensure proper machining techniques are being used; check the feeds and speeds for the tools and material being used.
- Light fretting and rust may be cleaned from the tool holder with a fine scotchbrite hand pad and solvent. If scotchbrite is used, clean the tool holder and spindle taper thoroughly after use with an alcohol pad. Apply a thin coat of light oil to the taper of the tool holder. Grease the pull stud.

1.3 Servo Motors / Lead Screws

Not Operating

All problems that are caused by servo motor failures should register an alarm. Check the alarm history to determine the problem's cause before any action is taken.

Servo motor is not functioning

- Check the power cable from electrical cabinet to ensure connection is tight.
- Encoder is faulty or contaminated (Alarms 139-142, 153-156). Replace motor assembly on brushless machines, replace the encoder on brush machine.
- Open circuit in motor (Alarms103-106). Replace motor assembly ("Axis Motor Removal / Installation").
- Motor has overheated, resulting in damage to the interior components (Alarms 135-138, 176). Replace motor assembly ("Axis Motor Removal/Installation").
- Wiring is broken, shorted, or missing shield (Alarms 153-156, 175, 182-185).
- Check for broken or loose coupling between the servo motor and the lead screw. Replace or repair the coupling ("Axis Motor Removal/Installation")
- Check for a damaged lead screw, and replace if necessary ("Lead Screw Removal and Installation" section).

Noise

Lead screw noise is usually caused by a lack of lubrication and is usually accompanied by heating. Other causes are misalignment, bearing sleeve damage, or ball nut damage. Check the alarm history of the machine and look for axis overcurrent and following error alarms.

NOTE: Do not replace lead screws or bearing sleeves without due consideration; they are extremely durable and reliable. Verify that problems are not due to tooling, programming, or fixturing problems.

Servo motor noise

- Disconnect the servo motor from the lead screw and rotate by hand. If the noise persists, replace the motor assembly ("Axis Motor Removal/Installation" section).
- Noise is caused by bearings. Rolling, grinding sound is heard coming from the motor. If bearings are making a consistently loud sound, replace the motor.

Lead screw noise

- Ensure oil is getting to the lead screw through the lubrication system (See Air and Oil Diagram). Check for a plugged metering valve.
- Check for damage to the bearing sleeve.

NOTE: The current angular contact design sleeve has a fixed pre-load; it cannot be adjusted.

- Run the axis back and forth. The motor will get very hot if the bearing sleeve is damaged. If so, turn the axis by hand and feel for roughness in the lead screw. Loosen the clamp nuts at both ends of the lead screw. If the symptom disappears, replace the bearing sleeve. Be certain to check for damage to the lead screw shaft where the bearing sleeve is mounted.
  If the noise persists, the lead screw is damaged and must be replaced. When replacing the lead screw in an older machine, always replace the bearing sleeve with the current angular contact design bearing sleeve.
- Check the lead screw for misalignment. If incorrect, perform alignment procedure in "Lead Screw" section.
- Misalignment in the lead screw itself will tend to cause the lead screw to tighten up and make excessive noise at both ends of the travel. The ballnut may get hot. Misalignment radially at the yoke where the lead screw ball nut mounts is indicated by heating up of the ball nut on the lead screw, and noise and tightness throughout the travel of the lead screw. Misalignment at the yoke where the ball nut mounts is indicated by noise and tightness at both ends of the travel of the lead screw. The ball nut may get hot.

NOTE: Customer complaints of Lead Screw noise may not indicate a bad screw. Screws from different manufacturers produce varying levels of noise. Often machines are built with two or more different brands of screws in the same machine. If complaints are generated about one axis screw in comparison to another, it is possible that the screws are simply sourced from different manufacturers.

Accuracy / Backlash

Accuracy complaints are usually related to tooling, programming, or fixturing problems. Eliminate these possibilities before working on the machine.

Poor positioning accuracy

- Check for a loose encoder on the servo motor. Also, ensure the key in the motor or the lead screw is in place and the coupling is tight (brush motors only).
- Check parameters for that axis.
- Check for backlash in the lead screw as outlined below:

INITIAL PREPARATION -

Turn the machine ON. Zero return the machine and jog the column to the approximate center of its travel in the X and Y directions. Move the Z-axis to its full travel forward.

CHECKING X-AXIS:

1. Set up a dial indicator and base on the mill table as shown in Fig. 1.3-1.

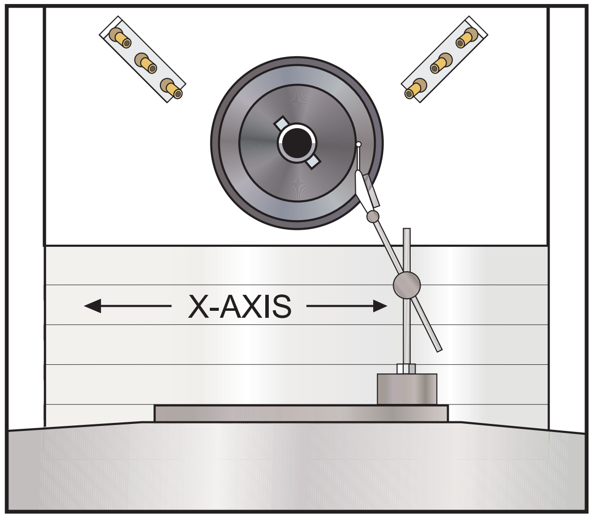


Figure 1.3-1. Dial indicator in position to check X-axis.

2. Set dial indicator and the “Distance to go” display in the HANDLE JOG mode to zero as follows:
   - Zero the dial indicator.
   - Press the MDI key on the control panel.
   - Press the HANDLE JOG key on the control panel.

The “Distance to go” display in the lower right hand corner of the screen should read: X=0 Y=0 Z=0

3. Set the rate of travel to .001 on the control panel and jog the machine .010 in the positive (+) X direction. Jog back to zero (0) on the display. The dial indicator should read zero (0) ± .0001.

4. Repeat Step 3 in the negative (-) direction.

TOTAL DEVIATION BETWEEN THE DIAL INDICATOR AND THE CONTROL PANEL DISPLAY SHOULD NOT EXCEED .0002.

An alternate method for checking backlash is to place the dial indicator as shown in Fig. 1.3-1 and manually push the mill column to the left and right while listening for a 'clunk'. The dial indicator should return to zero after releasing the column.

NOTE: The servo motors must be on to check backlash by this method.

5. If backlash is found, refer to "Backlash - Possible Causes" in this section.

CHECKING Y-AXIS:

1. Set up a dial indicator and base on the mill table as shown in Fig. 1.3-2.

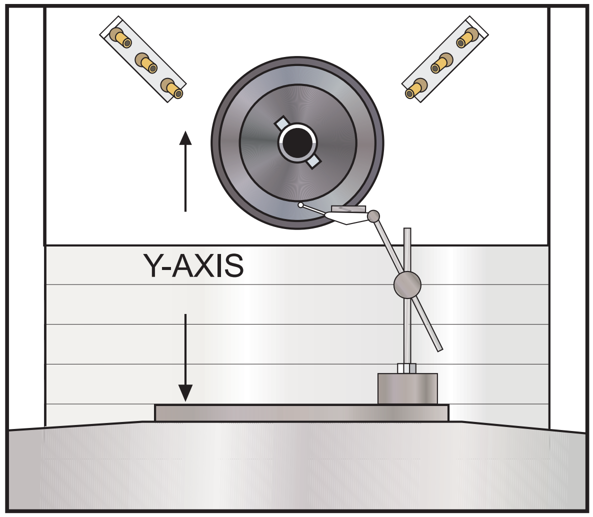


Figure 1.3-2. Dial indicator in position to check Y-axis.

2. Set dial indicator and the "Distance to go" display in the HANDLE JOG mode to zero as follows:
   - Zero the dial indicator.
   - Press the MDI key on the control panel.
   - Press the HANDLE JOG key on the control panel.

The "Distance to go" display in the lower right hand corner of the screen should read: X=0 Y=0 Z=0

3. Set the rate of travel to .001 on the control panel and jog the machine .010 in the positive (+) Y direction. Jog back to zero (0) on the display. The dial indicator should read zero (0) ± .0001.

4. Repeat Step 3 in the negative (-) direction.

TOTAL DEVIATION BETWEEN THE DIAL INDICATOR AND THE CONTROL PANEL DISPLAY SHOULD NOT EXCEED .0002.

An alternate method for checking backlash is to place the dial indicator as shown in Fig. 1.3-2 and manually push up and down on the spindle head while listening for a 'clunk'. The dial indicator should return to zero after releasing the spindle head.

NOTE: The servo motors must be on to check backlash by this method.

5. If backlash is found, refer to "Backlash - Possible Causes" in this section.

CHECKING Z-AXIS:

1. Set up a dial indicator and base on the mill table as shown in Fig. 1.3-3.

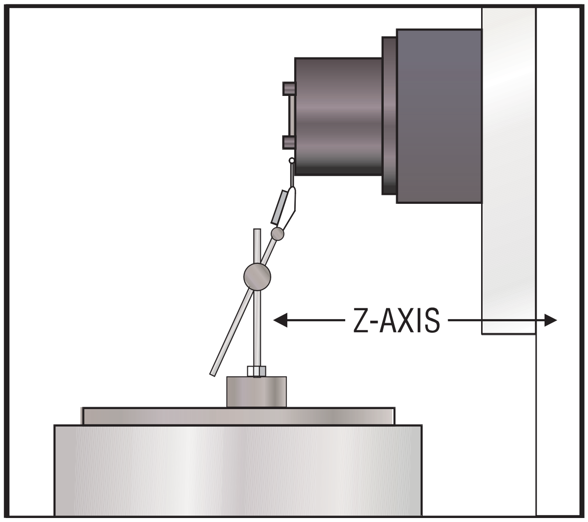


Figure 1.3-3. Dial indicator in position to check Z-axis.

2. Set dial indicator and the "Distance to go" display in the HANDLE JOG mode to zero as follows:
   - Zero the dial indicator.
   - Press the MDI key on the control panel.
   - Press the HANDLE JOG key on the control panel.

The "Distance to go" display in the lower right hand corner of the screen should read: X=0 Y=0 Z=0

3. Set the rate of travel to .001 on the control panel and jog the machine .010 in the positive (+) Z direction. Jog back to zero (0) on the display. The dial indicator should read zero (0) ± .0001.

4. Repeat Step 3 in the negative (-) direction.

An alternate method for checking backlash is to place the dial indicator as shown in Fig. 1.3-3 and manually push the column forward and back while listening for a 'clunk'. The dial indicator should return to zero after releasing the column.

NOTE: The servo motors must be on to check backlash by this method.

5. If backlash is found, refer to "Backlash - Possible Causes" in this section.

A-AXIS BACKLASH ADJUSTMENT

1. Check and record backlash near the outer edge of the platter face, using approximately 15-20 ft./lbs. The factory specification is 0.0003” to 0.0007”.

NOTE: Check backlash in each of the four quadrants (every 90°).

2. Remove the oil-fill port, if equipped. Remove the side cover sheetmetal which houses the black bearing cover and the oil level eye.

NOTE: In the process of removing the side cover, you will also have to remove the two BHCS that hold the oil level eye in place. As you remove the side cover, make sure you hold the sightglass in position. You will need to place a metal strap across the sightglass and secure it with the two BHCS.

3. Place a drip pan beneath the black bearing housing cover to catch any gear oil (keep this pan in place for Step 4). Remove the bearing housing cover. It may be necessary to apply channel lock pliers to the bearing housing in order to remove it; if necessary, then use a rag to prevent marring.

4. Note the position of the dimple located on the flange of the bearing housing. Mark this position on an adjacent part of the casting for reference. Remove the four 5/16-18 cap screws. Gear oil will pour out of the housing.

5. Index the bearing housing by one set of holes, moving clockwise. Bolt the bearing housing flange down. Torque the bolts to 25 ft./lbs. Check the backlash in each of the four quadrants. The factory specification is 0.0003” to 0.0007”.

   If necessary, repeat Steps 4 and 5.

6. Replace the bearing housing cover. Remove the metal strap installed in Step 2, taking care to hold the sightglass in place. Replace the side cover sheetmetal and reattach with the BHCS removed in Step 2.

7. If equipped, reinstall the oil-fill port and use this for the following step. If the Rotary Table does not have an oil-fill port, remove the pipe plug on the back side of the Rotary Table Body. Thread in a 1/4-18 90° street elbow into each tapped hole. Screw a short length of tubing into each elbow. Use one of the ports for the following step.

8. Refill the gear case with Mobil SHC-632 gear oil to the midpoint of the oil level eye.

9. Remove any fittings installed in Step 7. Properly discard the oil in the drip pan. Install the seal housing on the tool release piston (use Loctite on the screws). Connect the 5/32" drain line to the lower connector of the seal housing. The drain line connector should point toward the bottom of the machine. Connect the purge line to the top connector of the seal housing.

BACKLASH - POSSIBLE CAUSES:

If backlash is found in the system, check for the following possible causes:

- Loose SHCS attaching the ball nut to the nut housing. Tighten the SHCS as described in "Mechanical Service" section.
- Loose SHCS attaching the nut housing to the column, head, or saddle, depending on the axis. Tighten the SHCS as described in "Mechanical Service".
- Loose clamp nut on the bearing sleeve. Tighten the SHCS on the clamp nut.
- Loose motor coupling. Tighten as described in "Mechanical Service".
- Broken or loose flex plates on the motor coupling.

NOTE: The coupling cannot be serviced in the field and must be replaced as a unit if it is found to be defective.

- Loose SHCS attaching the bearing sleeve to the motor housing or top of column. Tighten as described in "Lead Screw" section.
- Defective thrust bearings in the bearing sleeve. Replace the bearing sleeve as outlined in "Bearing Sleeve" section.
- Loose SHCS attaching the axis motor to the motor housing. If the SHCS are found to be loose, inspect the motor for damage. If none is found, tighten as described in "Axis Motor" section. If damage is found, replace the motor.
- Incorrect backlash compensation number in Parameter 13, 27, or 41.
- Worn lead screw.

VIBRATION

Excessive servo motor vibration

- If no "A" axis is present, swap the suspected bad servo motor with the "A" driver and check to see if there is a driver problem. If needed, replace the DRIVER PCB ("Electrical Service").
- Check all parameters of the suspected axis against the parameters as shipped with the machine. If there are any differences, correct them and determine how the parameters were changed. PARAMETER LOCK should normally be ON.
- A bad motor can cause vibration if there is an open or short in the motor. A short would normally cause a GROUND FAULT or OVERCURRENT alarm; check the ALARMS. An ohmmeter applied to the motor leads should show between 1 and 3 ohms between leads, and over 1 megohm from leads to ground. If the motor is open or shorted, replace.

OVERHEATING

Servo motor overheating

- If a motor OVERHEAT alarm occurs (ALARMS 135-138), check the parameters for an incorrect setting. Axis flags in Parameters 1, 15, or 29 can invert the overheat switch (OVER TEMP NC).
- If the motor is actually getting hot to the touch, there is excessive load on the motor. Check the user's application for excessive load or high duty cycle. Check the lead screw for binding ("Accuracy/Backlash" section). If the motor is binding by itself, replace in accordance with "Axis Motor" section.

Following Error

Following error alarms occur on one or more axes sporadically

- Check DC bus voltage on "Diagnostics" page 2. Verify this voltage on the drive cards in the control panel. If it is at the low side of the recommended voltages, change the transformer tap to the next lower voltage group as explained in the Installation Manual.
- Check motor wiring for shorts.
- Replace driver card ("Electrical Service").
- Replace encoder on brush motor.
- Replace servo motor ("Axis Motor").

Lead Screws - Visual Inspection

The three main causes of Lead Screw failure are:

Loss of Lubrication
Contamination
Machine Crash

Wear of the Nut balls and the screw threads is generally a non-issue under proper operating conditions.

Each type of suspect cause will leave telltale signs on the Lead Screw itself.

Loss of Lubrication:

The lubrication system of the machine provides a layer of oil for the Lead Screw components to operate on, eliminating metal-to-metal contact. Should a problem with the lubrication system develop, that failure will accelerate all wear issues.

1. Dry metal-to-metal contact following lube breakdown will create intense heat at the contact points. The Nut balls will weld to the Nut races due to the heat and pressure of the preload. When movement of the Lead Screw continues, the welds will be broken, ripping off particles of both the balls and the races. This loss of diameter will reduce the preload, reducing machine accuracy. Lead Screws with this type of wear, but no screw surface marring, can be repaired by the factory.

2. A second cause of wear of the Lead Screws is material fatigue. Material fatigue typically occurs at the end of the Lead Screw service life. Signs of material fatigue include black, contaminated coolant, pitting of the screw surface, loss of preload, and metal flakes on the Lead Screw. Lead Screws suffering from material fatigue are not repairable and are considered scrap.

Contamination:

Contamination of the lubrication and/or coolant systems of the machine will produce problems with the Lead Screws.

Check the condition of the lube on the Lead Screw threads.

1. If the lube is wet and clean, this indicates a properly functioning lube system.
2. If the lube is thick and dark, but free of metal chips, the lube itself is old and must be changed out. The entire system should be cleaned of the old lube.
3. If the lube is wet and black, the lube system has been contaminated by metal particles. Inspect the Lead Screws for wear.

Contamination of the lube and/or coolant systems can be caused by a wearing Lead Screw, or by metal chips entering the systems through open or loose way covers. Check all way covers and seals for excessive clearances.

Machine Crash:

A hard machine crash can cause a Lead Screw to lock up. The static overload created during a machine crash can break apart the Nut balls, denting the thread surfaces. Turning the Nut by hand will result in an obvious grinding feeling and/or sound.

1. Check the screw for straightness.
2. Look for ball dents at the ends of the screw length. These indents will be a sure sign of a hard machine crash. The inertia of the table is transferred, due to the sudden stop, directly to the balls inside the Nut, creating impressions on the screw surface.

LEAD SCREW CLEANING

In most cases, a thorough cleaning of the suspect Lead Screw will resolve “bad screw” issues, including noise complaints.

1. Manually jog the Nut to one end of the screw.
2. Visually inspect the screw threads. Look for metal flakes, dark or thick lube, or contaminated coolant: See **Visual Inspection - Contamination** section.
3. Use alcohol, or other approved cleaning agents, to wash the screw.

CAUTION! Do not use detergents, degreasers, or solvents to clean Lead Screws or their components. Do not use water-based cleaners to avoid rust.

4. Jog the Nut to the other end of its travel. If metal flakes are now present on the screw threads, you may have wear issues.
5. Re-lubricate screw threads before returning the machine to service.

DAMAGED EXTRACTORS

Damage to the ATC is caused by either very hard or repeated crashes.

ATC extractor forks are damaged

- Check the condition of the extractor mounting holes in the carousel. If the threads are damaged, they must be repaired or the carousel replaced. See appropriate section for extractor fork replacement.

SPINDLE OPERATION

ATC out of orientation with the spindle. Incorrect spindle orientation will cause the ATC to crash, and Alarm 113 to be generated.

- Check the orientation of the spindle.

ATC will not run

- Check to be sure that the tool changer has been defined as a Horizontal (Parameter 209, bit "HORIZONTAL" is set to 1.)
- In all cases where the tool changer will not run, an alarm is generated to indicate either a tool changer in/out problem or an auxiliary axis problem. These alarms will occur either on an attempt to change tools (ATC FWD) or zero return the machine (AUTO ALL AXES). Use the appropriate alarm to select one of the following problems:

ATC carousel will not rotate. Carousel motor is getting power.

- Command a tool change, and check for power being applied to the servo motor.
  If power is applied, but the carousel does not turn, check for binding between the servo motor and the reducer ("Automatic Tool Changer" section). Check for a damaged servo motor or bound reducer.

NOTE: Do not attempt to repair the motor or to further isolate the problem in the motor.

ATC carousel will not rotate; servo motor is not getting power

- Command a tool change, and check for power being applied to the turret motor.
- Check for power supply to the tool changer single axis control (auxiliary axis control).
- Check for proper operation of the auxiliary axis control board.

DRIVE FAULT / OVERCURRENT

Y-axis motor overcurrent.

- Alarm not cleared
- Low counterbalance pressure
- Check Y axis parameters
- Check the lead screw for binding
- Check motor and cable for shorts
- Check amplifier

1.4 Pallet Changer

180 PALLET NOT CLAMPED Intended to keep the operator from machining on a pallet that is unclamped.

This is caused by a pallet change sequence interrupted by RESET, FEED HOLD, E-STOP, or POWER OFF before complete. Then, with the pallet not fully clamped, an attempt was made to run the spindle. To correct this, execute an M50 command (pallet change) in MDI mode, ensuring the sequence is completed this time.

In addition a broken belt, cable problems or a bad motor can cause this alarm.

650 RP-PALLET NOT ENGAGING RP MAIN DRAWBAR

This alarm occurs when the pullstud cannot properly engage the Ball Pull Collet as it has been pushed down into the Collet Housing and pallet clamping is not possible. To correct this, check alignment of the "H-frame" with the adjustable Hard Stops.

OR

Check the Pallet Pull Studs and the RP-Main Drawbar Ball Collet for damage or obstruction.

OR

Remove any debris that may have entered the Collet.

OR

Check that the six balls in the collet float within the holes.

1001 INDEX ST UNLOCKED The Index Station is not in the correct position for a pallet change.

This alarm occurs because the load station is not in the 0° position. To correct this, orient the load station, then execute an M50 command (pallet change).

OR

The indexing handle is jammed down. To correct this, free the indexing handle.

OR

The load station switch is unplugged or defective. To correct this, ensure the switch is plugged in. If so, replace the switch.

• Front door switch is damaged or the door is not closed.

1002 PALLET LOCKED DOWN Pallets did not lift even though the main drawbar is fully unscrewed.

This alarm is caused by the load station drawbar motor (machines with a load station motor only):

- •is unplugged,
- •is not getting power,
- •has a broken shaft,
- •has a broken idler in the geartrain,
- •has carbon buildup on the brushes.

To correct this, check the plug and brushes. Replace the motor if necessary. Check resistors on the I/O board. Check the M22 relay contacts on the I/O board.

OR

The load station floating nut assembly is spinning, not allowing the drawbar to thread out of the pallet nut, due to:

- •damaged load station drawbar threads,
- •contamination of floating nut assembly,
- •weak springs in the floating nut assembly.

To correct this, replace the damaged component(s). Check drawbar threads. Check the pallet nut threads.

OR

The load station drawbar motor I/O board:

- •relays have failed (M22),
- •circuit resistors have failed (M22 output).

To correct this, replace the I/O board.

OR

Missing spring stack and/or nylon thrust washers on the load station drawbar. To correct this, install spring stack and/or nylon thrust washers. Check motor integrity.

OR

Lift cylinder Up/Down limit switches installed incorrectly or plugged in incorrectly. To correct this, reinstall limit switches.

OR

Supply air pressure too low to lift pallets. To correct this, check all hoses and solenoid valve connections, and system air pressure is adequate.

OR

Weight on pallet changer exceeds system capability. To correct this, check system pressure. If correct, lessen the load on the pallet changer.

1003 PALLETS JAMMED Pallet changer did not rotate, rotate fast enough, or lower fast enough.

There is an obstruction to the H-frame or pallet rotation. To correct this, check for physical obstructions.

OR

CW/CCW limit switches are unplugged or reversed on mounts. To correct this, ensure discrete inputs RP CW and RP CCW on the Diagnostics page are correct (the correct one reads “1” while the other reads “0”).

OR

The air lines are disconnected or reversed on the cylinder. To correct this, connect properly or replace.

OR

CW/CCW air solenoids are not functioning or are disconnected. To correct this, connect properly or replace.

OR

The air pressure is too low to rotate the load. To correct this, check supply air pressure. Check all air hoses and fittings. Check for failed pallet rotate cylinder.

OR

Too much air pressure on the lift cylinder causing excessive resistance to rotation. To correct this, lower supply air pressure at the solenoid.

OR

No signal from I/O PCB Pallet CW/CCW. To correct this, check connectors and wiring. Replace the I/O board if necessary.

1004 CW/CCW SWITCH ILLEGAL CONDITION Limit switches erroneously indicate that the pallet changer is rotated fully CW and CCW at the same time.

This alarm indicates the CW/CCW limit switch is:
- •defective,
- •erroneously tripped (by a foreign object, etc.).

To correct this, ensure the discrete inputs RP CW and RP CCW on the Diagnostics page are correct (correct one reads “1” while the other reads “0”). The failed switch will be the one not tripped when the alarm occurs. Check for physical obstructions.

1007 UP/DOWN SWITCH ILLEGAL CONDITION Limit switches erroneously indicate that the pallet changer is fully lifted and lowered at the same time.

This alarm is caused by the UP/DOWN limit switch being:
- •defective,
- •erroneously tripped (by a foreign object, switch is sticking, etc.),
- •wired incorrectly.

To correct this, ensure the discrete inputs RP UP and RP DOWN on the Diagnostics page are correct (correct one reads “1” while the other reads “0”). The failed switch will be the one not tripped when the alarm occurs. Check for physical obstructions.

1008 MAIN DRAWBAR LOCKED IN UP POSITION The main drawbar will not unclamp the pallet.

The main drawbar and/or pallet nut are damaged. To correct this, replace damaged components.

OR

The main drawbar UP limit switch is:
- •unplugged,
- •defective.

To correct this, ensure discrete inputs RPDBDN and RPDBUP on the Diagnostics page are correct (both read “1” when the main drawbar is up and both read “0” when the main drawbar is down). Replace the switch if necessary.

OR

The main drawbar motor:
- •unplugged,
- •has a broken output shaft at the snap ring groove,
- •has failed,
- •has a geartrain failure.

To correct this, replace the motor or geartrain components as necessary.

OR

There has been a clutch failure. The reverse drive pin spring in the clutch hub has failed to push the pin out due to:
- •dust contamination
- •a broken spring.

Clutch failure will usually be apparent from the clamp force and cut quality. Upgrade to the clutchless system.

OR

The drive belt between the motor and the drawbar has broken. To correct this, replace the drive belt.

OR

The power supply relays (I/O board) have failed (M21). To correct this, replace the failed power supply relay. If the motor directional relay has failed, replace the I/O board.

OR

The current limit switch is set incorrectly (especially if the I/O board has been replaced). To correct this, set the current limit circuit correctly.

1009 MAIN DRAWBAR LOCKED IN DOWN POSITION The main drawbar will not clamp the pallet.

The main drawbar DOWN limit switch is:
- •unplugged,
- •defective.

To correct this, ensure the discrete inputs RPDBDN and RPDBUP on the Diagnostics page are correct (both read “1” when the main drawbar is up, and both read “0” when the main drawbar is down). Replace the switch if necessary.

OR

The main drawbar floating nut assembly is spinning, not allowing the drawbar to thread into the pallet nut due to:
- •damaged main drawbar threads,
- •contamination of floating nut assembly.

To correct this, replace the damaged component.

OR

The main drawbar motor:
- •is unplugged,
- •has broken the output shaft at the snap ring groove,
- •has failed,
- •has geartrain failure.

To correct this, replace motor or geartrain components if necessary.

OR

There has been a clutch failure/loss of torque. Clutch failure will usually be apparent from the clamp force and cut quality. Upgrade to the clutchless system.

OR

The drive belt between the motor and the drawbar has broken. To correct this, replace the drive belt.

OR

There is contamination of the drawbar splines, preventing free motion. To correct this, replace the drawbar and bearing sleeve assembly. Check for V-seals. Identify the source of the contamination.

OR

The bearing sleeve bearings seized due to contamination. To correct this, replace the bearing sleeve assembly. Check for V-seals. Identify the source of the contamination.

OR

The power supply relays (I/O board) have failed. To correct this, replace any failed power supply relays. If a motor directional relay has failed, replace the I/O board.

1010 MAIN DRAWBAR SWITCH ILLEGAL CONDITION The limit switches erroneously indicate that the drawbar has tripped the DOWN switch, but not the UP switch.

This is caused by the main drawbar UP/DOWN limit switches:
- •being mounted in reversed positions,
- •are plugged into the wrong connectors on the solenoid mounting bracket,
- •are defective.

To correct this, ensure the discrete inputs RPDBDN and RPDBUP on the Diagnostics page are correct (both read “1” when the main drawbar is up and both read “0” when the main drawbar is down). Replace the switch if necessary.

1011 MAIN DRAWBAR UNCLAMP TIMEOUT The main drawbar has unscrewed from the pallet nut, but reach the down position too slowly.

This is caused by the main drawbar floating nut assembly spinning, not allowing the drawbar to thread down, due to:
- •damaged main drawbar threads,
- •contamination of the floating nut assembly,
- •weak springs in the floating nut assembly.

To correct this, replace the damaged components. Check the drawbar threads. Check the pallet nut threads.

OR

The main drawbar motor:
- •is unplugged,
- •has broken the output shaft at the snap ring groove,
- •has failed,
- •has geartrain failure (unlikely).

To correct this, replace the motor or geartrain components if necessary.

OR

The is a clutch failure/loss of torque. Clutch failure will usually be apparent from the clamp force and cut quality. Upgrade to the clutchless system.

OR

The drive belt between the motor and the drawbar has broken. To correct this, replace the drive belt.

OR

The power supply relays (I/O board) have failed (M21). To correct this, replace the I/O board.

OR

The current limit circuit is set incorrectly. To correct this, set the current limit circuit correctly.

Alarm 1012 MAIN DRAWBAR CLAMP TIMEOUT The main drawbar started to travel upward, but reached the up position too slowly.

This is caused by the main drawbar floating nut assembly spinning, not allowing the drawbar to thread into the pallet nut, due to:
- •damaged main drawbar threads,
- •contamination of the floating nut assembly,
- •weak springs in the floating nut assembly.

To correct this, replace the damaged components. Check the drawbar threads. Check the pallet nut threads.

OR

The main drawbar motor:
- •is unplugged,
- •has broken the output shaft at the snap ring groove,
- •has failed,
- •has geartrain failure (unlikely).

To correct this, replace the motor or geartrain components if necessary.

OR

There is a clutch failure/loss of torque. Clutch failure will usually be apparent from the clamp force and cut quality.

OR

The drive belt between the motor and the drawbar has broken. To correct this, replace the drive belt.

(Alarm 1012 continued)

OR
The power supply relays (I/O board) have failed (M21). To correct this, replace the I/O board.
OR
The current limit circuit is set incorrectly. To correct this, set the current limit circuit correctly.

Alarm 1119

This alarm is caused by a corrupted pallet changer macro. To correct this, reload the macro.

Pallet does not sit correctly on the indexing pins.

This is caused by the H-frame being out of alignment. To correct this, refer to the “H-frame Alignment” section.

OR
The hardstops are not adjusted correctly. To correct this, refer to the “Pallet Rotation Hardstop Adjustment” section.
OR
Excess weight causes the pallet to go out of alignment. To correct this, check the load on the pallet changer. If it exceeds the weight capacity, reduce the loads.

Execution of an M50 results in a “Running” message, but nothing happens and no alarm is generated.

This is caused by a load station not properly oriented or, if M36 is being used, the PART READY light not pressed. To correct this, ensure the load station is properly oriented. If an M36 is being used, press the flashing PART READY light on the front switch box.
OR
The pallet changer macro program was loaded before MACROS was enabled, or while Setting 23, “9xxxx PROGS EDIT LOCK” was ON. To correct this, press RESET. Go to Setting 74, “9xxxx PROGS TRACE” and turn it on. From MDI, execute an M50. If the program is executing very rapidly, but nothing is happening, turn off Setting 74 and reload the 09000 macro.
OR
Front doors are open, on machines with door switches

1.5 Automatic Tool Changer

Deflection

Deflection is usually caused by ATC misalignment, and sometimes caused by damaged or poor quality tooling, a damaged spindle taper, or a damaged drawbar. Before beginning any troubleshooting, observe the direction of the ATC deflection.

During a tool change, ATC appears to be pushed out

- Check to see if pull studs on the tool holder are correct and tight.
- Check to see if the carousel is set correctly ("Tool Changer Alignment" section in Mechanical Service).
- Ensure the tool holders are held firmly in place by the extractor forks.
- Ensure the balls on the drawbar move freely in the holes in the drawbar when the TOOL RELEASE button is pressed. If they do not move freely, the ATC will be pushed out about 1/4" before the tool holder is seated in the taper. Replace the drawbar.

Tool holder sticking in the spindle taper accompanied by a popping noise as the tool holder pops out of the spindle taper

NOTE: This problem may occur after loading a cold tool into a hot spindle (a result of thermal expansion of the tool holder inside the spindle taper. It may also occur in cuts with heavy vibration. If sticking occurs only during these circumstances, no service is necessary.

- Check the condition of the customer's tooling, verifying the taper on the tool holder is ground and not turned. Look for damage to the taper caused by chips in the taper or rough handling. If the tooling is suspected, try to duplicate the symptoms with different tooling.
- Check the condition of the spindle taper. Look for damage caused by chips or damaged tooling. Also, look for damage such as deep gouges in the spindle taper caused by tool crashing. See "Spindle" section for spindle cartridge replacement.
- Duplicate the cutting conditions under which the deflection occurs, but do not execute an automatic tool change. Try instead to release the tool using the TOOL RELEASE key on the keypad. If sticking is observed, the deflection is not caused by improper ATC adjustment, but is a problem in the spindle head of the machine. See "Spindle" section for spindle cartridge replacement.

During a tool change, ATC appears to be pulled in; no popping noises

- Check to see if the carousel is set correctly ("Tool Changer Alignment" section in Mechanical Service).
- Ensure the tool holders are held firmly in place by the extractor forks.

NOTE: If the offset is incorrect, a tool changer crash has occurred, and a thorough inspection of the ATC is necessary at this time.

Tool holders twist against extractor fork during a tool change

- Check rotational alignment (Parameter 215).

Tool holders spin at all pockets of the ATC

- ATC is rotationally misaligned. Check the CAROUSEL OFFSET (Parameter 215). Realign the ATC ("Automatic Tool Changer")

NOTE: Observe the direction the tool holder rotates, as this will be the direction in which the X axis of the ATC needs to be moved.

Tool holders spin only at certain pockets of the ATC

- Check all of the extractor forks to ensure they are centered in the pocket of the ATC. Also, check the alignment and CAROUSEL OFFSET (Parameter 215). See "Extractor Fork Replacement", if necessary.

NOTE: If the ATC shows the problem as described here, each extractor fork must be checked and centered to eliminate the possibility of the ATC being aligned against an incorrectly-centered fork.

ATC properly deposits a tool holder in the spindle, but the tools are dropped onto the machine table or Z-axis way cover

- Inspect the balls and the Belleville springs in the drawbar. See appropriate section and replace drawbar.

Crashing

Crashing of the ATC is usually a result of operator error. The most common ATC crashes are outlined as follows:

The part or fixture on the mill table crashes into long tooling or into the ATC itself during a tool change

- Inspect the pocket involved in the crash for damage and replace parts as necessary.
- The machine will normally home the Z-axis as part of the tool change sequence. Check Parameter 209 bit "TC Z NO HOME", and ensure it is set to zero.

The part or fixture on the mill table crashes into long tooling or into the ATC itself when machining

- Either reposition the tools to remove the interference, or program the carousel to rotate long tooling out of the way of the part (USE THIS ONLY AS A LAST RESORT). **CAUTION!** If the carousel has to be programmed to rotate long tools clear of the part, the correct carousel position must be programmed back in before a tool change can be executed.

NOTE: If these crashes occur, thoroughly inspect the ATC for damage. Pay close attention to the extractor forks and the sliding covers on the ATC carousel. See the appropriate section for extractor fork replacement.

Side Mount Tool Changer Diagnostic Display

Tool changer status is displayed on the “Chain TC Inputs and Outputs” screen. This is reached by Pressing PARAM/DGNOS then pressing Page Down until the screen is displayed.

In addition to the inputs and outputs the lower rows of the tool changer status screen gives information on the current state of the tool changer. FG State, Foreground State, gives the actions of the tool changer while it is operating inside the machining area:

400 Series	Shuttle moving to the spindle from stand-by
500 Series	Swapping new tool with spindle tool
600 Series	Shuttle returning from spindle to stand-by

For example if a 420 is displayed, the tool changer faulted out while moving towards the spindle.

BG state, Background State, gives the current action of the tool changer as it moves outside of the machining area:

1-57	Chain Motion
200 Series	Retrieving a new tool from the chain.
300 Series	Returning a tool to the chain.

In the event of a tool changer related alarm. The FG state and BG state will be displayed as negative value. Entering Tool Change Recovery will clear the FG state and BG state values. PREV FG and PREV BG will contain the background and foreground states at the time of the last tool changer alarm.

HS-3 Hydraulic Tool Changer

Alarm Messages

Alarm #264 POCKET TABLE ERROR	This is caused because the tool number was never entered into the table. To correct this, enter the tool number into the pocket table. **OR** This is caused because the tool number was deleted from the table. To correct this, enter the tool number into the pocket table.
Alarm #266 T/C FAULT	This is caused by one or more of the toolchanger’s components is not in its correct position. This can occur if a power failure or <E-STOP> is pressed during a tool change. To correct this, run the Toolchanger Recovery sequence to rehome the toolchanger.
Alarm #269 T/C ARM FAULT	This is caused by the Cycle Start button being pressed when the toolchanger’s arm was not rotated completely towards the magazine. To correct this, run the Toolchanger Recovery sequence to rehome the toolchanger.

Non-Alarm Problems

Tool home pocket not in the correct position.

This is caused because the Index pin was not depressed into position. To correct this, increase the hydraulic system pressure.

OR

This is caused because the tool home pocket sensor failed or was not in position. To correct this, replace or reposition the sensor.

Arm does not fully rotate +/- 180 degrees.

This is caused because the stroke of the rotation cylinder is not correct. To correct this, adjust the rotation cylinder end of stroke stops.

Arm begins to rotate before it is fully pushed out of its end of travel.

This is caused because the sensor on the cap end of the carriage rotate cylinder is out of position and the slide system responds too early. To correct this, adjust the “swing arm to spindle” sensor on the cap end of the carriage rotate cylinder such that the cylinder must be fully collapsed before the sensor is triggered.

Arm slide mechanism makes a hard impact at the end of the stroke.

This is caused because the End-of-Travel shock is damaged. To correct this, replace the End-of-Travel shock.

OR

This is caused because the End-of-Travel shock is improperly adjusted. To correct this, adjust the dampening of the End-of-Travel shock.

Arm slide mechanism takes too long to reach end of travel.

This is caused because there is low flowrate to the hydraulic slide motor. To correct this, adjust the flowrate via the flow control valve for the hydraulic slide motor.

Arm slide mechanism stops early and does not reach the centerline of the spindle and/or carousel tool pocket.

This is caused because the travel stop-nut on the slide shock absorber has loosened and backed off. To correct this, readjust the shock absorber stop-nut.

Arm slide mechanism travels too far and overshoots the centerline of the spindle and/or carousel tool pocket.

This is caused because the travel stop-nut is not adjusted properly or has loosened and moved out of position. To correct this, readjust the shock absorber stop-nut.

Arm swing-to-spindle rotates too far or does not rotate far enough.

This is caused because the travel stop-bolt is not adjusted properly or has loosened and moved out of position. To correct this, readjust the swing-to-spindle stop-bolt by performing the Toolchanger Alignment Procedure.

Arm swing-to-magazine rotates too far or does not rotate far enough.

This is caused because the travel stop-bolt is not adjusted properly or has loosened and moved out of position. To correct this, readjust the swing-to-magazine stop-bolt by performing a Toolchanger Alignment Procedure with the alignment tool in the magazine tool pocket.

Arm does not push-out and/or pull-in far enough.
This is caused because the travel stroke adjustment screw is out of position. To correct this, establish the correct push-out and/or pull-in stroke distance by performing a Toolchanger Alignment Procedure using the alignment tool in the magazine's tool pocket.

Tool magazine rotates too slow or too fast.
This is caused because the hydraulic power unit flowrate is not correct. To correct this, readjust the flowrate of the hydraulic power unit.

NOTE: This will affect the speeds of other hydraulic functions.

Speed of arm functions (slide, rotate, or swing) is too slow or too fast.
This is caused because the hydraulic power unit flowrate is not correct. To correct this, readjust the flowrate of the hydraulic power unit.

NOTE: This will affect the speeds of other hydraulic functions.

OR

This is caused because the flow control valves are not properly adjusted. To correct this, readjust the flow control valves.

Tool holder falls out of gripper claws.
Gripper claw is broken.

Tool holder does not release from gripper claws.
This is caused because the release pin ramp on the magazine is worn or loose. To correct this, tighten or replace the release pin ramp.

OR

This is caused because the release pin depressor bolt on the carriage is out of position. To correct this, readjust the release pin depressor bolt.

OR

This is caused because the arm is not pulled in far enough. To correct this, adjust the hydraulic pressure or arm pull-in travel stop screw.

Tool holder falls out of the magazine tool pots.
This is caused because the tool pocket detents are stuck or the springs are broken. To correct this, lubricate and/or replace the detent springs on the tool pot.

Tool holder will not “bottom out” in magazine tool pot.
This is caused because the tool pocket detents are stuck. To correct this, lubricate, replace, or repair the tool holder detents.

One of the hydraulically actuated functions does not operate.

This is caused because the solenoid On valve has failed. To correct this, replace the solenoid On valve that controls the failed function.

1.6 Gearbox and Spindle Motor

The gearbox cannot be serviced in the field and must be replaced as a unit. **NEVER** remove a motor from the gearbox on an HS-Series mill, as this will damage the gearbox and void the warranty.

Noise

When investigating complaints of gearbox noise, also refer to "Spindle" troubleshooting section. Gearboxes can be damaged by failed air solenoids, gearshift cylinders, or bearings, resulting in noisy operation. While gearbox vibration can cause a poor finish on a workpiece, noisy gearbox operation may not.

Excessive or unusual noise coming from the gearbox.

Operate the machine in both high and low gears. Monitor the gearbox for noise in both gear positions, and determine if the pitch of the noise varies with the motor or the output shaft speed.

- If the noise only occurs in one gear throughout the entire RPM range of that gear position, the problem lies with the gearbox, and it must be replaced ("Transmission" section).
- If the noise occurs in both gear positions, disconnect the drive belt and repeat the previous step. If the noise persists, the gearbox is damaged and must be replaced ("Transmission" section).
- With the drive belt disconnected, run the machine at 1000 RPM in high gear. Command a change of direction and listen for a banging noise in the gearbox as the machine slows to zero RPM and speeds back up to 1000 RPM in reverse. If the noise occurs, the motor has failed and the gearbox must be replaced.

Gears Will Not Change

Machine will not execute a gear change.

NOTE: Whenever a gear change problem occurs, an alarm will also occur. Refer to the ALARMS section to diagnose each problem before working on the machine.

- Check air supply pressure. If pressure is too low, the gears will not change.
- Check the air solenoid assembly on the solenoid bracket. If the solenoid operates properly and the limit switches on the gearbox operate properly, the problem lies with the gear change piston. Replace the gearbox ("Transmission").
- Check contactor CB4.

Low Pressure Alarm

Alarm 179 (Low Pressure Transmission Oil) has been triggered.

- Check for low oil supply in reservoir.
- Check that pump motor is running.
- Check for an air leak in the suction side of the pump.
- Check for a bad pressure sensor.
- Check for a broken or damaged cable.
- Check for a worn pump head.

1.7 Through the Spindle Coolant

NOTE: Abrasive swarf from grinding or ceramic machining operations will cause heavy wear of TSC coolant pump, coolant tip and drawbar. This is not covered by warranty on new machines. Notify HAAS Service Department if machine is being used for this application.

Coolant Overflow

To begin troubleshooting, check the alarm history to determine the problem's cause before any action is taken.

Coolant pouring out of spindle head

- Check the customer's tooling for through holes in the pull stud, holder and tool.
- Check the purge and drain lines connected to the seal housing are intact. If not replace with (58-2010) 5/32" OD nylon tubing.
- Check for TSC seal failure. If failure is found, replace the seal housing (30-3298). Refer to the appropriate steps in "TSC-Tool Release Piston Replacement" section for procedure.
- Check pre-charge pressure in accordance with TSC "Pressure Regulator Adjustment' section and reset if necessary. Low pre-charge pressure can cause coolant to dump into the spindle head.
- Ensure the coolant pump relief valve has not been tampered with (yellow paint band is intact). Check the coolant pump pressure (should be 300 psi for high pressure TSC and 140 psi for old style TSC), with a standard (non-TSC) tool holder in spindle. If pump pressure is above 310 psi for high pressure TSC or above 140 psi for old style TSC, reset the pump relief valve in accordance with the "Setting TSC Pump Relief Valve".

Excessive coolant flow out of drain line

Pulsating flow through tool and drain line

- Check pre-charge pressure in accordance with TSC "Pressure Regulator Adjustment" section. Reset precharge pressure if necessary. Low pre-charge pressure will cause heavy or pulsating flow from the drain line. Check main air pressure regulator for 85 psi. A higher supply pressure will reduce precharge pressure. Lower supply pressure will increase precharge pressure.
- Ensure the coolant pump relief valve has not been tampered with (yellow paint band is intact). Check the coolant pump pressure (should be 300 psi for high pressure TSC and 140 psi for old style TSC), with a standard tool holder in spindle. If pump pressure is above 310 psi for high pressure TSC or above 140 psi for old style TSC, reset the pump relief valve in accordance with the "Setting TSC Pump Relief Valve".

Low Coolant

Alarm 151, "Low Thru Spindle Coolant"

- Check coolant tank level. Check for slow coolant drainage from the machine enclosure.
- Check the filter and intake strainer for any clogging. Read filter gauges with TSC running with no tool in spindle. Check coolant lines for any clogging or kinking. Clean or replace as needed.
- Check for overheating TSC pump motor. Single phase motors have a built in thermal cut-out. Three phase motors have a thermal circuit that will interrupt power to the relay coil.
- If received at start-up, check that the breaker hasn't tripped and that the pump is turning. Check the electrical continuity of cables.
- Check for pressure switch failure (refer to "Testing the Coolant Pressure Switch" section), and replace if necessary. Check the electrical continuity of the switch cable and the control function by monitoring the "LO CLNT" bit on the Diagnostics page (0 = pressure on, 1= pressure off). Shorting the leads should cause the bit to switch from 1 to 0. Check this before replacing the pressure switch. Leaking switches can give intermittent alarms.
- Check pump pressure with no tool in the spindle. If the pressure is less than 60 psi, replace the pump.
- May be generated if another machine alarm occurs during TSC operation.
- For the old TSC system, if the drawbar was replaced, check that the hole through the drawbar is 0.156 dia and not 0.190 dia. Replace the drawbar with the correct one if it is 0.190 dia.

Coolant Tip Wear

The carbide coolant tip should last for the life of the machine. The old bronze coolant tip should be checked every 1000 hours of TSC operation.

Seal housing assembly is wearing quickly and needs frequent replacement.

- Check the filtration system and that the coolant is not contaminated.
- Check pre-charge pressure (refer to the TSC Pressure Regulator Adjustment" section). Premature failure due to excessive heat if this pressure is too high.

NOTE: Main air supply below 85 psi can cause excessive pre-charge pressure and heavy coolant tip wear.

NOTE: Abrasive swarf from grinding or ceramic machining operations will cause heavy wear of TSC coolant pump, coolant tip and drawbar. This is not covered by warranty on new machines. Notify HAAS Service Department if machine is being used for this application.

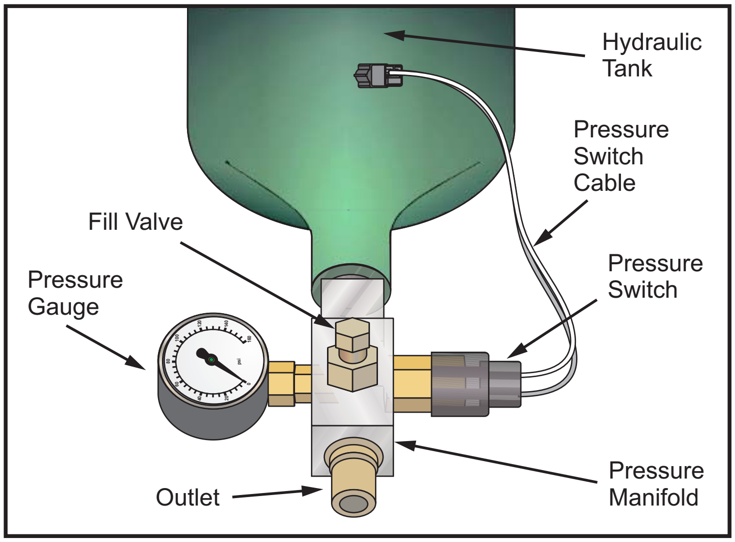
Pre-Charge Failure

Alarm 198, "Precharge Failure"

NOTE: This alarm only applies to the TSC system.

- Check for broken or disconnected pre-charge air line, and replace if necessary.
- Check if the "Tool Clamped" limit switch is sticking, and replace if necessary.
- Check the "Tool Clamped" limit switch adjustment (refer to "Tool Clamp/Unclamp Switch Adjustment").
- Check for low pre-charge pressure (refer to "Pressure Regulator Adjustment" section).
- Check pre-charge solenoid for proper operation.
- May be generated if another machine alarm occurs during TSC operation.

1.8 Hydraulic Counterbalance



Hydraulic Tank Assembly

Top of Travel Pressure

A reference table is listed below indicating top of travel pressure and switch setting pressure for each machine.

Machine	Top of Travel Pressure (PSI)	Switch Setting Pressure (PSI)
VF-E-2	750	600
VF-3, 4	1150	900
VF-5/40	875	750
VF-5/50	1100	1000
VF-6/40 – 11/40	750	600
VF-6/50, 7/50, 10/50	1150	900
VF-8/50, 9/50, 11/50	1550	1400
VR-11	1100	1000
VB-1	1550	1400
HS-1, 15AXT, 1R, 1RP	600	450
HS-3, 3R	1150	1000

TROUBLESHOOTING

The table below lists observable machine conditions and their probable cause. Find the appropriate corrective action step to fix the observed faults.

Machine Condition	Possible Problem(s)	Corrective Action
Machine alarms, pressure reading low.	-Cylinder leaks -Fitting leaks	1 2
Machine alarms, pressure reading ok, alarm does not reset.	-I/O board failure -Bad cable or dirty contacts -Switch setting too high and/or system is under-pressurized due to inaccurate gauge.	5 4 3
No alarm, pressure reading low (at or below switch setting).	-Cylinder leaks -Fitting leaks -Shorted cable -Switch setting too log and/or system has an inaccurate gauge.	1 2 6 7
Spindle head drifts up.	-Over-pressurized due to inaccurate gauge.	8
Spindle head drifts down, no alarm.	-Cylinder leaks -Fitting leaks -Switch setting too low and/or system under-presurized due to inaccurate gauge.	1 2 2

Corrective Action

Tools Required
Hand tools.
Charge/Discharge Kit P/N 35-4050A
Hydraulic Hand Pump Kit P/N 93-0206

1. Check for sufficient oil in system: Block spindle head at top of travel. Attach charge/discharge kit to schrader valve, slowly turn t-handle clockwise to begin releasing pressure and make one of the following observations:

   a) If oil is immediately present stop discharging, there is sufficient oil in the system. There are two courses of action at this point; add nitrogen to system to obtain top of travel pressure specification. This step may last indefinitely depending on the severity of the leak, or what caused it. The second course of action is to proceed to Corrective Action 2 if it is felt that the leak is substantial.

   b) If nitrogen gas is immediately present stop discharging and proceed to Corrective Action 2. There is not enough oil in the system.

2. Block spindle head at bottom of travel (if the cylinder is to be replaced block the head in the lowest position that will permit access to the rod attachment).

   a) Carefully drain remaining gas and oil.

   b) Replace faulty component(s). (SAE straight thread o-ring fittings are to be lubricated with a film of hydraulic oil prior to install) Note that machines built after August, 1999 use straight thread fittings with o-rings, and sealed connectors on the switch wires. Earlier machines have pipe thread connections. Replacing older style components with newer style requires that all components of the counter balance system be changed as well as the cable back to the control.

   c) Pump new Mobil DTE-25 oil (see chart for qty.) into system using Hydraulic Hand Pump Kit. (see "Hydraulic Hand Pump Instructions" below).

Machine	Quarts of Mobile DTE-25	# of Pump Strokes
VF-E-11, VR-11, HS-1	2 per tank	93
VB-1, HS-3	3 per tank	0140

   d) Pressurize with nitrogen using charge/discharge kit to spec. at top of travel.

3. Add 50 psi of nitrogen to the system at top of travel.

   Does the alarm clear?

   Yes: Now check if the head drifts up more than 1" upon E-stop at the bottom of travel. If it does then replace the switch as described in corrective action 2.

   No: Add another 50 psi to the system at top of travel. If the alarm still does not clear replace the switch as described in corrective action 2. If the alarm clears check if the head drifts up more than 1" upon E-stop at the bottom-of-travel. If it does then replace the switch as described in corrective action 2.

4. If the counter balance system pressure is ok and there is an E-stop alarm that won't reset check the cable for dirty contacts. Loose connections or broken wire can be tested by disconnecting the cable at the switch and adding a jumper across the connector pins of the cable and clear the alarm. If the alarm does not clear the cable is defective. Repair or replace the cable if necessary.

5. Check I/O board and replace if necessary.

6. Test for short in cable. Repair or replace if necessary.

7. Does spindle head drift down from top of travel upon E-stop?

   Yes: Replace switch as described in corrective action 2.
   No: Replace pressure gauge as described in corrective action 2.

8. Invert tank to bleed about 50 psi of nitrogen gas. Re-evaluate machine condition.

LEAK FAILURES

Leaks can occur at any fitting connection, at the hydraulic cylinder's rod seal (where the rod enters the cylinder), at the cylinder's piston seal, or through hose failures. Inspections for leaks are visual although rod seal leaks may be inconclusive because of way oil spatter. Piston seal leaks, if advanced, exit the top end of the cylinder and oil can be seen at the vent area. Early piston leaks accumulate over time on top of the piston to about ¾" high before they are pushed out the cylinder at top of travel. Leaks are normally very slow and machines can operate until the pressure switch sends an E-stop alarm.

MECHANICAL DIAGNOSIS

Important! Hydraulic counterbalance oil is dyed red for easier recognition.

Noise in the system

- Slight moan or creaking at slow speeds is normal for rubber seals
- While Y-axis is in motion a whistle sound at tank location is normal fluid flow.
- Verify cylinder is seated correctly in counterbore. If not then reseat the cylinder.
- Bumping or grinding noise indicates a mechanical cylinder failure. Replace cylinder assembly.
- Look for galling and wear on cylinder shaft. If so replace the cylinder assembly.

System is not holding pressure and/or has an E-STOP (Alarm 107) that cannot be reset.

Check for accurate pressure readings. If low then the following items need to be checked:

- Check for leaks at all cylinder fittings. If leaking then replace cylinder assembly.
- Remove the rear panel of the machine and look for any red oil pooled at the bottom of the column. If so, then fittings or seals could be damaged. Replace cylinder assembly.
- Remove cylinder vent fitting. If there is red oil inside the vent cavity then the cylinder assembly needs replacement.
- Check for leaks at all hydraulic tank fittings. If leaking then tank assembly needs replacement.

Over Current alarms

- Pressure is set too high
- Pressure is set too low
- Too much oil has been added. (Insufficient gas volume causes large pressure rise)
- Hydraulic cylinder is binding or is misaligned. Replace cylinder assembly.
- Length of replacement cylinder incorrect.

Over Current / Following errors

- Pressure is set too high
- Pressure is set too low
- Too much oil has been added. (Insufficient gas volume causes large pressure rise)
- Hydraulic cylinder is binding or is misaligned. Replace cylinder assembly.
- Length of replacement cylinder incorrect.

1.9 Electrical Troubleshooting

CAUTION! Before working on any electrical components, power off the machine and wait approximately 10 minutes. This will allow the high voltage power on the brushless amplifiers to be discharged.

Electrical Alarms

Axis Drive Fault Alarm

- Blown amplifier - indicated by a light at bottom of amplifier when power is on. Replace amplifier.
- Amplifier or MOCON is noise sensitive. If this is the case, the alarm can be cleared and the axis will run normally for a while.

To check an amplifier, switch the motor leads and control cables between the amplifier and the one next to it. If the same problem occurs with the other axis, the amplifier must be replaced. If the problem stays on the same axis, either the MOCON or control cable. The problem could also be the axis motor itself, with leads either shorted to each other or to ground.

- Amplifier faulting out for valid reason, such as overtemp, overvoltage, or +/-12 volt undervoltage condition. This usually results from running a servo intensive program, or unadjusted 12 volt power supply.

Overvoltage could occur if regen load is not coming on, but this does not usually happen. The problem could also be the axis motor itself, with leads either shorted to each other or to ground.

Axis Overload

- The fuse function built into the MOCON has been overloaded, due to a lot of motor accel/decels, or hitting a hard stop with the axis. This safety function protects the amplifier and motor, so find the cause and correct it. If the current program is the cause, change the program. If the axis hits a hard stop, the travel limits may be set wrong.

Phasing Error

- The MOCON did not receive the proper phasing information from the motors. DO NOT RESET the machine if this alarm occurs. Power the machine down and back up. If the problem persists, it is probably a broken wire or faulty MOCON connectors. This problem could also be related to the Low Voltage Power Supply. Check to see if the LVPS is functioning properly.

Servo Error Too Large

- This alarms occurs when the difference between the commanded axis position and the actual position becomes larger than the maximum that is set in the parameter.

This condition occurs when the amplifier is blown, is not receiving the commands, or the 320 volt power source is dead. If the MOCON is not sending the correct commands to the amplifier, it is probably due to a broken wire, or a PHASING ERROR that was generated.

Axis Z Fault or Z Channel Missing

- During a self-test, the number of encoder counts was found to be incorrect. This is usually caused by a noisy environment, and not a bad encoder. Check all shields and grounds on the encoder cables and the motor leads that come into the amplifiers. An alarm for one axis can be caused by a bad grounding on the motor leads of another axis.

Axis Cable Fault

- During a self-test, the encoder cable signals were found to be invalid. This alarm is usually caused by a bad cable, or a bad connection on the motor encoder connectors. Check the cable for any breaks, and the encoder connectors at the motor controller board. Machine noise can also cause this alarm, although it is less common.

Alarm 101, "MOCON Comm. Failure"

- During a self-test of communications between the MOCON and main processor, the main processor does not respond, and is suspected to be dead. This alarm is generated and the servos are stopped. Check all ribbon cable connections, and all grounding. Machine noise can also cause this alarm, although it is less common.

Alarm 157, "MOCON Watchdog Fault"

- The self-test of the MOCON has failed. Replace the MOCON.

Rotary CRC Error Alarm 261

- This alarm is normally the result of an incomplete software installation. To correct this error, Change Setting 30 to any selection but OFF (note the original selection). Then go to parameter 43 and change one of the bits from 1 to 0 or vice versa and press WRITE (The bit must be changed from its original value to its alternate value). Simply changing the Setting and Parameter bit from one value to another and then back again corrects the fault, and will clear any further occurrences of the alarm. Change the bit and Setting 30 back to their original values. Press Reset to clear the alarms or cycle power to the machine.

Alarm 354 - Aux Axis Disconnected

When this alarm is generated, do not press **RESET**. Turn Setting 7 **OFF**. Enter **DEBUG** mode, then view the Alarms/Messages page. On the Messages page, a code will appear similar to WO1. The list of codes and their descriptions appears below:

WO1 Power was just turned on or failed. Check the ribbon cables from the Aux Axis PCB to the processor for correct routing. Check for communication problems between the processor and the Aux Axis PCB.

WO2 Servo following error too large. Check the encoder for contamination or dirt. Check for an intermittent connection at both ends of the motor cable.

WO3 Emergency Stop. The E-STOP button was pressed, or an E-STOP condition occurred.

WO4 High load. Check for binding in the tool changer gearbox and motor. Rotate the carousel by hand and feel for any binding. Make sure the tool holders are the correct weight.

WO5 Remote RS-232 commanded off. Check the ribbon cable and the voltage to the Aux Axis PCB. Check for 115VAC (minimum) to the Aux Axis PCB from the main transformer. Check the fuse holder and the fuse that is protecting this circuit.

WO6 Air or limit switch or motor overheat. Check that the motor is not hot. Check for any binding in the motor. Check for overweight tooling.

WO7 Z channel fault. Either the encoder or the cable is bad. Change the encoder first, as it is easier to change than the cable. If the problem persists, change the cable.

WO8 Over-current limit, stalled or PCB fault. Check for binding in the tool changer gearbox. Make sure the belt is not too tight. Ohm out the motor cable, checking pins G to F (should be open), G to H (should be open), and F to H (should read between 2.5 and 5 ohms). Check all the connections on the Aux Axis PCB and motor cable.

WO9 Encode ES. Z channel is missing. Bad encoder or cable. See **WO7.**

WOA High voltage. Check the incoming voltage to the Aux Axis PCB. Incoming voltage must be 115 VAC. See **WO5.**

WOB Cable fault. Check the cable from the motor to the Aux Axis PCB. Check for loose connections at each end.

PROCESSOR STACK DIAGNOSTIC

(DISCONNECT CABLES FROM A NORMAL OPERATING SYSTEM)

Remove low voltage cable from Video & Keyboard PCB

- Processors LED's are normal
- Runs fine and the CRT is Normal
- No keypad beep

Remove the Data & or Address buss from the Video & Keyboard PCB

- Processors LED's Normal - then Run goes out

Remove the Data & or Address buss from the Micro Processor PCB

- Processors LED's - CRT and Run are out

KEYBOARD DIAGNOSTIC

This Keyboard Grid is for machines with a Keyboard Interface only. This Keyboard Grid is <u>not</u> for machines with a Serial Keyboard Interface.

NOTE: Refer to the "Cable Locations" section of this manual for a drawing of the Keyboard Interface PCB.

	1	2	3	4	5	6	7	8	9	10	11
12	OFSET	SETNG GRAPH		↑		↓	B	H	N	T	Z
13	POSIT	PARAM DGNOS		HOME	←	END	A	G	M	S	Y
14	PRGRM CONVRS	ALARM MESGS		*CLNT UP*	*CLNT DOWN*	*AUX CLNT*	*SHIFT*	F	L	R	X
15	POWER DOWN	F4	PART ZERO SET	-Y	-X	-A					*100% RAPID*
16	POWER UP RESTART	F3	TOOL RELEASE	+Z	JOG LOCK	-Z		+10	+10	CCW	50% RAPID
17	RESET	F2	NEXT TOOL	+B +A	<+X	+Y		100%	100%	STOP	25% RAPID
18		F1	TOOL OFSET MESUR	*CHIP FWD*	*CHIP STOP*	*CHIP REV*		-10	-10	CW	5% RAPID
19	CURNT COMDS	HELP	PAGE UP		→	PAGE DOWN	C	I	O	U	EOB
20	EDIT	MEM	MDI DNC	HANDLE JOG	ZERO RET	LIST PROG	D	J	P	V	[(
21	INSERT	SINGLE BLOCK	COOLNT	.0001 .1	AUTO ALL AXES	SELECT PROG	E	K	Q	W	])
22	ALTER	DRY RUN	ORIENT SPNDLE	.0001 1.	ORIGIN	SEND RS232	& 7	% 4	* 1	+ -	CANCEL
23	DELETE	OPT STOP	ATC FWD	.01 10.	ZERO SINGL AXES	RECV RS232	@ 8	$ 5	, 2	= 0	SPACE
24	UNDO	BLOCK DELETE	ATC REV	.01 100.	HOME G28	ERASE PROG	: 9	! 6	? 3	# PERIOD .	WRITE

KEYBOARD GRID

The following is an example of how to troubleshoot the keypad:

NOTE: Keypad Diodes 1-24 correspond to chart numbers 1-24

Example

1. Pressing the **RESET** button will cause diodes 1 and 17 to conduct.
   •With the POWER OFF read across diode 1. A typical reading is between .400-.700 ohms, note your reading.

2. Press and hold the **RESET** button. If the diode is conducting, the reading should drop about .03 ohms.
   •(If your reading was .486 and it dropped to .460, for a difference of .026; the diode is good)
   •The same will hold true for diode 17 in this example. If the reading stays the same or there is no change, the diode is not conducting. Pull P2 and read between pins 1 and 17.
   •Press and hold <**RESET**>. The meter should read a short (0 ohms) if not the keypad is bad.

ETHERNET

Error 53 The computer name specified in the network path cannot be located

This error usually happens when NET USE C: \\SERVER\HAAS/PERSISTENT: NO /YES is entered during the setup phase.

To fix this error first verify the following:

1. A 10 Base-T network is present.
   2. The network cable is coming from a hub (not the server).
   3. The server name that you specified in yo
2. u NET USE command is correct.
   4. Your network is running IPX/SPX protocol.

If all of the above is correct and communications between the Haas CNC and the network are not established, there may be compatibility issues between an older Novell network and an NT 4.0 server. If the NWLink IPX/SPX Compatible Transport on the NT server is set to auto detect the protocol's frame, the NT server may be detecting the Novell server first and setting the NWLink IPX/SPX Compatible Transport frame protocol to 802.3 The NWLink IPX/SPX Compatible Transport required for the mills to connect to an NT server is 802.2. Since these two frame protocols are different the mill would never connect to the desired NT server. To remedy this check the following:

1. On the Ethernet boot disk, edit the protocol.ini file in the NETI directory.
2. Find the line FRAME=ETHERNET_802.2 and change it to FRAME=ETHERNET_802.3
3. Save the file
4. Insert the boot disk back into the CNC and cycle the power.

If an Error 53 is still present, restore the protocol.ini file to its previous state and do the following to the NT server:

1. Open the control panel
2. Double click on the Network icon
3. Select the Protocols tab.
4. Highlight NWLINK IPX/SPX Compatible Transport.
5. Select properties.
6. Select Manual Frame Type Detection.
7. Click on Add.
8. Select Ethernet 802.2
9. Click on Add.
10. Click OK.
11. Close all windows and reboot the NT server.

Once the NT server is rebooted the NWLINK IPX/SPX Compatible Transport Frames is set to 802.2 and the mill will be able to see the desired server.

Mill code will not work

Make sure the command in the server routes back to the mill.

2. ALARMS

Any time an alarm is present, the lower right hand corner of the screen will have a blinking "ALARM". Push the ALARM display key to view the current alarm. All alarms are displayed with a reference number and a complete description. If the RESET key is pressed, one alarm will be removed from the list of alarms. If there are more than 18 alarms, only the last 18 are displayed and the RESET must be used to see the rest. The presence of any alarm will prevent the operator from starting a program.

The **ALARMS DISPLAY** can be selected at any time by pressing the ALARM MESGS button. When there are no alarms, the display will show NO ALARM. If there are any alarms, they will be listed with the most recent alarm at the bottom of the list. The CURSOR and PAGE UP and PAGE DOWN buttons can be used to move through a large number of alarms. The CURSOR **right** and **left** buttons can be used to turn on and off the ALARM history display.

Note that tool changer alarms can be easily corrected by first correcting any mechanical problem, pressing RESET until the alarms are clear, selecting ZERO RET mode, and selecting AUTO ALL AXES. Some messages are displayed while editing to tell the operator what is wrong but these are not alarms. See the editing topic for those errors.

The following alarm list shows the alarm numbers, the text displayed along with the alarm, and a detailed description of the alarm, what can cause it, when it can happen, and how to correct it.

Alarm number and text:	Possible causes:
101 Comm. Failure with MOCON	During a self-test of communications between the MOCON and main processor, the main processor does not respond, one of them is possibly bad. Check cable connections and boards.
102 Servos Off	Indicates that the servo motors are off, the tool changer is disabled, the coolant pump is off, and the spindle motor is stopped. Caused by EMERGENCY STOP, motor faults, tool changer problems, or power fail.
103 X Servo Error Too Large	Too much load or speed on X-axis motor. The difference between the motor position and the commanded position has exceeded a parameter. The motor may also be stalled, disconnected, or the driver failed. The servos will be turned off and a RESET must be done to restart. This alarm can be caused by problems with the driver, motor, or the slide being run into the mechanical stops.
104 Y Servo Error Too Large	Same as alarm 103.
105 Z Servo Error Too Large	Same as alarm 103.
106 A Servo Error Too Large	Same as alarm 103.
107 Emergency Off	EMERGENCY STOP button was pressed. After the E-STOP is released, the RESET button must be pressed once to correct this to clear the E-STOP alarm. This alarm will also be generated if there is a low pressure condition in the hydraulic counterbalance system. In this case, the alarm will not reset until the condition has been corrected.

108	X Servo Overload	Excessive load on X-axis motor. This can occur if the load on the motor over a period of several seconds or even minutes is large enough to exceed the continuous rating of the motor. The servos will be turned off when this occurs. This can be caused by running into the mechanical stops but not much past them. It can also be caused by anything that causes a very high load on the motors.
109	Y Servo Overload	Same as alarm 108.
110	Z Servo Overload	Same as alarm 108.
111	A Servo Overload	Same as alarm 108.
112	No Interrupt	Electronics fault. Call your dealer.
113	Shuttle In Fault	Tool changer is not completely to right. During a tool changer operation the tool in/out shuttle failed to get to the IN position. Parameters 62 and 63 can adjust the time-out times. This alarm can be caused by anything that jams the motion of the slide or by the presence of a tool in the pocket facing the spindle. A loss of power to the tool changer can also cause this. Check relays K9-K12, and fuse F1 on IOPCB.
114	Shuttle Out Fault	Tool changer not completely to left. During a tool change operation the tool in/out shuttle failed to get to the OUT position. Parameters 62 and 63 can adjust the time-out times. This alarm can be caused by anything that jams the motion of the slide or by the presence of a tool in the pocket facing the spindle. A loss of power to the tool changer can also cause this. Check relays K9-K12, and fuse F1 on IOPCB.
115	Turret Rotate Fault	Tool carousel motor not in position. During a tool changer operation the tool turret failed to start moving, failed to stop moving or failed to stop at the right position. Parameters 60 and 61 can adjust the time-out times. This alarm can be caused by anything that jams the rotation of the turret. A loss of power to the tool changer can also cause this. Check relays K9-K12, and fuse F1 on IOPCB.
116	Spindle Orientation Fault	Spindle did not orient correctly. This is either a vector drive problem or a mechanical problem on machines without a vector drive. During a spindle orientation function, the spindle is rotated until the lock pin drops in; but the lock pin never dropped. Parameters 66, 70, 73, and 74 can adjust time-out timers. This can be caused by a trip of circuit breaker CB4, a lack of air pressure, or too much friction with the orientation pin.
117	Spindle High Gear Fault	Gearbox did not shift into high gear. During a change to high gear, the spindle is rotated slowly while air pressure is used to move the gears but the high gear sensor was not detected in time. Parameters 67, 70 and 75 can adjust the time-out times. Check the air pressure, circuit breaker CB4,the circuit breaker for the air pressure solenoids, and the spindle drive.

118	Spindle Low Gear Fault	Gearbox did not shift into low gear. During a change to low gear, the spindle is rotated slowly while air pressure is used to move the gears but the low gear sensor was not detected in time. Parameters 67, 70 and 75 can adjust the time-out times. Check the air pressure, the solenoid's circuit breaker CB4, and the spindle drive.
119	Over Voltage	Incoming line voltage is above maximum. The spindle, tool changer, and coolant pump will stop. If this condition persists, an automatic shutdown will begin after the interval specified by parameter 296.
120	Low Air Pressure	Air pressure dropped below 80 PSI for a period defined by Parameter 76. The LOW AIR PR alarm will appear on the screen as soon as the pressure gets low, and this alarm appears after some time has elapsed. Check your incoming air pressure for at least 100 PSI and ensure that the regulator is set at 85 PSI.
121	Low Lube or Low Pressure	Way lube is low or empty or there is no lube pressure or too high a pressure. Check tank at rear of mill and below control cabinet. Also check connector on the side of the control cabinet. Check that the lube lines are not blocked.
122	Regen Overheat	The regenerative load temperature is above a safe limit. This alarm will turn off the spindle drive, coolant pump, and tool changer. One common cause of this overheat condition is an input line voltage too high. If this condition persists, an automatic shutdown will begin after the interval specified by parameter 297. It can also be caused by a high start/stop duty cycle of spindle.
123	Spindle Drive Fault	Failure of spindle drive, motor or regen load. This can be caused by a shorted motor, overvoltage, overcurrent, undervoltage, failure of drive, or shorted or open regen load. Undervoltage and overvoltage of DC bus are also reported as alarms 160 and 119, respectively.
124	Low Battery	Memory batteries need replacing within 30 days. This alarm is only generated at power on and indicates that the 3.3 volt Lithium battery is below 2.5 volts. If this is not corrected within about 30 days, you may lose your stored programs, parameters, offsets, and settings.
125	Shuttle fault	Tool shuttle not initialized at power on, CYCLE START or spindle motion command. This means that the tool shuttle was not fully retracted to the Out position.
126	Gear Fault	Gearshifter is out of position when a command is given to start a program or rotate the spindle. This means that the two speed gear box is not in either high or low gear but is somewhere in between. Check the air pressure, the solenoid's circuit breaker CB4, and the spindle drive. Use the POWER UP/RESTART button to correct the problem.
127	No Turret Mark	Tool carousel motor not in position. The turret motor only stops in one position indicated by a switch and cam on the Geneva mechanism. This alarm is only generated at power-on. The AUTO ALL AXES button will correct this but be sure that the pocket facing the spindle afterwards does not contain a tool.

129	M Fin Fault	M-Fin was active at power on. Check the wiring to your **M** code interfaces. This test is only performed at power-on.
130	Tool Unclamped	The tool appeared to be unclamped during spindle orientation, a gear change, a speed change, or TSC start-up. The alarm will also be generated if the tool release piston is energized during Power Up. This can be caused by a fault in the air solenoids, relays on the I/O assembly, the drawbar assembly, or in the wiring.
131	Tool Not Clamped	When clamping or powering up the machine, the Tool Release Piston is not HOME. This is a possible fault in the air solenoids, relays on the IO Assembly, the drawbar assembly, or wiring.
132	Power Down Failure	Machine did not turn off when an automatic power-down was commanded. Check wiring to POWIF card on power supply assembly, relays on the IO assembly, and the main contactor K1.
133	Spindle Locked	Shot pin did not release. This is detected when spindle motion is commanded. Check the solenoid that controls the air to the lock, relay K16, the wiring to the sense switch, and the switch.
134	Tool Clamp Fault	When UNCLAMPING, the tool did not release from spindle when commanded. Check air pressure and solenoid circuit breaker CB4. Can also be caused by misadjustment of drawbar assembly.
135	X Motor Over Heat	Servo motor overheat. The temperature sensor in the motor indicates over 150 degrees F. This can be caused by an extended overload of the motor such as leaving the slide at the stops for several minutes.
136	Y Motor Over Heat	Same as alarm 135.
137	Z Motor Over Heat	Same as alarm 135.
138	A Motor Over Heat	Same as alarm 135.
139	X Motor Z Fault	Encoder marker pulse count failure. This alarm usually indicates that the encoder has been damaged and encoder position data is unreliable. This can also be caused by loose encoder connectors.
140	Y Motor Z Fault	Same as alarm 139.
141	Z Motor Z Fault	Same as alarm 139.
142	A Motor Z Fault	Same as alarm 139.
143	Spindle Not Locked	Vector drive orientation lost or shot pin not fully engaged when a tool change operation is being performed. Check air pressure and solenoid circuit breaker CB4. This can also be caused by a fault in the sense switch that detects the position of the lock pin.
144	Time-out- Call Your Dealer	Time allocated for use prior to payment exceeded. Call your dealer.

145	X Limit Switch	Axis hit limit switch or switch disconnected. This is not normally possible as the stored stroke limits will stop the slides before they hit the limit switches. Check the wiring to the limit switches and connector P5 at the side of the main cabinet. Can also be caused by a loose encoder shaft at the back of the motor or coupling of motor to the screw.
146	Y Limit Switch	Same as alarm 145
147	Z Limit Switch	Same as alarm 145
148	A Limit Switch	Normally disabled for rotary axis.
149	Spindle Turning	Spindle not at zero speed for tool change. A signal from spindle drive indicating that the spindle drive is stopped is not present while a tool change operation is going on.
150	Z and Tool Interlocked	Changer not at home and either the **Z** or A or B axis (or any combination) is not at zero. If RESET, E-STOP, or POWER OFF occurs during tool change, Z-axis motion and tool changer motion may not be safe. Check the position of the tool changer and remove the tool if possible. Re-initialize with the AUTO ALL AXES button but be sure that the pocket facing the spindle afterwards does not contain a tool.
151	Low Thru Spindle Coolant	For machines with Through the Spindle Coolant only. This alarm will shut off the coolant spigot, spindle and pump all at once. It will turn on purge, wait for the amount of time specified in parameter 237 for the coolant to purge, and then turn off the purge. Check for low coolant tank level, any filter or intake strainer clogging, or for any kinked or clogged coolant lines. If no problems are found with any of these, and none of the coolant lines are clogged or kinked, call your dealer. Verify proper pump and machine phasing.
152	Self Test Fail	Control has detected an electronics fault. All motors and solenoids are shut down. This is most likely caused by a fault of the processor board stack at the top left of the control. Call your dealer.
153	X-axis Z Ch Missing	Z reference signal from encoder was not received as expected. Likely encoder contamination or parameter error.
154	Y-axis Z Ch Missing	Same as alarm 153.
155	Z-axis Z Ch Missing	Same as alarm 153.
156	A-axis Z Ch Missing	Same as alarm 153.
157	MOCON Watchdog Fault	The self-test of the MOCON has failed. Replace the MOCON.
158	Video/Keyboard PCB Failure	Internal circuit board problem. The VIDEO PCB in the processor stack is tested at power-on. This could also be caused by a short in the front panel membrane keypad. Call your dealer.

159	Keyboard Failure	Keyboard shorted or button pressed at power on. A power-on test of the membrane keypad has found a shorted button. It can also be caused by a short in the cable from the main cabinet or by holding a switch down during power-on.
160	Low Voltage	The line voltage to control is too low. This alarm occurs when the AC line voltage drops more than 10% below nominal.
161	X-Axis Drive Fault	Current in **X** servo motor beyond limit. Possibly caused by a stalled or overloaded motor. The servos are turned off. This can be caused by running a short distance into a mechanical stop. It can also be caused by a short in the motor or a short of one motor leads to ground.
162	Y-Axis Drive Fault	Same as alarm 161.
163	Z-Axis Drive Fault	Same as alarm 161.
164	A-Axis Drive Fault	Same as alarm 161.
165	X Zero Ret Margin Too Small	This alarm will occur if the home/limit switches move or are misadjusted. This alarm indicates that the zero return position may not be consistent from one zero return to the next. The encoder **Z** channel signal must occur between 1/8 and 7/8 revolution of where the home switch releases. This will not turn the servos off but will stop the zero return operation.
166	Y Zero Ret Margin Too Small	Same as alarm 165.
167	Z Zero Ret Margin Too Small	Same as alarm 165.
168	A Zero Ret Margin Too Small	This alarm will occur if the home/limit switches move or are misadjusted. This alarm indicates that the zero return position may not be consistent from one zero return to the next. The encoder Z channel signal must occur between 1/8 and 7/8 revolution of where the home switch releases. This will not turn the servos off but will stop the zero return operation.
169	Spindle Direction Fault	Problem with rigid tapping hardware. The spindle started turning in the wrong direction.
170	Phase Loss	Problem with incoming line voltage. This usually indicates that there was a transient loss of input power to the machine.
173	Spindle Ref Signal Missing	The **Z** channel pulse from the spindle encoder is missing for hard tapping synchronization.
174	Tool Load Exceeded	The tool load monitor option is selected and the maximum load for a tool was exceeded in a feed. This alarm can only occur if the tool load monitor function is installed in your machine.
175	Ground Fault Detected	A ground fault condition was detected in the 115V AC supply. This can be caused by a short to ground in any of the servo motors, the tool change motors, the fans, or the oil pump.

176	Over Heat Shutdown	An overheat condition persisted longer than the interval specified by parameter 296 and caused an automatic shutdown.
177	Over Voltage Shutdown	An overvoltage condition persisted longer than the interval specified by parameter 296 and caused an automatic shutdown.
178	Divide by Zero	Software Error; Call your dealer.
179	Low Pressure Transmission Oil	Spindle coolant oil is low or low pressure condition in lines.
180	Pallet Not Clamped	The APC pallet change was not completed for some reason (pressing E-stop, reset, or feedhold), and an attempt was made to run the spindle. Run M50 pallet change to reset the machine.
182	X Cable Fault	Cable from X-axis encoder does not have valid differential signals.
183	Y Cable Fault	Same as alarm 182.
184	Z Cable Fault	Same as alarm 182.
185	A Cable Fault	Same as alarm 182.
186	Spindle Not Turning	Status from spindle drive indicates it is not at speed when expected.
187	B Servo Error Too Large	Same as alarm 103.
188	B Servo Overload	Same as alarm 108.
189	B Motor Overheat	Same as alarm 135.
190	B Motor Z Fault	Encoder marker pulse count failure. This alarm usually indicates that the encoder has been damaged and encoder position data is unreliable. This can also be caused by loose encoder connectors.
191	B Limit Switch	Same as alarm 148.
192	B Axis Z Ch Missing	Z reference signal from encoder was not received as expected. Likely encoder contamination or parameter error.
193	B Axis Drive Fault	Same as alarm 161.
194	B Zero Ret Margin Too Small	This alarm will occur if the home/limit switches move or are misadjusted. This alarm indicates that the zero return position may not be consistent from one zero return to the next. The encoder Z channel signal must occur between 1/8 and 7/8 revolution of where the home switch releases. This will not turn the servos off but will stop the zero return operation.
195	B Cable Fault	Same as alarm 182.

196	Coolant Spigot Failure	Vertical mills only. Spigot failed to achieve commanded location after two (2) attempts.
197	100 Hours Unpaid Bill	Call your dealer.
198	Precharge Failure	During TSC operation, the precharge failed for greater than 0.1 seconds. It will shut off the feed, spindle and pump all at once. If received, check all air lines and the air supply pressure.
199	Negative RPM	A negative spindle RPM was sensed.
201	Parameter CRC Error	Parameters lost. Check for a low battery and low battery alarm.
202	Setting CRC Error	Settings lost. Check for a low battery and low battery alarm.
203	Lead Screw CRC Error	Lead screw compensation tables lost. Check for low battery and low battery alarm.
204	Offset CRC Error	Offsets lost. Check for a low battery and low battery alarm.
205	Programs CRC Error	Users program lost. Check for a low battery and low battery alarm.
206	Internal Program Error	Possible corrupted program. Save all programs to floppy disk, delete all, then reload. Check for a low battery and low battery alarm.
207	Queue Advance Error	Software Error; Call your dealer.
208	Queue Allocation Error	Software Error; Call your dealer.
209	Queue Cutter Comp Error	Software Error; Call your dealer.
210	Insufficient Memory	Not enough memory to store users program. Check the space available in the LIST PROG mode and possibly delete some programs.
211	Odd Prog Block	Possible corrupted program. Save all programs to floppy disk, delete all, then reload.
212	Program Integrity Error	Possible corrupted program. Save all programs to floppy disk, delete all, then reload. Check for a low battery and low battery alarm.
213	Program RAM CRC Error	Electronics fault; possibly with main processor.
214	No. of Programs Changed	Indicates that the number of programs disagrees with the internal variable that keeps count of the loaded programs. Possible processor board problem.
215	Free Memory PTR Changed	Indicates the amount of memory used by the programs counted in the changed system disagrees with the variable that points to free memory. Possible processor board problem.
216	EPROM Speed Failure	Possible processor board problem.

217	X Axis Phasing Error	Error occurred in phasing initialization of motor. This can be caused by a bad encoder, or a cabling error.
218	Y Axis Phasing Error	Same as alarm 217.
219	Z Axis Phasing Error	Same as alarm 217.
220	A Axis Phasing Error	Same as alarm 217.
221	B Axis Phasing Error	Same as alarm 217.
222	C Axis Phasing Error	Same as alarm 217.
223	Door Lock Failure	In machines equipped with safety interlocks, this alarm occurs when the control senses the door is open but it is locked. Check the door lock circuit.
224	X Transition Fault	Illegal transition of count pulses in X axis. This alarm usually indicates that the encoder has been damaged and encoder position data is unreliable. This can also be caused by loose connectors at the MOCON or MOTIF PCB.
225	Y Transition Fault	Same as alarm 224.
226	Z Transition Fault	Same as alarm 224.
227	A Transition Fault	Same as alarm 224.
228	B Transition Fault	Same as alarm 224.
229	C Transition Fault	Same as alarm 224.
231	Jog Handle Transition Fault	Illegal transition of count pulses in jog handle encoder. This alarm usually indicates that the encoder has been damaged and encoder position data is unreliable. This can also be caused by loose connectors.
232	Spindle Transition Fault	Illegal transition of count pulses in spindle encoder. This alarm usually indicates that the encoder has been damaged and encoder position data is unreliable. This can also be caused by loose connectors at the MOCON.
233	Jog Handle Cable Fault	Cable from jog handle encoder does not have valid differential signals.
234	Spindle Enc. Cable Fault	Cable from spindle encoder does not have valid differential signals.
235	Spindle Z Fault	Encoder marker pulse count failure. This alarm usually indicates that the encoder has been damaged and encoder position data is unreliable. This can also be caused by loose encoder connectors.
236	Spindle Motor Overload	This alarm is generated in machines equipped with a Haas vector drive, if the spindle motor becomes overloaded.

237	Spindle Following Error	The error between the commanded spindle speed and the actual speed has exceeded the maximum allowable (as set in Parameter 184).
238	Door Fault	The control failed to detect a low signal at the Door Switch when the door was commanded to close, or a high signal at the Door Switch when the door was commanded to open after the time allowed.
240	Empty Prog or No EOB	DNC program not found, or no end of program found.
241	Invalid Code	RS-232 load bad. Data was stored as comment. Check the program being received.
242	No End	Check input file for a number that has too many digits
243	Bad Number	Data entered is not a number.
244	Missing)	Comment must end with a ") ".
245	Unknown Code	Check input line or data from RS-232. This alarm can occur while editing data into a program or loading from RS-232. See MESSAGE PAGE for input line.
246	String Too Long	Input line is too long. The data entry line must be shortened.
247	Cursor Data Base Error	Software Error; Call your dealer.
248	Number Range Error	Number entry is out of range.
249	Prog Data Begins Odd	Possible corrupted program. Save all programs to floppy disk, delete all, then reload.
250	Program Data Error	Same as alarm 249.
251	Prog Data Struct Error	Same as alarm 249.
252	Memory Overflow	Same as alarm 249.
253	Electronics Overheat	The control box temperature has exceeded 135 degrees F. This can be caused by an electronics problem, high room temperature, or clogged air filter.
254	Spindle Overheat	The motor driving spindle is too hot. The spindle motor temperature sensor sensed a high temperature for greater than 1.5 seconds.
255	No Tool In Spindle	There is an invalid tool number in the spindle entry of the POCKET-TOOL table. The spindle entry cannot be 0 and must be listed in the body of the table. If there is no tool in the spindle, enter the number for an empty pocket into the spindle entry. If there is a tool number in the spindle entry, make sure that it is in the body of the table and that the pocket is empty.
257	Program Data Error	Possible corrupted program. Save all programs to floppy disk, delete all, then reload. Possible processor board problem.
258	Invalid DPRNT Format	Macro DPRNT statement not structured properly.

259	Language Version	Possible processor board problem.
260	Language CRC	Indicates FLASH memory has been corrupted or damaged. Possible processor board problem.
261	Rotary CRC Error	Rotary table saved parameters (used by Settings 30, 78) have a CRC error. Indicates a loss of memory - possible processor board problem.
262	Parameter CRC Missing	RS-232 or disk read of parameter had no CRC when loading from disk or RS-232.
263	Lead Screw CRC Missing	Lead screw compensation tables have no CRC when loading from disk or RS-232.
264	Rotary CRC Missing	Rotary table parameters have no CRC when loading from disk or RS-232
265	Macro Variable File CRC Error	Macro variable file has a CRC error. Indicates a loss of memory. Possible processor board problem.
266	Tool Changer Fault	The tool changer did not return to the proper starting position. Run Toolchanger Recovery.
267	Tool Door Out of Position	Horizontal mills only. Alarm will be generated during a tool change when parameter 278 TC DR SWITCH is set to 1, and the tool carousel air door and the tool carousel air door switch indicates that the door is open after commanded to be closed, or closed after it was commanded to be open. This alarm will most likely be caused by a stuck or broken switch.
268	Door open @ M95 Start	Generated whenever an M95 (Sleep Mode) is encountered and the door is open. The door must be closed in order to start sleep mode
269	TOOLARM FAULT	The toolchanger arm is not in position. Run Toolchanger Recovery.
270	C Servo Error Too Large	Same as alarm 103.
271	C Servo Overload	Same as alarm 108.
272	C Motor Overheat	Same as alarm 135.
273	C Motor Z Fault	Encoder marker pulse count failure. This alarm usually indicates that the encoder has been damaged and encoder position data is unreliable. This can also be caused by loose encoder connectors.
274	C Limit Switch	Same as alarm 145.
275	C Axis Z Ch Missing	Z reference signal from encoder was not received as expected. Likely encoder contamination or parameter error.
276	C Axis Drive Fault	Same as alarm 161.
277	C Zero Ret Margin Too Small	Same as alarm 165.

278	C Cable Fault	Same as alarm 182.
279	X Axis Linear Scale Z Fault	Encoder marker pulse count failure. This alarm usually indicates that the Z Fault encoder has been damaged and encoder position data is unreliable. This can also be caused by loose scale connectors.
280	Y Axis Linear Scale Z Fault	Encoder marker pulse count failure. This alarm usually indicates that the Z Fault encoder has been damaged and encoder position data is unreliable. This can also be caused by loose scale connectors.
281	Z Axis Linear Scale Z Fault	Encoder marker pulse count failure. This alarm usually indicates that the Z Fault encoder has been damaged and encoder position data is unreliable. This can also be caused by loose scale connectors.
282	A Axis Linear Scale Z Fault	Encoder marker pulse count failure. This alarm usually indicates that the Z Fault encoder has been damaged and encoder position data is unreliable. This can also be caused by loose encoder connectors.
283	X Axis Linear Scale Z CH Missing	Broken wires or encoder contamination. All servos are turned off. This Z Channel Missing can also be caused by loose scale connectors.
284	Y Axis Linear Scale Z CH Missing	Broken wires or encoder contamination. All servos are turned off. This Z Channel Missing can also be caused by loose encoder connectors.
285	Z Axis Linear Scale Z CH Missing	Broken wires or encoder contamination. All servos are turned off. This Z Channel Missing can also be caused by loose encoder connectors.
286	A Axis Linear Scale Z CH Missing	Broken wires or encoder contamination. All servos are turned off. This Z Channel Missing can also be caused by loose encoder connectors.
287	X Axis Linear Scale Cable Fault	Cable from X-axis scale does not have valid differential signals.
288	Y Axis Linear Scale Cable Fault	Cable from Y-axis scale does not have valid differential signals.
289	Z Axis Linear Scale Cable Fault	Cable from Z-axis scale does not have valid differential signals.
290	A Axis Linear Scale Cable Fault	Cable from A-axis scale does not have valid differential signals.
291	Low Air Volume/Pressure During ATC	An automatic tool change was not completed due to insufficient volume or pressure of compressed air. Check air supply line.
292	320V Power Supply Fault	Incomming line voltage is above maximum. The servo will be turned off and the spindle, tool changer, and coolant pump will stop. If this persists, an automatic shutdown will begin after the interval specified by parameter 296.

297	ATC Shuttle Overshoot	The ATC shuttle has failed to stop within the standby position window during a tool change. Check for a loose drive belt, damaged or over heated motor, sticking or damaged shuttle standby switch or shuttle mark switch, or burned ATC control board relay contacts. Use tool changer restore to recover the ATC, then resume normal operation.
298	ATC Double Arm Out of Position	The ATC double arm mark switch, CW position switch or CCW position switch is in an incorrect state. Check for sticking, misaligned or damaged switches, mechanism binding, damaged motor, or debris build up. Use tool changer restore to recover the ATC, then resume normal operation.
299	ATC Shuttle Out of Position	The ATC shuttle mark switch is in an incorrect state. Check for a sticking, misaligned, or damaged switch, mechanism binding, damaged motor, or debris build up. Use tool changer restore to recover the ATC, then resume normal operation.
302	Invalid R In G02 or G03	Check your geometry. **R** must be greater than or equal to half the distance from start to end within an accuracy of 0.0010 inches.
303	Invalid X, Y, or Z In G02 or G03	Check your geometry.
304	Invalid I, J, Or K In G02 Or G03	Check your geometry. Radius at start must match radius at end of arc within 0.001 inches (0.01 mm).
305	Invalid Q In Canned Cycle	**Q** in a canned cycle must be greater than zero.
306	Invalid I, J, K, or Q In Canned Cycle	**I**, **J**, **K,** and **Q** in a canned cycle must be greater than zero.
307	Subroutine Nesting Too Deep	Subprogram nesting is limited to nine levels. Simplify your program.
309	Exceeded Max Feed Rate	Use a lower feed rate.
310	Invalid G Code	**G** code not defined and is not a macro call.
311	Unknown Code	Program contained a line of code that is not understood.
312	Program End	End of subroutine reached before M99. Need an M99 to return from subroutine.
313	No P Code In M97, M98, or G65	In M97, M98 or G65 a subprogram number must be put in the P code. G47 must have P0 for text engraving or P1 for sequential serial numbers.
314	Subprogram or Macro Not In Memory	Check that a subroutine is in memory or that a macro is defined.
315	Invalid P Code In M97, M98 or M99	The P code must be the name of a program stored in memory without a decimal point for M98 and must be a valid N number for M99. G47 must have P0 for text engraving or P1 for sequential serial numbers.
316	X Over Travel Range	Commanded X-axis move would exceed the allowed machine range. Machine coordinates are in the negative direction. This condition indicates either an error in the user's program or improper offsets.
317	Y Over Travel Range	Same as alarm 316.

318	Z Over Travel Range	Same as alarm 316.
319	A Over Travel Range	Commanded A-axis move would exceed the allowed machine range. Machine coordinates are in the negative direction. This condition indicates either an error in the user's program or improper offsets.
320	No Feed Rate Specified	Must have a valid **F** code for interpolation functions.
321	Auto Off Alarm	Occurs in debug mode only.
322	Sub Prog Without M99	Add an M99 code to the end of program called as a subroutine.
324	Delay Time Range Error	**P** code in G04 is greater than or equal to 1000 seconds (over 999999 milliseconds).
325	Queue Full	Control problem; call your dealer.
326	G04 Without P Code	Put a **Pn.n** for seconds or a **Pn** for milliseconds.
327	No Loop For M Code Except M97, M98	**L** code not used here. Remove **L** Code.
328	Invalid Tool Number	Tool number must be between 1 and the value in Parameter 65.
329	Undefined M Code	That **M** code is not defined and is not a macro call.
330	Undefined Macro Call	Macro name O90nn not in memory. A macro call definition is in parameters and was accessed by user program but that macro was not loaded into memory.
331	Range Error	Number too large.
332	H and T Not Matched	This alarm is generated when Setting 15 is turned ON and an **H** code number in a running program does not match the tool number in the spindle. Correct the **Hn** codes, select the right tool, or turn off Setting 15.
333	X-Axis Disabled	Parameters have disabled this axis. Not normally possible in VF Series CNC Mill.
334	Y-Axis Disabled	Same as alarm 333.
335	Z-Axis Disabled	Same as alarm 333.
336	A-Axis Disabled	An attempt was made to program the A-axis while it was disabled (DISABLED bit in Parameter 43 set to 1) or invisible (INVIS AXIS bit in Parameter 43 set to 1).
337	GOTO or P line Not Found	Subprogram is not in memory, or **P** code is incorrect. P not found
338	Invalid IJK and XYZ in G02 or G03	There is a problem with circle definition; check your geometry.
339	Multiple Codes	Only one M, X, Y, Z, A, Q etc. allowed in any block, only one G codes in the same group.
340	Cutter Comp Begin With G02 or G03	Select cutter compensation earlier. Cutter comp. must begin on a linear move.

341	Cutter Comp End With G02 or G03	Disable cutter comp later.
342	Cutter Comp Path Too Small	Geometry not possible. Check your geometry.
343	Display Queue Record Full	Software error. Call your dealer.
344	Cutter Comp With G18 and G19	Cutter comp only allowed in XY plane (G17).
346	Illegal M Code	There was an M80 or M81 commanded. These commands are not allowed while Setting 51 DOOR HOLD OVERRIDE is OFF. Also check Setting 131 for Auto Door and Parameter 57 for DOOR STOP SP.
347	Invalid or Missing E Code	All 5-axis canned cycles require the depth to be specified using a positive E code.
348	Motion Not Allowed In G93 Mode	This alarm is generated if the mill is in Inverse Time Feed mode, and a G12, G13, G70, G71, G72, G150, or any Group 9 motion command is issued.
349	Prog Stop W/O Cancel Cutter Comp	An X/Y cutter compensation exit move is required before a program stop.
350	Cutter Comp Look Ahead Error	There are too many non-movement blocks between motions when cutter comp is being used. Remove some intervening blocks.
351	Invalid P Code	In a block with G103 (Block Lookahead Limit), a value between 0 and 15 must be used for the P code.
352	Aux Axis Power Off	Aux C, U, V, or W axis indicate servo off. Check auxiliary axes. Status from control was OFF.
353	Aux Axis No Home	A ZERO RET has not been done yet on the aux axes. Check auxiliary axes. Status from control was LOST.
354	Aux Axis Disconnected	Aux axes not responding. Check auxiliary axes and RS-232 connections.
355	Aux Axis Position	Mismatch between machine and aux axes position. Check aux axes and Mismatch interfaces. Make sure no manual inputs occur to aux axes.
356	Aux Axis Travel Limit	Aux axes are attempting to travel past their limits.
357	Aux Axis Disabled	Aux axes are disabled.
358	Multiple Aux Axis	Can only move one auxiliary axis at a time.
359	Invalid I, J, or K In G12 or G13	Check your geometry.
360	Tool Changer Disabled	Check Parameter 57. Not a normal condition for VF Series CNC Mill.
361	Gear Change Disabled	Check Parameter 57. Not a normal condition for VF Series CNC Mill.

362	Tool Usage Alarm RESET.	Tool life limit was reached. To continue, reset the usage count in the Current Commands display and press
363	Coolant Locked Off	Override is off and program tried to turn on coolant.
364	No Circ Interp Aux Axis	Only rapid or feed is allowed with aux axes.
367	Cutter Comp Interference	G01 cannot be done with tool size.
368	Groove Too Small	Tool too big to enter cut.
369	Tool Too Big	Use a smaller tool for cut.
370	Pocket Definition Error	Check geometry for G150.
371	Invalid I, J, K, OR Q	Check G150.
372	Tool Change In Canned Cycle	Tool change not allowed while canned cycle is active.
373	Invalid Code in DNC	A code found in a DNC program could not be interpreted because of DNC restrictions.
374	Missing XYZA in G31 or G36	G31 skip function requires an **X**, **Y**, **Z**, or **A** move.
375	Missing Z or H in G37	G37 automatic tool length measurement function requires **H** code, **Z** value, and tool offset enabled. **X**, **Y**, and **A** values not allowed.
376	No Cutter Comp In Skip	Skip G31 and G37 functions cannot be used with cutter compensation.
377	No Skip in Graph/Sim	Graphics mode cannot simulate skip function.
378	Skip Signal Found	Skip signal check code was included but skip was found when it was not expected.
379	Skip Signal Not Found	Skip signal check code was included but skip was not found when it was expected.
380	X, Y, A, or G49 Not Allowed in G37	G37 may only specify Z-axis and must have tool offset defined.
381	G43 or G44 Not Allowed in G36 or G136	Auto work offset probing must be done without tool offset.
382	D Code Required in G35	A **Dnnn** code is required in G35 in order to store the measured tool diameter.
383	Inch Is Not Selected	G20 was specified but settings have selected metric input.
384	Metric Is Not Selected	G21 was specified but settings have selected inches.
385	Invalid L, P, or R	G10 was used to change offsets but **L**, **P**, or **R** code is missing or Code In G10 invalid.
386	Invalid Address Format	An address A...Z was used improperly.
387	Cutter Comp Not Allowed With G103	If block buffering has been limited, Cutter comp cannot be used.

388	Cutter Comp Not Allowed With G10	Coordinates cannot be altered while cutter comp is active. Move G10 outside of cutter comp enablement.
389	G17, G18, G19 Illegal in G68	Planes of rotation cannot be changed while rotation is enabled.
390	No Spindle Speed	**S** code has not been encountered. Add an **S** code.
391	Feature Disabled	An attempt was made to use a control feature not enabled by a parameter bit. Set the parameter bit to 1.
392	B Axis Disabled	An attempt was made to program the B-axis while it was disabled (DISABLED bit in Parameter 151 set to 1) or invisible (INVIS AXIS bit in Parameter 151 set to 1).
393	Invalid Motion In G74 or G84	Rigid Tapping can only be in the Z minus G74 or G84 direction. Make sure that the distance from the initial position to the commanded Z depth is in the minus direction.
394	B Over Travel Range	Same as alarm 316.
395	No G107 Rotary Axis	A rotary axis must be specified in order to perform cylindrical mapping Specified (G107).
396	Invalid G107 Rotary Axis Specified	The rotary axis specified is not a valid axis, or has been disabled.
397	Aux Axis In G93 Block	This alarm is generated if a G-code block specifies any form of interpolated motion that involves BOTH one or more of the regular axes (X, Y, Z, A, B, etc...) AND one or more of the auxiliary axes (C, U, V, W).
398	Aux Axis Servo Off	Aux. axis servo shut off due to a fault.
400	Skip Signal During Restart	A skip signal G-code (G31, G35, G36, G37, G136) was found during program restart.
403	RS-232 Too Many Progs	Cannot have more than 200 programs in memory.
404	RS-232 No Program Name	Need name in programs when receiving ALL; otherwise has no way to store them.
405	RS-232 Illegal Prog Name	Check files being loaded. Program name must be **Onnnnn** and must be at beginning of a block.
406	RS-232 Missing Code	A receive found bad data. Check your program. The program will be stored but the bad data is turned into a comment.
407	RS-232 Invalid Code	Check your program. The program will be stored but the bad data is turned into a comment.
408	RS-232 Number Range Error	Check your program. The program will be stored but the bad data is turned into a comment.
409	RS-232 Invalid N Code	Bad Parameter or Setting data. User was loading settings or parameters and something was wrong with the data.

410	RS-232 Invalid V Code	Bad parameter or setting data. User was loading settings or parameters and something was wrong with the data.
411	RS-232 Empty Program	Check your program. Between **%** and **%** there was no program found.
412	RS-232 Unexpected End of Input	Check Your Program. An ASCII EOF code was found in the input data before program receive was complete. This is a decimal code 26.
413	RS-232 Load Insufficient Memory	Program received does not fit. Check the space available in the LIST PROG mode and possibly delete some programs.
414	RS-232 Buffer Overflow	Data sent too fast to CNC. This alarm is not normally possible as this control can keep up with even 115200 bits per second. Computer sending data may not respond to X-OFF
415	RS-232 Overrun	Data sent too fast to CNC. This alarm is not normally possible as this control can keep up with even 115200 bits per second.
416	RS-232 Parity Error	Data received by CNC has bad parity. Check parity settings, number of data bits and speed. Also check your wiring.
417	RS-232 Framing Error	Data received was garbled and proper framing bits were not found. One or more characters of the data will be lost. Check parity settings, number of data bits and speed.
418	RS-232 Break	Break condition while receiving. The sending device set the line to a break condition. This might also be caused by a simple break in the cable.
419	Invalid Function For DNC	A code found on input of a DNC program could not be interpreted.
420	Program Number Mismatch	The **O** code in the program being loaded did not match the **O** code entered at the keyboard. Warning only.
421	No Valid Pockets	Pocket Table is full of dashes.
422	Pocket Table Error	If the machine is equipped with a 50 taper spindle there must be 2 dashes between L's (large tools). L's must be surrounded by dashes.
429	Disk Dir Insufficient Memory	Disk memory was almost full when an attempt was made to read the disk directory.
430	Disk Unexpected End of Input	Check your program. An ASCII EOF code was found in the input data before program receive was complete. This is a decimal code 26.
431	Disk No Prog Name	Need name in programs when receiving ALL; otherwise has no way to store them.
432	Disk Illegal Prog Name	Check files being loaded. Program must be **Onnnnn** and must be at the beginning of a block.
433	Disk Empty Prog Name	Check your program. Between % and % there was no program found.

434	Disk Load Insufficient Memory	Program received does not fit. Check the space available in the LIST PROG mode and possibly delete some programs.
435	Disk Abort	Could not read disk.
436	Disk File Not Found	Could not find disk file.
501	Too Many Assignments In One Block	Only one assignment macro assignment is allowed per block. Divide block into multiple blocks.
502	[Or = Not First Term In Expressn	An expression element was found where it was not preceded by "[" or "=", that start expressions.
503	Illegal Macro Variable Reference	A macro variable number was used that is not supported by this control, use another variable.
504	Unbalanced Brackets In Expression	Unbalanced brackets, "[" or "]", were found in an expression. Add or delete a bracket.
505	Value Stack Error	The macro expression value stack pointer is in error. Call your dealer.
506	Operand Stack Error	The macro expression operand stack pointer is in error. Call your dealer.
507	Too Few Operands On Stack	An expression operand found too few operands on the expression stack. Call your dealer.
508	Division By Zero	A division in a macro expression attempted to divide by zero. Re-configure expression.
509	Illegal Macro Variable Use	See "MACROS" section for valid variables.
510	Illegal Operator or Function Use	See "MACROS" section for valid operators.
511	Unbalanced Right Brackets	Number of right brackets not equal to the number of left brackets.
512	Illegal Assignment Use	Attempted to write to a read-only macro variable.
513	Var. Ref. Not Allowed With N Or O	Alphabetic addresses N and O cannot be combined with macro variables. Do not declare N#1, etc.
514	Illegal Macro Address Reference	A macro variable was used incorrectly with an alpha address. Same as 513.
515	Too Many Conditionals In a Block	Only one conditional expression is allowed in any WHILE or IF-THEN block.
516	Illegal Conditional Or No Then	A conditional expression was found outside of an IF-THEN, WHILE, or M99 block.
517	Exprsn. Not Allowed With N Or O	A macro expression cannot be linked to N or O. Do not declare O[#1], etc.
518	Illegal Macro Exprsn Reference	An alpha address with expression, such as A[#1+#2], evaluated incorrectly. Same as 517.

519	Term Expected	In the evaluation of a macro expression an operand was expected and not found.
520	Operator Expected	In the evaluation of a macro expression an operator was expected and not found.
521	Illegal Functional Parameter	An illegal value was passed to a function, such as SQRT[or ASIN[.
522	Illegal Assignment Var Or Value	A variable was referenced for writing. The variable referenced is read only.
523	Conditional Reqd Prior To THEN	THEN was encountered and a conditional statement was not processed in the same block.
524	END Found With No Matching DO	An END was encountered without encountering a previous matching DO. DO-END numbers must agree.
525	Var. Ref. Illegal During Movement	Variable cannot be read during axis movement.
526	Command Found On DO/END Line	A G-code command was found on a WHILE-DO or END macro block. Move the G-code to a separate block.
527	= Not Expected Or THEN Required	Only one Assignment is allowed per block, or a THEN statement is missing.
528	Parameter Precedes G65	On G65 lines all parameters must follow the G65 G-code. Place parameters after G65.
529	Illegal G65 Parameter	The addresses G, L, N, O, and P cannot be used to pass parameters.
530	Too Many I, J, or K's In G65	Only 10 occurrences of I, J, or K can occur in a G65 subroutine call. Reduce the I, J, or K count.
531	Macro Nesting Too Deep	Only four levels of macro nesting can occur. Reduce the amount of nested G65 calls.
532	Unknown Code In Pocket Pattern	Macro syntax is not allowed in a pocket pattern subroutine.
533	Macro Variable Undefined	A conditional expression evaluated to an UNDEFINED value, i.e. #0. Return True or False.
534	DO Or END Already In Use	Multiple use of a DO that has not been closed by and END in the same subroutine. Use another DO number.
535	Illegal DPRNT Statement	A DPRNT statement has been formatted improperly, or DPRNT does not begin block.
536	Command Found On DPRNT Line	A G-code was included on a DPRNT block. Make two separate blocks.
537	RS-232 Abort On DPRNT	While a DPRNT statement was executing, the RS-232 communications failed.
538	Matching END Not Found	A WHILE-DO statement does not contain a matching END statement. Add the proper END statement.

539	Illegal Goto	Expression after GOTO not valid.
540	Macro Syntax Not Allowed	A section of code was interpreted by the control where macro syntax is not permitted.
541	Macro Alarm	This alarm was generated by a macro command in a program.
600	U Over Travel Range	Same as alarm 316.
601	V Over Travel Range	Same as alarm 316.
602	W Over Travel Range	Same as alarm 316.
603	U Limit Switch	Same as alarm 145.
604	V Limit Switch	Same as alarm 145.
605	W Limit Switch	Same as alarm 145.
609	U Servo Error Too Large	Same as alarm 103.
610	V Servo Error Too Large	Same as alarm 103.
611	W Servo Error Too Large	Same as alarm 103.
612	U Servo Overload	Same as alarm 108.
613	Command Not Allowed In Cutter Comp.	A command (m96, for example) in the highlighted block cannot be executed while cutter comp. Is invoked.
614	V Servo Overload	Same as alarm 108.
615	W Servo Overload	Same as alarm 108.
616	U Motor Over Heat	Same as alarm 135.
617	V Motor Over Heat	Same as alarm 135.
618	W Motor Over Heat	Same as alarm 135.
619	U Motor Z Fault	Same as alarm 139.
620	C Axis Disabled	Parameters have disabled this axis
621	C Over Travel Range	C-axis will exceed stored limits. This is a parameter in negative direction and is machine zero in the positive direction. This will only occur during the operation of a user's program.

The following alarms apply only to the Vertical Mills with a sidemount tool changer:

622	Tool Arm Fault	This alarm supports the side mount tool changers. It is generated if the arm is not at the Origin position, or the arm motor is already on when a tool change process is started.

623 Side Mount Carousel Error — This alarm supports the side mount tool changers. It is generated if the carousel motor is still on when the tool pocket is unlocked and lowered prior to a tool change.

624 Invalid Tool — This alarm is generated by a side mount tool changer if the tool specified by the G-code program is not found in the POCKET-TOOL table, or the searching pocket is out of range.

625 Carousel Positioning Eror — This alarm is generated by a side mount tool changer if conditions are not correct when:
• The carousel or tool arm was started and one or more of the following incorrect conditions existed:
The carousel or arm motor already on, arm not at Origin, tool carousel not at TC mark.
• The tool carousel was in motion and Tool One Mark was detected but the current pocket facing the spindle was not at pocket one, or the current pocket was at pocket one but Tool One Mark was not detected.

626 Tool Pocket Slide Error — This alarm is generated by a side mount tool changer. It is generated if the tool pocket has not moved to its commanded position (and settled) within the total time allowed by parameters 306 and 62.

627 ATC Arm Position Timeout — This alarm supports the side mount tool changers. It is generated if the tool arm has not moved after the allowed time or has not stopped after the allowed time. Refer to Parameter 309 MOTOR COAST TIME.

628 ATC ARM Positioning Error — This alarm supports the side mount tool changers. It is generated if:
• The arm was being moved from the ORIGIN position to the CLAMP position and it coasted past the MOTOR STOP point or could not get to the CLAMP point.
• The arm was being moved from the CLAMP position to the UNCLAMP position and it coasted past the MOTOR STOP point or could not get to the UNCLAMP point (same physical point as CLAMP).
• The arm was being moved back to the ORIGIN position and it coasted past the MOTOR STOP point or could not get to the ORIGIN point.

629 Carousel Position Timeout — This alarm supports the side mount tool changers. It is generated if the tool carousel has not moved after the allowed time or has not stopped after the allowed time specified by parameter 60 TURRET START DELAY and parameter 61 TURRET STOP DELAY, respectively.

630 APC-Door SW Fault-Switch Not Equal To Solenoid
The APC Door Switch indicates the door is open but the solenoid shows the door has been commanded to close. Either the door failed to close and is stuck or the switch itself is broken or stuck. Also, the door switch wiring may have a fault. Check switch then cable.

631	APC-Pallet Not Clamped Or Home	DO NOT ATTEMPT TO MOVE X OR Y AXES OR MILL UNTIL APC IS IN A SAFE CONDITION. CAUTION- The APC is not in a safe operating condition. One pallet is at home but the other pallet is neither clamped nor at home. Locate the unclamped pallet, go to the lube/air panel at rear of mill and continuously press both white buttons in center of solenoid air valves while an assistant pulls the pallet off the receiver.
632	APC-Unclamp Error	The pallet did not unclamp in the amount of time allowed. This can be caused by a bad air solenoid, a blocked or kinked air line, or a mechanical problem.
633	APC-Clamp Error	The pallet did not clamp in the amount of time allowed by parameter 316. This alarm is most likely caused by the VMC table not being in the correct position. This can be adjusted using the setting for the X position (#121, #125) as described in the 'Installation' section. If the pallet is in the correct position but not clamped, push the pallet against the hard stop and run M18. If the pallet is clamped, but not correctly, run an M17 to unclamp, push the pallet to the correct position, and run an M18 to clamp the pallet. Less common causes could be that the slip clutch is slipping, the motor is at fault, or an air line is blocked or kinked.
634	APC-Mislocated Pallet	A pallet is not in the proper place on the APC. The pallet must be pushed back against the hard stop by hand.
635	APC-Pal Num Conflict Rec & Ch	Pallet Number Conflict Receiver and Pallet Changer: The pallet number in memory does not agree with the actual pallet in use. Run an M50 to reset this variable.
636	APC-Switch Missed Pal 1	Pallet #1 did not return from the receiver to the APC in the allowed time. This can be caused by the chain switch block missing the limit switch, or from another mechanical problem, such as clutch slippage.
637	APC-Switch Missed Pal 2	Pallet #2 did not return from the receiver to the APC in the allowed time. This can be caused by the chain switch block missing the limit switch, or from another mechanical problem, such as clutch slippage.
638	APC- Door Not Open	The automatic door did not open (in the allowable time), or may have fallen during an APC function. This can be caused by a bad air solenoid, a blocked or kinked air line, or a mechanical problem.
639	APC- Door Not Closed	The automatic door did not close (in the allowable time), when necessary after an APC function has been performed. This can be caused by a bad air solenoid, a blocked or kinked air line, or a mechanical problem.
640	APC- Missing Pallet @ Rec	Pallet change sequence was halted because receiver switch was not activated. Pallet is either unclamped or not on the receiver. Ensure the pallet is correctly located on the receiver (against the hard stop) then run M18 to clamp the pallet.

641 APC-Unknown Chain Location — Neither chain location switch is tripped, so the control cannot locate the chain position. This can occur if a pallet change is interrupted for any reason, such as an alarm or an E-stop. To correct this problem, the pallets and chain must be moved back into a recognized position, such as both pallets home or one pallet home and one on the receiver. The chain position adjustment tool must be used to rotate the chain into position. The pallets must be pushed into place by hand.

CAUTION! The pallets weigh 300 lbs. each, and can cause serious injury. Use extreme caution when moving them.

642 APC- Incorrect Chain Location — Chain not in position to load or unload pallets when necessary. To correct this, the mislocated pallet must be moved back into the proper position by hand.

CAUTION! The pallets weigh 300 lbs. each, and can cause serious injury. Use extreme caution when moving them.

643 RP-Index Station Unlocked (Verify Lever Up) Or Front Doors Open
The index station is not in the correct orientation for a pallet change or the front doors are open. Check whether the handle is in the fully up position, close the front doors, check the function of the front door switches.

644 RP-Pallet Changer Will Not Rise, Verify Air Supply To The Lift Cylinder
The pallet did not begin to lift within a reasonable time after command, or did not complete lifting within a reasonable time. Verify air supply to the pallet changer valve assembly, verify proper adjustment of the lift cylinder regulator (40 PSI), verify the function of the lift cylinder air valve and solenoid, verify the operation of the lift cylinder position sense switches.

645 RP-Pallet Jammed, Check For Obstruction
The pallet changer has not rotated away from its original position (CW/CCW) in a reasonable time, or has not achieved its final position (CW/CCW) in a reasonable time, or has not been permitted to lower to the fully DOWN position

646 RP-CW/CCW Switch Illegal Condition — Both of the switches that sense the rotational position of the pallet changer are indicating the impossible condition that the pallet changer is rotated CW and CCW at the same time. Only one switch should be tripped at a time. Check the function of the rotational sense switches, their connectors, and their wiring.

647 RP-Up/Down Switch Illegal Condition, Lift Cylinder
The switches that sense the lifted and lowered position of the pallet changer are indicating the impossible condition that the pallet changer is both lifted and lowered at the same time. Check the function of the lift and lower sense switches, check the adjustment of the top switch, check both switch electrical connections and their wiring.

648	RP-Main Drawbar Locked In Pallet Clamped Position	The drawbar has not tripped the unclamp sense switch in a reasonable amount of time. Check to see that the motor is plugged in at the connector panel in the rear of the machine and at the motor through the access panel; check the function of the main drawbar motor (does it turn or try to turn); check the condition of the drive belt, check power supply to the motor; check the relays that supply power to the motor, check the condition of the current limiting resistors.
649	RP-Main Drawbar Locked In Pallet Unclamped Position	The drawbar has not come off the unclamp sense switch in a reasonable amount of time. Check to see that the motor is plugged in at the connector panel in the rear of the machine and at the motor through the access panel; check the function of the main drawbar motor (does it turn or try to turn); check the condition of the drive belt, check power supply to the motor; check the relays that supply power to the motor, check the condition of the current limiting resistors.
650	RP-Pallet Not Engaging RP Main Drawbar	This alarm occurs when the pullstud cannot properly engage the Ball Pull Collet. If this happens, the Ball Pull Collet has been pushed down into the Collet Housing and pallet clamping is not possible. Check alignment of the 'H'-frame with the adjustable Hard Stops. Check the Pallet Pull Studs and the RP-Main Drawbar Ball Collet for damage or obstruction. Remove any debris that may have entered the Collet. Check that the six balls in the collet float within the holes.
651	Z Axis Is Not Zeroed	The Z-axis has not been zeroed. In order to continue the Toolchanger Recovery the Z-axis must be zeroed. Once the Z-axis has been zeroed, continue with the Toolchanger Recovery.
652	U ZERO RET MARGIN TOO SMALL	Same as alarm 168.
653	V ZERO RET MARGIN TOO SMALL	Same as alarm 168.
654	W ZERO RET MARGIN TOO SMALL	Same as alarm 168.
655	U CABLE FAULT	Same as alarm 182.
656	V CABLE FAULT	Same as alarm 182.
657	W CABLE FAULT	Same as alarm 182.
658	U PHASING ERROR	Same as alarm 217.
659	V PHASING ERROR	Same as alarm 217.
660	W PHASING ERROR	Same as alarm 217.
661	U TRANSITION FAULT	Same as alarm 224.
662	V TRANSITION FAULT	Same as alarm 224.
663	W TRANSITION FAULT	Same as alarm 224.

664	U AXIS DISABLED	Same as alarm 336.
665	V AXIS DISABLED	Same as alarm 336.
666	W AXIS DISABLED	Same as alarm 336.
667	U AXIS LINEAR SCALE Z FAULT	Same as alarm 279.
668	V AXIS LINEAR SCALE Z FAULT	Same as alarm 279.
669	W AXIS LINEAR SCALE Z FAULT	Same as alarm 279.
670	TT OVER TRAVEL RANGE	Same as alarm 316.
671	TT LIMIT SWITCH	Same as alarm 145.
673	TT SERVO ERROR TOO LARGE	Same as alarm 103.
674	TT SERVO OVERLOAD	Same as alarm 108.
675	TT MOTOR OVER HEAT	Same as alarm 135.
676	TT MOTOR Z FAULT	Same as alarm 273.
677	TT AXIS Z CH MISSING	Same as alarm 275.
678	TT AXIS DRIVE FAULT	Same as alarm 161.
679	TT ZERO RET MARGIN TOO SMALL	Same as alarm 168.
680	TT CABLE FAULT	Same as alarm 182.
681	TT PHASING ERROR	Same as alarm 217.
682	TT TRANSITION FAULT	Same as alarm 224.
683	TT AXIS DISABLED	Same as alarm 336.
684	TT AXIS LINEAR SCALE Z FAULT	Same as alarm 279.
685	V MOTOR Z FAULT	Same as alarm 273.
686	W MOTOR Z FAULT	Same as alarm 273.
687	U MOTOR Z FAULT	Same as alarm 273.
688	U AXIS Z CH MISSING	Same as alarm 275.
689	V AXIS Z CH MISSING	Same as alarm 275.
690	W AXIS Z CH MISSING	Same as alarm 275.
691	U AXIS DRIVE FAULT	Same as alarm 161.

692	V AXIS DRIVE FAULT	Same as alarm 161.
693	W AXIS DRIVE FAULT	Same as alarm 161.
694	ATC SWITCH FAULT	Conflicting switch states detected, such as shuttle at spindle and shuttle at chain simultaneously. Check for damaged or sticking switches, damaged wiring, or debris build up.
695	ATC AIR CYLINDER TIME OUT	The ATC double arm did not complete extending or retracting within the time allowed by Parameter 61. Check for proper spindle orientation, correct alignment of the double arm with the chain or spindle, adequate air supply, mechanism binding, air leakage, excessive tool weight, debris build up, adequate chain tension, and correct chain guide strip adjustment. Use tool changer restore to recover the ATC, then resume normal operation.
696	ATC MOTOR TIME OUT	The ATC shuttle motor or double arm motor failed to complete the commanded movement within the time allowed by Parameter 60. Check, for mechanism binding, correct motor and switch operation, damaged ATC control board relays, damaged electrical wiring, or blown fuses on the ATC control board. Use tool changer restore to recover the ATC, then resume normal operation.
697	ATC MOTOR FAULT	The ATC shuttle motor or double arm motor was on unexpectedly. Use tool changer restore to recover the ATC, then resume normal operation.
698	ATC PARAMETER ERROR	The ATC type cannot be determined. Check Parameter 278, bit 10, HS3 HYD TC, or Parameter 209, bit 2, CHAIN TC, as appropriate for the installed tool changer.
699	ATC CHAIN OUT OF POSITION	An incorrect tool change position was detected during a tool change. Use tool changer restore to recover the ATC, then resume normal operation.
900	Par No xxx Has Changed. Old Value Was xxx.	When the operator alters the value of a parameter, alarm 900 will be added to the alarm history. When the alarm history is displayed, the operator will be able to see the parameter number and the old value along with the date and time the change was made. Note that this is not a resetable alarm, it is for information purposes only.
901	Parameters Have Been Loaded By Disk	When a file has been loaded from floppy disk, alarm 901 will be added to the alarm history along with the date and time. Note that this is not a resetable alarm, it is for information purposes only.
902	Parameters Have Been Loaded By RS-232	When a file has been loaded from RS-232, alarm 902 will be added to the alarm history along with the date and time. Note that this is not a resetable alarm, it is for information purposes only.
903	CNC Machine Powered Up	When the machine is powered up, alarm 903 will be added to the alarm history along with the date and time. Note that this is not a resetable alarm, it is for information purposes only.

904	TOOL CHANGER AXIS VISIBLE	The tool changer axis must be invisible for tool change operations with the HS tool changers. Set Parameter 462, bit 18, INVIS AXIS to 1. This will make the tool changer axis invisible and tool changes will be allowed.

NOTE: Alarms 1000-1999 are user defined by macro programs.

The following alarms only apply to horizontal mills with a pallet changer:

1001	Index St Unlocked	The index station is not in the correct orientation for a pallet change.
1002	Pallet Locked Down	The pallet did not begin to lift within two seconds of command, or did not complete lifting within six seconds.
1003	Pallets Jammed	The lift cylinder has not moved from the clockwise position within three seconds, or has not reached the counter clockwise position within twelve seconds.
1004	CW/CCW Switch Illegal Condition	One or both of the switches that sense the rotational position of the pallet changer has failed it's self-test.
1007	Up/Down Switch Illegal Condition	One or both of the switches that sense the lifted/lowered position of the pallet changer has failed its self-test.
1008	Main Drawbar Locked In Up Position	The main drawbar will not disengage from the pallet nut.
1009	Main Drawbar Locked In Down Position	The main drawbar will not move upward to the pallet nut.
1010	Main Drawbar Switch Illegal Condition	One or both of the switches that sense the up/down position of the main drawbar has failed it's self-test.
1011	Main Drawbar Unclamp Timeout	The main drawbar has disengaged from the pallet nut, but did not reach the main drawbar down switch.
1012	Main Drawbar Clamp Timeout	The main drawbar has begun to travel upward, but did not reach the fully raised position within 15 seconds.

3. MECHANICAL SERVICE

RECOMMENDED TORQUE VALUES FOR MACHINE FASTENERS

The following chart should be used as a reference guide for torquing machine fasteners where specified.

DIAMETER	***TORQUE***
1/4 - 20	15 ft. lb.
5/16 - 18	30 ft. lb.
3/8 - 16	50 ft. lb.
M10 - 100	50 ft. lb.
M12 - 65	100 ft. lb.
1/2 - 13	80 ft. lb.
3/4 - 10	275 ft. lb.
1 - 8	450 ft. lb.

3.1 Way Covers

Upper Y-Axis Way Cover

REMOVAL-

1. Handle jog the X-axis to center of travel. Handle jog the Y-axis down fully.

2. POWER OFF the machine.

3. Remove the left and right intermediate shields (five SHCS each) at the top of the Y-axis (behind the tool changer cover).

4. Remove the four SHCS that attach the upper way cover to the vertical guides.

5. Remove the seven SHCS that the attach the way cover to the spindle head.

6. Lift the bottom of the way cover to collapse it. Lift the cover up until it is above the top of the column. Pull up on one side of the way cover and slip it out from between the vertical guide and the tool changer.

INSTALLATION-

1. To install a new upper Y-axis way cover, strap both ends with nylon tie wraps (through the holes in the end mounting plates that are closest to the leaves of the cover) while the cover is fully collapsed. Ensure that the slots are aligned.

2. Carefully install cover into Y-axis vertical guides without damaging cover or guides. Once the cover is in place, cut and remove the tie-wraps.

3. Install the four SHCS at the top of the way cover. Slide the bottom of the way cover up and down to ensure it moves freely. Also, pull each leaf of the cover gently away from the column to be certain the tabs are in the guide slots.

4. Install the left and right intermediate shields at the top of the way cover with five SHCS each.

5. Install the bottom seven SHCS and tighten evenly.

Lower Y-Axis Way Cover

REMOVAL-

1. Zero return all axes.

2. POWER OFF the machine.

3. Remove the seven SHCS that attach the top of the lower Y-axis way cover to the spindle head casting. Collapse the way cover down fully.

4. Remove the X-axis chip guard (seven SHCS) that is directly below the lower Y-axis way cover.

5. Remove the four SHCS that attach the bottom of the way cover to the left and right vertical guides.

6. Remove the way cover from the bottom.

INSTALLATION-

1. To install a new lower Y-axis way cover, strap both ends with nylon tie wraps (through the holes in the end mounting plates that are closest to the leaves of the cover) while the cover is fully collapsed. Ensure that the slots are aligned.

2. Carefully install cover into Y-axis vertical guides without damaging cover or guides. Once the cover is in place, cut and remove the tie-wraps.

3. Install the four SHCS at the bottom of the way cover, and tighten evenly.

4. Attach the top of the way cover to the spindle head casting with seven SHCS. Slide the bottom of the way cover up and down to ensure it moves freely. Also, pull each leaf of the cover gently away from the column to be certain the tabs are in the guide slots.

5. Replace the X-axis chip guard and attach with seven SHCS.

3.2 Tool Release Piston (TRP)

Tool Release Piston Replacement

TOOLS REQUIRED
- **2.5" diameter, 2.5' long steel tube**
- **Magnetic base indicators (2)**
- **TRP alignment tool, TSC (T-1519)**

REMOVAL-

NOTE: Newer machines will have a hex-carbide coolant tip that has a left-hand thread.

1. Remove the rear enclosure panel (seven SHCS).

2. **IMPORTANT!** Jog the X-axis all the way to the operator's side of the machine. Place the steel tube through the 3" diameter holes (second from bottom) on either side of the column. Ensure the tube passes completely through the column and extends out an equal distance from each side. This tube will prevent the spindle head from falling in the event of an accident.

3. Jog the Y-axis down until the bottom of the motor is approximately 1/2" above the steel tube.

4. If machine is equipped with Through the Spindle Coolant (TSC), place a tool holder in the spindle.

5. POWER OFF the machine.

6. Disconnect the main air supply at the lube/air panel.

7. Remove the seven SHCS attaching the lower Y-axis way cover to the spindle head casting, and collapse it downward. It is easiest to reach the TRP from the front side of the machine.

8. Disconnect the air lines at the tool unclamp solenoid and precharge line. If machine is equipped with TSC, also remove the precharge air hose and coolant hose from the tool release spring.

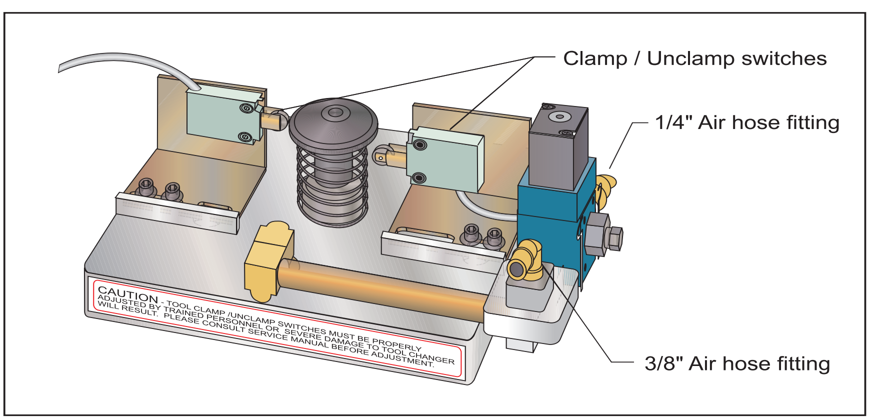


Figure 3.2-1. TRP assembly.

9. Disconnect clamp/unclamp cables (quick disconnect and solenoid wiring located on the solenoid bracket on top of the transmission).

10. Remove the two SHCS and two HHB holding the tool release piston assembly to the head casting.

11. Remove the entire tool release piston assembly.

NOTE: Step 11 applies only to machines with TSC.

12. Remove the seal housing from the tool release piston.

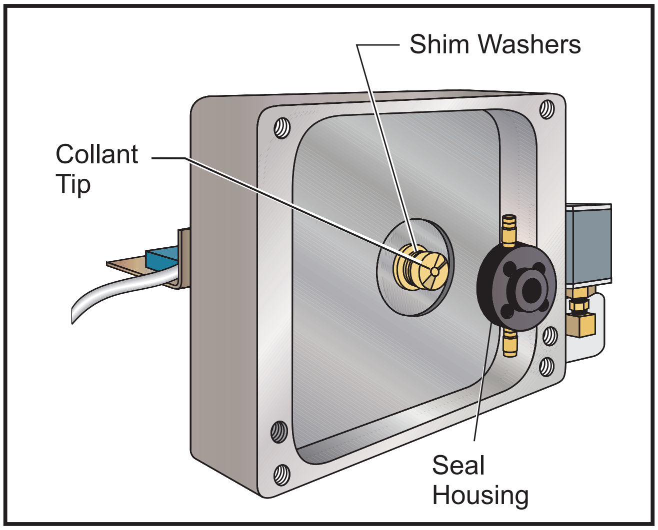


Figure 3.2-2. TSC tool release piston.

INSTALLATION-

NOTE: Newer machines will have a hex-carbide coolant tip that has a left-hand thread.

1. Ensure spindle, drawbar and spindle drive belt are properly in place.

2. Install the seal housing on the tool release piston (use Loctite on the screws). Connect the 5/32" drain line to the lower connector of the seal housing. The drain line connector should point toward the bottom of the machine. Connect the purge line to the top connector of the seal housing.

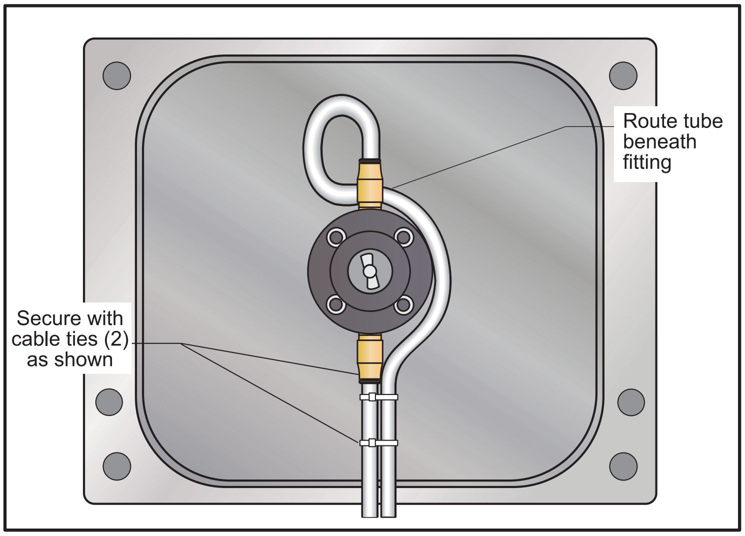


Figure 3.2-3. Purge line routing.

NOTE: The drain line must run straight through the cable tie loop on the transmission, and must not interfere with the pulley or belts.

3. Loosely reinstall the tool release piston with two SHCS at the bottom and two HHB (with spacer) at the top.

4. Reconnect clamp/unclamp cables (quick disconnect and solenoid wiring located on the solenoid bracket).

5. Reconnect air lines at the tool unclamp solenoid and precharge line.

6. If machine is equipped with TSC, install the coolant hose (3/8" diameter x 27" long plastic tubing).

7. Refer to the “Tool Clamp/Unclamp Switch Adjustment” section to verify the tool clamp/unclamp switch has been properly adjusted and the drawbar height properly set.

NOTE: Steps 7 through 13 apply only to machines with TSC. Steps 9-11 apply only to those machines that have a modified TSC Housing, starting with machine serial number 50250.

8. Allow the bore of the seal housing to rest on the drawbar. Tighten the TRP mounting screws slightly. If you are working on a TSC system without a modified housing go to Step 12.

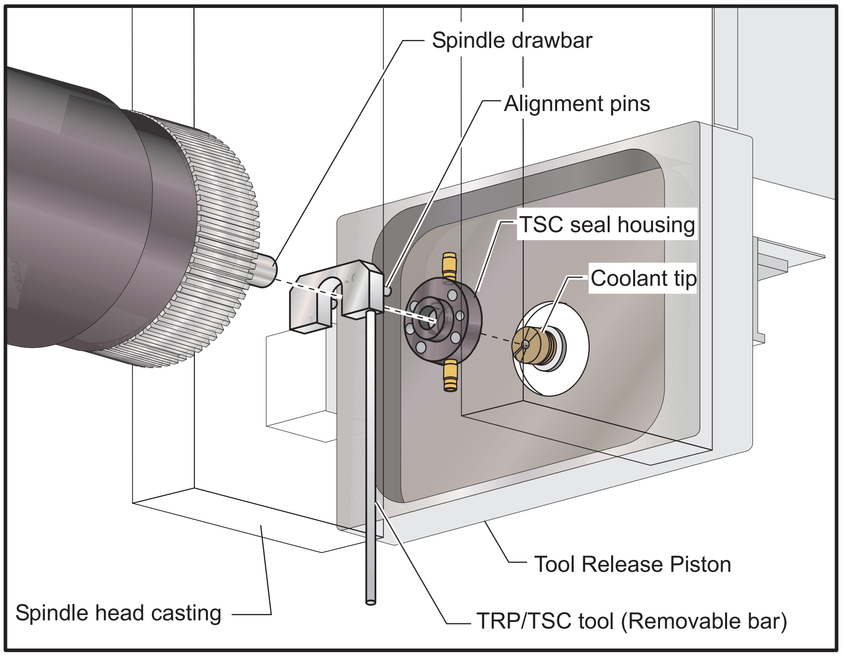


Figure 3.2-4. TSC Alignment Tool.

Steps 9-11 apply to machines with modified TSC housing. If not applicable, skip to Step 12.

9. Place the alignment tool (T-1519) on top of the drawbar with the pins facing the TRP.

10. Lift the TRP assembly slightly and push the pins into the TSC Housing.

11. Finish tightening the four SHCS that mount the TRP to the Spindlehead. Go to step 14.

12. Jog the spindle head upward. Place two magnetic bases on the column below the TRP. Set their indicators on opposite ends of the bottom face of the TRP housing. Set both indicator dials to zero.

13. Carefully move the TRP upward a distance of 0.005 on each indicator.

14. Tighten down the two mounting SHCS and two HHB alternately until all are completely tight.

15. Slide the lower Y-axis way cover up into place and tighten the seven SHCS.

16. **IMPORTANT!** Remove the steel tube from the column.

CAUTION! This step must be followed or the machine will be seriously damaged.

17. Replace the rear enclosure panel with seven SHCS.

Setting Pre-Charge

CAUTION! Do not perform this procedure on machines equipped with Through the Spindle Coolant (TSC). It will damage the machine. Refer to the "TSC Adjustments" section.

1. POWER ON the machine.

2. Remove the rear enclosure panel (seven SHCS).

3. Turn the air pressure regulator down (located on top of the transmission) to zero (0). The knob must be pulled out to unlock before adjusting.

NOTE: At "0" pressure on the pre-charge regulator, the adjustment knob is out as far as it will turn.

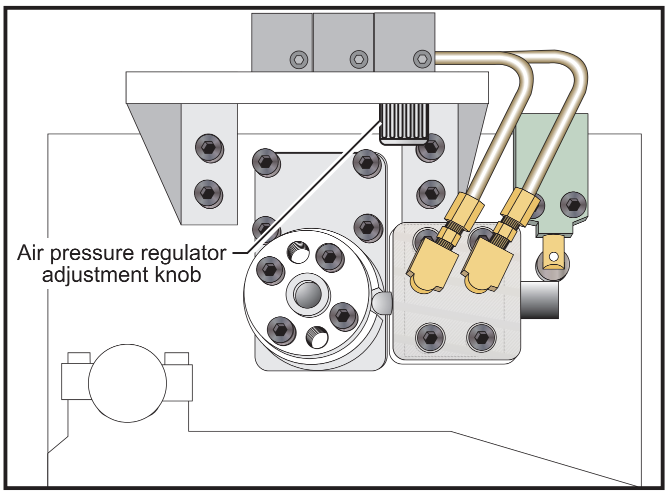


Figure 3.2-5. Air pressure regulator adjustment knob.

4. Go to "Parameters" page of CRT and ensure PRE-CHARGE DELAY is set to 300. If not, set it at this time.

5. Press the TOOL RELEASE button on control panel. A banging noise will be heard as the tool release piston contacts the drawbar.

6. Turn the air pressure regulator ½ turn in. Execute a tool change and listen for the banging noise. If it is heard, repeat this step until no noise is heard. There should be no noise with or without a tool in the spindle.

CAUTION! Only increase the pressure to the point where tool changes become obviously quiet. Any further pressure increases are not beneficial. Excessive pressure to the pre-charge system will cause damage to the tool changer and tooling in the machine.

3.3 Spindle Drive Belts

Please read this section in its entirety before attempting to replace the drive belts.

TOOLS REQUIRED

- 2.5" diameter, 2.5' long steel tube
- Lift fixture (T-1491)
- Belt tensioning fixture (T-1511)

Belt Removal

NOTE: For easier belt removal, place transmission in high gear (M42) before beginning.

NOTE: When servicing drive belts, always replace BOTH belts.

1. Remove the rear enclosure panel (seven SHCS).
2. **IMPORTANT!** Jog the X-axis all the way to the operator side of the machine. Place the steel tube through the 3" diameter holes (second from bottom) on either side of the column. Ensure the tube passes completely through the column and extends out an equal distance from each side. This tube will prevent the spindle head from falling in the event of an accident.
3. Jog the Y-axis down until the bottom of the motor is approximately 1/2" above the steel tube.
4. Remove the tool release piston assembly in accordance with "Tool Release Piston Assembly Removal".
5. Remove the steel tube, and jog the Y-axis down to where the six transmission mounting SHCS can be accessed.
6. Slightly loosen and hand tighten each of the six transmission mounting SHCS, one at a time.
7. Move the transmission down (if it is not already) by shaking it from the back of the motor, until there is slack in the spindle drive belts. Remove the belts from the spindle and drive pulleys.

NOTE: DO NOT bend or kink the belts in any way; damage to the fibers in the belt may result, and it will fail soon after installation.

Belt Installation

1. From the rear of the machine, install the new belts onto the top (drive) pulley. From the front of the machine, place the belts on the bottom pulley.

NOTE: Be careful not to damage the inside of the belts.

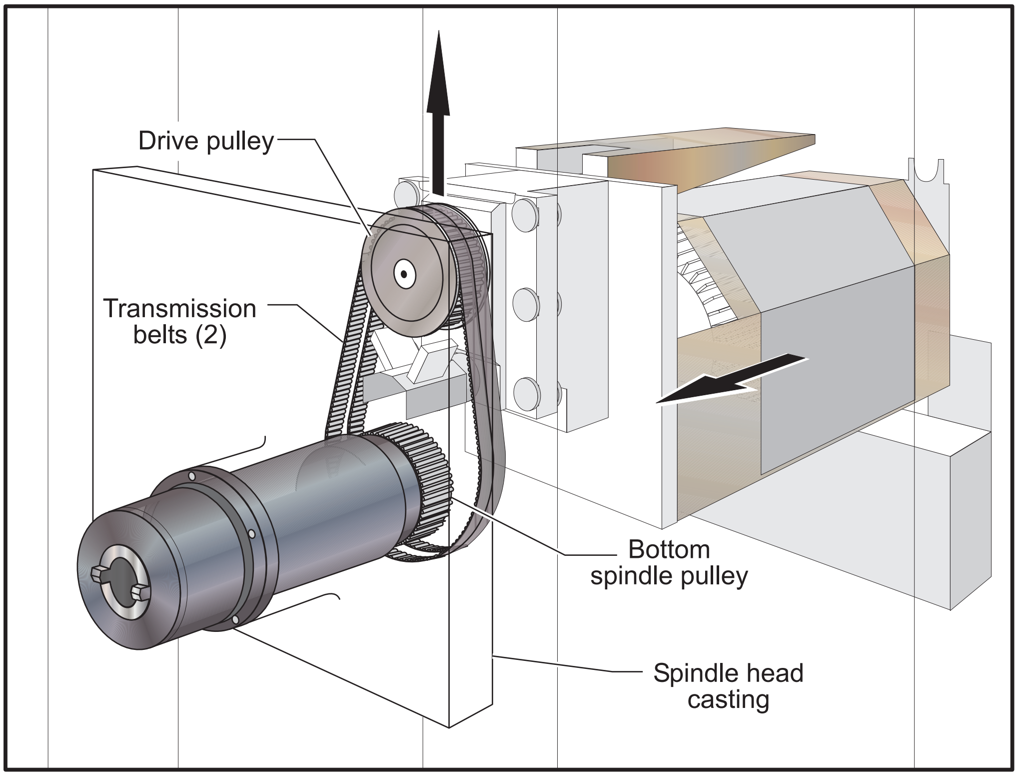


Figure 3.3-1. Spindle drive belt replacement.

2. Install the tool release piston assembly in accordance with appropriate section, and reconnect all switches and air lines.

3. Loosen the top two transmission mounting SHCS about 1-1/2 turns.

4. Refer to the "Belt Tension" section and tension the belts.

5. Reset the spindle orientation in accordance with the appropriate section.

NOTE: The following step is necessary only if the spindle or transmission was exchanged prior to belt replacement.

6. Double-check the spindle sweep to assure that nothing has moved during the previous steps. If sweep is within tolerance, continue; if not, sweep must be readjusted.

NOTE: Drive belt tension must be adjusted after every installation.

7. Slide the lower Y-axis way cover up into place and tighten the seven SHCS.

8. **IMPORTANT!** Remove the steel tube from the column. **CAUTION!** This step must be followed or the machine will be seriously damaged.

9. Replace the rear enclosure panel (seven SHCS).

BELT TENSION ADJUSTMENT

NOTE: The drive belt's tension should be adjusted after every service on the transmission or spindle of the machine.

1. Place the lift fixture onto the transmission (Figure 3.3-2). Attach to the motor mounting plate with two SHCS.

2. Place the two bars (3/4" diameter) of the belt tensioning fixture through the top two holes (1" diameter) in the column. Set the fixture plate in place on the two bars, with the eyeholes facing downward.

3. Hook the three springs into the eyeholes of the fixture plate. Jog the Y-axis up into place, then hook the other end of the springs into the eyebolts of the lift fixture.

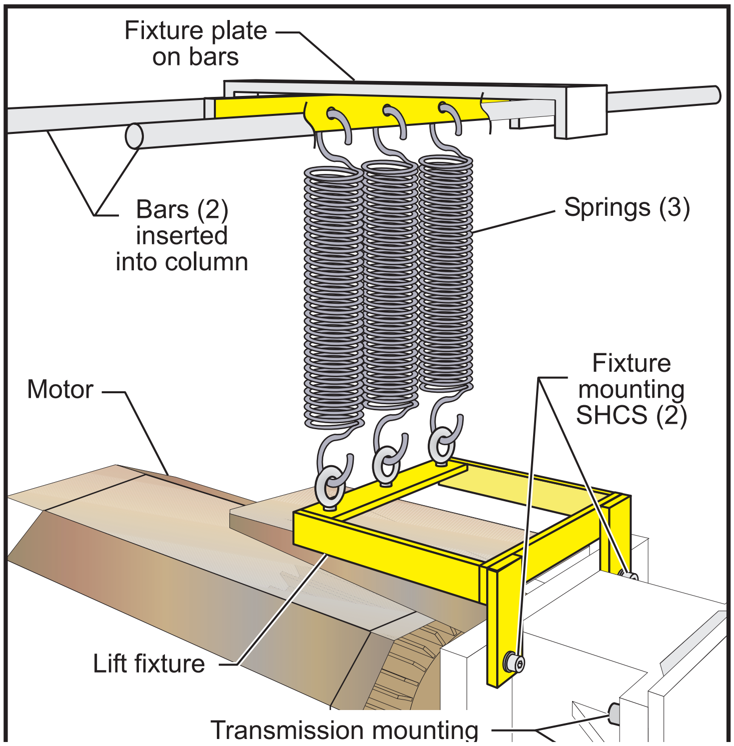


Figure 3.3-2. Belt tensioning fixture shown in place.

4. Jog the Y-axis down until the spring hooks are just touching the top of the eyebolts on the lift fixture.

5. Zero the POSITION display screen in the control. Jog the Y-axis down exactly 8.5 inches. Monitor the screen to verify the position. The belt is correctly tensioned.

NOTE: A belt that is correctly tensioned will whine slightly, and requires approximately 12 hours of break-in time.

6. Tighten down the six transmission mounting SHCS, beginning with the bottom two.

7. Run the spindle at various speeds and listen for any unusual noise or vibration. If there are any problems, examine the belts for damage, and replace if necessary.

CAUTION! Ensure all parts of the belt tensioning fixture and transmission lift fixture are removed before running the machine. Serious machine damage could occur if any of these are left on the machine.

3.4 Spindle

TOOLS REQUIRED

- **2.5" diameter, 2.5' long steel tube**

Spindle Cartridge

REMOVAL-

1. Remove the rear enclosure panel (seven SHCS).

2. **IMPORTANT!** Jog the X-axis all the way to the operator side of the machine. Place the steel tube through the 3" diameter holes (second from bottom) on either side of the column. Ensure the tube passes completely through the column and extends out an equal distance from each side. This tube will prevent the spindle head from falling in the event of an accident.

3. Jog the Y-axis down until the bottom of the motor is approximately 1/2" above the steel tube.

4. Remove tool release piston assembly in accordance with appropriate section.

5. Remove spindle drive belts in accordance with appropriate section.

6. Remove quick disconnect air line (1/4" O.D., 3/16" I.D.) at back side of spindle cartridge.

7. Remove the quick disconnect fitting from the back side of the spindle.

8. Remove the six SHCS that mount the spindle to head casting.

9. Slide the spindle out from the front side of machine.

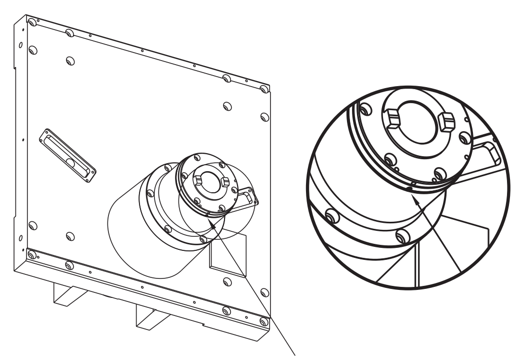
INSTALLATION-

1. Inspect the mating surface for high spots on the spindle and spindle head casting before installing spindle.

2. Increase the air pressure to clear out any contamination in the lubrication line. Once the line is cleaned out, return pressure to 3 psi.

3. Carefully install new spindle into bored sleeve of head casting. Apply grease to the inside of the through bore in the spindle head (see Figure 3.4-1).

NOTE: Spindle is a grease-packed cartridge on machines assembled before January 1999. Machines made after that have air-oil lubrication



Spindle must be installed with oil drain notch in spindle lock at the bottom

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CAUTION! When replacing an oil spindle on all HS (horizontal spindle) machines, the oil drain hole must point down. Failure to do so will cause the spindle to overheat, fail, and will void the warranty.

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4. Evenly tighten the six mounting SHCS on the front side of the spindle in a cross pattern until all bolts are completely tight.

5. Install spindle drive belts in accordance with appropriate section.

6. Connect the air line at the rear of the spindle cartridge. Check the pressure gauge at the rear of the lube/air panel. It should be 3 psi on grease-pack spindles or 17psi on air-oil spindles.

7. Install the tool release piston assembly in accordance with appropriate section. Adjust for proper tool push and switch settings.

8. Reset spindle orientation and check the tool changer adjustment.

9. Refer to the "Spindle - Overheating" section of "Troubleshooting" and run the spindle break-in program. Verify that spindle temperatures are acceptable.

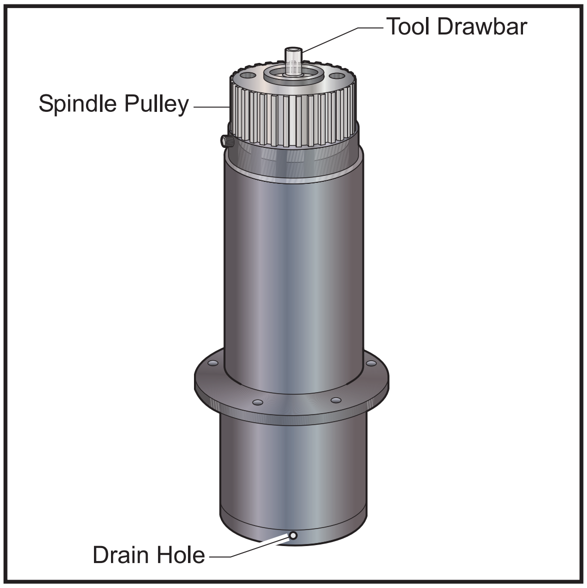

Figure 3.4-1. Spindle cartridge.

10. **IMPORTANT!** Remove the steel tube from the column.

CAUTION! This step must be followed or the machine will be seriously damaged.

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11. Replace the rear enclosure panel with seven SHCS.

SPINDLE ORIENTATION

1. Remove the rear enclosure panel (seven SHCS).

2. In MDI mode, press the ORIENT SPINDLE key.

3. Loosen the four SHCS on the orientation ring (Figure 3.4-2). Remove two of these screws and insert them into the two threaded holes in the ring. Evenly tighten these two screws until the taper lock is broken free from the shaft.

4. Remove the two screws and place them into their original holes. Tighten them finger tight, then 1/2 turn more. Ensure that the orientation ring is snug, but not tight.

5. Set up a magnetic base with a 0.001" indicator on the table. Zero the indicator on the spindle dogs parallel to the Y-axis travel.

6. Jog the spindle dogs across the indicator and note the indicator reading. The spindle dogs should be parallel to the Y axis within 0.010". If the reading is acceptable, skip to Step 8.

NOTE: There is a 0.015"-0.030" backlash in the spindle system when it is oriented. Be certain to compensate for this backlash when performing this adjustment.

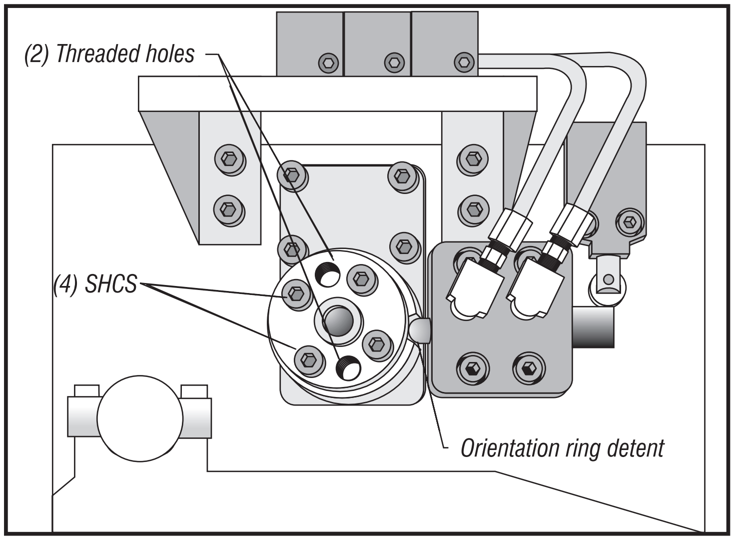


Figure 3.4-2. Rear view of spindle orientation components.

7 Using an open end wrench, rotate the spindle until the appropriate alignment is attained. If the spindle is very difficult to rotate, STOP and return to Step 3.

8. Tighten the orientation screws evenly to 15 ft-lbs. Verify that spindle alignment has not changed.

NOTE: It is vital that the screws be tightened evenly. If not, the top of the orientation ring will run out and the ring will slip.

9. Make at least 100 tool changes to test the spindle orientation.

10. If the spindle is found to be out of alignment, check all tool changer alignments.

11. Replace the rear enclosure panel with seven SHCS.

Spindle Sweep Adjustment

NOTE: The machine must be properly leveled for the spindle sweep adjustment to be accurate.

1. Place an indicator on the table and insert a 6" tool bar into the spindle.

2. Jog the Z-axis while indicating the bottom, and then the side, of the test bar. The readings must be within 0.0005/10" in both the Y/Z and X/Z planes, as stated in the inspection report supplied with the machine.

3. Shim the spindle, if necessary, to correct the spindle sweep to specifications. Recheck spindle sweep.

Orientation - Vector Drive

1. Place the machine in low gear.

2. Adjust Parameter 257, "SPINDL ORIENT OFSET", until the spindle dogs are parallel to the Y-axis on HS-1 and X axis on HS-2. Ensure that the dogs are within 0.010" using a dial indicator. See Figure 3.4-3.

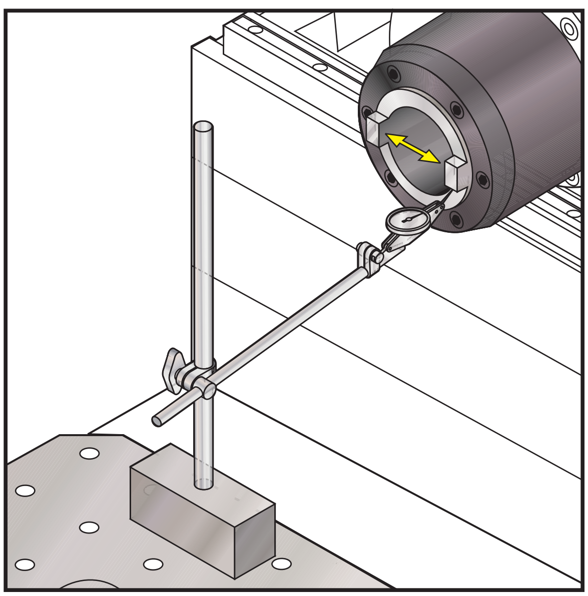


Figure 3.4-3 Parallel to X axis

3.5 Drawbar Replacement

TOOLS REQUIRED

- **2-1/2-13 x 2 SHCS**
- **1 inch thick, 6 inch long piece of aluminum**

NOTE: The aluminum bar will need to have two holes that align with the threaded holes in the spindle pulley.

REMOVAL-

1. Remove the spindle.

2. Place the aluminum bar on top of the draw bar and screw the two SHCS bolts into the top of the spindle pulley. See Figure 3.5-1 below.

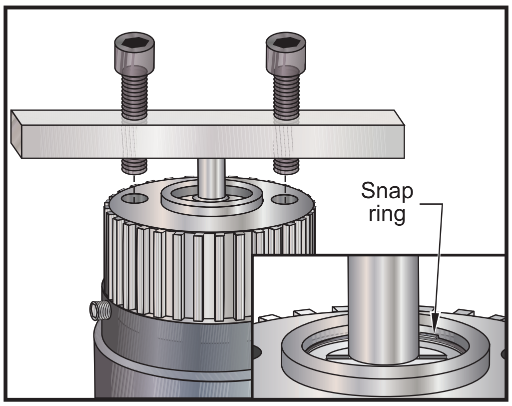


Figure 3.5-1. Retaining ring removal.

3. Tighten the bolts until the draw bar is compressed enough to remove the snap or spiral retaining ring.

4. Remove the retaining ring.

5. Remove the aluminum bar from the spindle pulley.

6. Remove the draw bar.

INSTALLATION-

1. Thoroughly coat the replacement drawbar with grease, including the end of the shaft where the four holding balls are located.

CAUTION! Insert the drawbar gently so the O-rings are not damaged. DO NOT use a hammer to force it.

NOTE: Carefully inspect the inside of the spindle shaft, where the end of the drawbar rides, for galling or burrs. If it is damaged, the spindle must be replaced.

CAUTION: Excessive amounts of grease on the TSC drawbar will prevent the drawbar from moving through a complete stroke.

2. Inspect the o-rings on the TSC drawbar. Grease if necessary.

3. Insert four new balls in the replacement drawbar and insert into the spindle shaft. Be sure that, as the shaft is installed, the balls do not fall out of the bores in the drawbar.

4. Place the aluminum bar on top of the draw bar and screw the two SHCS bolts into the top of the spindle pulley. See Figure 3.5-1. Tighten the SHCS until the draw bar is compressed enough to install the retaining ring.

5. Install the spiral ring on the spindle shaft. Carefully install the spiral ring on the spindle shaft. Feed one end of the spiral ring into the shaft groove. Rotate the ring until the entire ring is in the groove.

6. Install the spindle cartridge. Reinstall the tool release piston in accordance with the appropriate section.

7. **IMPORTANT!** Remove the steel tube from the column.

8. Refer to the appropriate sections and set the drawbar height, and clamp and unclamp switches.

NOTE: Step 10 must be followed or damage to the Automatic Tool Changer will result.

9. Set the spindle orientation.

CAUTION! This step must be followed or the machine will be seriously damaged.

10. Replace the rear enclosure panel with seven SHCS.

11. Test-run the machine and adjust the ATC as necessary.

3.6 Tool Clamp/Unclamp Switch Adjustment

TOOLS REQUIRED

- **Right angle plate**
- **Machined aluminum block (2"x4"x4")**
- **Flexible ruler**
- **1" diameter pipe or pry bar**

Tool Clamp/Unclamp Switch Adjustment - Initial Preparation

1. Remove the rear enclosure panel (seven SHCS). Disconnect the lower Y-axis way cover from the bottom of the spindle head and collapse it downward.
2. Secure the right angle plate in place on the table.
3. Place the machined block of aluminum against the right angle plate.
4. POWER ON the machine.
5. Insert an empty tool holder into the spindle taper.
6. Go to HANDLE JOG mode. Choose Z-axis and set the jog increments to .01.
7. Jog the Z-axis in the negative (-) direction until the tool holder is approximately .03" from the block. At this point, stop jogging and press the TOOL RELEASE button (top left). The tool holder will come out of the taper.
8. The clearance from the tool holder to the block should be zero (0). To accomplish this, set the jog increments to .001 and jog in the negative (-) Z direction a few increments at a time. Between these moves, push the TOOL RELEASE button and feel for movement by placing your finger between the tool holder and the spindle. ***Do this until no movement is felt.*** You are now at zero (0).

NOTE: Do not jog too far in the negative (-) direction! This will cause overcurrent in the Z-axis.

Setting Drawbar Height

1. Press the MDI key and turn the jog handle to zero (0).
2. Press HANDLE JOG and set the increments to .01. Jog the Z-axis in the positive (+) direction .100".
3. Press and hold the TOOL RELEASE button, and try to move the block by hand. The block should be tight at .100" and loose at .110". If it moves at .100", jog the Z-axis in the negative (-) direction one increment at a time. Press the TOOL RELEASE button and check for movement between increments until the block is tight.

NOTE: The increments jogged in the Z negative (-) direction are the amount of shim washers that must be added to the tool release bolt (or coolant tip for TSC). Refer to the "Shim Washers" section.

If the block is tight at .110", move the Z-axis in the positive (+) direction one increment at a time. Press the TOOL RELEASE button and check movement between increments until the block is loose.

NOTE: The increments jogged in the Z positive (+) direction are the amount of shim washers that must be removed from the tool release bolt (or coolant tip for TSC). Refer to the "Shim Washers" section.

CHECKING DRAWBAR HEIGHT

TOOLS REQUIRED

•Right angle fixture, such as a right angle plate
•Machined aluminum block (2"x4"x4")
•Tool holder (without a tool)

1. Secure the rigid fixture in place on the table. Place a sheet of paper on the table for protection, then place the machined block of aluminum against the rigid fixture.

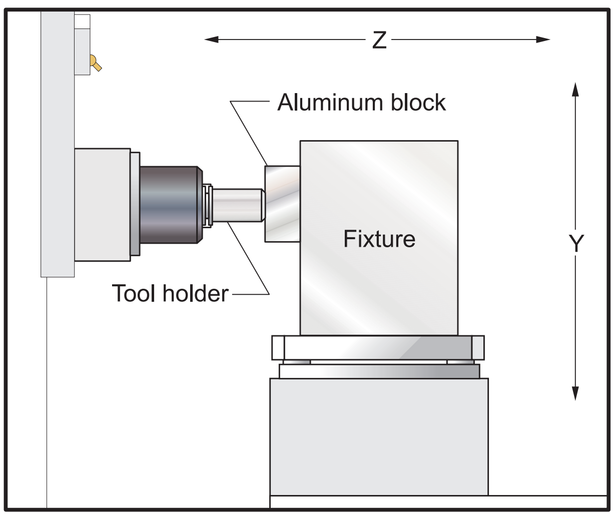


Figure 3.6-1. Setup for checking drawbar height.

2. POWER ON the machine. Insert an empty tool holder into the spindle taper.

3. Go to HANDLE JOG mode. Choose Z-axis and set the jog increments to .01.

4. Jog the Z-axis in the negative (-) direction until the tool holder is approximately .03" from the block. At this point, stop jogging and press the TOOL RELEASE button. The tool holder will come out of the taper.

5. The clearance from the tool holder to the block should be zero (0). To accomplish this, set the jog increments to .001 and jog in the negative (-) Z direction a few increments at a time. Between these moves, push the TOOL RELEASE button and feel for movement by placing your finger between the tool holder and the spindle. ***Do this until no movement is felt.*** You are now at zero (0).

NOTE: Do not jog too far in the negative (-) direction! This will cause overcurrent in the Z-axis.

6. Press the MDI key and turn the jog handle to zero (0). Press HANDLE JOG. Jog the Z-axis in the positive (+) direction .100".

7. Press and hold the TOOL RELEASE button, and try to move the block by hand. The block should be tight at .100" and loose at .110".
   •If block moves at .100, jog the Z-axis in the negative (-) direction one increment at a time. Press the TOOL RELEASE button and check for movement between increments until block is tight.
   •If the block is tight at 0.070 or less, the Coolant Tip (figure 3.6-2) must be replaced. Call your dealer for replacement of the Coolant Tip and the seal housing.

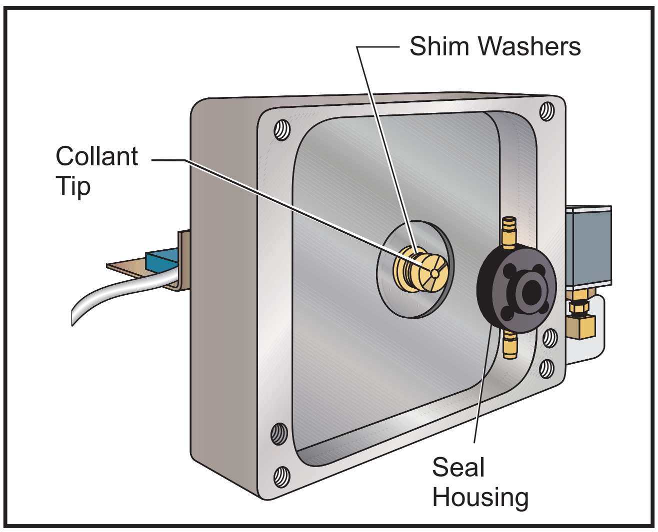


Figure 3.6-2. Coolant tip and seal housing (TSC machines only).

Shim Washers

1. To add or subtract shim washers, remove the tool release piston assembly in accordance with the "Tool Release Piston" section.

NOTE: Shims may need replacement when the spindle cartridge, tool release piston assembly, or drawbar is replaced.

2. Remove the tool release bolt. If the machine is equipped with TSC, built before May 1999, loosen the three set screws and remove the coolant tip. On TSC machines built after May 1999 the tip is hex shaped and has left hand threads, unscrew to remove it.

3. Add or subtract the required number of shim washers (from previous section).

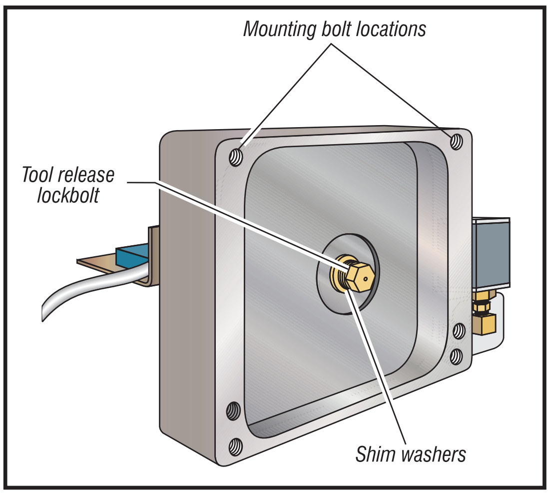


Figure 3.6-3a Shim location (without TSC).

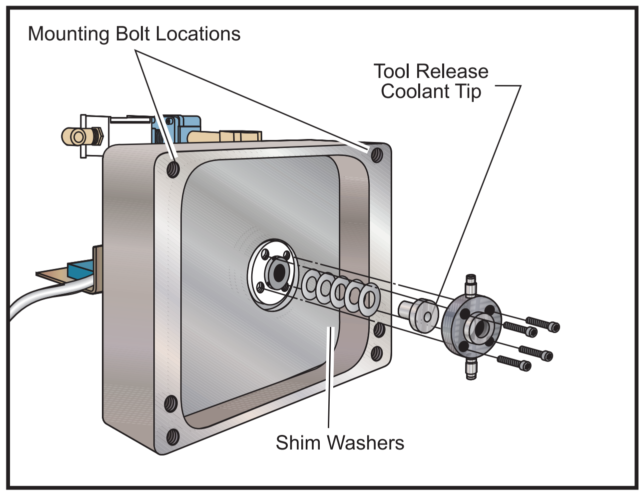


Figure 3.6-3b. Shim location (with TSC).

4. Put a drop of serviceable (blue) Loctite® on the threads of the tool release bolt and install. If replacing tool release coolant tip, put a drop of Loctite® on the threads before installing.

5. Install the tool release piston assembly and recheck settings. If within specifications, continue; if not, readjust.

Lower (Unclamp) Switch

1. Push the PARAM/DGNOS button (top center) twice. You are now in diagnostics mode. Look at the bottom left corner of the page and you should see DB OPN 0 (tool unclamped) and directly under that, DB CLS 1 (tool clamped). If not, push PAGE DOWN until you do. A "1" means that particular switch is being tripped. A "0" means it is not being tripped.

2. With the tool holder resting on the block and set at zero ("Setting Drawbar Height" section), jog Z-axis in the positive (+) direction .06.

3. Press the tool release button and hold it. DB OPN should change from a "0" to a "1". If it does not, slightly loosen the two ¼-20 x ½" SHCS holding the unclamp switch bracket (switch on right) to the tool release assembly.

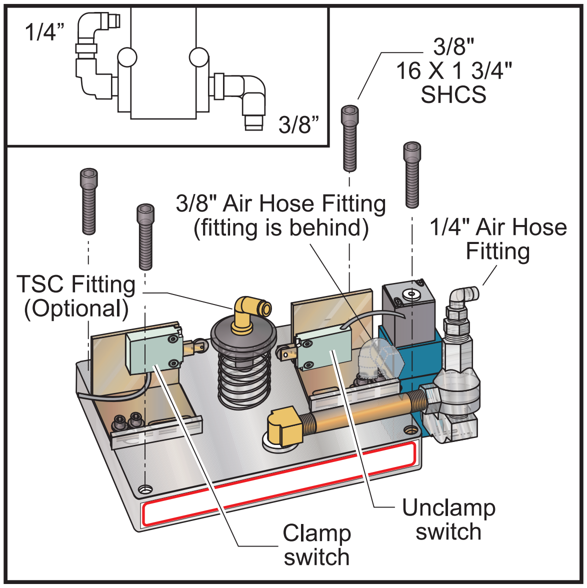


Figure 3.6-4. Tool release piston assembly.

4. While activating tool release, tap unclamp switch assembly towards spring retainer until it just trips. Switch must trip at .060 +/- .010.

THIS ADJUSTMENT IS VERY IMPORTANT FOR PROPER TOOL CHANGER OPERATION, AND MUST BE PROPERLY SET!

5. Check the adjustment by setting the jog handle at .06 and activating the tool release. The DB OPN signal should be a "1". If the adjustment is not correct, adjust until it is within specifications. You may have to readjust the switch several times. Set jog handle at 0.050 and activate tool release DB OPN signal should be a "0".

Upper (Clamp) Switch

CAUTION! Remove the tool holder from the spindle before performing the upper (CLAMP) switch adjustment. Failure to remove it could result in damage to the tool holder, the mill table, or cause severe personal injury.

6. Place a shim (approximately .020 thick), or the flexible ruler, between the tool release piston adjustment bolt and the drawbar. For TSC equipped machines, this step must be done with the seal housing removed.

7. Move the tool release piston in so the shim is pressed against the drawbar. This can be done in one of the following two ways:

   •Using the pipe or pry bar as a lever, ***carefully*** push on the piston until it contacts the drawbar and the shim is held in place. Push the piston down until it contacts the drawbar and the shim is held in place. Monitor the "Tool Unclmp" status in the Diagnostics display.

   WARNING

   Use extreme care when performing this procedure on TSC equipped machines, or the pipe fitting will break off the top of the TRP shaft.

   •If the machine is equipped with the "MACROS" option: in MDI, program #1120=1 and execute. This will energize the pre-charge solenoid, bringing the TRP in contact with the drawbar (no prying is necessary). To de-energize the solenoid, press RESET or in MDI, program #1120=0 and execute.

8. While the tool release piston is against the shim, move the switch bracket all the way in and check for "Tool Unclmp" status on the CRT (DB OPN=0, DB CLS=0), and tighten the bracket bolts. If not, move the switch out until "Tool Unclmp" status appears on the CRT and then tighten the bolts.

9. Check the switch several times. This is done by moving the piston in and out to ensure that the "Tool Unclmp" status appears when the piston makes contact with the shim and drawbar, and does not appear when it is in the retracted position. "Tool Unclmp" status appears on the screen as (DB OPN=0, DB CLS=0).

NOTE: For TSC equipped machines refer to "Tool Release Piston Replacement" section for proper installation and alignment of seal housing.

10. Replace the rear enclosure panel with seven SHCS. Replace the lower Y-axis way cover in accordance with the appropriate section.

3.7 Transmission

Please read this section in its entirety before attempting to remove or replace the transmission.

TOOLS REQUIRED

- Transmission removal kit, includes:
- Transmission removal fixture (T-1482)
- Transmission lift fixture (T-1491)
- Chain hoist

REMOVAL-

1. Remove the rear enclosure panel (seven SHCS).

2. Press RESET. Jog the Z-axis all the way back, and the X-axis to the center of its travel. This will allow easier access to the motor from the rear of the machine.

3. **IMPORTANT!** Jog the X-axis all the way to the operator side of the machine. Jog the Y-axis all the way up. Place the steel tube through the 3" diameter holes (second from bottom) on either side of the column. Ensure the tube passes completely through the column and extends out an equal distance from each side. This tube will prevent the spindle head from falling in the event of an accident.

4. Jog the Y-axis down until the bottom of the motor is approximately 1/2" above the steel tube. EMERGENCY STOP the machine.

5. Loosen (but do NOT remove) the six SHCS holding the transmission to the spindle head. Gently shake the motor from the back to make sure there is slack between the spindle drive belts and pulleys.

6. Remove the seven SHCS that attach the lower Y-axis way cover to the spindle head, and collapse it downward. It is easiest to reach the tool release piston and motor wires through the front of the machine.

7. Remove the two SHCS and two HHB that hold the tool release piston to the head casting, but DO NOT disconnect the air hoses and switches.

8. Remove both spindle drive belts. Replace the tool release piston and hand tighten the two SHCS and two HHB.

9. **IMPORTANT!** Remove the steel tube from the column. **CAUTION!** This step must be followed or the machine will be seriously damaged.

10. Press RESET. Jog the Z-axis all the way back, and the X-axis to the center of its travel. This will allow easier access to the motor from the rear of the machine.

11. Jog the Y-axis until the two lower holes in the column and the corresponding holes in the spindle head are aligned (at approx. Y=16.25"). Place two of the original shipping lockbolts (5/8-11 x 4" SHCS) through the two holes and snug tighten. **CAUTION!** This step must be followed to keep the spindle head from moving during service. If this is not done, serious injury could occur.

12. POWER OFF the machine and disconnect the main air line.

13. Disconnect all electrical lines and air lines from the transmission solenoid bracket.

NOTE: The motor wires can be disconnected from the front of the machine.

Disconnect the electrical and oil lines from the oil pump. Plug the oil lines to prevent contamination. Most of the lines should be marked and identified. If not marked, do so as it is removed.

If machine is equipped with the Through the Spindle Coolant option, remove the pressure regulator, check valve assembly, and bracket from the old transmission, so they can be installed later on the new transmission.

14. Place the lift fixture onto the transmission (Figure 3.7-1). Attach to the motor mounting plate with two SHCS (1/2-13 x 1-1/4).

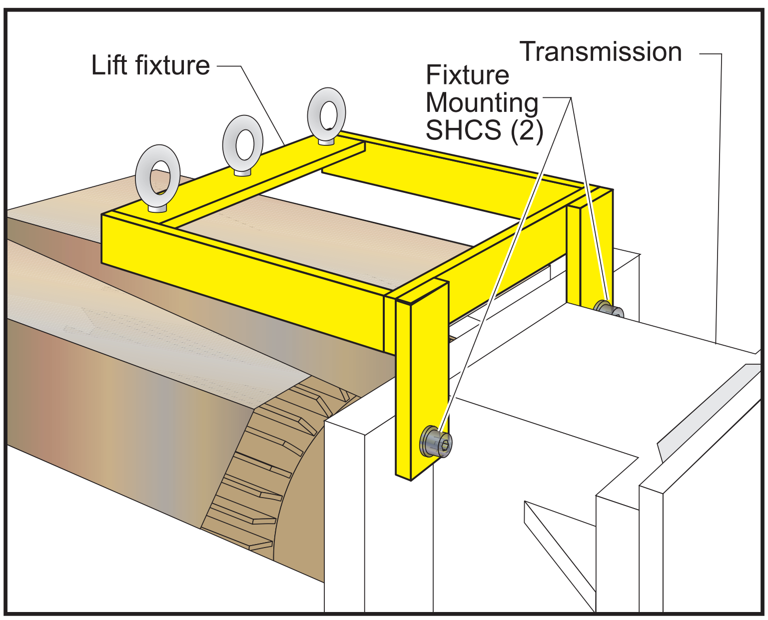


Figure 3.7-1. Transmission lift fixture.

15. Secure the transmission removal fixture support bracket to the back of the column with four SHCS.

16. Assemble the support arms (3) of the transmission removal fixture by placing a thrust washer at the bottom of each joint and inserting the dowel pins from the top side (Figure 3.7-2). Grease the joints to ensure smooth arm movement.

17. Hook the chain hoist onto the transmission removal fixture, then attach the chain's hook onto the center eyebolt of the lift fixture.

18. Remove **ALL** slack in the hoist's chain, then remove the six transmission mounting SHCS. **CAUTION!** The transmission might swing out when the mounting screws are removed, so hold it in place and ***carefully*** swing the transmission out of the back of the machine. Lower the transmission to the ground or a pallet.

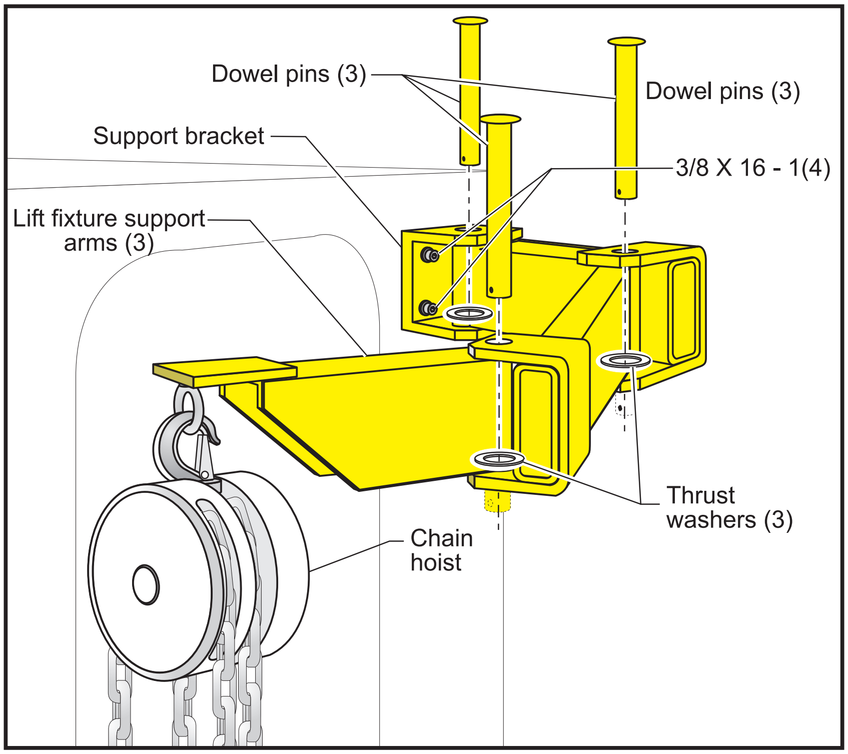


Figure 3.7-2 Transmission removal fixture and chain hoist.

INSTALLATION-

1. If machine is equipped with Through the Spindle Coolant option, reinstall the pressure regulator, check valve assembly, and bracket onto the new transmission.

2. Remove the lift fixture from the old transmission and place it on the new transmission.

3. Hook the chain hoist onto the transmission removal fixture, then attach the chain's hook onto the center eyebolt of the lift fixture.

4. Hoist the transmission into place. Only lift the transmission high enough to clear the enclosure and to swing into place.

5. Grease the rubber vibration isolators on the new transmission with general purpose grease.

6. Lift the new transmission up close to the spindle head, and secure it with six SHCS. Make sure the transmission is all the way down in the clearance holes. Tighten the two top transmission mounting SHCS.

7. Remove the transmission lift fixture from the transmission, and the transmission removal fixture from the column.

8. **IMPORTANT!** Isolate the three motor wires, which are to be connected later. This keeps the wires from getting shorted out.

9. Reconnect all electrical and fluid lines. Replace any leaking or kinked lines at this time, if necessary.

10. **IMPORTANT!** Remove the two shipping lockbolts from the column and spindle head.

CAUTION! Serious machine damage will occur if the axes are moved with the lockbolts in place.

---

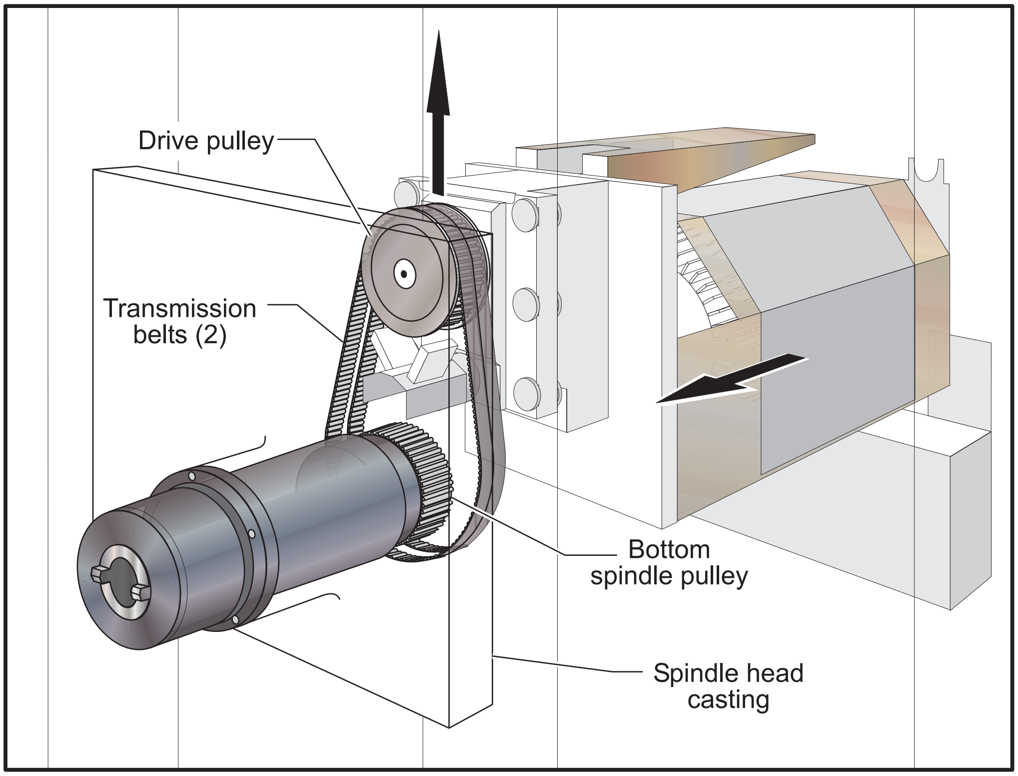
11. Zero return the machine. Jog the Y-axis all the way up.

12. **IMPORTANT!** Insert the steel tube in place through the column, as described in the "Removal" section.

13. Connect the three motor wires and the ground wire to the motor.

14. Remove the tool release piston in accordance with the appropriate section.

15. Install the drive belts in accordance with the "Spindle Drive Belts - Belt Installation" section.



Drive belt replacement (after transmission replacement).

16. **IMPORTANT!** Remove the steel tube from the column. **CAUTION!** This step must be followed or the machine will be seriously damaged.

17. Replace the rear enclosure panel with seven SHCS. Slide the lower Y-axis way cover into place and replace the seven SHCS.

3.8 TOOL CHANGER ASSEMBLY

CT-EXTRACTOR REPLACEMENT

REMOVAL -

1. Zero return all axes and remove any tooling.

2. Rotate the carousel into position by pressing M39 T__ (Enter the tool position number that needs replacement.)

3. Jog the Y-axis down, away from the tool changer.

4. POWER OFF the machine.

5. Retract the carousel door and clamp open.

CAUTION! The door spring is under high tension.

6 Remove one SHCS that fastens the extractor to the carousel.

CAUTION! The extractor spring is under high compression. Once it is removed, one extractor and the spring should come out. Remove the other SHCS to remove the extractor clip and block.

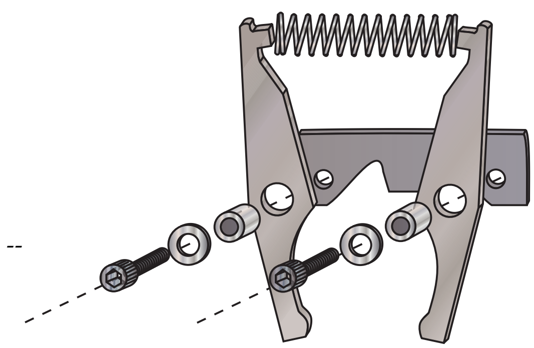


Figure 3.8-1 C-T Extractor Assembly.

INSTALLATION-

Assembly Parts:
(2) Extractor clips
(2) Extractor sleeves
(2) Screws and (2) washers
(1) Extractor block
(1) Compression spring

NOTE: Be sure to check for proper extractor assembly orientation.

1. Insert sleeve into pivot hole of each extractor and assemble each extractor with a SHCS and hard washer (round edge facing head of screw). Before mounting the assembly to the carousel, apply a small amount of semi-permanent Loctite® to each screw, then thread the screws just a few turns.

2. Place one end of the spring onto the top notch of the extractor and pivot the opposite extractor until both ends are firmly seated.

3. Evenly tighten the extractor screws to the carousel housing.

4. Verify the extractor assembly is properly oriented for the tool type.

CAROUSEL MOTOR

REMOVAL-

1. POWER OFF the machine.

2. Disconnect the carousel wire harness at carousel motor junction box.

3. Remove the four bolts mounting motor to carousel reduction transmission.

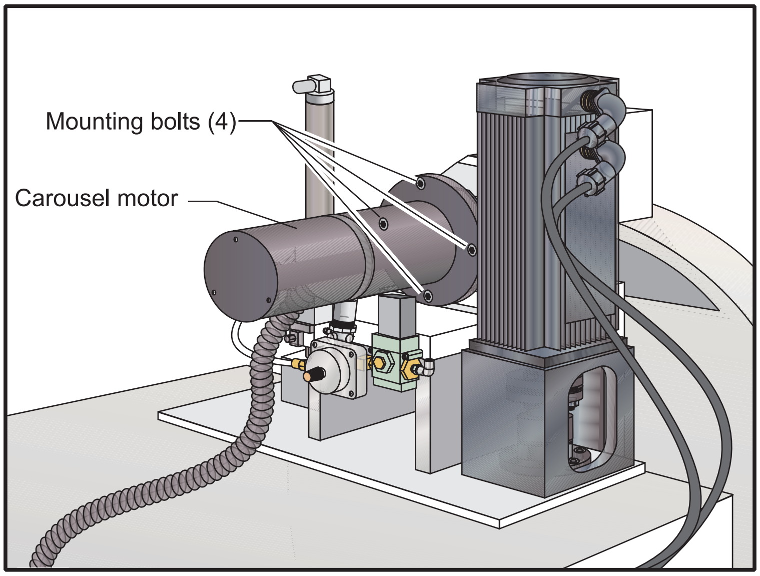


Figure 3.8-2 Tool changer carousel motor.

4. Motor output shaft locates on a keyway and will pull directly out.

INSTALLATION-

1. Line up keyway with output shaft and slide motor into place.

2. Tighten the four motor mounting bolts to the carousel transmission box.

3. Reconnect the wire harness to the carousel motor.

4. Check that the carousel indexing alignment is correct by doing a ZERO RET / AUTO ALL AXES. Adjust the rotational offset, Parameter 215, according to the "Tool Changer Alignment" section.

TOOL CHANGER DOOR

REMOVAL-

1. Disconnect the air supply to the machine.

2. Disconnect the door spring.

3. Remove the rubber bumper and door return spring from the back side of the carousel cover.

4. Remove the air door cylinder swivel mount from the cylinder front mount.

NOTE: The air door cylinder is under spring tension.

5. Remove the cylinder front mount from the door, being careful not to lose the small spring or nylon door slider.

6. Rotate the trap door clockwise past the "closed" position. Continue rotating and gently pull down on the door. It will slide down once it has been rotated far enough.

INSTALLATION-

1. Clean the washer contact surface of the tool changer cover, and apply a thin coat of grease.

2. With the door rotated to the right slightly, lift the door up between the carousel cover and the tool changer front plate, making sure the door nylon washer is between the door and the cover.

3. With the door in the up position, rotate the door counterclockwise past its normal "closed" position to it's normal "open" position to assure smooth operation.

4. Replace the rubber bumper on the back side of the carousel cover.

5. Apply a small coat of grease to the inside of the carousel cover, just above the door opening. Also apply grease to the nylon door slider and small spring.

6. Install the cylinder front mount, being sure the nylon door slider and spring are in place.

7. Install the cylinder swivel mount onto the cylinder front mount.

8. Install the door return spring on the back of the carousel.

9. Check for smooth operation and adjust the air door regulator (located on top of the tool changer) to assure adequate opening of the door.

Tool Changer Carousel Replacement

REMOVAL-

1. Center the X-axis. Jog the Y-axis all the way down.

2. Manually open the tool changer door and brace it open.

3. Turn off the three circuit breakers on the Power PCB.

NOTE: This allows no power to the motors and keeps the lights on.

CAUTION! Make sure that fingers are clear of carousel while performing the following:

4. Press the carousel "IN" solenoid and hold it while someone places a 4 x 4 to hold the carousel in the "IN" position.

5. With the 4x4 in place and all fingers clear, release the "IN" solenoid.

6. Remove the four SHCS that mount the gearbox to the top mounting plate. (Fig. 3.8-3 #1)

7. Tilt the motor forward and remove the belt.

8. Remove the four SHCS that secure the (2) switch brackets and place them clear of the large pulley (Fig. 3.8-3, #2).

CAUTION! Make sure that fingers are clear of carousel while performing the following:

9. While someone holds the 4x4 (fingers clear), press the turret "IN" solenoid and hold while the 4x4 is removed.

10. After the 4x4 is removed, release the "IN" solenoid.

CAUTION! Do not remove the cylinder cap with the carousel in the tool change (outmost) position. It is under spring pressure.

11. Remove the six SHCS that mount the cylinder cap to the carousel. (Fig. 3.8-3, #3)

12. Remove the 7/16” hex nut that attaches the shock absorber to the cylinder cap (Fig 3.8-3, #5).

13. Remove the cylinder cap.

14. Remove the six SHCS that attach the locking cap to the shaft assembly (Fig 3.8-3, #6). Do not lose the two nylon washers that are behind the locking cap.

15. Slide the carousel assembly off.

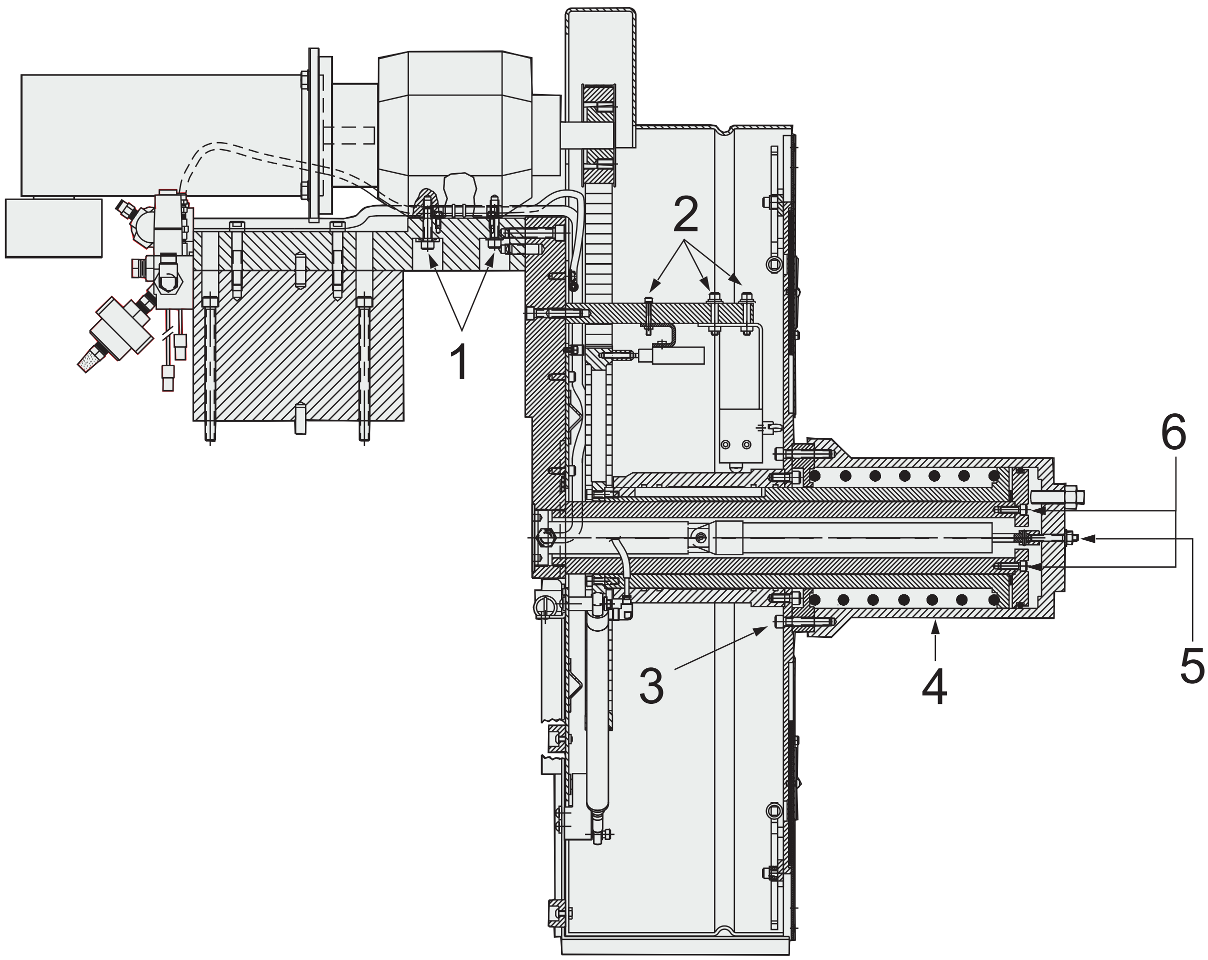


Figure 3.8-3. Carousel replacement.

INSTALLATION-

1. Grease the tool changer shaft.

2. Ensure the drive belt is in place before installing the carousel. Slide the carousel assembly on the shaft.

3. Place the belt on the drive pulley.

4. Install the locking cap (Fig. 3.8-3, #6). Use care to align the spacer washer so it is not damaged when the locking cap is installed.

5. Install the cylinder cap. Pull the shaft of the shock absorber through the front hole of the cylinder cap.

6. Install the shock absorber nut. (Fig. 3.8-3, #5)

7. Install the six SHCS that attach the cylinder cap to the carousel (Fig. 3.8-3, #3). Tighten evenly.

CAUTION! Make sure that fingers are clear of turret while performing the following:

---

8. Carefully press the turret "IN" solenoid and hold while someone places a 4x4 to hold the turret in the "IN" position.

9. With the 4x4 in place and all fingers clear, release the "IN" solenoid.

10. Install the switch bracket and four SHCS. (Fig. 3.8-3, #2)

11. Tilt the motor forward and mount the belt to the pulley.

12. Install the four SHCS that mount the gearbox to the top mounting plate. (Fig. 3.8-3, #1)

13. While someone holds the 4x4 (fingers clear), press the turret "IN" solenoid and remove the 4 x 4.

14. Release the "IN" solenoid.

15. Turn the three circuit breakers on the Power PCB back on.

16. Go to the next section and perform all alignment procedures under Tool Changer Alignment.

TOOL CHANGER ALIGNMENT PROCEDURES

Carousel In/Out Procedure:

1. Check that the main air regulator is set at 85 psi.

2. Zero return all axes.

3. In MDI mode, type "T1" and press ATC FWD. Turn Setting 7 off.

4. Select the ALARM page. Type "debug" and press the WRITE key.

5. Press the ORIENT SPINDLE key.

NOTE: Ensure the tool pushout switch adjustment for tool clamp/unclamp adjustment has been completed.

6. Manually open and secure the air door.

7. In HANDLE JOG mode, select the Y axis. Slowly move the Y axis up towards the spindle until the extractor on station #1 is close to engaging the tool holder.

8. Ensure that the tool carousel in/out adjustment is correct by checking the centerline of the tool extractor groove in reference to the extractor centerline.

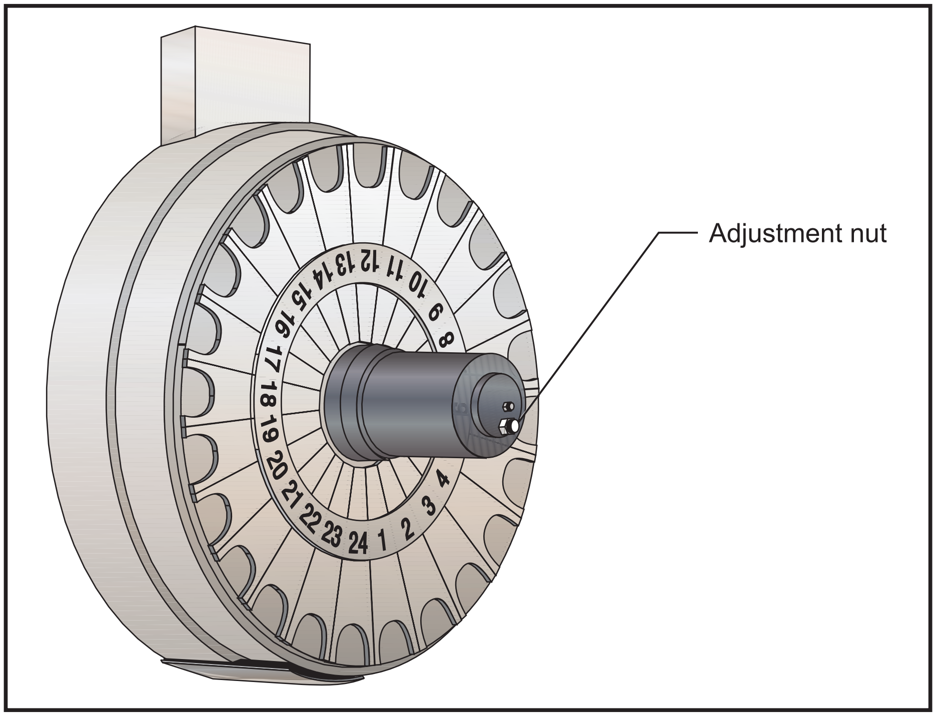


Figure 3.8-4. Tool Changer IN/OUT adjustment nut

NOTE: Do not loosen the 1/4" nut located at center. Tighten the 1/2" locknut without turning the adjustment screw.

Adjustments are made by loosening the 1/2" locknut located at the nose of the actuation cylinder, and turning the setscrew clockwise or counterclockwise.

NOTE: Do not loosen the 1/4" nut located at center. Tighten the 1/2" locknut without turning the adjustment screw.

9. After completing the carousel adjustment, the switch adjustments for carousel in/out must be done.

NOTE: On the Diagnostics page, TC OUT must be 1 and TC IN must be 0.

SETTING PARAMETER 215

IF YOUR MACHINE IS OPERATING WITH 9.20 TO 10.XX SOFTWARE SKIP TO STEP 15, FOR MACHINES EQUIPPED WITH A BRUSHLESS TOOLCHANGER, SEE THE BRUSHLESS TOOLCHANGER ALIGNMENT FOR HS-SERIES MACHINES SECTION.

10. Loosen the two 1/4" SHCS on top of the switch bracket, inside the tool carousel. Adjust the bracket until the TC OUT switch reads 1. Manually override the shuttle solenoid to shuttle out the carousel and release it. The TC OUT switch must always trip.

11. Manually override the shuttle solenoid to bring the shuttle out. Check that the TC IN switch trips to 1 and the TC OUT switch trips to 0.

NOTE: Verify the tool changer is empty for the next step.

12. Jog the spindle (with tool holder) towards the tool changer. When the tool changer extractor is close to engaging the tool holder, confirm that the carousel rotation is in line with the tool side-to-side engagement. If the carousel is too far in the clockwise direction, Parameter 215, "Carousel Offset", must be set to a lower value. Increase the value if the carousel is too far counterclock-wise.

On machines before software version 9.14, the carousel offset number must **not** be 15,000 or an even multiple of it (30,000; 45,000; etc.). This is because 15,000 (9,000 for **HS-2**) is the exact distance between pockets. Machines with software version 9.14 or later do allow the use of these numbers.

NOTE: The ZERO RET key must be pressed EVERY TIME Parameter 215 is changed.

13. Jog the Y-axis up slowly until the extractors have fully engaged the tool, ensuring that the spindle orientation is still correct. Ensure the extractor is fully engaged, but not overloading the servo motor.

NOTE: There should be a small amount of clearance to prevent the extractor from knocking when the Y-axis moves into position. Parameter 211, "Y-Axis Tool Change Offset", will adjust this distance.

14. **IMPORTANT!** Once you have completed this procedure, type "debug" on the ALARMS page, then press the WRITE key to exit. Turn Setting 7 on.

15. Press "POWER UP RESTART", the tool changer will align to tool number #1.

STEPS 16-21 OF THIS PROCEDURE ARE FOR SETTING PARAMETER 215 AND ONLY APPLY TO MACHINES OPERATING WITH 9.20 TO 10.XX SOFTWARE.

16. Go to parameter 215 and set it to zero

17. Enter "DEBUG" mode and go to the POSITION page and page up to "POS RAW-DAT" SCREEN.

18. ENTER "W" and HANDLE JOG

19. Slowly turn the jog handle and observe how the carousel rotates as a normal axis. Be careful not to turn the jog handle too fast or else the carousel will begin to oscillate.

20. The screen will display a "**CO**" and a number. This stands for **C**)arousel **O**)ffset.

21. Rotate the carousel to tool ZERO (on the HS-1 this is pocket #24, HS-2 is #40) This number is then entered in Parameter 215.

22. Press "POWER UP RESTART" and the tool changer will align to tool #1.

FOR MACHINES EQUIPPED WITH A BRUSHLESS TOOLCHANGER, SEE THE BRUSHLESS TOOLCHANGER ALIGNMENT FOR HS-SERIES MACHINES SECTION.

Setting Parameter 211

NOTE: For machines equipped with macros: In MDI Mode type #1126=1 (air door open), but do not execute the program yet.

NOTE: For machines not equipped with macros, manually open the toolchanger air door.

1. Go to the alarms page and enter DEBUG Mode.

2. Execute the MDI program to open the air door.

3. Orient the spindle.

4. Manually load a tool into the spindle.

5. Slowly jog the Y-axis up past the HOME position, into the tool change position.

6. Visually watch for the tool carousel fingers to expand over the tool and close in around it.

7. Continue jogging up slowly just until the tool applies slight pressure upwards on the carousel.

8. Go to the POSITION DISPLAY and page up to "POS-RAW DAT" page and read the actual Y-axis position.

9. Enter the number from the Y-axis from the actual position then put in Parameter 211. The controls default setting is 780000.

10 Handle jog down past the home switch into the normal operating envelope.

11. Exit DEBUG.

12. In MDI execute a tool change by pressing ATC FWD.

13. Note the reaction of the carousel as the tool enters the extractor fingers:
    If the **carousel deflects up** then **decrease** the number in Parameter 211.
    If the **tool deflects down** as it enters the carousel then **decrease** the number in Parameter 211.
    If the **tool deflects up** as it is pulled out of the spindle by the carousel, then **decrease** the number in Parameter 211.

Side Mount Tool Changer Alignment HS-2RP (Brush Motor)

NOTE: For Brushless Toolchanger alignment instructions, see the Brushless Tool Changer Alignment for HS-Series Machines section.

1. Remove the tool changer's shipping retainer bolt. Refer to Figure 3.8-5.

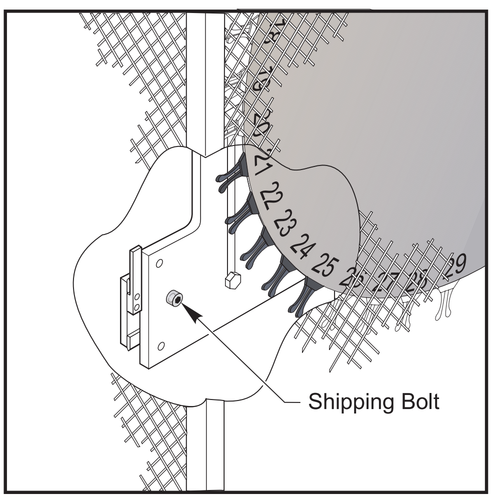


Figure 3.8-5.

NOTE: Check Parameter 209. Bit AUX AXIS TC must be set to 1 on brush motor toolchangers.

2. There are four tool changer cable connectors that must be plugged in before the tool changer is operable.

   Cables shipped in the tool changer enclosure include:

   Cable 1 (Carousel Drive Motor Cable). The cable is encased in flexible conduit and supplied with an amphenol connector. This cable must be routed around the back of the machine under the apron and connected to the "**Tool Changer**" connector on the side of the control panel.

   Cable 2 (Shuttle Motor Drive Cable). The cable is routed around the back of the machine and is supplied with a connector bracket, found at the left rear corner of the machine behind an access panel. The connector bracket is labeled **TC IN/OUT** for this cable connector.

   Cable 3 (Shuttle-In) **TC IN, #820B** / **Cable 4** (Shuttle-Out) **TC OUT, #820** limit switch cables. The connections for these cables are located near the base of the tool changer. The wiring for the connectors are located behind the side apron, near the tool changer's base support tube. Remove the factory-installed shuttle out jumper, before plugging the shuttle-out connector on the tool changer to its matching connector from the machine.

NOTE: Keep the shuttle-out jumper, as it will be used later in the tool changer alignment procedures.

3. **POWER-UP** the machine.

4. Press the **RESET** button to clear the alarm message.

5. Press the **ZERO RET** and then the **AUTO ALL AXES** button. The machine will move the spindle to its home position (Zero X, Y, Z, and A).

6. Go to the **SETTINGS** screen. Cursor to Setting 51, **DOOR HOLD OVERRIDE**. Toggle the **DOOR HOLD OVERRIDE** to "**ON**". With the setting toggled to "ON", press the **WRITE/ENTER** button to enter this value into the control. With this setting set to "ON" the operator side door can be open during the next steps without generating an alarm.

7. Command the shuttle door to open. Move to the **MDI** screen. Enter value #1126="**1**" from the keypad, then press **INSERT**. Press **RESET** and then **CYCLE START**. The tool changer door will open.

8. Move to the **SETTING** screen. Cursor to Setting **(7) PARAMETER LOCK**. Toggle the **PARAMETER LOCK** to "**OFF**", then press the **WRITE/ENTER** button to enter this value.

9. Press the **E-STOP** button.

10. Go to the **PARAMETER** screen, cursor to Parameter **215**. This parameter controls the position of the "zero" pocket for the tool changer carousel. Record the value for this parameter, set the Parameter to zero by entering "**0**" and press the **WRITE/ENTER** button.

NOTE: Check Parameter Settings after all procedures have been completed and press machine POWER-UP/RE-START.

11. Enter **DEBUG** Mode. Move to the **POS-RAW DAT** screen.

12. The lower right hand area of the screen will display "**CO**" and a number. The **C**)arousel **O**)ffset number will be used to orient the tool changer carousel's rotational position. Turn the **E-STOP** off and press the **RESET** button three times to clear the alarm message(s).

13. Enter "**W**" and then press the **HANDLE/JOG** button. Slowly turn the **HANDLE/JOG** control in ½ turn increments and observe the rotation of the carousel. The carousel will alternate between counterclockwise and clockwise motion but will eventually stop. Continue to rotate the carousel until tool pocket **#40** (designated ZERO tool) is at or near the three o'clock position.

14. Install two ¼-20 x 2 in. shoulder bolts into threaded holes on the face of the carousel as shown in Figure 3.8-6. Place a 48" bubble level or a flat bar with a torpedo level across the two shoulder bolts.

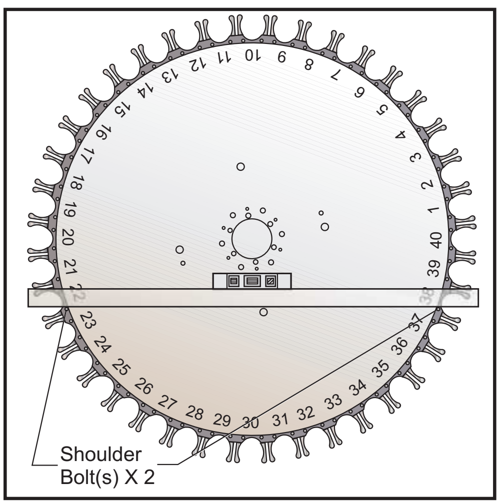


Figure 3.8-6.

15. Continue to handle jog the tool changer's carousel to achieve a level condition. Record the Carousel Offset number given on the **POS-RAW DAT** screen. Move to the **PARAMETER** screen. Enter the recorded Carousel Offset value into **PARAMETER 215.**

16. Remove the leveling tools.

17. Command shuttle door to close. Move to the **MDI** screen. Cursor to number "1", enter "**0**" from the keypad and press the **ALTER** button. Press **RESET** and then **CYCLE START**. The tool changer door will close.

18. Press the **ZERO RET** button and then the **AUTO ALL AXES** button. The machine will move to its home position (zero X, Y, Z, A and Tool Changer Carousel).

19. Command Shuttle Door to open, again. Move to the **MDI** screen. Cursor to the number “0”, enter “**1**” from the keypad and press the **ALTER** button. Press **RESET** and then **CYCLE START**. The tool changer door will open.

20. Press the **E-STOP** button.

21. Disconnect the **TC IN** limit switch connector (#820B) and the **TC OUT** limit switch connector (#820) located at the base of the tool changer. Re-install the previously removed jumper into the **TC IN** connector on the wiring coming from the machine-side.

22. Disconnect the tool changer’s shuttle motor cable connector, behind the rear access panel on the control box side of the machine. See Figure 3.8-7.

23. The next step requires the tool changer carousel to be manually shuttled into the machine enclosure. To shuttle the carousel out, its shuttle arm must be fully rotated. First, reach in through the tool changer's window, push up on the cam follower bolt (as shown in Figure 3.8-8) and then move the carousel to its fully extended position in the enclosure. Verify that it is fully extended by inspecting the location of the cam follower bolt. The cam follower bolt should bottom out at the end of the guide slot.

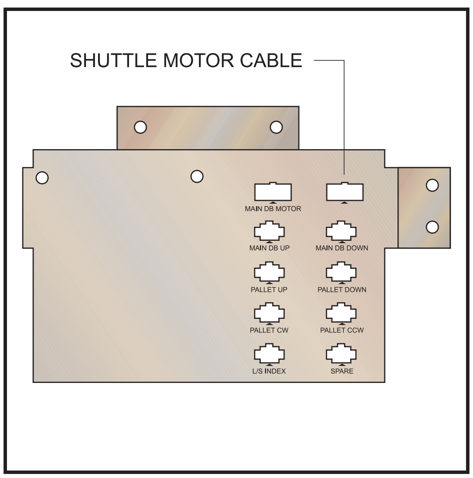


Figure 3.8-7.

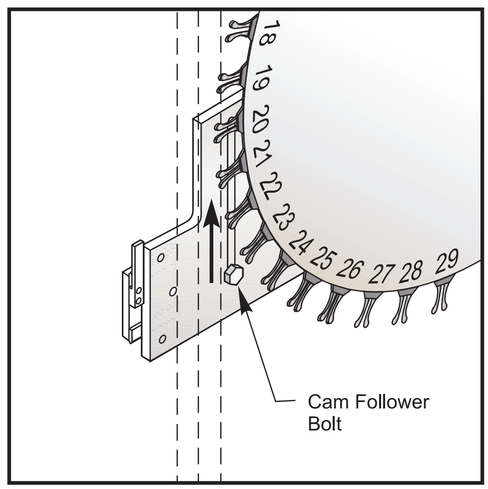


Figure 3.8-8.

24. Next, move to **PARAMETERS** screen. Record the values for the Parameters **#210** (X-axis), **#211** (Y-axis) and **#64** (Z-axis). After recording the values for these Parameters, enter "**0**" for their values.

25. Go to **ALARMS** page, enter “**DEBUG**” from the keypad and press **WRITE/ENTER.** Move to the **POSITION** screen to enter the **POS-RAW DAT** screen.

26. Handle jog the X, Y and Z axes as necessary to place the spindle centerline inline with the centerline of the tool changer's extractor fingers. Align the spindle centerline with the center of the tool changer's fingers in the X , Y plane only.

NOTE: As an alignment aid, a 2.325" diameter disk mounted into a tool holder may be used (Refer to Figure 3.8-9). Handle jog as necessary to bring the disk in line with the center of the tool changer's fingers.

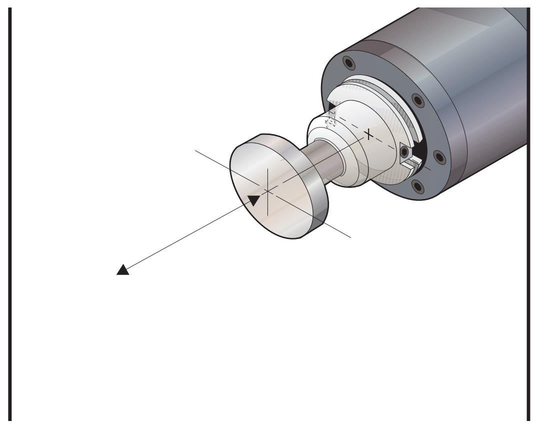


Figure 3.8-9.

27. Record the values in the **ACTUAL** column for the position of the X and Y-axes given on the **POS-RAW DAT** screen.
Enter the position value for the X-axis in **Parameter 210** (This can only be a negative number).

NOTE: This number is entered without the decimal point and must be the same sign as that given on the **POS-RAW DAT** screen. For example –0.7094 would be entered as –7094, and –278.8854 would be –2788854.

Enter the position value for the Y-Axis in **Parameter 211**.

28. Align the **Z-axis.** Line up the finger groove in the tool holder with the extractor fingers on the carousel. Handle jog the spindle in +Z direction (towards the rear of the machine). Then handle jog the -X direction (towards the control panel). Stop when it is clear that the tool holder groove can be jogged towards the front of the machine without hitting the extractor fingers.

NOTE: It should not be necessary to move the Y-axis during this exercise.

29. Handle Jog the spindle in the -Z direction (towards the front of the machine) and align the tool changer's fingers with the groove in the tool holder. Handle jog the spindle in the +X direction (towards the tool changer) and slowly move the tool holder into the extractor fingers. **STOP AND RE-ALIGN IF ANY MISALIGNMENT IS FOUND**. Continue to move the tool holder into the fingers until the drive notch on the side of the tool holder is approximately 0.050 in. from bottoming out on the carousel's alignment key. Refer to Figure 3.8-9.

30. Record the values for the position of the Z-axis given on the **POS-RAW DAT** screen.
Enter the position value for the Z-Axis in **Parameter 64** (This can only be a positive number).

31. Move the spindle in the –X direction to extract the tool holder from the tool changer's extractor fingers. Jog the spindle as necessary to move it clear of the tool changer. Remove the tool holder from the spindle.

32. Manually pull the carousel out of the machine enclosure, into its retracted position.

33. Close the tool changer door. Press **MDI/DNC,** move to **PROGRAM** screen. Toggle the cursor to the number 1 after the equal sign. Enter "**0**" and press **ALTER** button. Next press **RESET** and **CYCLE START**. The tool changer door will close.

34. Press **ZERO RET** button and then **AUTO ALL AXES** button, to move the machine spindle to its home position.

35. Remove the jumper installed in the **TCIN** limit switch connector (#820B) at the base of the tool changer and reconnect the previously disconnected limit switch cables.

36. **POWER OFF**, then **POWER ON** the machine. Press **RESET** button to clear any alarm messages.

NOTE: Verify all **Parameter Value(s)** have been recorded.

37. Press the **ZERO RET** and then **AUTO ALL AXES** button.

38. Install a tool holder into the spindle. See *Figure 3.8-10.*

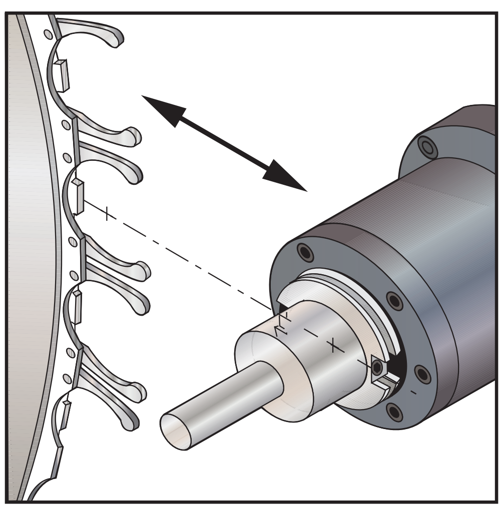


Figure 3.8-10.

39. Press the **MDI/DNC** button, then **ATC FORWARD** button. Repeat steps 22 and 23, to manually move the carousel into the machine enclosure.

NOTE: The spindle will move to its tool change position and the machine will fault-out and display a **SHUTTLE FAULT ALARM**. This is due to the shuttle motor cable disconnection.

40. Move the carousel into the tool holder and verify that proper extractor finger alignment has been made. (Repeat steps 23 through 30 as necessary to align the tool changer extractor fingers to the tool holder.)

41. Once alignment has been verified, pull the tool changer carousel out of the enclosure, close the shuttle door and reconnect the shuttle motor cable connector at the rear of the machine.

42. Press the **MDI/DNC** button and then press the **ATC FORWARD** button to verify proper operation of the tool changer.

43. Go to the **SETTING 7**, toggle **PARAMETER LOCK** to "**ON**". With the setting toggled to "ON", press **WRITE/ENTER** button to enter this value.

44. Set Parameter 34, Z axis Maximum travel. The formula for doing this is:
Parameter 33 X 31" (inches) - Parameter 64= The value to be entered in Parameter 34

NOTE: In order to bring the tool changer carousel back to home position a "Tool Changer Recovery" must be done.

Brushless Tool Changer Alignment for HS-Series Machines

Horizontal machine models HS-1 and HS-2 use a brushless servo motor for carousel rotation. The alignment procedure for the new tool changers differs from the previous tool changers in that it uses a grid offset parameter to rotationally align the motor.

Determining the correct tool changer carousel axis and grid offset parameter

Machines with 3 or 4 axes have the tool carousel is assigned to the B-axis, machines with 5 axes have the tool carousel assigned to the Tt-axis. Verify this is true for your machine.

Machines with a B-axis for the tool carousel use parameter 170 for setting the grid offset.
Machines with a Tt-axis for the tool carousel use parameter 481 for setting the grid offset.

Alignment Procedure

1. Enable the toolchanger axis.

2. Set the appropriate tool changer grid offset parameter to zero, B-axis 170, Tt-axis 481. Additionally set parameter 215 to 0.

3. Zero the B or tt axis. To do this press Zero Return, Type B or T, and press Zero Single Axis.

4. Access the position page and note the value of distance-to-go for the appropriate B or Tt axis. For the subsequent calculations this variable will be designated as "n".

5. Determine the correct grid offset value for the B or Tt axis by performing the following calculation:

(n-1.8) x (axis steps/unit) = Grid Offset Parameter

where:

(axis steps/unit)= (encoder steps/rev [par162]) x (1rev/360º) x (ratio [motor rev/carousel rev])

EXAMPLE: 9102 = 32768 x (1/360) x (100)

so, say n=1.1, then:

Grid offset Parameter = (1.1-1.8) x (9102)
Grid offset parameter = -6371

This value would then be entered, with the correct sign, into the appropriate grid offset parameter.

Determining the Carousel Offset

HS-1 Series Machines

At this point the tool changer motor has rotated itself to a correct and reliable grid offset position. The next step moves the carousel from its grid offset position to a position that lines up the tool changer's extractor fingers with the groove in the tool holder.

This step assumes that the tool changer's carousel has been correctly located in the ± Z direction such that the extractor fingers are aligned in the vertical plane with the groove in the tool holder.

1. After zeroing the B or Tt axis, jog the tool carousel (jog B or Tt as appropriate by typing in B or T and pressing the Handle Jog button) so the extractor fingers of Tool #1 are lined up with the tool holder's groove.

Jog the spindle head up and note how well the tool holder groove and the fingers align as the tool holder enters the fingers. If necessary, rotationally reposition the carousel and re-check the alignment until the tool holder slides into the fingers without causing the carousel to rotate.

2. Go to the position page and note the value of the tool carousel B or Tt axis. This is the angular position of the carousel in degrees relative to the grid offset value. Multiply this value by 1000 and enter this new value into the carousel offset parameter (parameter 215).

Setting the Tool Changer Turret Axis to "Invisible"

B-axis: Set parameter 170, the INVIS AXIS, to 1.
Tt-axis: Set parameter 481, the "INVIS AXIS", to 1.

HS-2 Machines

Install the tool changer as described in the Operator's Manual.

Tool Changer Alignment

1. Remove the tool changer's shipping retainer bolt. Refer to Figure 1.

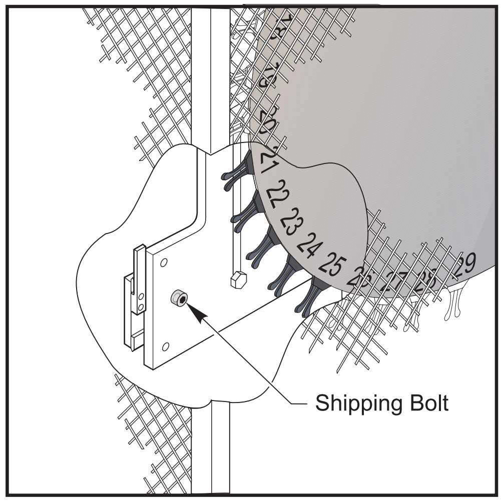


Figure 1

2. There are four tool changer cable connectors that must be plugged in before the tool changer is operable.

Cables shipped in the tool changer enclosure include:

Cable 1 (Carousel Drive Motor Cable). The cable is encased in flexible conduit and supplied with an amphenol connector. This cable must be routed around the back of the machine under the apron and connected to the "**Tool Changer**" connector on the side of the control panel.

Cable 2 (Shuttle Motor Drive Cable). The cable is routed around the back of the machine and is supplied with a connector bracket, found at the left rear corner of the machine behind an access panel. The connector bracket is labeled **TC IN/OUT** for this cable connector.

Cable 3 (Shuttle-In) **TC IN, #820B** / **Cable 4** (Shuttle-Out) **TC OUT, #820** limit switch cables. The connections for these cables are located near the base of the tool changer. The wiring for the connectors are located behind the side apron, near the tool changer's base support tube. Remove the factory-installed shuttle out jumper, before plugging the shuttle-out connector on the tool changer to its matching connector from the machine.

NOTE: Keep the shuttle-out jumper, as it will be used later in the tool changer alignment procedures.

3. **POWER-UP** the machine.

4. Press the **RESET** button to clear the alarm message.

5. Press the **ZERO RET** and then the **AUTO ALL AXES** button. The machine will move the spindle to its home position (Zero X, Y, Z, and A).

6. Go to the **SETTINGS** screen. Cursor to Setting 51, **DOOR HOLD OVERRIDE**. Toggle the **DOOR HOLD OVERRIDE** to "**ON**". With the setting toggled to "ON", press the **WRITE/ENTER** button to enter this value into the control. With this setting set to "ON" the operator side door can be open during the next steps without generating an alarm.

7. Move to the **SETTING** screen. Cursor to Setting **(7) PARAMETER LOCK**. Toggle the **PARAMETER LOCK** to "**OFF**", then press the **WRITE/ENTER** button to enter this value.

8. Command the shuttle door to open. Move to the **MDI** screen. Enter value #1126="**1**" from the keypad, then press **INSERT**. Press **RESET** and then **CYCLE START**. The tool changer door will open.

9. Press the **E-STOP** button.

10. Go to the **PARAMETER** screen, cursor to Parameter **215**. This parameter controls the position of the "zero" pocket for the tool changer carousel. Record the value for this parameter, set the Parameter to zero by entering "**0**" and press the **WRITE/ENTER** button.

NOTE: Check Parameter Settings after all procedures have been completed and press machine POWER-UP/RE-START.

11. Enter **DEBUG** Mode. Move to the **POS-RAW DAT** screen.

12. The lower right hand area of the screen will display "**CO**" and a number. The **C**)arousel **O**)ffset number will be used to orient the tool changer carousel's rotational position. Turn the **E-STOP** off and press the **RESET** button three times to clear the alarm message(s).

13. Enter the letter for the tool turret axis (B or T) and then press the **HANDLE/JOG** button. Slowly turn the **HANDLE/JOG** control in ½ turn increments and observe the rotation of the carousel. The carousel will alternate between counterclockwise and clockwise motion but will eventually stop. Continue to rotate the carousel until tool pocket **#40** (designated ZERO tool) is at or near the three o'clock position.

14. Install two ¼-20 x 2 in. shoulder bolts into threaded holes on the face of the carousel as shown in Figure 2. Place a 48" bubble level or a flat bar with a torpedo level across the two shoulder bolts.

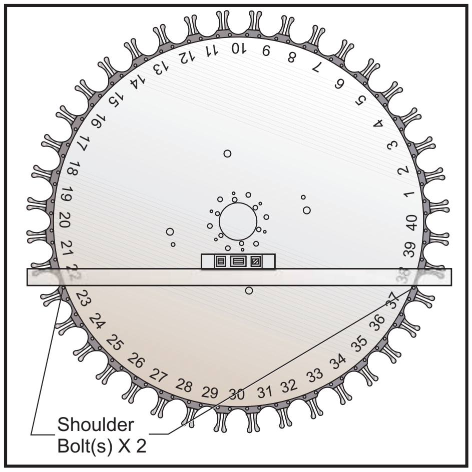


Figure 2

15. Continue to handle jog the tool changer's carousel to achieve a level condition. Record the Carousel Offset number given on the **POS-RAW DAT** screen. Move to the **PARAMETER** screen. Enter the recorded Carousel Offset value into **PARAMETER 215.**

16. Remove the leveling tools.

17. Press the **ZERO RET** button and then the **AUTO ALL AXES** button. The machine will move to its home position (zero X, Y, Z, A and Tool Changer Carousel).

18. Press the **E-STOP** button.

19. Disconnect the **TC IN** limit switch connector (#820B) and the **TC OUT** limit switch connector (#820) located at the base of the tool changer. Re-install the previously removed jumper into the **TC IN** connector on the wiring coming from the machine-side.

20. Disconnect the tool changer's shuttle motor cable connector, behind the rear access panel on the control box side of the machine. See Figure 3.

21. The next step requires the tool changer carousel to be manually shuttled into the machine enclosure. To shuttle the carousel out, its shuttle arm must be fully rotated. First, reach in through the tool changer's window, push up on the cam follower bolt (as shown in Figure 4.) and then move the carousel to its fully extended position in the enclosure. Verify that it is fully extended by inspecting the location of the cam follower bolt. The cam follower bolt should bottom out at the end of the guide slot.

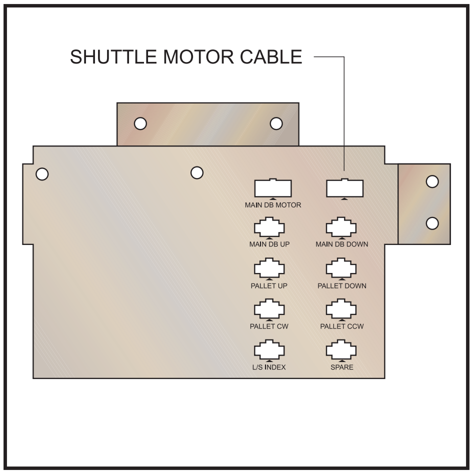


Figure 3

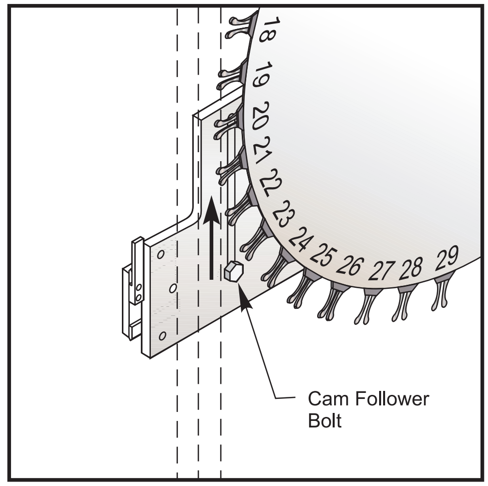


Figure 4

22. Next, move to **PARAMETERS** screen. Record the values for the Parameters **#210** (X-axis), **#211** (Y-axis) and **#64** (Z-axis). After recording the values for these Parameters, enter "**0**" for their values.

23. Go to **ALARMS** page, enter "**DEBUG**" from the keypad and press **WRITE/ENTER.** Move to the **POSITION** screen to enter the **POS-RAW DAT** screen.

24. Handle jog the X, Y and Z axes as necessary to place the spindle centerline inline with the centerline of the tool changer's extractor fingers. Align the spindle centerline with the center of the tool changer's fingers in the X , Y plane only.

NOTE: As an alignment aid, a 2.325" diameter disk mounted into a tool holder may be used (Refer to Figure 5). Handle jog as necessary to bring the disk in line with the center of the tool changer's fingers.

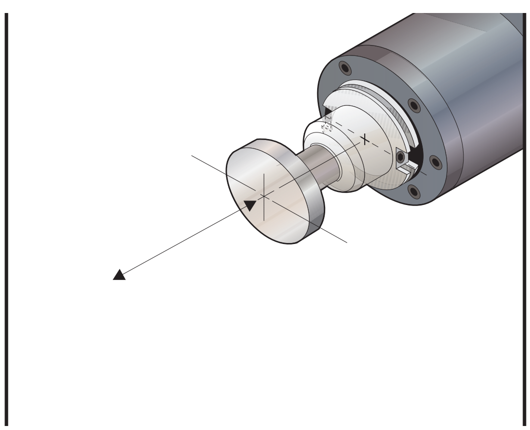


Figure 5

25. Record the values in the **ACTUAL** column for the position of the X and Y-axes given on the **POS-RAW DAT** screen.
    Enter the position value for the X-axis in **Parameter 210** (This can only be a negative number).

NOTE: This number is entered without the decimal point and must be the same sign as that given on the **POS-RAW DAT** screen. For example –0.7094 would be entered as –7094, and –278.8854 would be –2788854.

Enter the position value for the Y-Axis in **Parameter 211**.

26. Align the **Z-axis.** Line up the finger groove in the tool holder with the extractor fingers on the carousel. Handle jog the spindle in +Z direction (towards the rear of the machine). Then handle jog the -X direction (towards the control panel). Stop when it is clear that the tool holder groove can be jogged towards the front of the machine without hitting the extractor fingers.

NOTE: It should not be necessary to move the Y-axis during this exercise.

27. Handle Jog the spindle in the -Z direction (towards the front of the machine) and align the tool changer's fingers with the groove in the tool holder. Handle jog the spindle in the +X direction (towards the tool changer) and slowly move the tool holder into the extractor fingers. **STOP AND RE-ALIGN IF ANY MISALIGNMENT IS FOUND**. Continue to move the tool holder into the fingers until the drive notch on the side of the tool holder is approximately 0.050 in. from bottoming out on the carousel's alignment key. Refer to Figure 6.

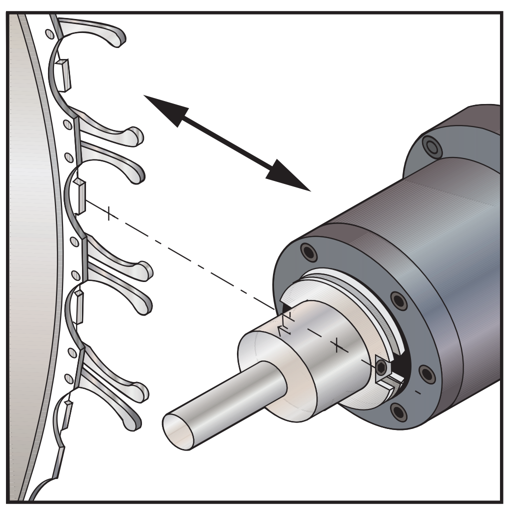


Figure 6

28. Record the values for the position of the Z-axis given on the **POS-RAW DAT** screen.
    Enter the position value for the Z-Axis in **Parameter 64** (This can only be a positive number).

29. Move the spindle in the –X direction to extract the tool holder from the tool changer's extractor fingers. Jog the spindle as necessary to move it clear of the tool changer. Remove the tool holder from the spindle.

30. Manually pull the carousel out of the machine enclosure, into its retracted position.

31. Close the tool changer door. Press **MDI/DNC,** move to **PROGRAM** screen. Toggle the cursor to the number 1 after the equal sign. Enter "**0**" and press **ALTER** button. Next press **RESET** and **CYCLE START**. The tool changer door will close.

32. Remove the jumper installed in the **TCIN** limit switch connector (#820B) at the base of the tool changer and reconnect the previously disconnected limit switch cables.

33. **POWER OFF**, then **POWER ON** the machine. Press **RESET** button to clear any alarm messages.

NOTE: Verify all **Parameter Value(s)** have been recorded.

34. Press the **ZERO RET** and then **AUTO ALL AXES** button.

35. Install a tool holder into the spindle.

36. Press the **MDI/DNC** button, then **ATC FORWARD** button. Repeat steps 22 and 23, to manually move the carousel into the machine enclosure.

NOTE: The spindle will move to its tool change position and the machine will fault-out and display a **SHUTTLE FAULT ALARM**. This is due to the shuttle motor cable disconnection.

37. Move the carousel into the tool holder and verify that proper extractor finger alignment has been made. (Repeat steps 23 through 30 as necessary to align the tool changer extractor fingers to the tool holder.)

38. Once alignment has been verified, pull the tool changer carousel out of the enclosure, close the shuttle door and reconnect the shuttle motor cable connector at the rear of the machine.

39. Press the **MDI/DNC** button and then press the **ATC FORWARD** button to verify proper operation of the tool changer.

40. Go to the **SETTING 7**, toggle **PARAMETER LOCK** to "**OFF**" . With the setting toggled to "**OFF**", press **WRITE/ENTER** button to enter this value.

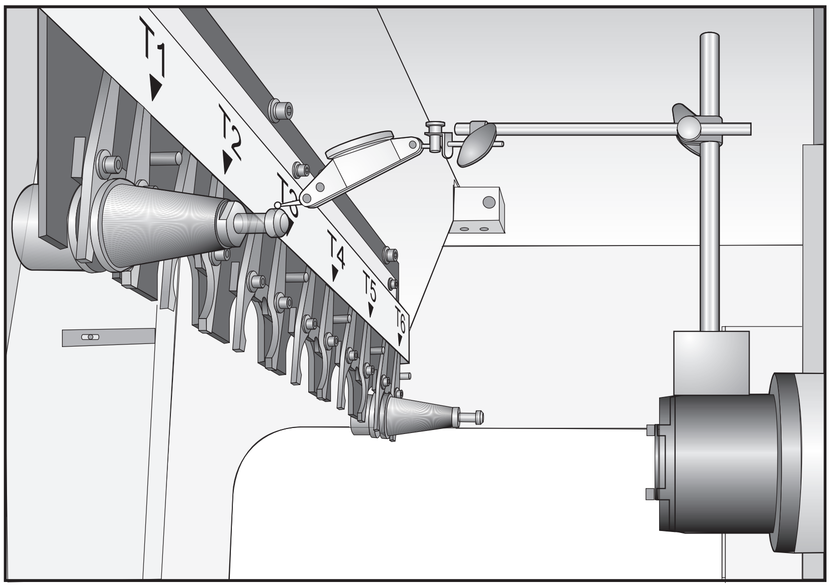
41. Set Parameter 34, Z axis Maximum travel. The formula for doing this is:
Parameter 33 X 31" (inches) - Parameter 64= The value to be entered in Parameter 34

NOTE: In order to bring the tool changer carousel back to home position a "Tool Changer Recovery" must be done.

Linear Tool Changer Alignment (HS-1/R)

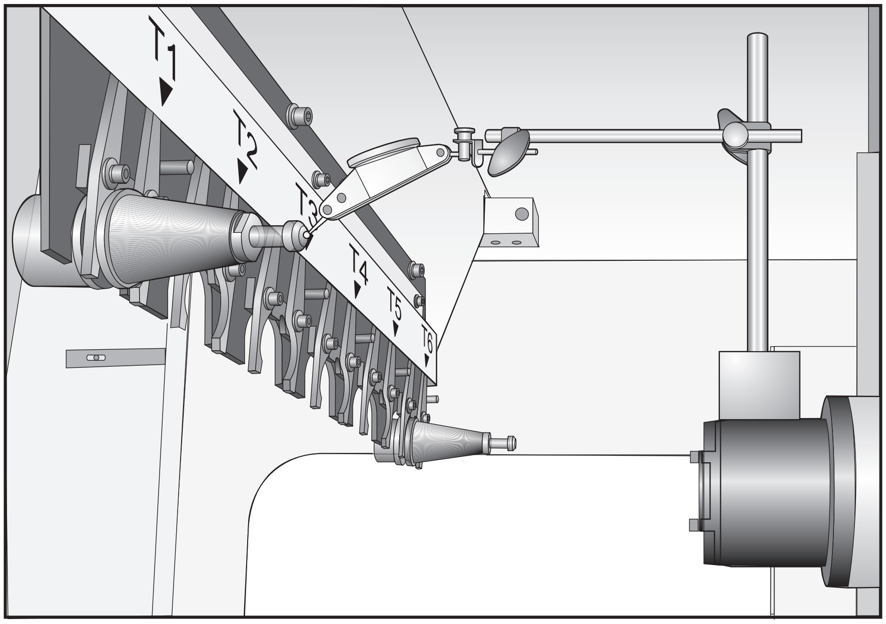
1. Install by hand a 40 taper tool holder into tool positions #1 and #6 on the linear tool changer. Whether the tool holders have a tool installed or not is not important, only that the tool holders be in good condition and have a stock CT pull stud installed.

2. Mount a Mag. Base and 1/10th indicator on to the spindle nose. Using the Jog Mode, position the spindle with the indicator attached so that the probe on the indicator just rests on top of the flat of the pull stud of the tool holder mounted in tool position #1, see figure below.



3. Zero the indicator. Leaving the Y-axis alone, jog the indicator in the X-axis from the #1 pull stud over to the pull stud on #6. Find the high point on this pull stud. The idea is to note which end of the tool changer is high or low, we are looking for an average change in height. Using shims slipped under the Top Beam mounting pad at the low end, retighten the screws, re-zero the indicator and repeat the same run. Keep adding shims as necessary. The goal is to achieve a plus or minus 0.010 reading from nominal on each pull stud.

4. After successfully completing step 3, reposition the indicator and jog the spindle so that the probe just touches the back end of the pull stud on tool holder #1, see the figure below.



5. Tighten one of the Top Beam hold down screws on the side nearest tool position #1 and zero the indicator on the back of the pull stud. Now jog the indicator over to the pull stud on tool #6 and note the reading. Adjust the fore / aft position of the Top Beam assembly as necessary, hand tighten the screws and repeat the same run starting back at tool position #1. Repeat as necessary, the goal is to achieve a reading < 0.010 from position #1 to position #6. Do not remove / disturb the shims added in step 3.

6. After successfully completing step 5, tighten all Top Beam hold down screws and repeat the indicator runs performed in steps 5 and 3 to confirm the tool changer assembly has not moved. If satisfied, remove the Mag Base and indicator.

7. Remove all the tool holders from the tool changer assembly. Install in position #1 the tool holder half of the 40 Taper Alignment Tool (T-2086). Install the other half of the Alignment Tool in the Spindle. Using the Handle Jog, slowly and carefully position the spindle nose just behind the alignment tool in position #1. Using small movements on the handle jog, position the alignment tool mounted in the spindle until the 40 taper Alignment Tool Pin can be passed through both halves of the alignment tool. Note the Spindle Position as displayed on the screen in the “X”, “Y”, & “Z” axis. These should all be negative numbers. Write them down, you will need them in a few minutes. Remove the alignment tool from the tool changer assembly.

3.9 Chain style Side Mount Tool Changer

Automatic Operation Warning

Exercise caution when working on or around the SMTC. There are many pinch points, and it may move unexpectedly. Press emergency stop before working in any areas where you could get hurt if it moved. If there is a tool shown in the arm, the SMTC will initiate a tool put-away sequence if reset is pressed. This will happen based on whether the control shows a tool in the arm, not whether there actually is one.

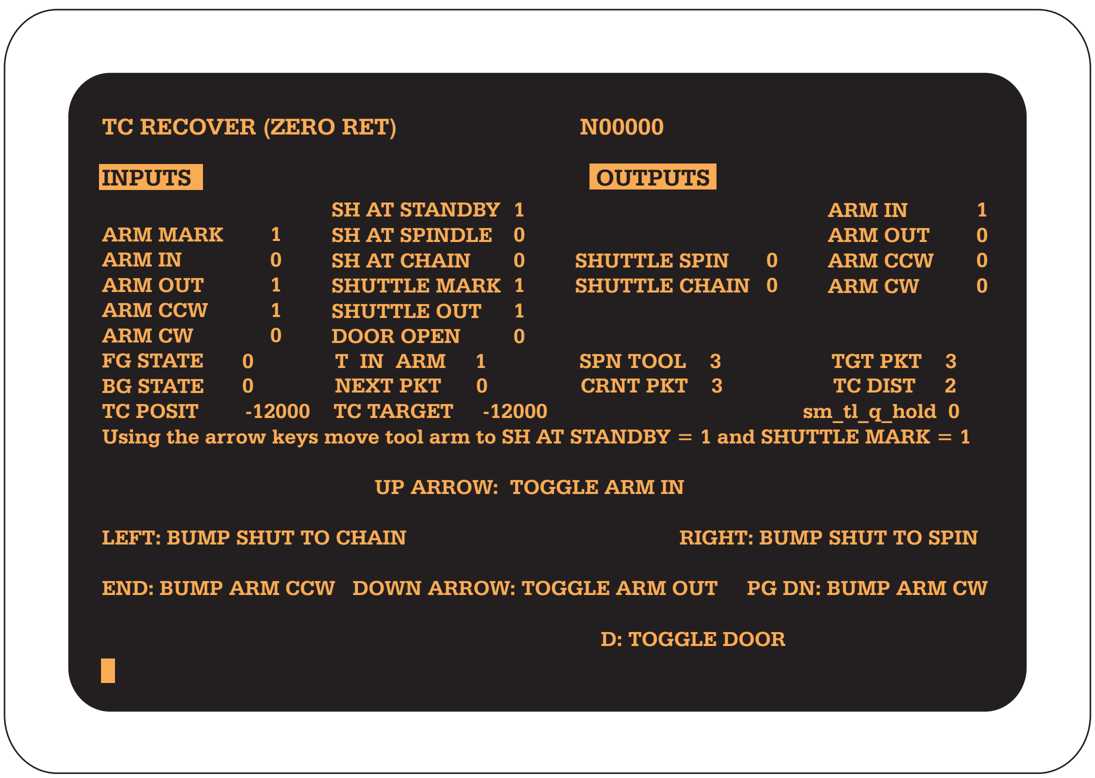
Invisible Axis Explanation

The SMTC uses an invisible axis to control the tool chain. If the axis is made visible to service or adjust it, the safety interlocks to prevent the chain from rotating are disabled. Be sure the double arm is out of the way before rotating the chain or machine damage will occur.

Tool Change Recovery

Tool Change Recovery

If a problem occurs during a tool change, or Zero Return results in an alarm or the MV SHUT TO STBY message, a tool change recovery (TCR) must be performed. For the HS 60/120 SMTC, tool change recovery is a manual process. To enter TCR, press the Tool Change Recovery button on the keypad. The display will appear as in the figure below:



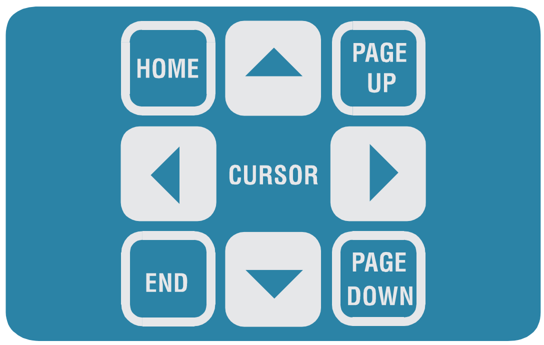
The tool change recovery procedure will be complete when the following state is reached:

The INPUTS portion of the TCR display (upper right corner) indicates:

SH AT STANDBY	1
SHUTTLE MARK	1
SHUTTLE OUT	1
ARM MARK	1
ARM CW or CCW	1
ARM IN or OUT	1

TCR Keys

The tool changer can be manually recovered from a fault or alarm state using the keypad keys listed below:



Cursor Up Arrow - Toggle Arm In
Cursor Down Arrow - Toggle Arm Out
Cursor Left Arrow - Bump Shuttle towards Chain
Cursor Right Arrow - Bump Shuttle towards Spindle
Cursor End - Bump Arm counterclockwise
Cursor Page Down - Bump Arm clockwise
Keypad D - Toggle Tool Door open and close

TCR Status

WARNING!

Only rotate the arm (end or page down keys) with the arm out (Down arrow key). Rotating the arm while the arm is in (arm in = 1) will not allow the arm to rotate fully and may damage the position switches.

The basic theory involved with the TCR process is to ensure:

1. The actual tool in the spindle (SPN TOOL) and the tool in the arm (T IN ARM) match what is indicated on the TCR display.

2. If there is one tool in the arm, the arm is positioned with this tool nearest the chain. There must be an empty pocket for this tool.

Shuttle at Standby

3. The shuttle is at the STANDBY position as indicated on the TCR display. STANDBY is reached when the following is true:

SH AT STANDBY	1
SHUTTLE MARK	1

Arm at Home

4. The double arm is at the home position when the following is displayed on the TCR screen:

ARM MARK	1
ARM CW or CCW	1

The ARM CW or ARM CCW must be 1 (indicating the Double Arm is completely rotated CW or CCW).

TCR With NO Tools in Arm

A TCR is necessary and there are no tools in the arm.

1. Press RESET to clear any alarms.

2. Enter TCR by pressing the Tool Change Recovery button on the keypad.

3. If the arm is not at the home position, move the arm home.

4. Using the Left Arrow and/or Right Arrow cursor keys as necessary, jog the shuttle to Standby.

TCR with ONE Tool in Arm

A TCR is necessary and there is one tool in the arm.

1. Press RESET to clear any alarms. Enter TCR by pressing the Tool Change Recovery button on the keypad.

2. Record the T IN ARM number. If the T IN ARM number is 0, remove the tool manually.

3. Go to the Tool Pocket Table and confirm which pocket the tool in the arm belongs in. Make sure the pocket in the tool changer is empty. Jog the shuttle to the Standby position, close the tool door, and let the tool changer put the tool away.

Upon exiting the Tool Change Recovery, the control will put away any tool shown to be in the arm.

Tool Pocket Occupied

4. If the tool pocket for the tool currently in the arm is occupied, find an empty pocket in the Tool Pocket Table.

5. Reassign the tool in the arm to an empty pocket.

6. Jog the shuttle to the Standby position, close the tool door, and let the tool changer put the tool away. The tool changer pocket must be empty to receive the tool. The tool table screen will show which tool is in the spindle, confirm that the corresponding pocket on the tool changer is empty.

A Position Underrun or Time Out condition exists. The shuttle and/or tool arm may be in any position.

1. Press RESET to clear any alarms.

2. Enter TCR by pressing the Tool Change Recovery button on the keypad.

3. Identify which tool in the arm belongs in the spindle. Reference the SPN TOOL number on the TCR screen.

4. Use the DOWN ARROW cursor key to move the double arm to the OUT position.

5. Use the PAGE DOWN and/or END cursor keys to bump the arm so that either the ARM CW or ARM CCW input reads 1, Arm Mark reads 1, and the tool that belongs in the spindle is closest to you.

6. Use the RIGHT ARROW cursor key to bump the shuttle until the SH AT SPINDLE and SHUTTLE MARK inputs read 1. The double arm should be in tool change position in front of the spindle.

7. Press TOOL RELEASE. Press the UP ARROW to move the arm in cursor key. Press TOOL RELEASE.

8. Press the LEFT ARROW cursor key to bump the shuttle to the Standby position.

9. Press D to close the tool changer door.

10. The tool changer pocket must be empty to receive the tool. The tool table screen will show which tool is in the spindle, confirm that the corresponding pocket on the tool changer is empty. Enter MDI mode. The tool changer will automatically put away the tool in the arm.

Door Out Of Position Alarm

During a tool change, the DOOR OUT OF POSITION alarm occurs.

1. Press RESET to clear any alarms.

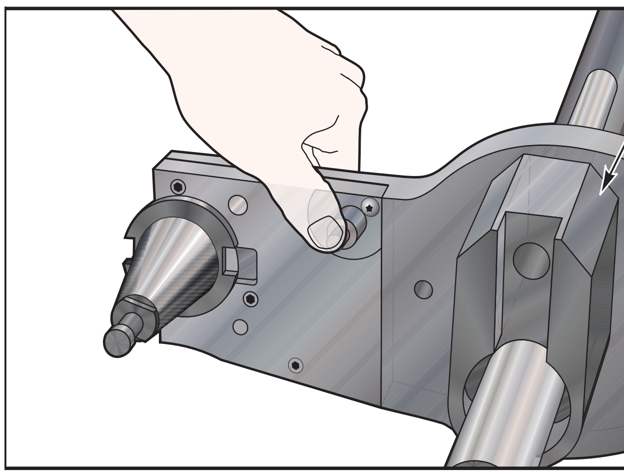
2. Enter TCR by pressing the Tool Change Recovery button on the keypad.

3. Using the TCR screen and features, move the shuttle to the Standby position.

4. Press D to close the tool changer door.

Tool Removal From Double Arm

Arm Link



To remove tools from the double arm it is necessary to press the plunger on the same end of the arm as the tool while pulling the tool out sideways. 2 persons may be required. Wear gloves, cutting tools are sharp!

Tool Removal From Chain With Incorrect Pull Stud

Wear gloves, cutting tools are sharp, and the tool pockets are spring loaded.

If a tool becomes stuck in the chain due to an incorrect pull stud do not attempt to pry the tool loose from the chain. Damage to the atc and tool may result. Instead, use this technique. Rotate the chain to a position where the back of the tool pocket is accessible. Press emergency stop. Remove the spring from the tool pocket by carefully lifting it out of its groove using 2 screwdrivers. Make sure you do not kink the spring in the process. Remove the 4 plungers using a magnet. The tool holder may now be removed without further damage. Re-grease and reinstall the plungers and spring. It may be helpful to insert one side of the spring into the groove and roll the remainder in place. Be careful not to line up the plungers with a space between the spring coils.

Tool Removal From Chain With Correct Pull Stud

Wear gloves, cutting tools are sharp, and the tool pockets are spring loaded.

If it is necessary to manually remove a tool from the chain this can be accomplished in the following manner. Press emergency stop. Insert a large screwdriver between the front face of the toolholder and the rear face of the tool's flange. A slight lever motion of the screwdriver will dislodge the tool.

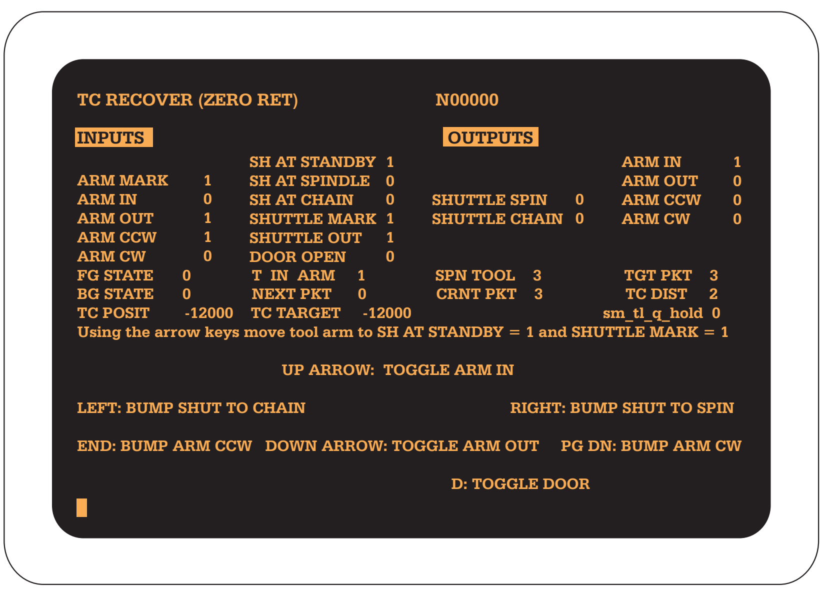
Aligning The 60/120 SMTC Changer To The Mill

CAUTION: **Stand clear of all parts of the tool changer when commanding movements during normal operation or Tool Change Recovery.**

CAUTION: **If the control shows there is a tool in the arm, after exiting the Tool Change Recovery function, the tool changer will put the tool away. If the control thinks there is a tool in the double arm, ensure the corresponding tool pocket is empty.**

1. Enter Tool Change Recovery and jog the shuttle to the Standby position. See figure below for correct diagnostic readouts for Standby position. For more detail, refer to the Tool Change Recovery section.

NOTE: Press Tool Change Restore to enter the tool changer recovery mode. Familiarize yourself with the commands on this screen. The tool changer limit switch outputs are also displayed on this screen. This will be helpful when setting the shuttle to a particular position (e.g. At Standby).



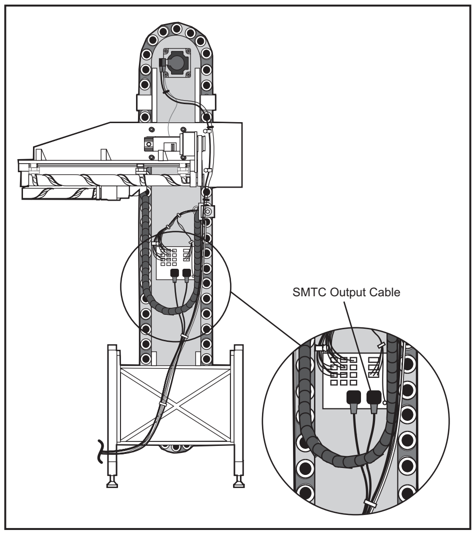
The TCR screen above shows the shuttle At Standby

NOTE: When moving the shuttle to position via Tool Change Recovery, move the shuttle to position, then press the button one additional time. This will ensure the shuttle cam is not on the edge of the Shuttle Mark switch.

2. Verify that parameter 278 TC DR Switch is set to 1. Write down the value in parameter 64. Change the value to 0 (zero). Zero return all axes.

3. Enter DEBUG mode.

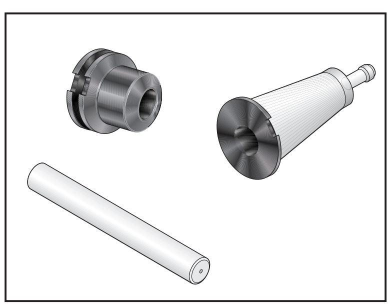
4. Unplug the tool changer output cable at the tool changer.



5. Select MDI mode and command ATC forward. The machine will display an alarm.

6. Press reset to clear the alarm, then enter tool change recovery.

7. Slide the dowel through the alignment tool, (this will act as a handle) and snap the alignment tool into the arm. The flat side of the tool should be toward the spindle. Remove the dowel pin. Note: the release pin on the double arm must be depressed to insert the alignment tool. Be sure the tool is seated firmly in the arm.

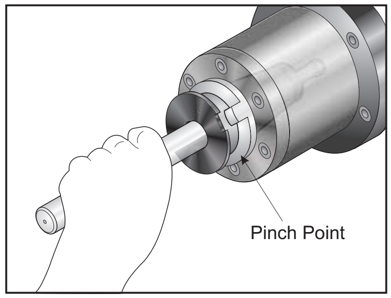


Alignment tool

8. Insert the dowel pin into the alignment tool and use the dowel pin as a handle to push the alignment tool into the spindle.

Caution: Pinched fingers could result if this is not done. Press tool release once to unclamp and again to clamp.

Remove the dowel pin and orient the spindle.



9. Plug in the ATC output cable. While in tool change recovery move the double arm out by pressing the down arrow once. Move the shuttle to the spindle by pressing the right arrow repeatedly until both the input for “Shuttle at Spindle” is 1 and the input for “Shuttle Mark” is 1. Be careful not to hit the spindle nose with the ATC. This may happen if parameters 210 or 211 have been changed.

10. Press the down arrow again to turn off the air solenoid, this will allow the double arm to be moved in towards the spindle by hand. Slowly move the 2 halves of the alignment tool together watching for any interference from the spindle dogs etc.

11. Handle jog the X or Y axis in .001 jog increment as necessary to align the double arm to the spindle. When the dowel pin slides freely through both halves of the alignment tool the spindle is in the correct position.

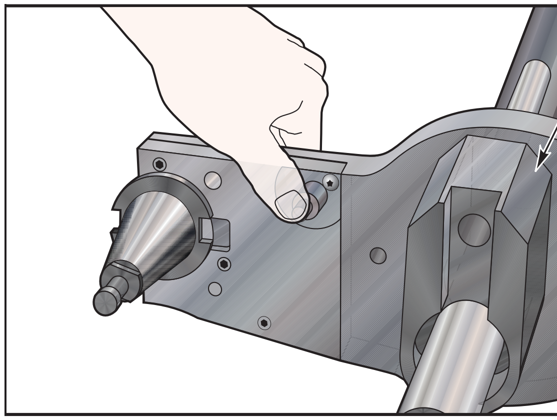
12. Record the actual value for X and Y axis on the “pos-raw dat” screen. Omit the decimal but include the negative sign . Enter the X value in parameter 210 and the Y value in parameter 211.

13. Remove alignment tool from spindle and double arm. While in tool change recovery, use the left arrow to move the shuttle away from the spindle until the “Shuttle at Standby” and “Shuttle Mark” inputs are both 1.

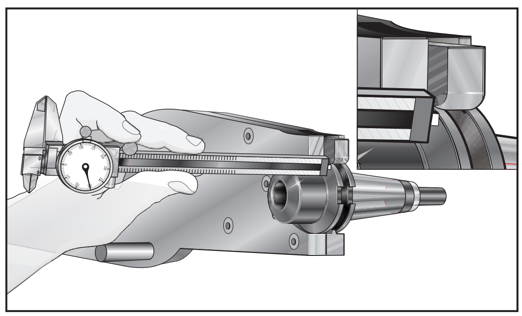
14. Repeat steps - to check the X-Y alignment. Correct as necessary.

15. Remove alignment tool from spindle and double arm.

16. Install a tool holder in the double arm jaw nearest the spindle.



17. Use a dial caliper to measure the distance from the face of the tool holder to the front surface of the double arm gripper. (See figure) Note value and remove the tool.

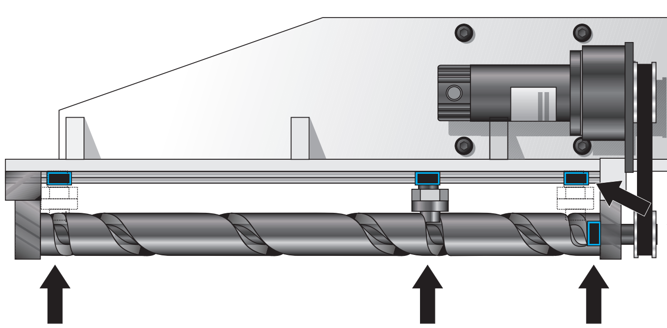


18. Place the same tool holder in the spindle.

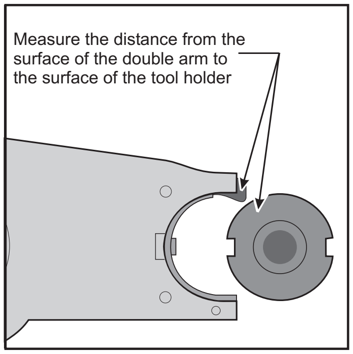
19. Using tool change recovery, press the up arrow to hold the double arm in.

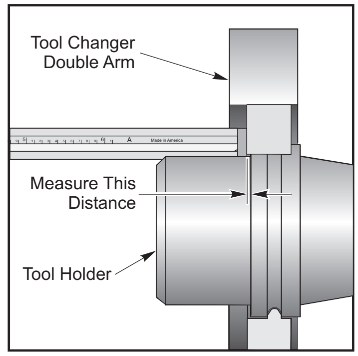
20. Press the right arrow repeatedly until the shuttle is close to the spindle. Unplug the tool changer output cable at the tool changer. Manually rotate the shuttle cam until the shuttle is very close to, but not touching, the tool in the spindle.

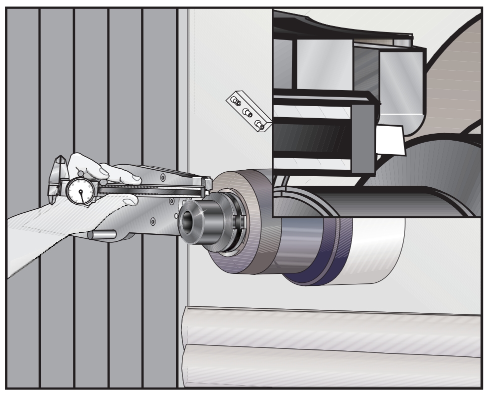
Caution: When rotating the tool changer cams by hand, wear protective gloves. The edges of the cams are very sharp



21. Measure the distance between the front surface of the double arm gripper and the front face of the tool holder, using a dial caliper.







22. Jog the spindle in .001” increments until the measurement is the same as that previously taken.

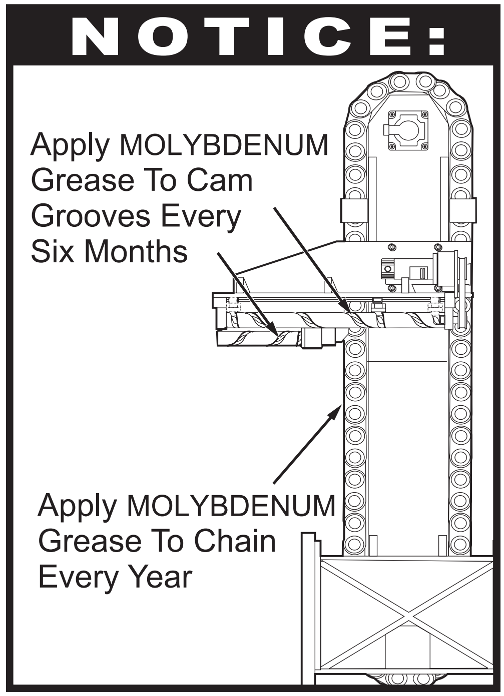
23. Display the POS-RAW DAT screen. Write down the Actual value for Z. Enter this number into Parameter 64.

24. Remove the tool from the machine. Plug in the ATC output cable. Return the shuttle to the Standby position. Close the tool door and exit DEBUG.

25. Zero-Return (Auto All Axes) the machine.

26. Verify the tool changer Z-axis alignment by repeating steps 4-22. If alignment is correct jog the tool changer to where you can remove the alignment tools. Complete the tool changer restore and close the door. Without a tool in the spindle enter MDI and command ATC FWD . After checking without tool for proper operation install a tool and test again.

Lubrication



Re-grease the shuttle mechanism every 6 months.

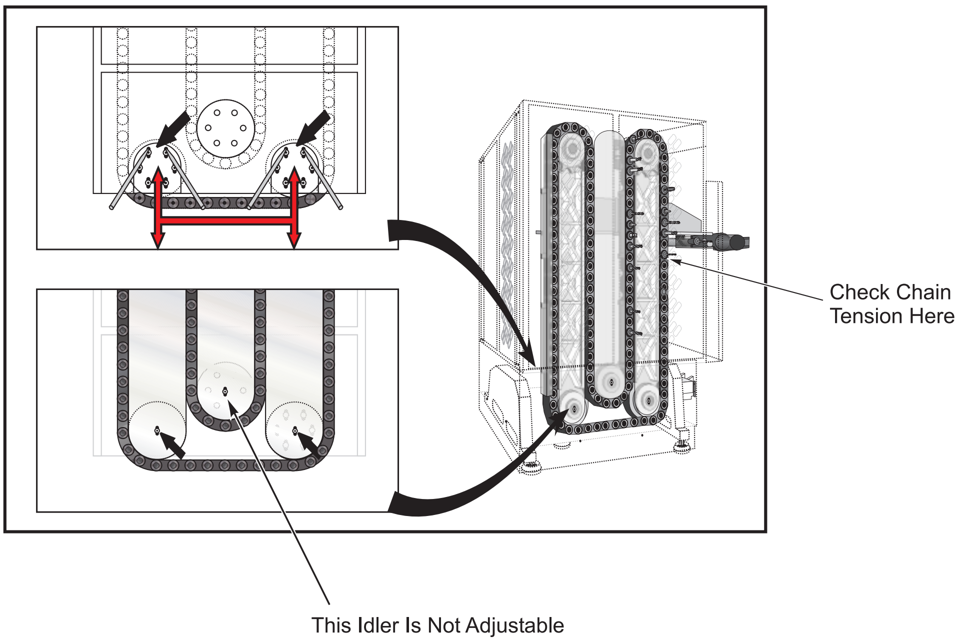
Regrease the tool chain every year.

The gearboxes are permanently lubricated.

To apply grease a small brush may be used. Common Molybdenum grease is used. To grease the chain, coat the sliding surfaces of the links, and the outside of the tool pockets where they contact the sprockets. The shuttle mechanism requires grease in 6 places. The linear guide trucks have 2 zerk fittings. Be careful not to overgrease them. A small amount is sufficient. Grease the shuttle cam and double arm cam grooves with a small brush. Use caution, the cam edges may be sharp. Grease the double arm link groove and link rod with a small brush.

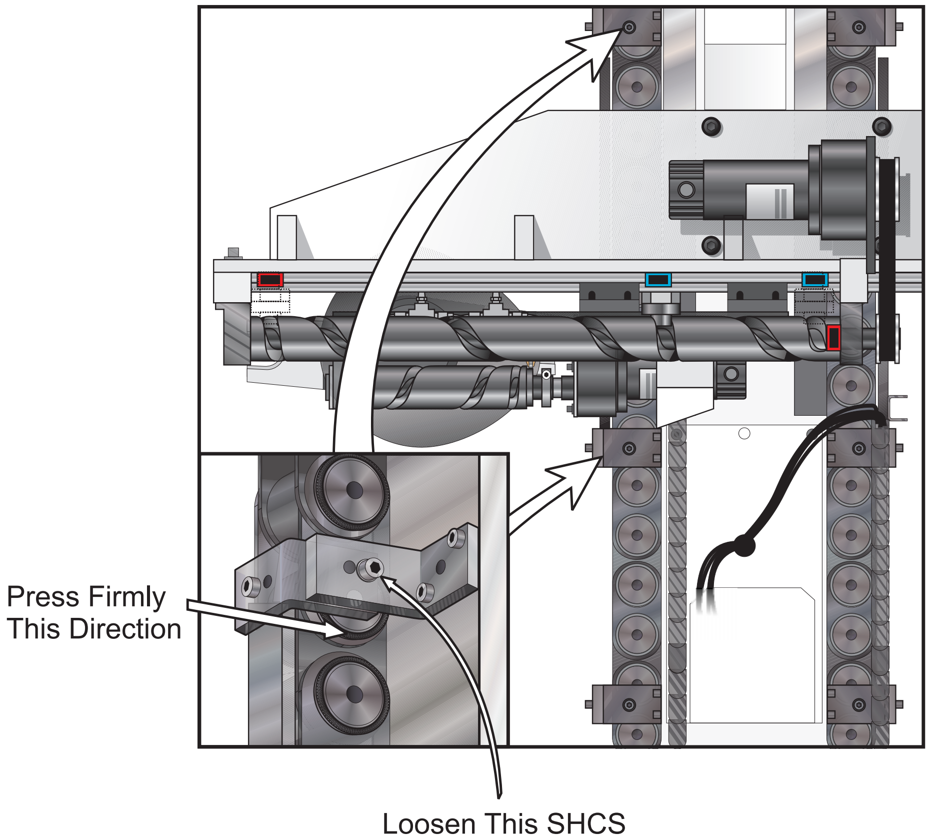
Chain Tensioning

The chain tension should be sufficient to prevent hand pressure from moving the tool chain sideways more than 3/8" in one of the unsupported areas of the chain (see illustration).



To adjust chain tension press emergency stop. Remove the front screen, and rear lower sheet metal panels (see illustration). Loosen the 1/4" shcs holding the sheetmetal cover to the idler(s). Loosen the 6 1/2" shcs attaching the idler. Using a suitable pry bar, press down on the idler, and hold tension while re-torquing the 6 shcs with blue Loctite. Retighten the front cover shcs. Recheck tension. Reassemble sheetmetal. On 120 tool ATCs the 2 bottom idlers should be adjusted equally, the middle idler is not adjustable.

Chain Guide Adjustment



The chain guides near the double arm need to be snug against the chain to prevent the tool pocket from shifting during toolchanges. To adjust, loosen the indicated SHCS, as shown, and retighten, with blue Loctite, while pressing the guide firmly against the chain. Adjust one end of the guide at a time. It may be useful to use a large c clamp to hold the guide while tightening it. The other guides do not normally need readjusting, but the procedure is the same, if required.

Double Arm Alignment

Aligning the double arm consists of 3 adjustments.

1. First adjust it rotationally, so the arm is horizontal.

2. Next adjust it in the z direction, so it lines up with the chain.

3. Then adjust it in the x direction, so it lines up with the chain.

4. Check and or adjust the chain tension and chain guides before adjusting the double arm alignment.

If the double arm alignment is changed, recheck the tool chain alignment to the double arm and recheck the spindle alignment to the double arm.

Double Arm Rotational Alignment

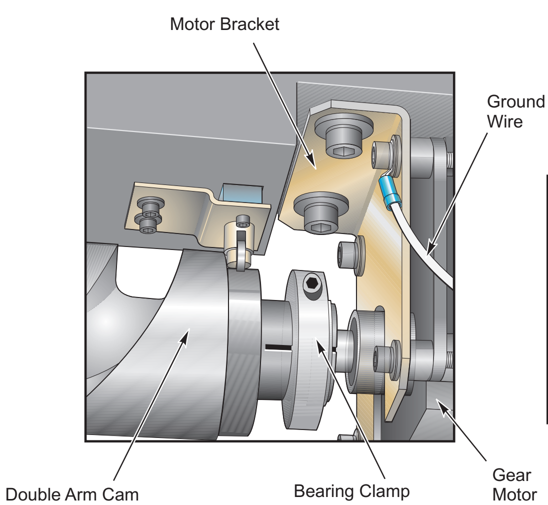
The object is to get the double arm horizontal, with both ends of the double arm lining up equally well.

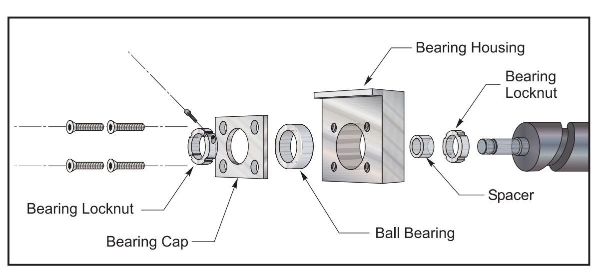
1. Using tool change recovery, make sure the double arm is either cw, or ccw. And arm mark is 1.

2. Place a level on the horizontal surface of the double arm nearest the spindle. This surface should be level. If not, adjust.

3. Rotate the arm 180 degrees and recheck. If the arm was cw, move to ccw. If the arm was ccw, move to cw. If they are not quite the same, adjust to split the difference. If there is a large difference, the cam arm may be damaged or bent.

4. If the arm is level, verify the 2 bearing nuts and bearing clamp on the double arm cam are tight, and proceed to z direction alignment.





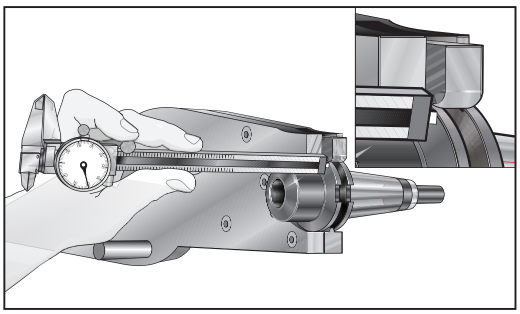
If leveling is needed, loosen the bearing clamp on the end of the cam closest the motor. This will allow the cam to slide on the motor shaft without harming the gearmotor. Early units, without this bearing clamp, are adjusted by slightly loosening the 2 3/8 shcs holding the motor bracket to the shuttle.

To rotate the arm more cw shift the double arm cam left as viewed from front. To rotate the arm more ccw shift the double arm cam right. To shift, on the non motor end of the cam there are 2 bearing locknuts. Loosen the clamp shcs on both of them. Loosen the locknut in the direction you wish to shift the cam, then tighten the locknut on the other side of the bearing until it is again tight. Retighten the clamp shcs on the 2 bearing locknuts and the bearing clamp. Recheck leveling. Repeat if needed.

Double Arm Z Direction Alignment.

The in and out adjustment of the double arm is accomplished by loosening the double arm clamp bolts and sliding the double arm to the correct position. Set the double arm to the chain position, not the spindle. The spindle can be adjusted by parameter to match the double arm.

1. To check alignment, place a tool holder in the double arm. Be sure the tool holder is not touching the chain or spindle.

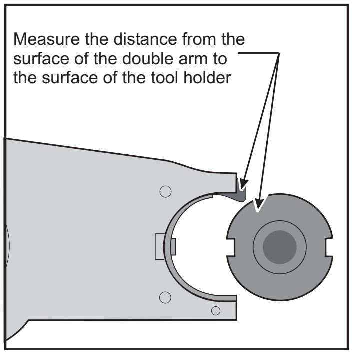


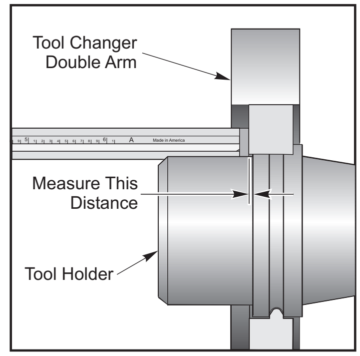
2. Use a dial caliper to measure the distance from the face of the tool holder to the front surface of the double arm gripper(see figure)note value and remove tool.

3. Place the same tool holder in the tool pocket nearest the double arm.

4. Using tool change recovery, move the shuttle to standby, then press the up arrow to hold the double arm in.

5. Press the left arrow repeatedly to bring the double arm close to the tool, but not quite touching it. Take a measurement between the same 2 surfaces(see illustration).





6. The measurement should be the same. If adjustment is needed, loosen the double arm clamp bolts and slide the double arm in or out until the correct adjustment is reached. See section on double arm replacement for more detail if needed.

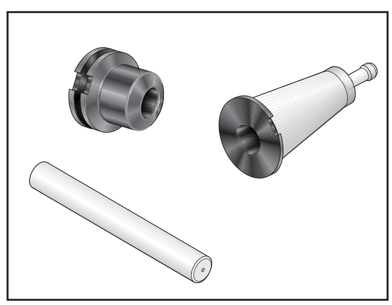
7. Retighten the double arm clamp bolts and recheck alignment. Be sure to check both ends of the arm. If they are different, check for bent or damaged components.

Double Arm X Direction Alignment.

The sideways alignment of the double arm is adjusted by shifting the shuttle cam left or right.

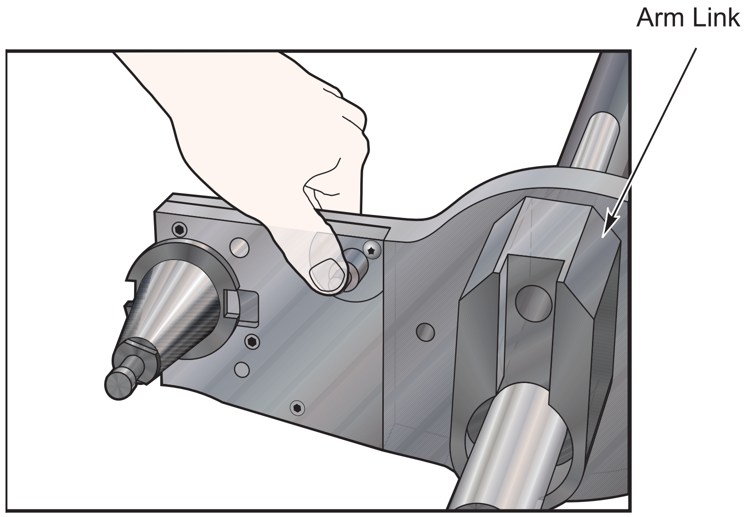
1. Zero return auto all axis.

2. Use a split alignment tool to align the atc(see illustration)



3. Insert the tapered half of the tool into pocket 1.

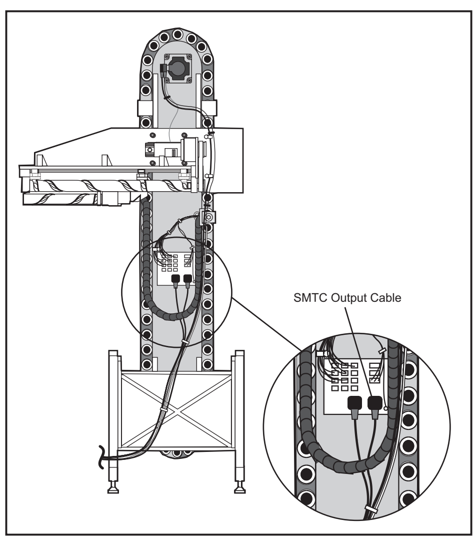
4. Insert the front half into the side of the double arm nearest the chain.



5. Using tool change recovery, position the arm out, arm either cw or ccw, at chain, arm mark, shuttle mark.

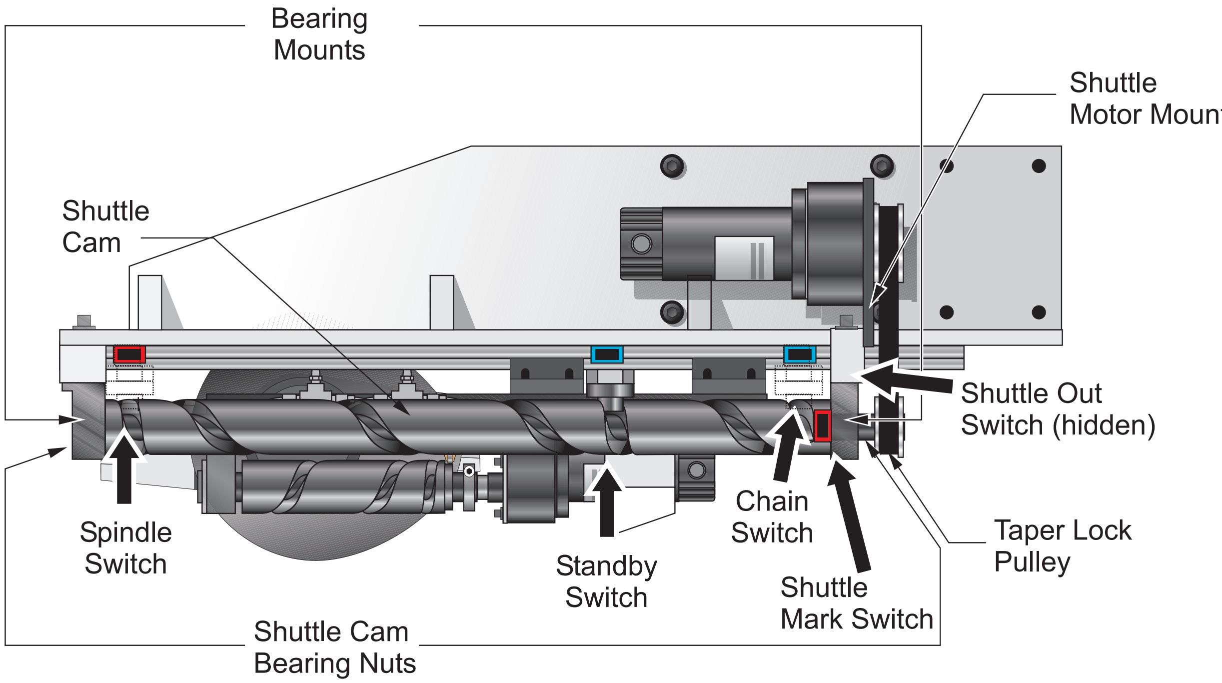
6. Press emergency stop.

7. Unplug the smtc output cable.



8. Gently push the 2 halves together, observing the alignment.

9. The shuttle may be moved either left or right by shifting the shuttle cam in the desired direction.



10. To shift the shuttle cam, loosen the lock shcs on both of the shuttle cam bearing nuts.

11. Loosen the bearing nut on the end you want the cam to move away from.

12. Tighten the bearing nut on the end you want the cam to move toward until the bearings are again lightly preloaded.

13. Tighten the locknut shcs.

14. Recheck alignment.

15. To remove the tapered half of the alignment tool from the chain, rotate the chain to another pocket so that the back of pocket 1 is exposed. A rod may then be used to push the tool out from the back.

Chain Axis (TT) Grid Offset Setting

To set the grid offset for the tool changer axis, adjust the grid offset value until the distance to go reads:
0.24 for a 60 tool SMTC, or
0.12 for a 120 tool SMTC

1. Zero return the tool changer axis (zero return auto all axes). Record the current distance to go for this axis.

2. Increase or decrease the grid offset parameter for this axis until the correct value is reached. If the result is a negative number, add that number to 32768 to obtain a positive number. The resulting value must be less than 32768. Grid offsets must always be -, if + is used for chain, zero return position will be unreliable if it happens to stop with the axis home switch pressed.

3. Zero return auto all axis and recheck distance to go. If necessary, repeat step 2.

Chain Axis (TT) Tool Change Offset Setting

The grid offset must be set prior to setting this offset.

The chain axis tool change offset is used to adjust the chain position so that the double arm is centered on tool pocket 1 after zero returning (auto all axis). If both ends of the double arm are not in the same position, realign the double arm before setting this parameter.

Set or check the TT axis grid offset (distance to go) before setting the tool change offset.

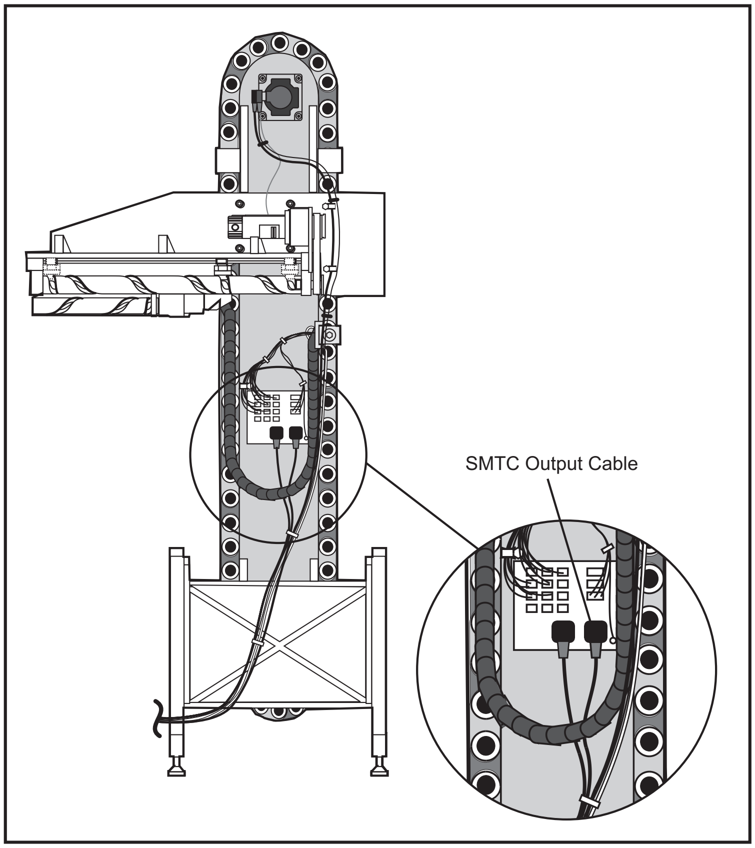
1. Zero return auto all axis.

2. Turn setting 51 off. (Door hold)

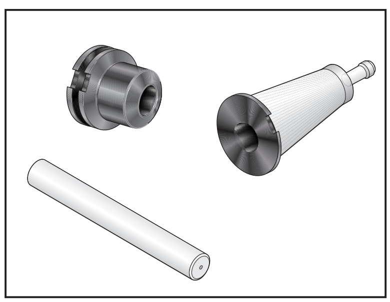
3. Enter debug mode.

4. Using tool change recovery mode, position the shuttle in front of the chain, arm horizontal, so that status is at chain, shuttle mark, arm mark, arm out.

5. Unplug the ATC output cable. This will allow the double arm and shuttle to be moved by hand. Caution, there is still servo power to the chain.



6. Install the tapered half of the split alignment tool into pocket #1



7. Install the flange half of the split alignment tool into the double arm.

8. Gently push the 2 halves together, observing the alignment.

9. Pull the double arm away from the chain (extend the double arm).

10. Set the TT invisible axis parameter to 0. Note this disables the interlocks between the double arm and the tool chain axis. Be careful not to bend the double arm or crash tools into it.

11. Handle jog the chain axis till the alignment is correct. T axis, or B axis on some early installations. Note the double arm has some backlash, adjust the chain position to split the backlash evenly.

12. Repeat steps 8,9,11 until the alignment dowel slides freely through both halves of the split tool.

13. Press posit, and scroll to the POS-RAW DAT page. This is the raw positioning data display screen.

14. Write down the T axis actual number from the pos-raw dat display.

15. Enter this number into the tool change axis (TT) tool change offset parameter.

16. Move the shuttle to standby position.

17. Zero return auto all axis.

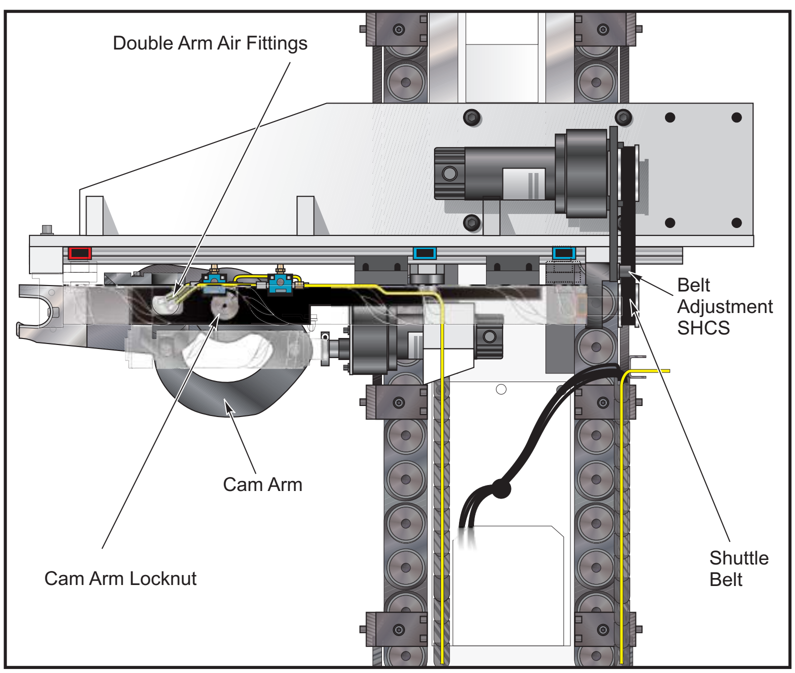
18. Recheck the alignment to the double arm.

19. If correct, proceed. If not, reverse the sign on the tool change offset parameter & recheck.

20. The tool chain axis is now set. If the alignment is incorrect in and out (Z), or sideways (X), or if both ends of the double arm do not line up the same, see section on aligning the double arm.

Shuttle Belt Tensioning

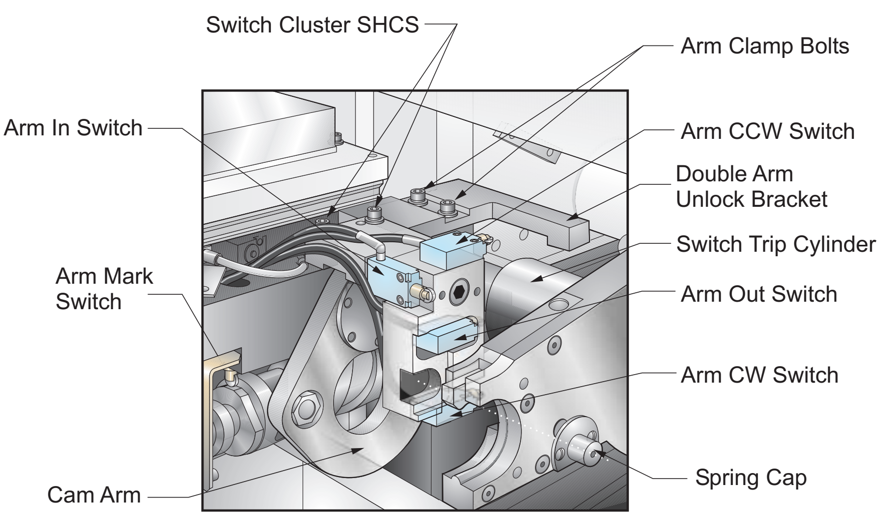
The shuttle drive belt should not be excessively tight. You should be able to deflect the belt 1/8-3/8" with a finger. To adjust the tension, loosen the 2 3/8" bolts and retighten them while lifting up on the gearmotor. Use blue Loctite.

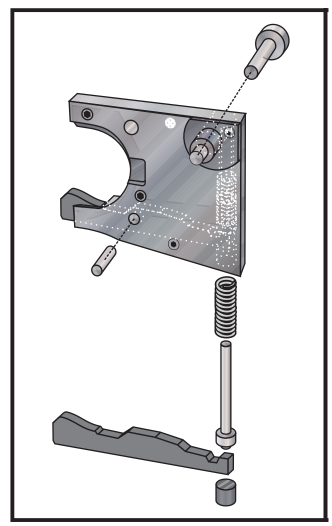


Gripper Assembly Replacement

The gripper assemblies are serviced as a unit. One assembly is used for each end of the double arm. If it is desired to field retrofit a CT mill to BT operation or vice-versa, this can be accomplished by replacing the gripper assemblies. Do not mix parts between various assemblies, they are pre tested as an assembly.

Remove any tools from the spindle and double arm. Using tool change recovery mode, open the tool door. Move the shuttle into the mill enclosure where it can be easily reached. It may help to extend the double arm. Disconnect the air supply from the mill. This will keep the tool door from closing on the shuttle. Press emergency stop. Remove the spring cap, being careful not to lose the spring or plunger. Remove the 5 5/16-18 FHCS holding the gripper assembly in place. Tap the gripper assembly loose and off of the rear of the double arm. The thin steel wear plate is removed with the gripper assembly. Replace the gripper assembly. Torque the FHCS with blue Loctite. Grease and replace the spring, plunger, and spring cap. Use blue Loctite on the 1/4-20 button head screws. Due to the short hex engagement, it is recommended to replace these screws with new ones when replacing the gripper assemblies. Recheck alignment of the double arm and correct if necessary.

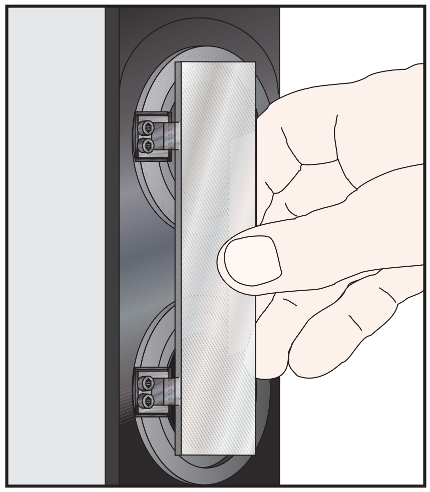




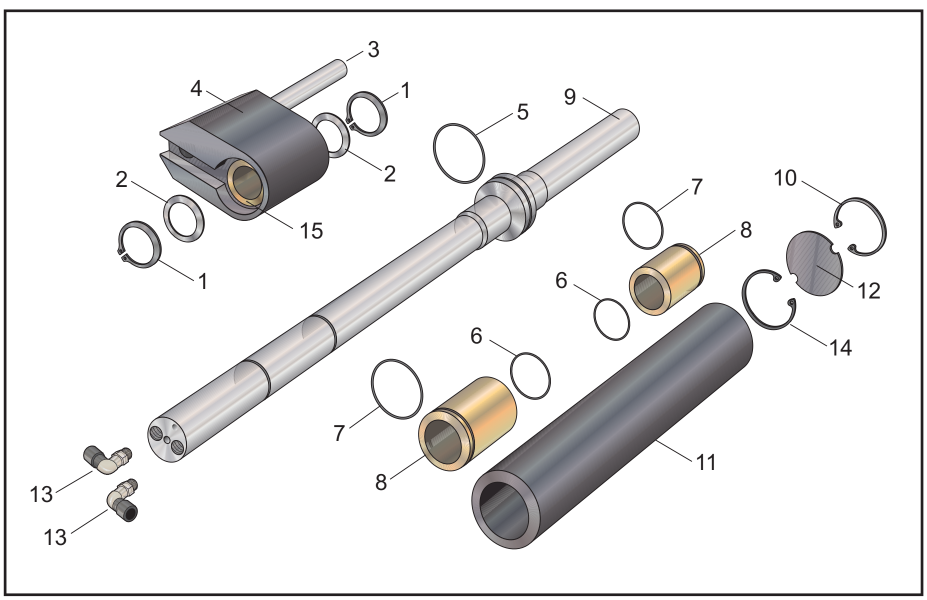
Gripper Assembly

Chain Key Replacement

To replace chain keys in the field, work on one link at a time. Remove the old keys. Clean any grease, etc. from the key area and screw holes. Loosely install the new keys. Apply blue Loctite to the screws. Be cautious of too much Loctite, it can weep between the chain links. Torque the screws while holding a straight edge across them to keep them straight. Regrease the chain if required.



Double Arm Air Cylinder

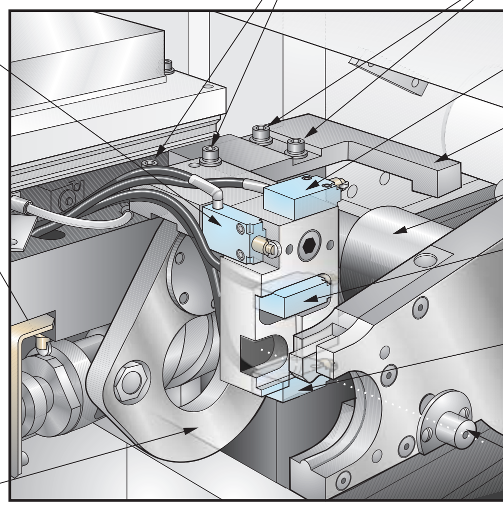


The air cylinder, and 4 of the 5 O-rings can be inspected without complete double arm removal. If the double arm clamp bolts are not disturbed, the cylinder may be inspected or 4 O-rings replaced without realigning the atc.

To dissasemble the air cylinder on the mill:

1. Press emergency stop.

2. Remove the switch trip cylinder



3. Remove the 6 3/8" shcs holding the cylinder to the double arm.

4. Gently pull the air cylinder off of the double arm shaft.

5. The piston o-ring and 1 seal housing outer o-ring are now visible.

6. Inspect or replace as appropriate.

7. Very lightly grease the o-rings with black molybdenum grease.

8. Excessive grease will impair proper cylinder operation.

9. If access to the outer seal housing outer o ring is needed, remove the 2 circlips, #10 & #14. This is normally not required.

10. The inner seal housing o-ring can be replaced without removing the circlips by using a dental probe or equivalent to remove.

11. If the rear seal housing inner o ring needs replacement the double arm and link must first be removed.

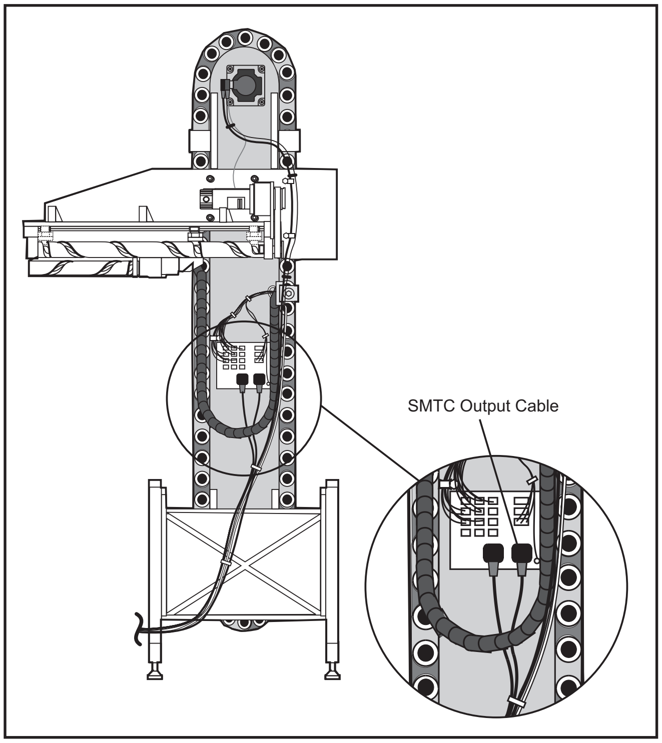
12. Reassemble in reverse order,

DOUBLE ARM REPLACEMENT

Removal

CAUTION: When rotating the tool changer cams by hand, wear protective gloves. The cams' machined edges are very sharp.

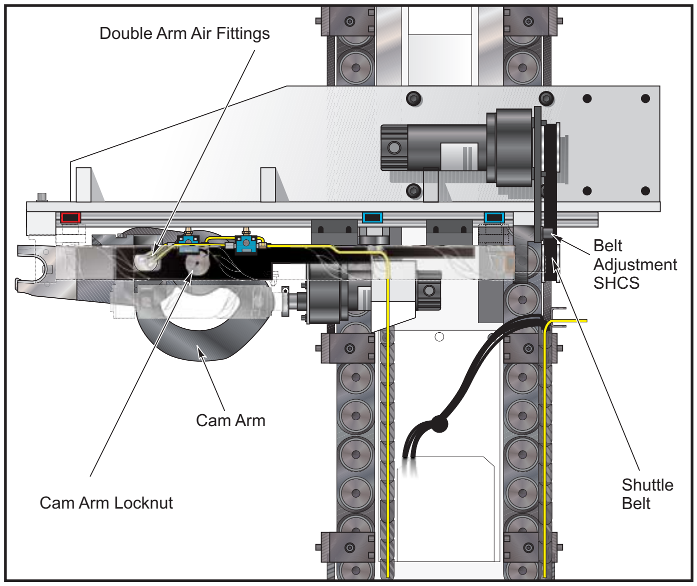
1. Unplug the SMTC output cable.

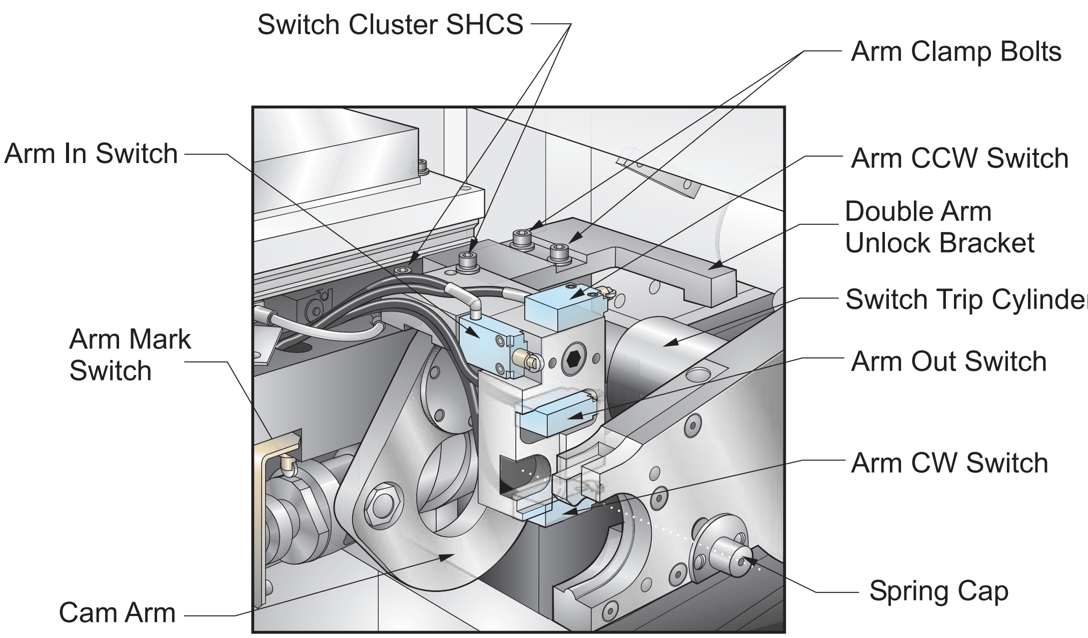


2. Press the **E-STOP** button. Disconnect machine air to prevent the tool changer door from closing.

3. Rotate the shuttle cam to allow access to the double arm clamp bolts. It is easiest to move the double arm to the At Spindle position.

4. Disconnect the air lines to the double arm.





5. From the tool changer side of the mill, reach in through the open tool changer door and loosen the SHCS clamp bolts, located on the top of the shuttle.

6. Remove the double arm unlock bracket.

7. Reinstall one of the 1/2-13 SHCS into the jack bolt hole; this is accessible once the bracket was removed

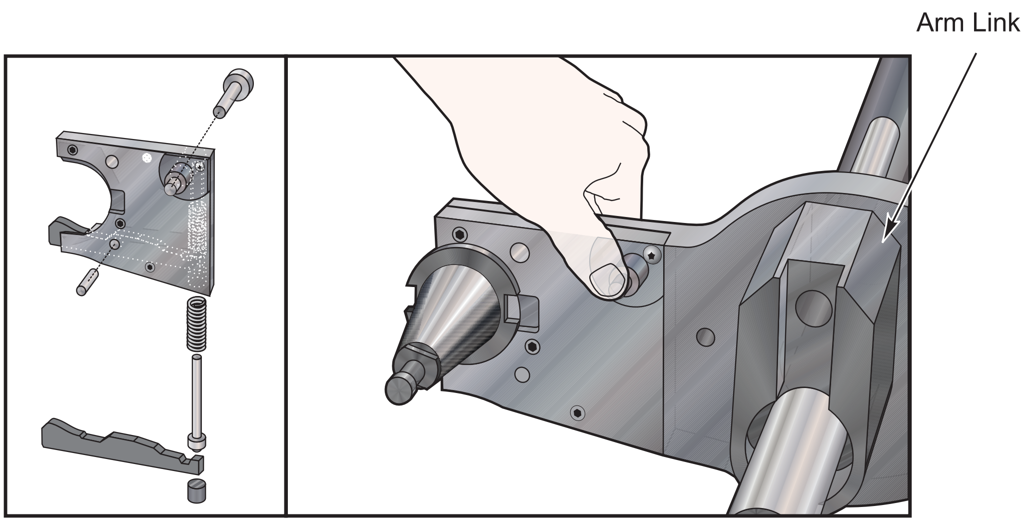
8. Slide a small piece of sheetmetal into the slot in the shuttle for the jack bolt to press against.

9. Gently tighten the jackbolt until the double arm can be removed.

10. Remove the switch cluster bracket and switches. The swich cluster bracket is held by two SHCS located on top of the bracket.

11. Remove the switch trip cylinder.

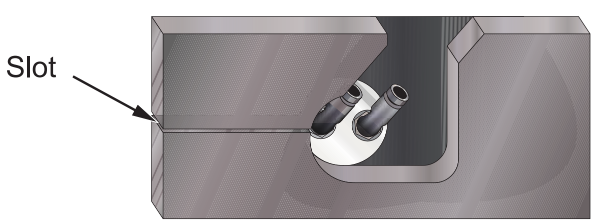
12. Move the double arm forward just enough to disengage the cam follower, in the cam arm, from the arm link. Be careful not to damage the plastic air line fittings.



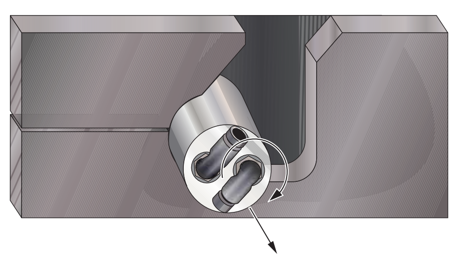
13. Rotate the link out of the way of the cam arm.

14. Move the double arm rearward as far as possible.

15. The air fittings now must be rotated in order to remove the assembly



Operational Position



Removal Position

16. Pull the double arm assembly out from the front of the tool changer.

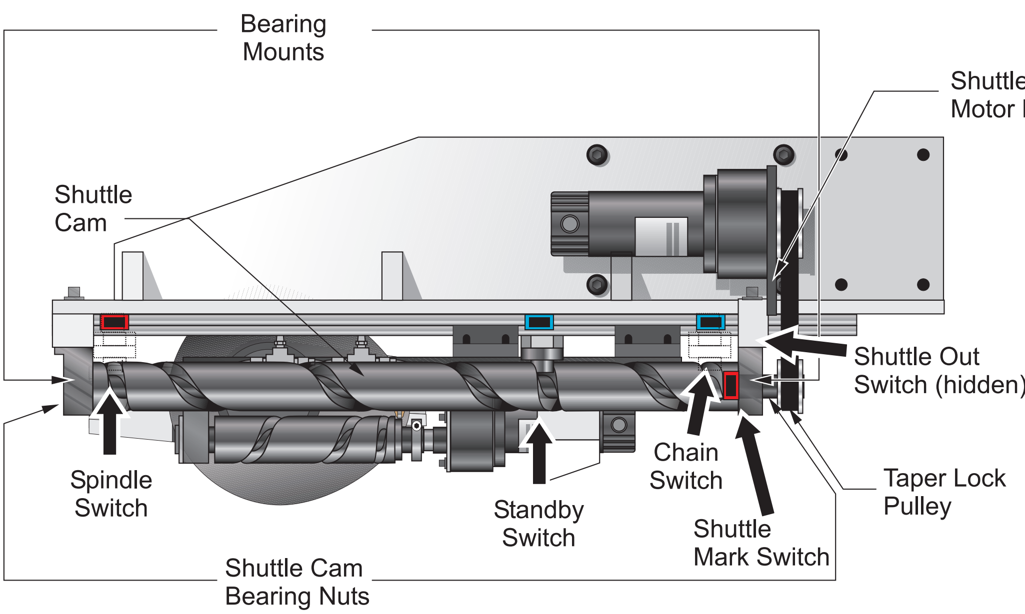
Installation

The installation process is the reverse of the removal. Then align the double arm.

SHUTTLE CAM REPLACEMENT

Removal

CAUTION: When rotating the tool changer cams by hand, wear protective gloves. The cams' machined edges are very sharp.



1. Press Emergency stop.

2. Unplug the SMTC output cable.

3. Loosen the two HHB securing the shuttle motor mount. Remove one HHB and tilt the shuttle motor to allow the belt to be removed from the shuttle motor pulley. Replace the HHB and leave loose.

4. Remove the Shuttle Mark and Shuttle Out limit switches.

5. Move the shuttle cam to the At Chain position. Loosen the four SHCS securing the bearing mounts to the tool changer. Remove the four SHCS and lower the cam assembly. Place on a suitable working surface.

6. Remove the taper lock pulley. To remove a taper lock pulley, remove the two SHCS and insert one in the hole 90° off. Tighten this SHCS, it will act as a jack bolt. Remove the pulley insert, key, and pulley.

7. Remove bearing mounts, bearings and locknuts.

Installation

1. Loosely reinstall the harware on the shuttle cam.

2. Raise the cam into position. Insert the cam follower into the cam at the At Chain position.

3. Press the bearing mounts over the dowel pins. Secure the cam assembly by threading the SHCS into the mounts. Tighten the SHCS. Remove 1 SHCS at a time, apply a drop of Loctite, then torque to 100 ft./lbs.

NOTE: At this point the bearing lock nuts are still loose.

4. Install the Shuttle Mark and Shuttle Out switches. Apply Loctite to the SHCS before securing.

5. When the double arm is in correct alignment with the tool chain, tighten the bearing lock nuts.

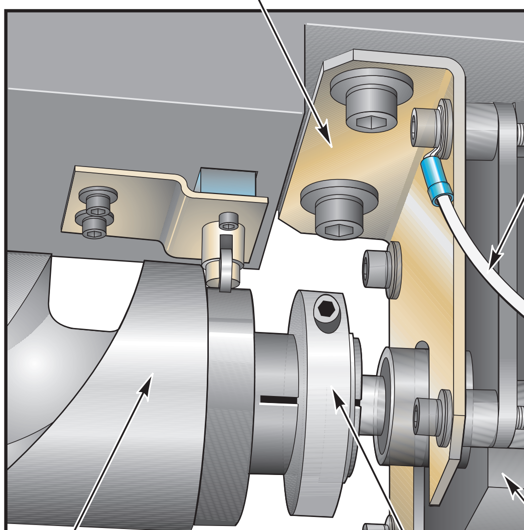
6. Remove one HHB from the shuttle motor mount. Tip the shuttle motor down and install the belt. Secure the shuttle motor mount with the HHB.

7. Adjust the taper lock cam pulley to align it with the shuttle motor pulley. Spin the shuttle cam and observe the tracking of the belt on the pulleys. Readjust if necessary.

8. Plug in the SMTC output cable.

Double Arm Cam & Motor Replacement.

Some early units had the double arm cam shrink fitted to the motor. If there is a bearing clamps as shown, either part may be replaced individually. If they are shrink fit, they must be replaced as an assembly. Both styles are interchangeable as assemblies. The following assumes both the cam and motor are being removed, if not shrink fit, the motor may be removed separately.



1. Press E-stop.

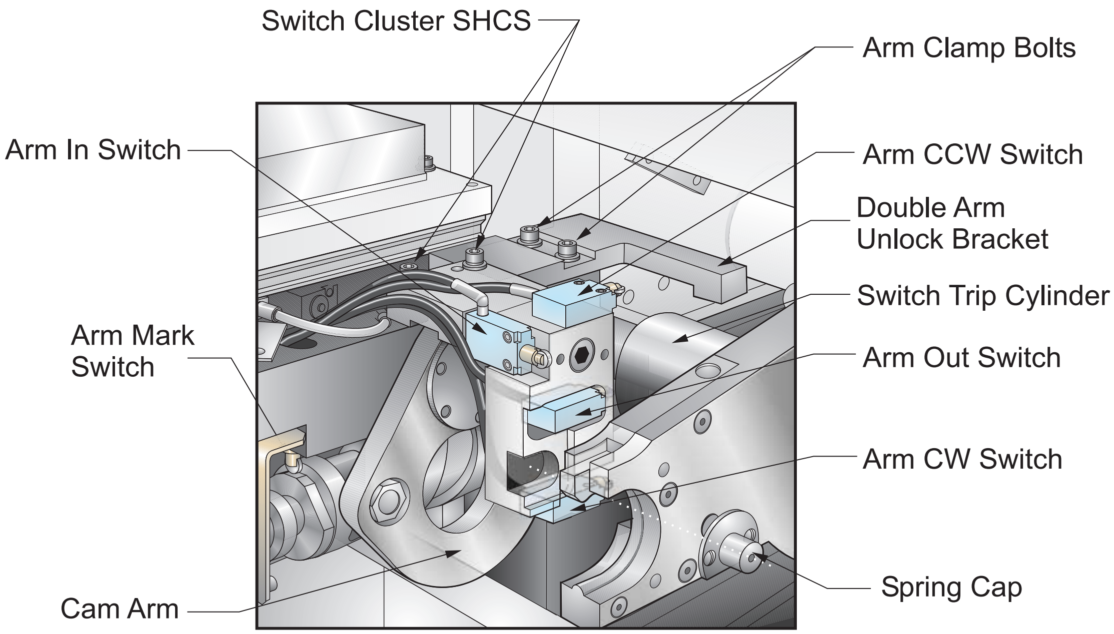
2. Remove the front and rear sheet metal access panels.

3. Disconnect the arm motor connection at the motor. It is normally tucked into the cable carrier bracket.

4. Remove the rear SHCS that secures the motor bracket to the shuttle.

5. Remove the ground wire.

6. Remove the 2 shcs arm clamp bolts. Try not to disturb the arm position.



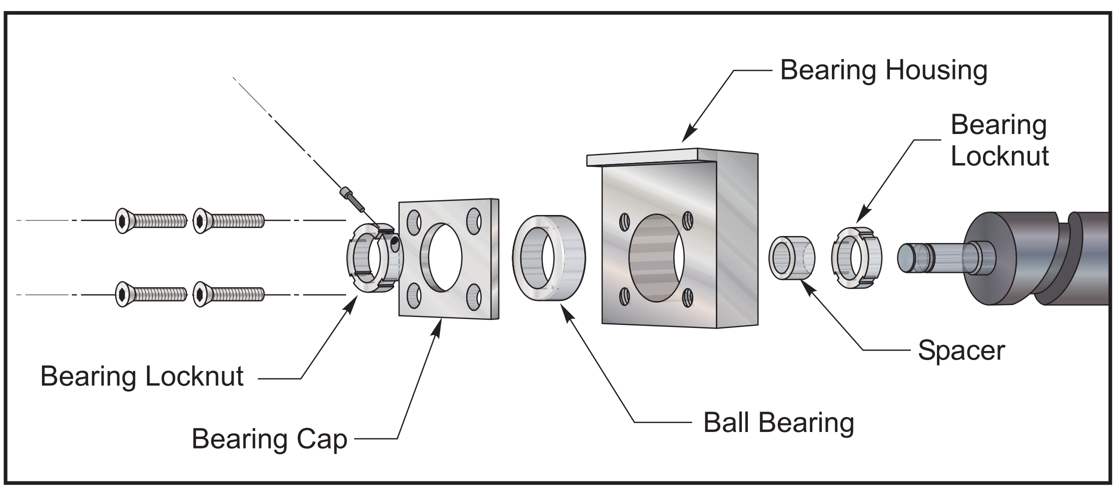
7. While supporting the cam and motor, remove the last shcs holding the motor bracket to the shuttle.

8. Remove the assembly.

9. Remove the motor bracket from the motor.

10. Loosely install the motor bracket on the new motor using only 3 screws. Do not use the screw that retains the ground wire yet.

11. If changing the cam, swap the bearing housing and hardware over to the new cam.



12. Leave the bearing locknuts loose for now.

13. Carefully supporting the cam and motor, reinstall the assembly on the dowels, using the 2 motor mount shcs loosely installed to support the weight of the assembly.

14. Reinstall the arm clamp shcs with blue Loctite. Torque to 80 lbs/ft

15. Use the arm cam alignment tool to locate the cam up and down, and front to rear.

16. While holding it in this position, snug the shcs between the motor bracket and the shuttle.

17. Tighten the 3 SHCS between the motor and the motor mount (use blue loctite).

18. Tighten the shcs between the motor mount and shuttle. Use blue Loctite.

19. Remove the cam alignment tool.

20. Install the 4th SHCS and ground wire, using blue Loctite.

21. Plug in the motor, tucking the wires out of harms way.

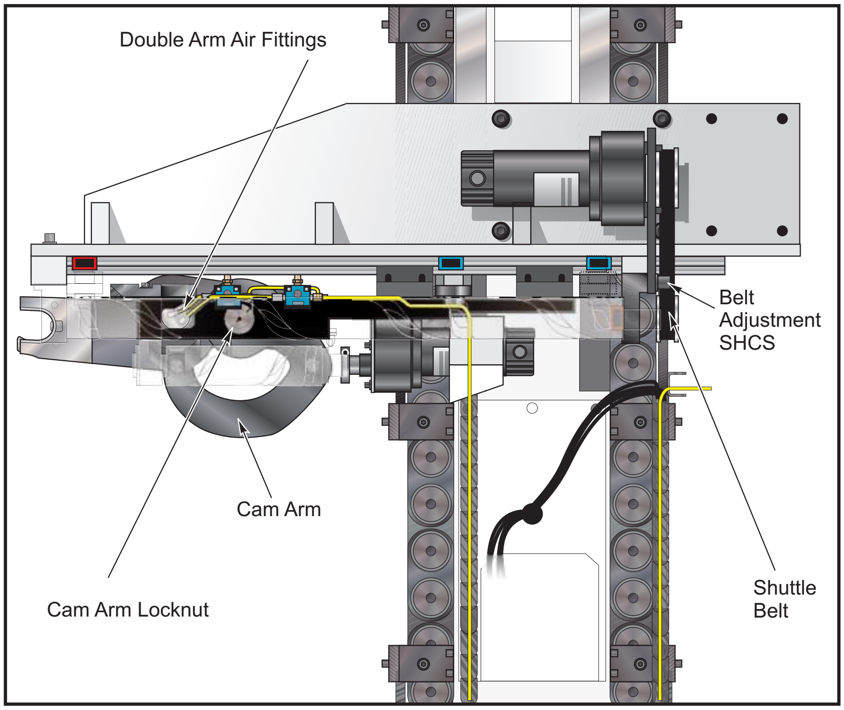
22. Align the double arm.

23. Tighten the bearing clamp between the cam and motor.

24. Reinstall sheetmetal.

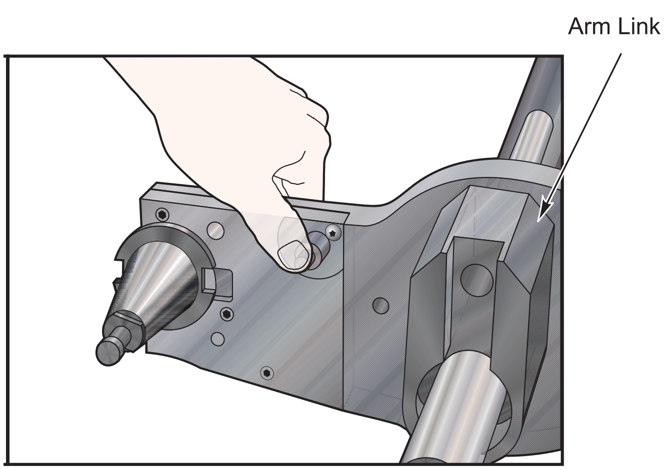
Cam Arm Replacement

If the cam arm has been damaged in a crash, the following procedure can be used to replace it.

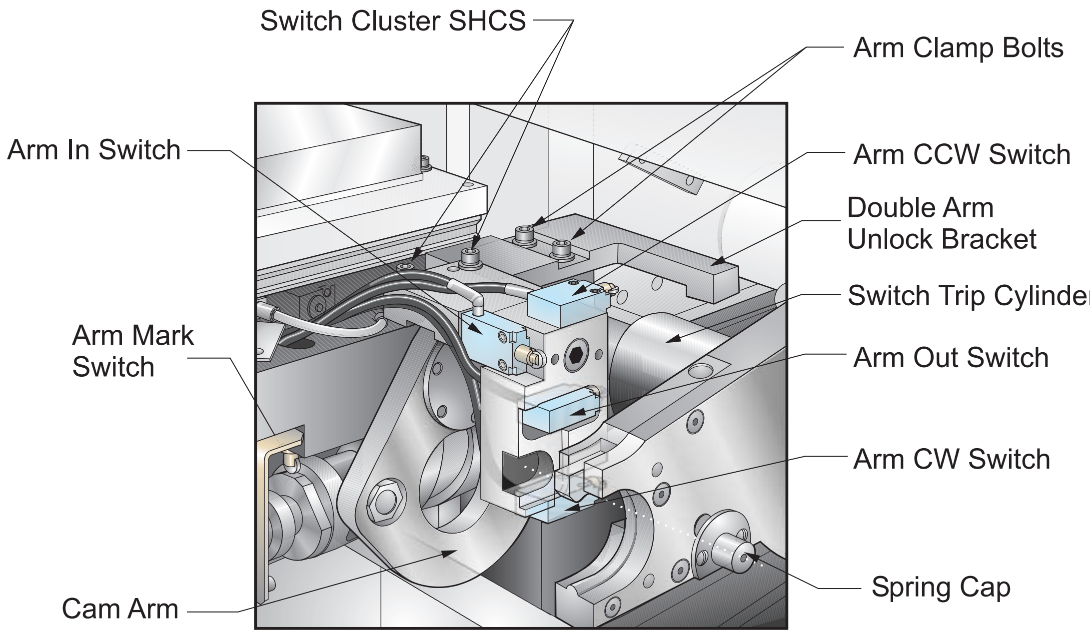


1. Loosen the double arm clamp bolts and move the arm forward just enough to disconnect the arm link from the cam follower on the cam arm. This can usually be done without complete double arm removal. Be careful not to damage the plastic air fittings on the end of the double arm.

2. Rotate the arm and link out of the way of the cam arm.



3. Remove the switch cluster by removing the 2 SHCS and sliding the cluster up off of the 2 dowels.



4. Support the cluster so the wires are not damaged.

5. Loosen the bearing locknut shcs in the side of the bearing locknut.

6. Remove the bearing locknut.

7. Slide the cam arm assembly out the front of the shuttle.

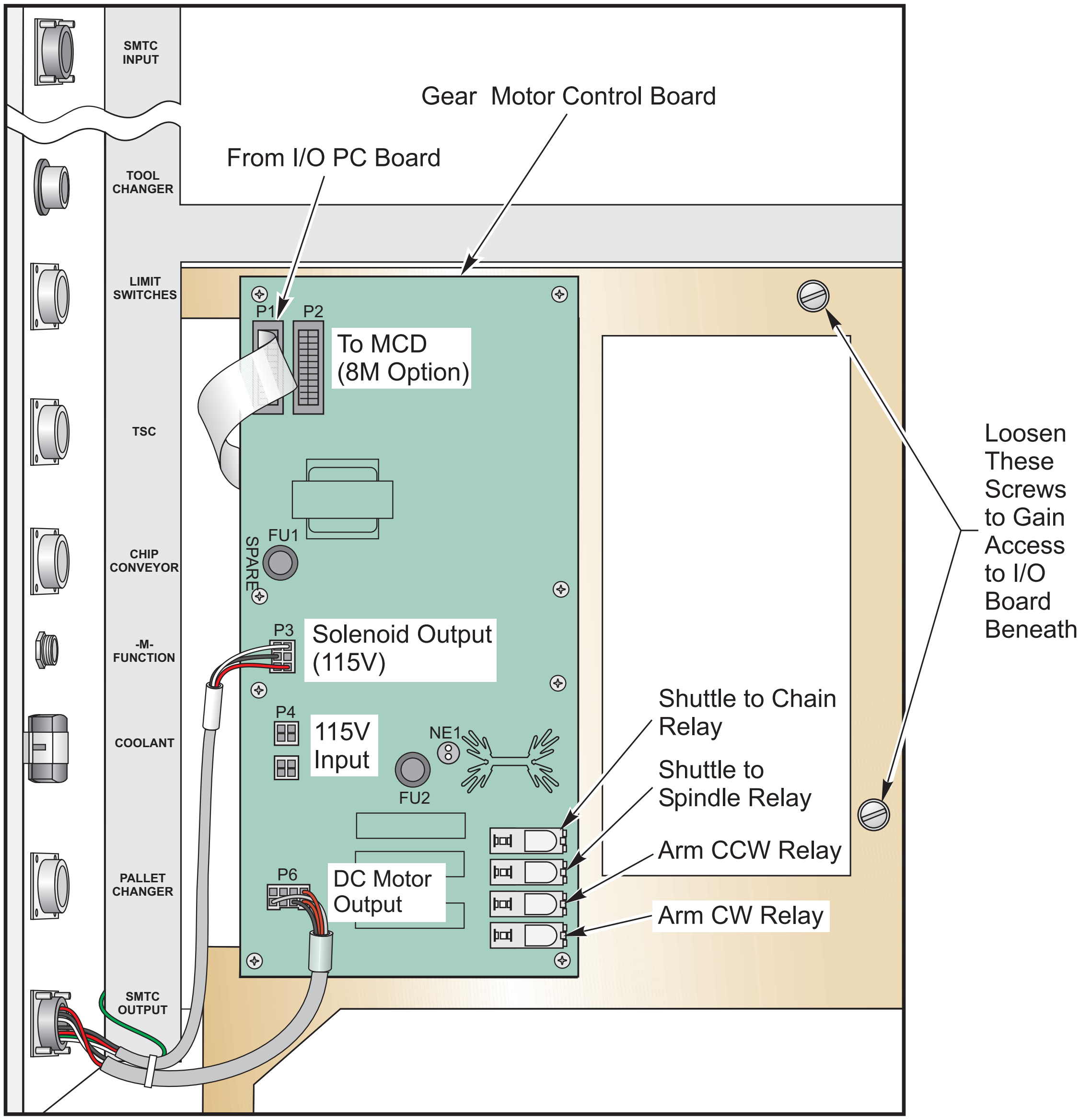
8. Inspect the bearings, replace as needed.

9. Install the replacement assembly in the reverse order.

10. Very lightly preload the bearings, the locknut does not need to be excessively tight.

11. Realign the double arm.

HS SMTC PC Board



Location of SMTC Electrical Components

3.10 Axis Motor

Please read this section in its entirety before attempting to remove or replace the axis motors.

X-Axis Motor

REMOVAL-

1. Power ON the machine. Zero return all axes and put machine in HANDLE JOG mode.

2. Jog the Y-axis to the bottom of its travel. Jog the X-axis away from the motor.

3. Remove the rear enclosure panel (seven SHCS).

4. POWER OFF the machine.

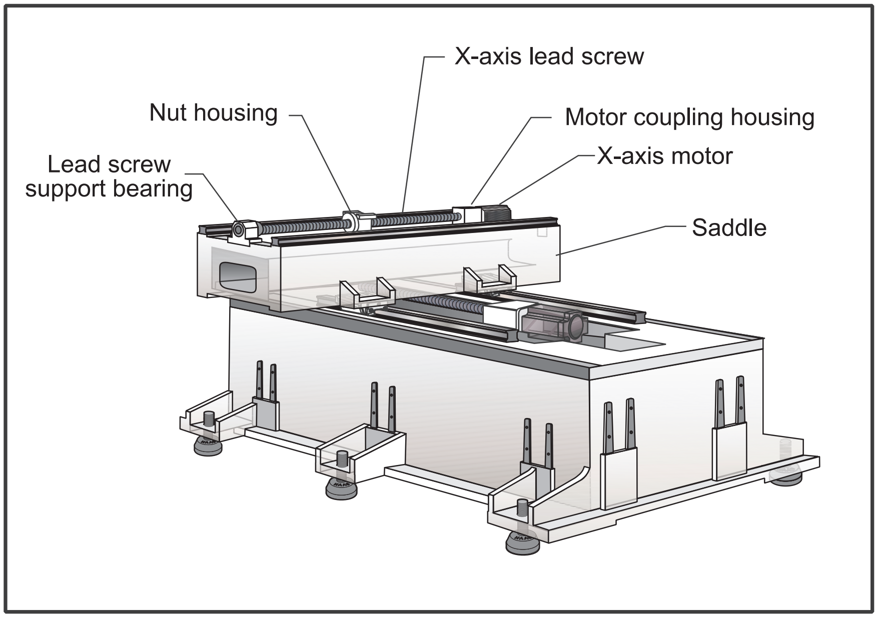


Figure 3.9-1. X-axis motor and lead screw assembly.

5. On the top of the motor coupling housing, remove the four BHCS and remove the cover plate.

6. Loosen the SHCS on the motor coupling at the lead screw.

7. On the motor coupling housing, loosen the four SHCS and remove the motor from the housing.

8. Disconnect all wiring from the motor and remove.

INSTALLATION-

1. Inspect the motor coupling and replace it if required. Visually inspect the flex plates to ensure they are parallel to the coupling halves. Slide the new coupling onto the motor shaft until the coupling half is flush to the end of the shaft.

NOTE: The slot in the locking collar must be positioned 45 degrees between the bolt hole pattern of the coupler. If improperly aligned, the coupler will not have enough clamping force on the leads screw or motor shaft. **Refer to diagram in coupling replacement section**.

2. Reconnect all wiring to the motor.

3. Align the key on the motor shaft. Slide the motor into the motor housing, inserting the end of the lead screw into the motor coupling.

4. Reinstall and tighten down the four SHCS that hold the motor to the housing.

5. Tighten the SHCS on the motor coupling at the lead screw. (Place a drop of blue Loctite® on the screw before inserting.)

6. Replace the cover plate and fasten with four BHCS.

7. Replace the rear enclosure panel with seven SHCS.

8. Check for backlash in the X-axis lead screw ("Troubleshooting" section) or noisy operation.

9. Set grid offset.

Note: Work offsets will change.

Y-AXIS MOTOR

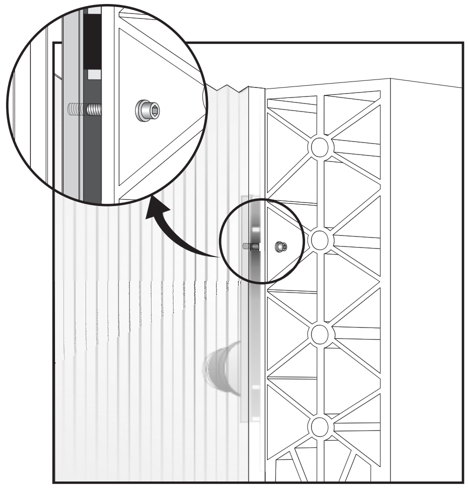
REMOVAL-

1. Power ON the machine. Zero return all axes and put machine in HANDLE JOG mode.

2. Remove the rear enclosure panel (seven SHCS).

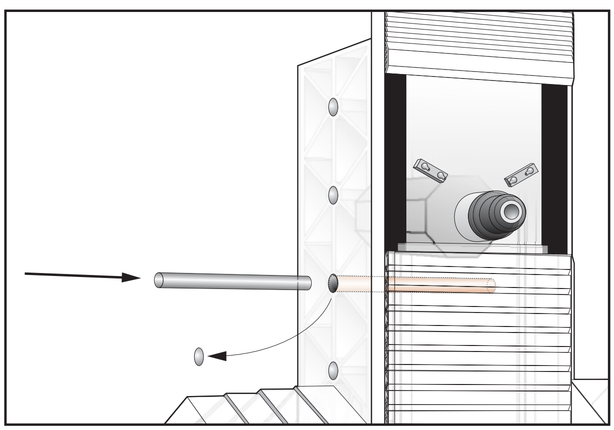
3. Jog the X-axis until the Y-axis lead screw can be easily accessed from the rear.

4. **a. HS-1** - Jog the Y-axis until the two upper holes in the column and the corresponding holes in the spindle head are aligned. Place the shipping lockbolts (5/8-11 x 4" SHCS) through the two holes and tighten. **CAUTION!** This step must be followed to keep the spindle head from falling during service. If this is not done, serious injury could occur.



HS-1 lock-bolts

b. HS-2 - Remove the lower plugs in the column side cover. Slide a bar through the holes. lower the spindle down until it rests on the bar. **CAUTION!** This step must be followed to keep the spindle head from falling during service. If this is not done, serious injury could occur.



HS-2, use a bar to support the spindle head

5. POWER OFF the machine.

6. Loosen the four SHCS and remove the upper bellows guide from the X-axis way bellows supports so the motor can be pulled up from the motor mount.

7. Loosen the SHCS on the motor coupling at the lead screw.

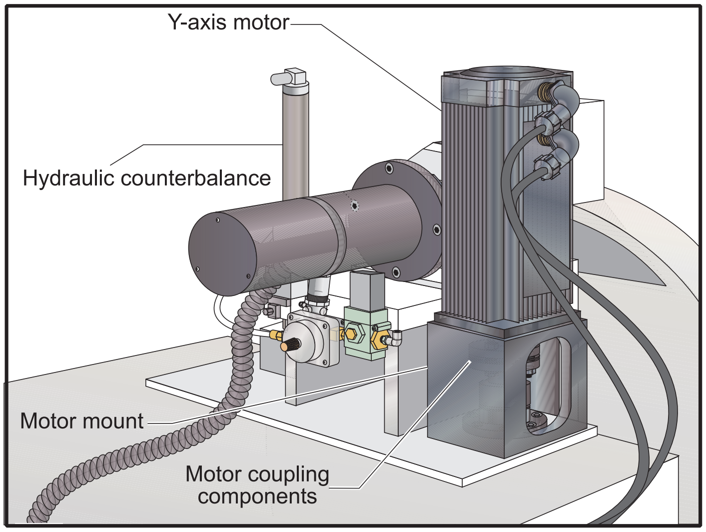


Figure 3.9-2. Y-axis motor and coupling.

8. Loosen the four SHCS and remove the motor from the motor mount.

9. Disconnect all wiring from the motor.

10. Remove the motor.

INSTALLATION-

Important! If the motor coupling housing was replaced or adjusted, verify the alignment of the motor coupling housing to the Y-axis ball screw.

1. Inspect the motor coupling and replace it if required. Visually inspect the flex plates to ensure they are parallel to the coupling halves. Slide the new coupling onto the motor shaft until the coupling half is flush to the end of the shaft.

NOTE: The slot in the locking collar must be positioned 45 degrees between the bolt hole pattern of the coupler. If improperly aligned, the coupler will not have enough clamping force on the leads screw or motor shaft. **Refer to diagram in Coupling Replacement section**.

2. Reconnect all wiring to the motor.

3. Align the key on the motor shaft. Slide the motor into the motor housing, inserting the end of the lead screw into the motor coupling.

4. Reinstall and tighten down the four SHCS that hold the motor to the housing.

5. Tighten the SHCS on the motor coupling at the lead screw. (Place a drop of blue Loctite® on the screw before inserting.)

CAUTION! Remove the shipping lockbolts from the column and spindle head. Failure to remove these will cause severe damage to the machine.

6. Replace the rear enclosure panel with seven SHCS.

7. Check for backlash in the Y-axis lead screw (Troubleshooting section) or noisy operation.

8. Check that Parameter 211, "Y-Axis Tool Change Offset", is set correctly, and adjust if necessary.

9. Set the grid offset after the new motor has been installed.

Y-axis Motor Coupling Housing and Ball Screw Alignment

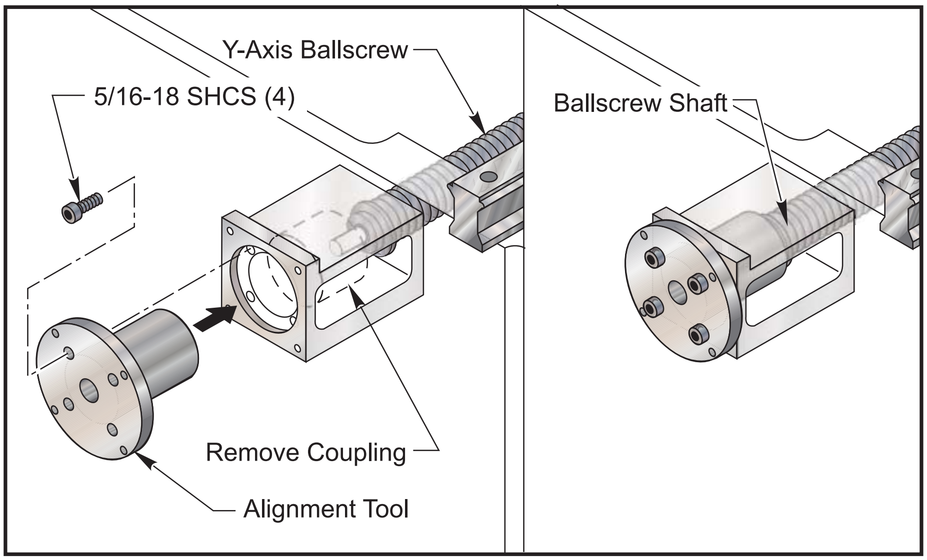
Fatigue and eventual failure of the motor-end Y-axis ball screw will result if it is not aligned properly with the servo motor. Correct alignment requires the use of the appropriate alignment tool and procedure. When the procedure is completed, the keyed shaft of the ball screw will be aligned radially and axially with the shaft of the servo motor when it is mounted.

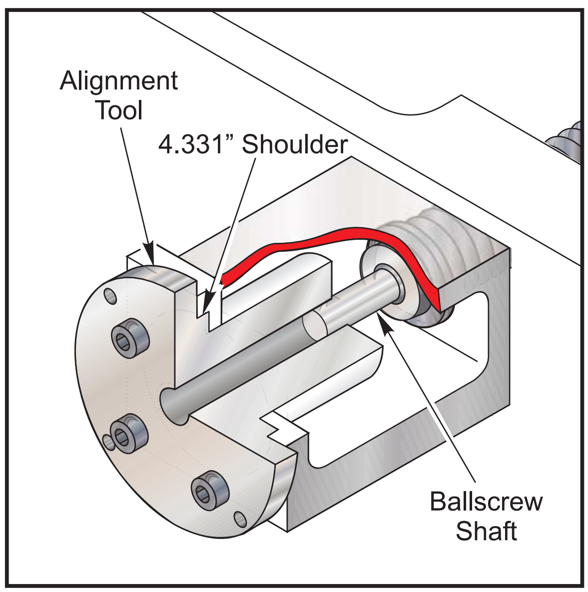
1. If currently mounted, remove the Y-axis servo motor from the motor mount and flex coupling as described in the motor removal section. **CAUTION:** The spindle head will fall if the motor is removed incorrectly. Remove the flex coupling from the Y-axis ball screw shaft, including the shaft key. Loosen, but do not remove, all the bolts holding the motor mount to the column.

2. Obtain the correct alignment tool for your machine. For all HS-1 series machines which use a 32mm Y-axis ball screw, use alignment tool **P/N T-2028**. For all HS-2 and HS-3 series machines which use a 40mm Y-axis ball screw, use alignment tool **P/N T-2029**.

3. Slide the alignment tool, boss-side first, down into the motor mount until it contacts the ball screw shaft. Carefully place the center hole in the alignment tool over the shaft of the ball screw. Continue sliding the alignment tool downward until the 4.331" diameter shoulder of the alignment tool is inserted into the recess in the motor mount. Slide the alignment tool further until the top face of the motor mount contacts the surface of the alignment tool. See the figure on the next page.

NOTE: Only slight resistance should be encountered during this process. DO NOT FORCE the alignment tool. If binding occurs, stop and determine cause.





Y-Axis Alignment Tool Insertion

4. Once the alignment tool is fully inserted, rotate until the four holes near the O.D. of the tool line up with the holes near the corners of the motor mount. Attach the alignment tool to the motor mount using four 5/16-18 x 5/8" SHCS and snug the screws. See the figure above.

5. Torque the bolts loosened in Step 1 to their proper value.

6. Remove the SHCS installed in Step 4. Carefully remove the alignment tool from the motor mount and off the ball screw shaft. Only slight resistance should be encountered during this process.

7. Install the shaft key, flex coupling, and the servo motor following established procedures.

Z-Axis Motor

REMOVAL-

1. Power ON the machine. Zero return all axes and put machine in HANDLE JOG mode.

2. Jog the Y-axis to the bottom of its travel. Jog the Z-axis all the way towards the back of the machine.

3. Remove the thirteen SHCS that attach the Z-axis way cover to the table, and collapse it back towards the saddle.

4. POWER OFF the machine.

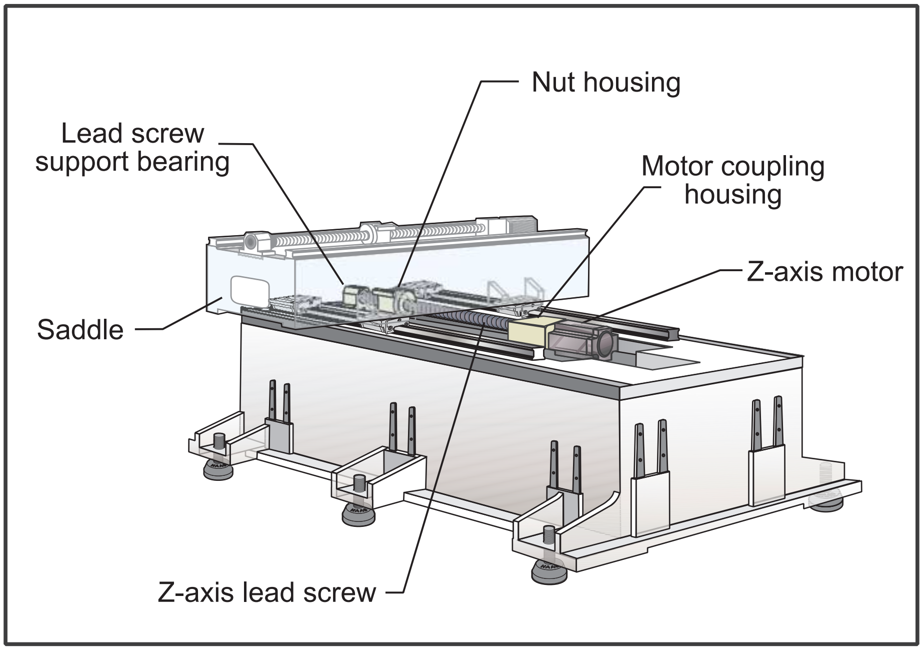


Figure 3.9-3. Z-axis motor and lead screw assembly.

5. On the motor mount, loosen the four BHCS and remove the cover plate.

6. Loosen the SHCS on the motor coupling at the lead screw.

7. Loosen the four SHCS and remove the motor from the mount.

8. Disconnect all wiring from the motor and remove.

INSTALLATION-

1. Inspect the motor coupling and replace it if required. Visually inspect the flex plates to ensure they are parallel to the coupling halves. Slide the new coupling onto the motor shaft until the coupling half is flush to the end of the shaft.

NOTE: The slot in the locking collar must be positioned 45 degrees between the bolt hole pattern of the coupler. If improperly aligned, the coupler will not have enough clamping force on the leads screw or motor shaft. **Refer to diagram in Coupling Replacement section**.

2. Reconnect all wiring to the motor.

3. Align the key on the motor shaft. Slide the motor into the motor housing, inserting the end of the lead screw into the motor coupling.

4. Reinstall and tighten down the four SHCS that hold the motor to the housing.

5. Tighten the SHCS on the motor coupling at the lead screw. (Place a drop of blue Loctite® on the screw before inserting.)

6. Replace the cover plate and fasten with four BHCS.

7. Replace the Z-axis way cover with thirteen SHCS.

8. Check for backlash in the Z-axis lead screw ("Troubleshooting" section) or noisy operation.

9. Set the grid offset after the new motor has been changed.

Coupling Replacement

REMOVAL-

1. Remove the axis motor in accordance with "Axis Motor Removal/Installation" section.

NOTE: It will not be necessary at this time to completely remove the motor. Do not disconnect the electrical components.

2. Completely loosen the two SHCS on the two coupling clamp rings and remove the coupling.

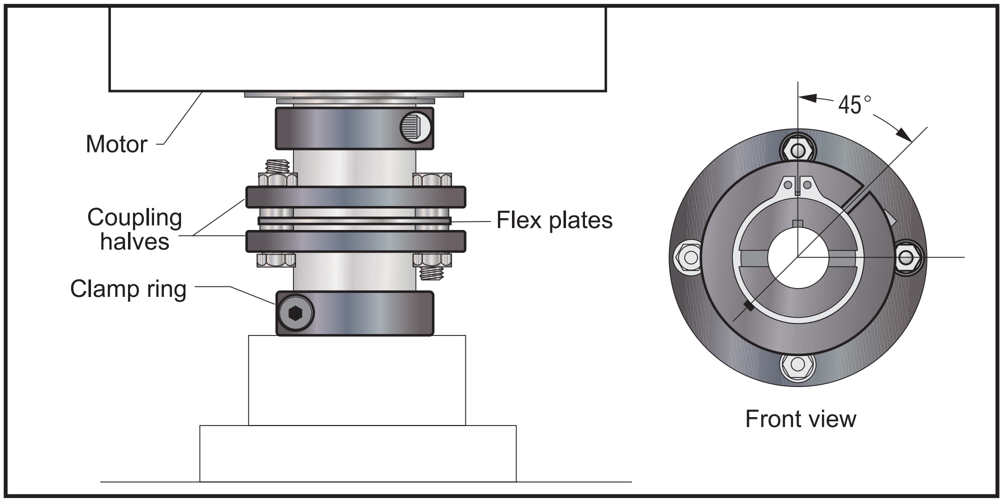


Figure 3.9-4. Motor coupling components.

INSTALLATION-

3. Slide the new coupling onto the motor shaft until the coupling half is flush to the end of the shaft.

NOTE: The slot in the locking collar must be positioned 45 degrees between the bolt hole pattern of the coupler. If improperly aligned, the coupler will not have enough clamping force on the leads screw or motor shaft.

4. Tighten the two SHCS on the coupling's clamp ring. Before tightening, add one drop of blue Loctite® to each screw.

5. Reinstall the axis motor.

3.11 Bearing Sleeve

Please read this section in its entirety before attempting to remove or replace the bearing sleeve.

X-Axis Bearing Sleeve

REMOVAL-

1. POWER ON the machine. Zero return all axes and put the machine in HANDLE JOG mode.

2. Remove the rear enclosure panel (seven SHCS).

3. Jog the Y-axis to the bottom of its travel. Jog X-axis away from bearing support.

4. POWER OFF the machine.

5. Remove the hardstop bracket from bearing support end.

6. Remove the clampnut.

7. Manually screw the column over in order to access the motor.

CAUTION! Do not screw the column too far over since the hardstops are removed!

8. Remove the X-axis motor in accordance with "X-Axis Motor - Removal".

9. Remove the coupling.

NOTE: The motor's electrical connections do not need to be removed for this operation. After removing the motor from the motor mount, set it aside.

10. Loosen the SHCS on the clamp nut at the motor end of the lead screw, and remove the clamp nut.

11. Loosen the six SHCS and remove the bearing sleeve from the motor mount. Push on the column or the opposite end of the lead screw to loosen.

CAUTION! Do not pry the bearing sleeve away from the housing. Damage to the sleeve, bearing, motor housing or lead screw will result.

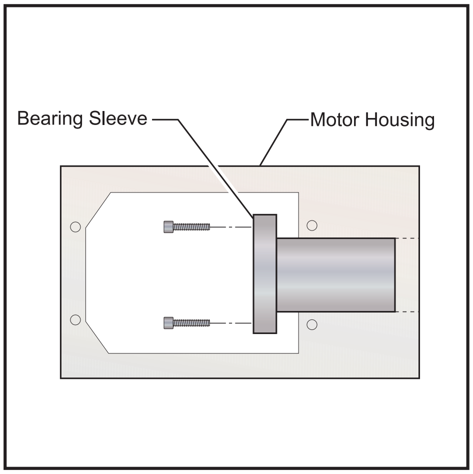


Figure 3.10-1. Bearing sleeve mounting location.

INSTALLATION-

1. Ensure all mating surfaces on the bearing sleeve, motor housing, nut housing, and ball nut are free of dirt, burrs, grease, or other contaminants.

CAUTION! Mating surfaces must be clean or misalignment may occur, seriously affecting the proper operation of the machine.

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2. With the column all the way to the left, place the bearing sleeve in the motor mount. It may be necessary to align the bearings in the sleeve to facilitate mounting on the lead screw.

3. Install the six SHCS on the bearing sleeve, and torque to 15 ft-lbs. (Place a drop of blue Loctite on each of the SHCS before inserting.)

4. Manually screw the column over in order to access the bearing support.

CAUTION! Do not screw the column too far over since the hardstops are removed!

Screw the clamp nut on the bearing support end of the lead screw two or three turns, but do not tighten.

5. Screw the clamp nut on the motor end of the lead screw two or three turns, but do not tighten.

6. Loosen all of the SHCS on the bearing sleeve approximately 1/4 turn, then torque to 15 ft-lbs. DO NOT SKIP THIS STEP. It ensures the lead screw is installed and runs parallel and flat to the linear guides and the saddle.

7. Tighten the lead screw against the clamp nuts as follows:
   • Tighten the clamp nut on the motor housing end of the lead screw to 15 ft-lbs.
   • Tighten the SHCS on the clamp nut.
   • Place a spanner nut over the clamp nut on the support bearing end of the lead screw and slowly tighten to 4 inch-lbs. Remove the spanner nut.
   •Tighten the SHCS on the clamp nut with Loctite, and mark it with yellow marking paint.

8. Reinstall and tighten the hard stop on the bearing support.

9. Reinstall the X-axis motor as described in "X-Axis Motor - Installation".

10. Check for backlash in the X-axis lead screw ("Troubleshooting" section), or noisy operation.

11. Set the grid offset.

12. Replace the rear panel enclosure with seven SHCS.

Y-Axis Bearing Sleeve

REMOVAL-

1. POWER ON the machine. Zero return all axes and put machine in HANDLE JOG mode.

2. Remove the seven SHCS attaching the lower Y-axis way cover to the head casting, and collapse it downward in order to access the support bearing.

3. Remove the rear enclosure panel (seven SHCS).

4. Jog the X-axis until the Y-axis lead screw can be easily accessed from the rear.

5. Jog the Y-axis until the two upper holes in the column and the corresponding holes in the spindle head are aligned. Place two of the original shipping lockbolts (5/8-11 x 4" SHCS) through the two holes and tighten.

CAUTION! This step must be followed to keep the spindle head from crashing down during service. If this is not done, serious injury could occur.

6. POWER OFF the machine.

7. Remove the axis motor in accordance with "Y-Axis Motor - Removal". **CAUTION:** The spindle head will fall if the motor is removed incorrectly.

8. Loosen the SHCS and remove the clamp nut on the lead screw bearing plate end.

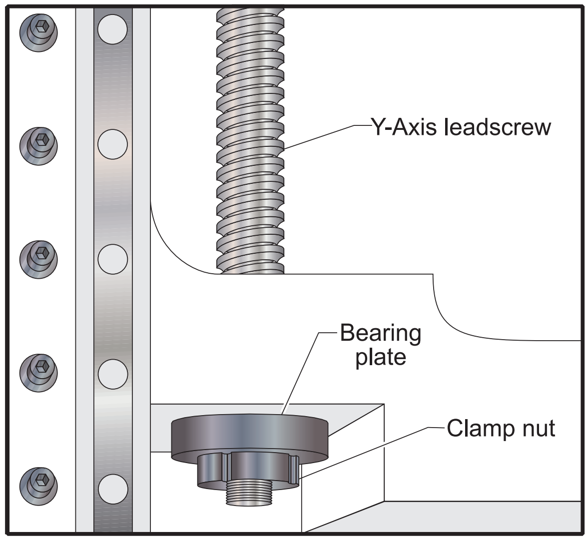

Figure 3.10-2. Y-axis lead screw bearing support end clamp nut.

9. Loosen the SHCS and remove the clamp nut on the motor end of the lead screw.

10. Loosen the six SHCS and remove the bearing sleeve from the top of the column.

CAUTION! Do not pry the bearing sleeve away from the top of the column. Damage to the sleeve, bearing, top of column or lead screw will result.

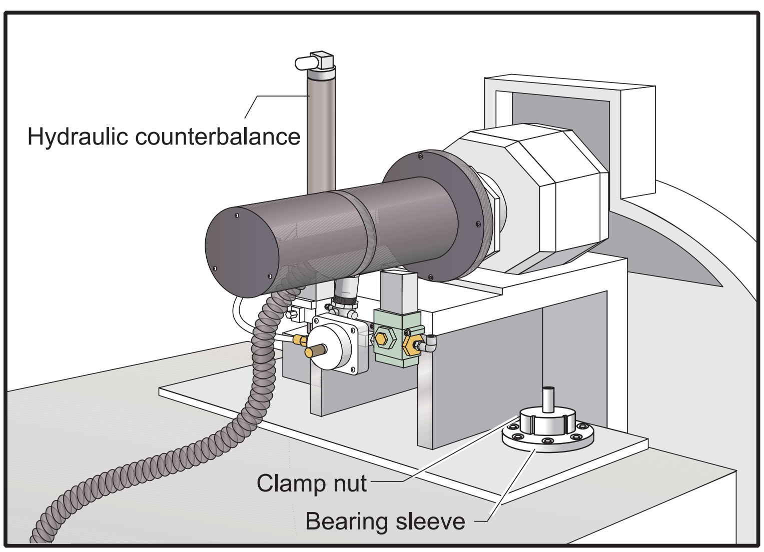

Figure 3.10-3. Y-axis lead screw motor end clamp nut and bearing sleeve.

INSTALLATION-

1. Ensure all mating surfaces on the bearing sleeve, motor housing, top of column, and ball nut are free of dirt, burrs, grease, or other contaminants.

CAUTION! Mating surfaces must be clean or misalignment may occur, seriously affecting the proper operation of the machine.

2. Install the bearing sleeve on top of the column with six SHCS. (Place a drop of blue Loctite on each of the SHCS before inserting.) Tighten down to 15 ft-lbs. It may be necessary to align the bearings in the sleeve to facilitate mounting on the lead screw.

3. Screw the clamp nut on the motor end of the lead screw two or three turns, but do not tighten.

4. Loosen all of the SHCS on the bearing sleeve approximately 1/4 turn, then torque to 15 ft-lbs. DO NOT SKIP THIS STEP. It ensures the lead screw is installed and runs parallel and flat to the linear guides and the saddle.

5. The following sequence is important to ensure proper installation of the lead screw:
   - Tighten the clamp nut, hand tight, against the bearing sleeve.
   - Install the shaft lock onto the bearing support end of the leadscrew. This will keep the lead screw from turning while torquing the clamp nut.
   - Place a spanner wrench on the clamp nut at the motor end of the assembly.
   - Torque the clamp nut against the bearing sleeve to 15 FT-LBS.
   - Remove the shaft lock.
   - With a T-handle wrench hand tighten the clamp nut screw and mark with yellow paint.
   - Screw the clamp nut against the bearing at the bearing support end, hand tight. Tighten the clamp nut another 1/8. (If you have a torque screwdriver, torque the clamp nut to 4 IN-LBS.)
   - With a T-handle wrench hand tighten the clamp nut screw and mark with yellow paint.

6. Reinstall the axis motor in accordance with "Y-Axis Motor - Installation".

7. Replace the lower Y-axis way cover and attach it to the head casting with seven SHCS.

CAUTION! Remove the shipping lockbolts from the column and spindle head. Failure to remove these will cause severe damage to the machine.

8. Check for backlash in the lead screw (Troubleshooting section), or noisy operation.

9. Replace the rear enclosure panel with seven SHCS.

Z-Axis Bearing Sleeve

REMOVAL-

1. POWER ON the machine. Zero return all axes and put the machine in HANDLE JOG mode.

2. Jog the Y-axis to the bottom of its travel. Jog the Z-axis all the way towards the back of the machine.

3. Remove the thirteen SHCS that attach the Z-axis way cover to the table, and collapse it towards the saddle.

4. Remove the rear enclosure panel (seven SHCS).

5. POWER OFF the machine.

6. Remove the Z-axis motor in accordance with "Z-Axis Motor - Removal".

NOTE: The motor's electrical connections do not need to be removed for this operation. After removing the motor from the mount, set it to one side.

7. Loosen the SHCS on the clamp nut at the motor end of the lead screw, and remove the clamp nut.

8. Pry open the sheet metal bracket, and remove the hard stop from the lead screw support bearing end of the lead screw.

9. Loosen the SHCS on the clamp nut at the bearing support end, and remove the clamp nut.

10. Loosen the six SHCS and remove the bearing sleeve from the motor mount (Fig. 3.10-1). Push on the opposite end of the lead screw to loosen.

CAUTION! Do not pry the bearing sleeve away from the housing. Damage to the sleeve, bearing, motor housing or lead screw will result.

INSTALLATION-

1. Ensure all mating surfaces on the bearing sleeve, motor housing, nut housing, and ball nut are free of dirt, burrs, grease, or other contaminants.

CAUTION! Mating surfaces must be clean or misalignment may occur, seriously affecting the proper operation of the machine.

2. Place the bearing sleeve in the motor mount. It may be necessary to align the bearings in the sleeve to facilitate mounting on the lead screw.

3. Install and tighten the six SHCS on the bearing sleeve. (Place a drop of blue Loctite on each of the SHCS before inserting.) Torque to 15 ft-lbs.

4. Screw the clamp nut on the bearing support end of the lead screw two or three turns, but do not tighten, and temporarily place the hard stop over the bearing support.

5. Loosen all of the SHCS on the bearing sleeve approximately 1/4 turn, then torque to 15 ft-lbs. DO NOT SKIP THIS STEP. It ensures the lead screw is installed and runs parallel and flat to the linear guides and the saddle.

6. The following sequence is important to ensure proper installation of the lead screw:
   - Tighten the clamp nut, hand tight, against the bearing sleeve.
   - Install the shaft lock onto the bearing support end of the leadscrew. This will keep the lead screw from turning while torquing the clamp nut.
   - Place a spanner wrench on the clamp nut at the motor end of the assembly.
   - Torque the clamp nut against the bearing sleeve to 15 FT-LBS.
   - Remove the shaft lock.
   - With a T-handle wrench hand tighten the clamp nut screw and mark with yellow paint.
   - Screw the clamp nut against the bearing at the bearing support end, hand tight. Tighten the clamp nut another 1/8. (If you have a torque screwdriver, torque the clamp nut to 4 IN-LBS.)
   - With a T-handle wrench hand tighten the clamp nut screw and mark with yellow paint.

7. Reinstall and tighten the hard stop.

8. Reinstall the Z-axis motor as described in "Z-Axis Motor - Installation".

9. Check for backlash in the Z-axis lead screw ("Troubleshooting" section), or noisy operation.

10. Replace the rear panel enclosure with seven SHCS.

11. Replace the Z-axis way cover, and attach it to the table with thirteen SHCS.

3.12 Lead Screw

Please read this section in its entirety before attempting to remove or replace the lead screws.

TOOLS REQUIRED:
• Torque wrench
• Spanner nut

X-Axis Lead Screw

REMOVAL-

1. Turn the machine ON. Zero return all axes and put the machine in HANDLE JOG mode.
2. Remove the rear enclosure panel.
3. Jog the Y-axis to the bottom of its travel. Jog the X-axis all the way towards the control.
4. POWER OFF the machine.
5. Remove the hardstop and locknut from the bearing support.
6. Remove the five SHCS that secure the nut housing to the lead screw nut.
7. Remove the oil line from the lead screw nut.
8. Rotate the nut on the lead screw, in order to move the nut near the bearing support end of the leadscrew.
9. Temporarily replace the hardstop bearing support and push the column all the way away from the control box.
10. Remove the X-axis motor and bearing sleeve in accordance with appropriate sections.
11. Push column towards the control box.

CAUTION! Do not move the column too far over since the hardstops are removed!

12. Pull the lead screw toward control box side, out of the bearing in the bearing support.
13. Lift the lead screw up, forward, and to the side of the machine until the motor end of the lead screw is free. Carefully remove the lead screw.

INSTALLATION-

1. Ensure all mating on the bearing sleeve, motor housing, nut housing, and ball nut are free of dirt, burrs, grease, or other contaminants.

CAUTION! Mating surfaces must be clean or misalignment may occur, seriously affecting the proper operation of the machine.

2. Hold the lead screw vertically with the motor end down and the nut near the support end (top).

3. Hold the lead screw at the left side of the machine near the front of the saddle and lower into place, rotating the leadscrew into position.

CAUTION! Be careful not to bump or scratch lead screw against column, saddle or bellows support.

4. Once in position, gently push the bearing support end of the lead screw into the bearing in the bearing support.

5. Replace the bearing pack.

6. Rotate the nut.

7. Rotate the leadscrew nut so it goes into the nut housing and start the five SHCS that secure the leadscrew nut to the nut housing. Do not tighten.

8. Reattach the oil line to the lead screw nut.

9. Replace the X-axis motor in accordance with the appropriate section.

10. With the lead screw secured in place, torque the five SHCS from the nut to the nut housing to 15 ft-lbs.

11. The following sequence is important to ensure proper installation of the lead screw:
    - Tighten the clamp nut, hand tight, on the motor end.
    - Install and tighten clamp nut on bearing support. Ensure the nut **does not** touch the support bearing.
    - Install the shaft lock onto the bearing support end of the leadscrew. This will keep the lead screw from turning while torquing the clamp nut.
    - Place a spanner wrench on the clamp nut at the motor end of the assembly.
    - Torque the clamp nut against the bearing sleeve to 15 FT-LBS.

NOTE: The 40/50 mm leadscrew clamp nut should be torqued to 50 FT-LBS.

- With a T-handle wrench hand tighten the clamp nut screw and mark with yellow paint.
- Remove the shaft lock.
- Loosen the clamp nut screw and clamp nut at the bearing support end and tighten to 4 IN-LBS. against the bearing. Retighten the clamp screw.

12. Replace the bearing support end hard stop.

13. POWER ON the machine.

14. Rotate the leadscrew by hand to assure free movement.

15. Jog the X-axis to the left end of travel and check for free movement.

NOTE: During assembly, the leadscrew is tested for a maximum rotational torque of 12 in-lbs.

20. Replace the rear enclosure panel (seven SHCS).

Y-Axis Lead Screw

REMOVAL-

1. POWER ON the machine. Zero return all axes and put machine in HANDLE JOG mode.

2. Remove the seven SHCS attaching the upper Y-axis way cover to the head casting, collapse it upward, and tie-wrap it in place.

3. Jog the Y-axis all the way down, resting on the hard stop. Jog the X-axis to the center of travel so the lead screw can be easily accessed from the rear.

4. POWER OFF the machine.

5. Remove the rear enclosure panel (seven SHCS).

6. Remove the axis motor in accordance with "Y-Axis Motor - Removal".

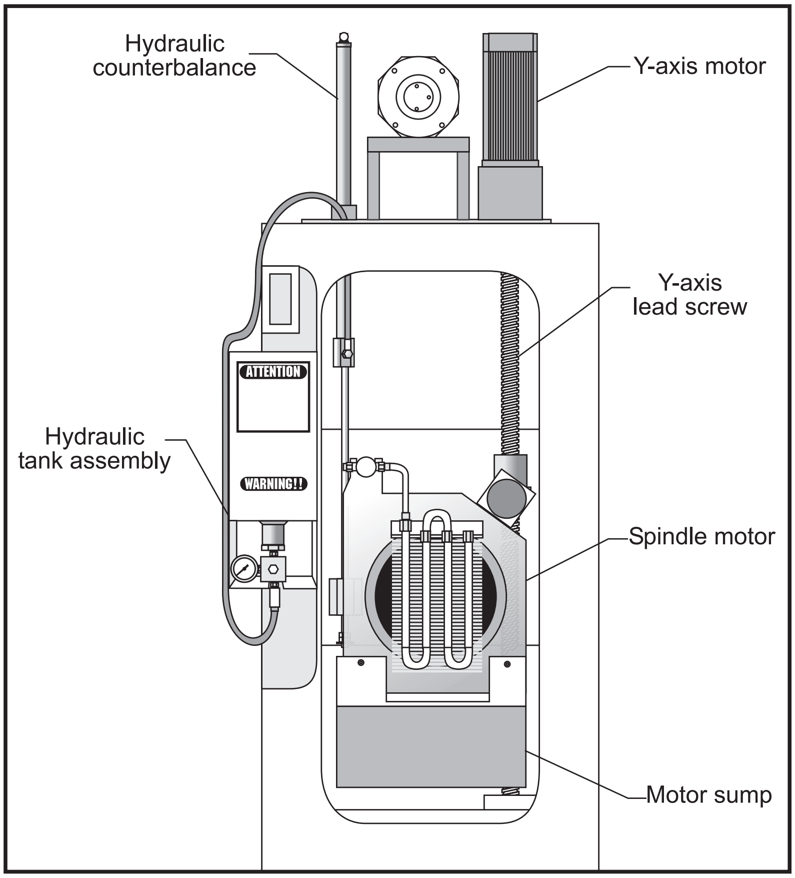

Figure 3.11-1. Y-axis lead screw and motor assembly (from rear).

7. Remove the SHCS securing the hood to the machine. Unplug the service light and gently move the hood forward approximately one foot.

NOTE: It is not necessary to fully remove the hood from the machine.

8. Remove the seven SHCS attaching the lower Y-axis way cover to the head casting, and collapse it downward.

9. Loosen the SHCS and remove the clamp nut on the lead screw bearing plate end.

10. Loosen the SHCS and remove the clamp nut on the motor end of the lead screw.

11. Disconnect the oil line from the ball nut.

12. Loosen the six SHCS and remove the bearing sleeve from the top of the column.

13. Remove the five SHCS on the ball nut flange. Remove the ball nut from the ball nut housing by manually screwing the nut up the lead screw.

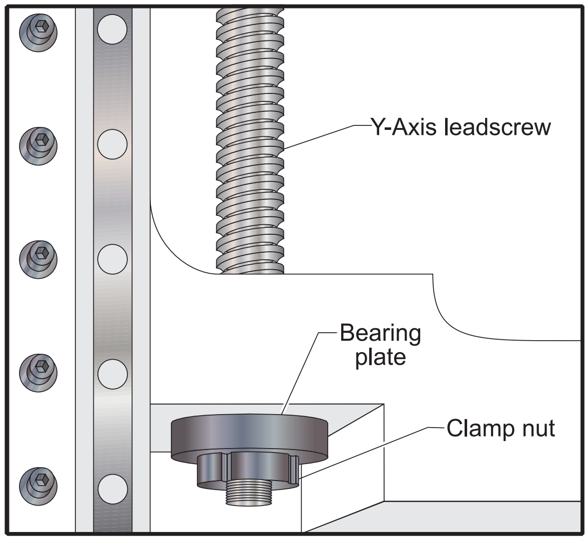

Figure 3.11-2. Y-axis lead screw bearing support end clamp nut.

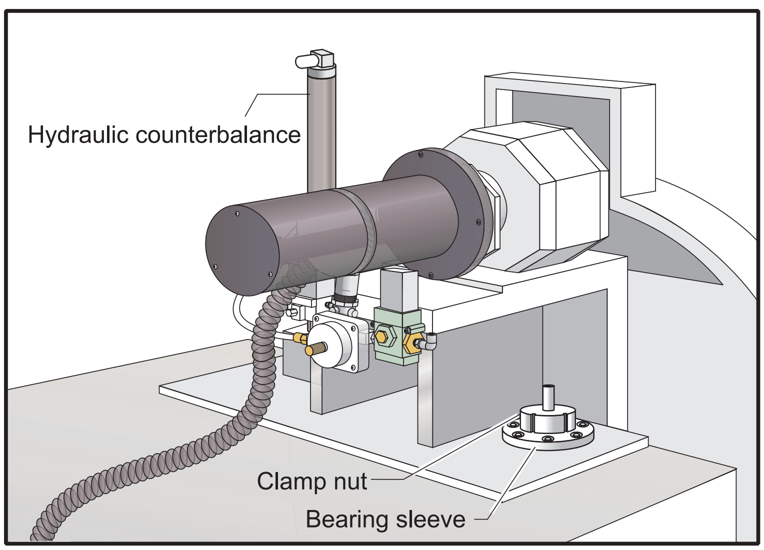

Figure 3.11-3. Y-axis lead screw motor end clamp nut and bearing sleeve.

14. Remove the lead screw from the column by lifting it out of the bearing support, pulling the lower end of the lead screw out the front of the column (over the top of the spindle head), and lowering the motor end out of the top of the column.

15. Remove the hard stop from the old lead screw for use on the new lead screw.

INSTALLATION-

1. Place the hard stop on the new lead screw, so the hard stop is at the top of the column and the flange of the lead screw is mounted on the upper side of the nut housing.

2. Manually turn the ball nut up the lead screw until it will be possible to install the nut into the nut housing (about halfway).

3. Insert the motor end of the lead screw through the upper bearing support hole. Lift the bottom of the lead screw over the spindle head, then lower the lead screw, guiding the bearing support end of the screw into the bearing.

NOTE: Correct alignment is critical to sliding the ball screw into the bearing. Binding will not occur if it is guided carefully and correctly into the bearing.

4. Place the bearing sleeve onto the lead screw and attach it to the top of the column with the six SHCS. Torque the SHCS to 15 ft-lbs.

5. Loosely screw the clamp nut on the bearing plate end of the lead screw.

6. Orient the ball nut so the oil line can be connected, then turn the lead screw by hand to pull the ball nut flange down until it contacts the nut housing.

7. Insert the five SHCS that hold the ball nut to the ball nut housing, but do not tighten completely.

8. Loosely install the clamp nut on the motor end of the lead screw.

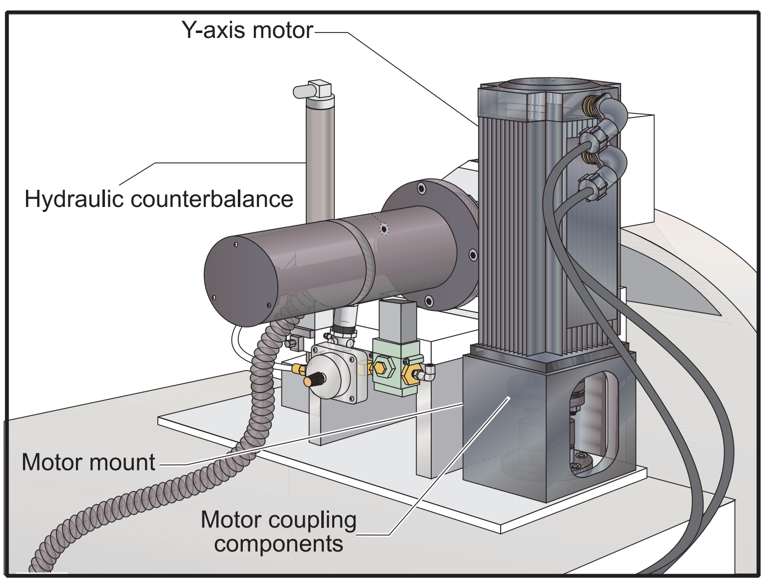

Figure 3.11-4. Y-axis lead screw motor.

9. Hand-turn the lead screw to move the spindle motor up and down, to assure free movement of the lead screw.

10. Torque the five SHCS that hold the ball nut to the nut housing to 15 ft-lbs.

11. The following sequence is important to ensure proper installation of the lead screw:
• Tighten the clamp nut, hand tight, on the motor end.
• Install and tighten clamp nut on bearing support. Ensure the nut **does not** touch the support bearing.
• Install the shaft lock onto the bearing support end of the leadscrew. This will keep the lead screw from turning while torquing the clamp nut.
• Place a spanner wrench on the clamp nut at the motor end of the assembly.
• Torque the clamp nut against the bearing sleeve to 15 FT-LBS.

NOTE: The 40/50 mm leadscrew clamp nut should be torqued to 50 FT-LBS.

• With a T-handle wrench hand tighten the clamp nut screw and mark with yellow paint.
• Remove the shaft lock.
• Loosen the clamp nut screw and clamp nut at the bearing support end and tighten to 4 IN-LBS. against the bearing. Retighten the clamp screw.

12. Reinstall the axis motor in accordance with "Y-Axis Motor - Installation".

13. Reconnect the oil line to the ball nut.

14. Check for backlash in the lead screw ("Troubleshooting" section), or noisy operation.

15. Check the grid offset and tool changer height.

16. Replace both Y-axis way covers and attach them to the head casting with seven SHCS each.

17. Replace the hood and plug in the service light.

18. Replace the rear enclosure panel with seven SHCS.

Z-Axis Lead Screw

REMOVAL-

1. Turn the machine ON. ZERO RETURN all axes and put the machine in HANDLE JOG mode.

2. Jog the Y-axis to the bottom of its travel.

3. Remove the thirteen SHCS that attach the Z-axis way cover to the table, and collapse it towards the saddle.

4. Remove the rear enclosure panel (seven SHCS).

5. Remove the axis motor in accordance with "Z-Axis Motor - Removal".

NOTE: The motor's electrical connections do not need to be removed for this operation. After removing the motor from the mount, set it to one side.

6. Remove the hard stop from the lead screw support bearing end of the lead screw, at the rear of the machine.

7. Loosen the SHCS on the clamp nut at the bearing support end, and remove the clamp nut. For safety, replace the hardstop.

8. Loosen the SHCS on the clamp nut at the motor end, and remove the clamp nut.

9. Disconnect the oil line at the ball nut.

10. Loosen the six SHCS and remove the bearing sleeve from the motor mount. Push on the column or the opposite end of the lead screw to loosen.

CAUTION! Do not pry the bearing sleeve away from the housing. Damage to the sleeve, bearing, or lead screw will result.

11. Loosen and remove the five SHCS attaching the ball nut to the nut housing.

12. Hand-turn the lead screw toward the front of the machine until the rear end of the lead screw clears the bearing by approximately six inches (6").

13. Carefully push the lead screw back, to the right of the support bearing, and under the saddle until the front of the lead screw clears the nut housing. Move the lead screw to the right of the nut housing, and remove from the front of the machine.

INSTALLATION-

1. Ensure all mating on the bearing sleeve, motor housing, nut housing, and ball nut are free of dirt, burrs, grease, or other contaminants.

CAUTION! Mating surfaces must be clean or misalignment may occur, seriously affecting the proper operation of the machine.

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2. Slide the bearing support end of the lead screw under the saddle, taking care not to damage the screw threads. Position the lead screw to the right side of the nut housing and slide toward the front of the machine.

3. Place the motor end of the lead screw through the nut housing, and pull it toward the front of the machine until the ball nut is seated in the nut housing.

4. Place the bearing sleeve in the motor mount. It may be necessary to align the bearings in the sleeve to facilitate mounting on the lead screw.

5. Screw the clamp nut on the bearing support end of the lead screw two or three turns, but do not tighten.

6. Pull the lead screw through the motor mount and loosely install the clamp nut as on the opposite end.

IMPORTANT! DO NOT SKIP STEPS 7-10. These steps ensure the lead screw is installed and runs parallel and flat to the linear guides and the saddle.

7. Install and tighten the six SHCS on the bearing sleeve. (Place a drop of blue Loctite on each of the SHCS before inserting). Torque to 15 ft-lbs.

8. Hand-turn the lead screw until the saddle is as far forward as possible while still allowing room to install the SHCS on the ball nut.

9. Install the two outer SHCS of the five SHCS that secure the ball nut to the nut housing. (Place a drop of blue Loctite on each of the SHCS before inserting). Torque to 15 ft-lbs.

10. Loosen all of the SHCS on the bearing sleeve approximately 1/4 turn, but do not remove.

11. Hand-turn the lead screw until it is at the rear of its travel. Retighten all six of the SHCS on the bearing sleeve, torquing them to 15 ft-lbs.

12. Install and torque down the three remaining SHCS that secure the ball nut to the nut housing. (Place a drop of blue Loctite on each of the SHCS before inserting). Torque to 15 ft-lbs.

13. Reinstall and tighten the hard stop on the lead screw support bearing.

14. Reconnect the oil line to the ball nut.

15. Tighten the lead screw against the clamp nuts as follows:

16. The following sequence is important to ensure proper installation of the lead screw:
•Tighten the clamp nut, hand tight, on the motor end.
• Install and tighten clamp nut on bearing support. Ensure the nut **does not** touch the support bearing.
• Install the shaft lock onto the bearing support end of the leadscrew. This will keep the lead screw from turning while torquing the clamp nut.
• Place a spanner wrench on the clamp nut at the motor end of the assembly.
• Torque the clamp nut against the bearing sleeve to 15 FT-LBS.

NOTE: The 40/50 mm leadscrew clamp nut should be torqued to 50 FT-LBS.

• With a T-handle wrench hand tighten the clamp nut screw and mark with yellow paint.
• Remove the shaft lock.
• Loosen the clamp nut screw and clamp nut at the bearing support end and tighten to 4 IN-LBS. against the bearing. Retighten the clamp screw.

17. Reinstall the axis motor in accordance with "Z-Axis Motor - Installation".

18. Check for backlash in the Z-axis lead screw (Troubleshooting section), or noisy operation, and the grid offset

19. Clean and seal (Permatex) surfaces, then reattach the Z-axis way cover to the saddle cover.

20. Replace the rear enclosure panel with seven SHCS.

3.13 Pallet Changer

Stabilizer Replacement

REMOVAL-

1. Loosen the six BHCS and one SHCS that attach the left front splash shield (on side opposite operator) and remove.

2. Loosen the hex bolts (2) that mount the stabilizers to the mounting bracket at each end and remove the stabilizers and metal bushings.

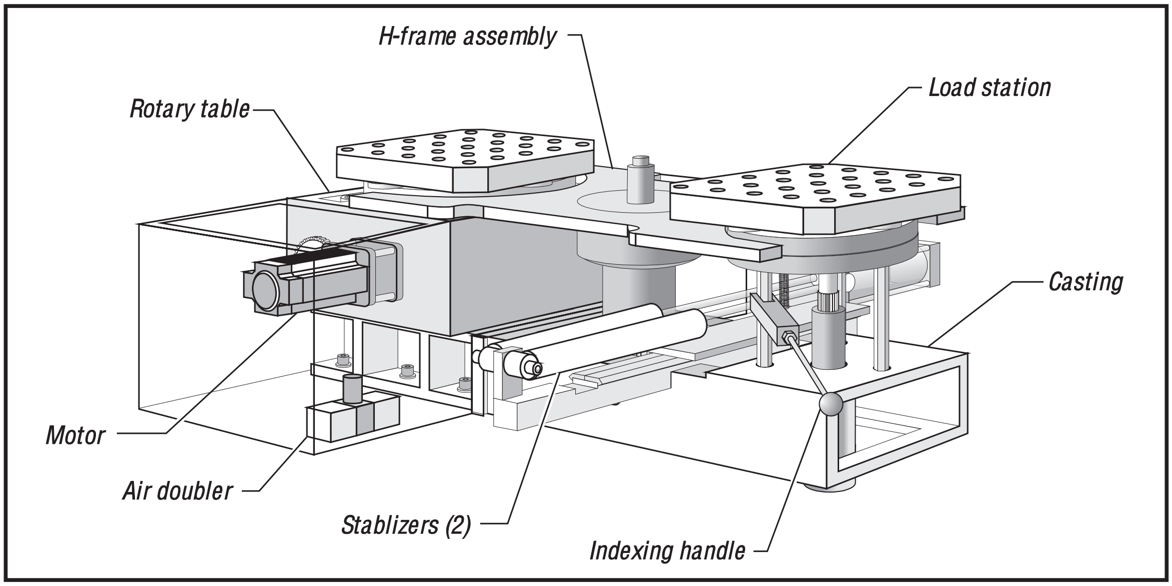


Figure 3.12-1. Pallet changer.

INSTALLATION-

3. Ensure that the metal bushings have been reinstalled at each end.

4. Replace the stabilizers, with the rod extending toward the rotating cylinder, and replace and tighten the two mounting hex bolts.

5. Replace the left front splash shield and tighten the six BHCS and one SHCS.

Rotary Table Drawbar Limit Switches

REMOVAL-

1. Remove the thirteen SHCS that attach the Z-axis way cover to the rotary table bottom cover.

2. Collapse the Z-axis way cover so the linear guides are exposed. The Drawbar Up and Down Limit Switches, beneath the rotary table, can be accessed from the side of the linear guides.

3. Remove the two SHCS that mount the affected limit switch.

4. Disconnect the switch from the solenoid mounting bracket. This bracket is located at the rear of the machine on the control box side, behind an access panel.

INSTALLATION-

5. Replace the switch and mount it with two SHCS.

6. Reconnect the switch at the solenoid mounting bracket.

7. Go to the “Diagnostics” page on the control, in order to monitor the limit switch’s performance.

8. Execute an M50 cycle start, and ensure that the drawbar data is correct.

   For early machines with a threaded drawbar: The switches are designated as “RPDBUP” and “RPDBDN” on the “Diagnostics” page. When the drawbar is in the up position, both switches should read “0"; when in the down position, both should read “1”. If this data is incorrect, install a new limit switch. Refer to the "Discrete Inputs/Outputs" in "Technical Reference" for more information.

   For later machines with a Pull Stud type drawbar: There is only one switch and RPDBUP always reads “1”.
   *Machines with Serial Number #50760 or later have an additional limit switch mounted beneath the RPDBUP switch to indicate a Pallet Changing System Failure.

   If necessary, perform the H-Frame Alignment.

9. Tie-wrap the switch cable to the cable group beneath the rotary table and in the base.

10. Apply sealant and install a gasket where the Z-axis way cover meets the rotary table bottom cover.

11. Extend the Z-axis way cover and secure it to the rotary table bottom cover with thirteen SHCS.

ROTARY TABLE DRAWBAR UP AND DOWN LIMIT SWITCH (PULL STUD TYPE)

NOTE: This only applies to machines with serial numbers 50478 and up

REMOVAL-

1. Remove the thirteen SHCS that attach the Z-axis way cover to the rotary table bottom cover.
2. Collapse the Z-axis way cover so the linear guides are exposed. The Drawbar Up and Down Limit Switches are beneath the rotary table and can be accessed from the side of the linear guides.
3. Remove the two SHCS that mount the limit switch.
4. Disconnect the switch from the solenoid mounting bracket. This bracket is located at the rear of the machine on the control box side, behind an access panel.

INSTALLATION-

1. Replace the switch and mount it with two SHCS.
2. Reconnect the switch at the solenoid mounting bracket.
3. Go to the “Diagnostics” page on the control, in order to monitor the limit switch’s performance.
4. Execute an M50 cycle start, and ensure that the drawbar data is correct.

NOTE: The switch is designated as “RPDBUP” and “RPDBDN” on the “Diagnostics” page. When the drawbar is in the up position, the switch should read “0"; when in the down position, it should read “1”. If this data is incorrect, install a new limit switch. Refer to the "Discrete Inputs/Outputs" in "Technical Reference" for more information.

5. Tie-wrap the switch cable to the cable group beneath the rotary table and in the base.
6. Apply sealant and install a gasket where the Z-axis way cover meets the rotary table bottom cover.
7. Extend the Z-axis way cover and secure it to the rotary table bottom cover with thirteen SHCS. Drive torque to the pulley for controlled clamping of the drawbar.

ROTARY TABLE DRAWBAR CLUTCH / MOTOR SUBASSEMBLY

REMOVAL-

1. Remove the access panel closest to operator, of the rotary table top cover.
2. Loosen and remove the four drawbar motor mounting SHCS, and slip the drawbar drive motor and pulley out of the drive belt.
3. Disconnect the motor power cable at the solenoid mounting bracket (on older machines). This bracket is located at the rear of the machine on the control box side, behind an access panel. On new machines the power cable may be disconnected from the plug at the motor end of the cable.
4. On older machines it may be necessary to remove the thirteen SHCS that attach the Z-axis way cover to the rotary table bottom cover, and collapse it towards the column to access the tie wraps that secure the motor power cable in place.

INSTALLATION-

1. Ensure the drive belt is wrapped around the driven pulley.
2. Slip the new drawbar motor and pulley into the drive belt, and mount it to the casting with four SHCS.
3. Move the drawbar motor assembly all the way to the left in the slots so the belt is at the desired tension. Tighten the four mounting SHCS.

NOTE: Proper belt tension should place the motor mounting bracket all the way to the left on machines after serial #50148, and all the way to the right on machines up to serial #50148 (except machines #50132 and #50139).

4. Verify drawbar operation by executing an M50 command in MDI mode.
5. Complete 10 continuous pallet change cycles to check for any faults.
6. Apply sealant and install a gasket, then replace the access panel.
7. Apply sealant and install a gasket where the Z-axis way cover meets the rotary table bottom cover.
8. Extend the Z-axis way cover and secure to the rotary table bottom cover.

REMOVAL OF OLD STYLE CLUTCH FROM MOTOR

1. Loosen the sixteen BHCS that attach the right side access panel (closest to operator) to the rotary table top cover and remove.

2. Loosen and remove the four drawbar motor mounting SHCS, and slip the drawbar drive motor and pulley out of the drive belt.

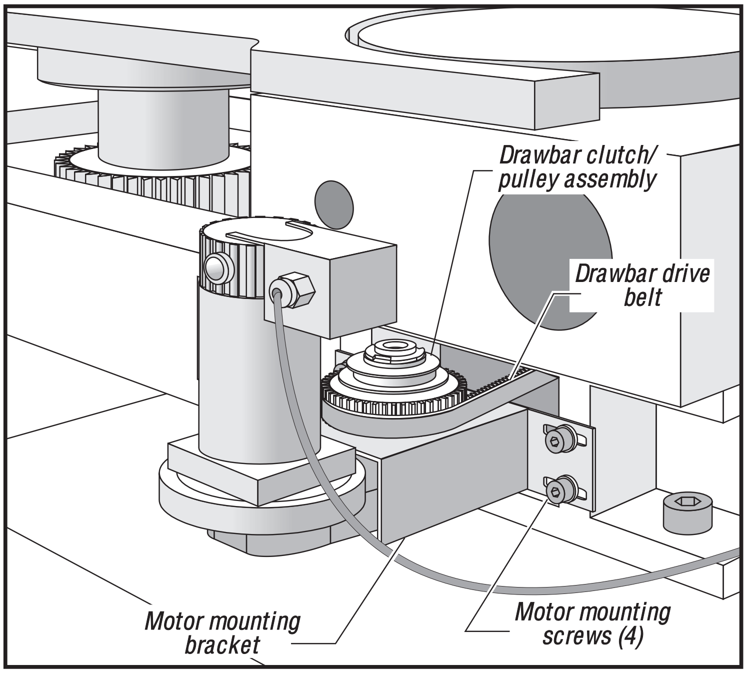


Figure 3.12-2. View of pallet changer rotary table (showing drawbar drive assembly)

3. Make sure the drive belt is out of the way, then replace the drive motor and pulley onto the casting. Tighten the four mounting SHCS.

4. Loosen the set screw that pushes on the key at the bottom of the clutch hub, under the pulley.

5. Using a flat tip screwdriver under each side of the pulley, exert a uniform force to lift the pulley off the motor shaft. On clutches with a large hex nut on the top, use a 1/2-13 bolt to thread through the nut and push on the top of the motor shaft, lifting the clutch off the shaft.

Motor Pulley Removal / Installation

REMOVAL

1. Remove both set screws

2. Reinstall one set screw into the center hole. Tighten until the pulley comes free of the shaft

3. Remove pulley assembly

INSTALLATION

1. Loosely install both set screws

2. Slide the assembly onto the motor shaft.

3. Secure by tightening the set screws.

Rotary Table Drawbar Drive Belt

REMOVAL-

1. Loosen the sixteen BHCS that attach the right side access panel (closest to operator) to the rotary table top cover and remove.

2. Remove the thirteen SHCS that attach the Z-axis way cover to the rotary table bottom cover. Collapse the Z-axis way cover so the linear guides are exposed. The driven pulley and drive belt can be accessed from the side of the linear guides.

3. Manually unscrew both the main drawbar and the load station drawbar. Manually activate the pallet lift cylinder solenoid to lift the pallets. Rotate the pallets and H-frame past the rotary table.

4. Remove the four SHCS that attach the air blast manifold and remove the manifold. Remove the six SHCS that secure the main drawbar and nut housing to the rotary table and remove the drawbar.

5. Remove the four drawbar motor mounting SHCS. Slip the rotary table drawbar drive motor and pulley out of the drive belt.

6. Slide the drive belt between the driven pulley and the air blast adapter (beneath the rotary table), and remove.

INSTALLATION-

7. Slide the new drive belt between the driven pulley and the air blast adapter, and wrap it around the driven pulley.

8. Slip the drawbar drive motor and pulley into the drive belt.

9. Mount the motor and pulley to the casting with four SHCS. Move the drawbar motor assembly until the belt is at the desired tension, and tighten the screws.

NOTE: The proper belt tension should place the motor mounting bracket all the way to the left.

10. Replace the drawbar and air blast manifold.

11. Active the pallet lift cylinder solenoid to lift the pallets, then rotate the pallets into position over the rotary table. Allow the pallets to settle down into place.

12. Execute an M50 CYCLE START (pallet change), ensuring that the new drive belt does not slip on the pulley, and that the clutch assembly in the drive pulley does slip as the drawbar applies clamping force to the pallet.

13. Complete 50 continuous pallet change cycles to check for any faults.

14. Apply sealant and install a gasket, then replace the right side access panel. Tighten the sixteen mounting BHCS.

15. Apply sealant and install a gasket where the Z-axis way cover meets the rotary table cover.

16. Extend the Z-axis way cover and secure to the rotary table bottom cover with thirteen SHCS.

ROTARY TABLE MOTOR AND BELT SUBASSEMBLY

REMOVAL-

1. Loosen the sixteen BHCS that attach the left side access panel (opposite the operator) to the rotary table top cover and remove.

2. Loosen the adjustment socket set screw and remove the motor adjustor plate (beside the rotary table motor mounting plate).

3. Disconnect the two air lines and two electrical connections to the motor assembly.

4. Loosen the two motor mounting HHB, but do not remove.

5. Move the motor assembly until the drive belt is loose, and remove the belt from the driven pulley.

6. Remove the two mounting HHB and the motor assembly.

7. The drive belt may be removed from the motor assembly by loosening the four SHCS and removing the mounting plate from the motor.

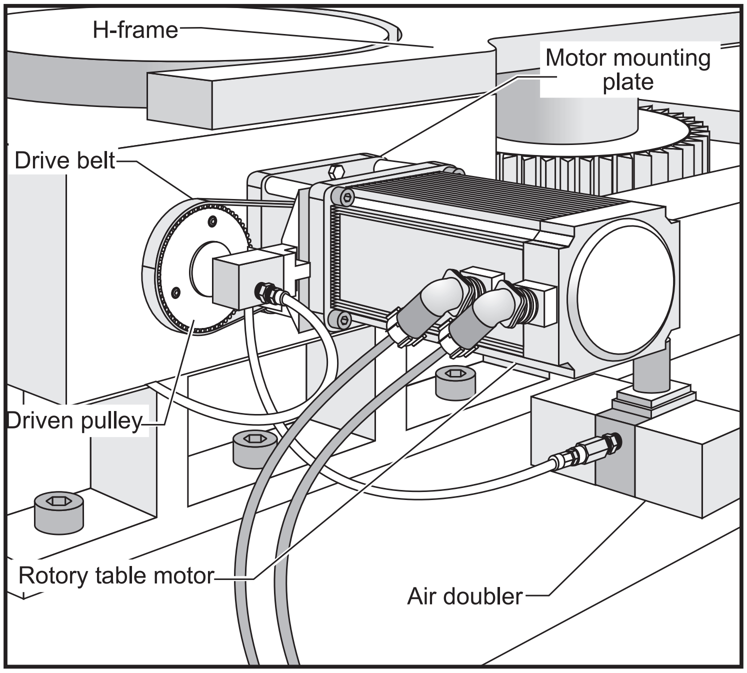


Figure 3.12-3. Rotary table motor and belt assembly

INSTALLATION-

8. Replace the drive belt on the motor pulley, then replace the four SHCS into the mounting plate and tighten.

9. Mount the motor assembly onto the side of the rotary table with the two mounting HHB, but do not tighten.

10. Place the other end of the drive belt on the driven pulley.

11. Replace the motor adjustor plate onto the two pins and tighten the adjustment socket set screw until the belt is at the desired tension.

12. Tighten the two motor mounting HHB.

13. Reconnect the two air lines and two electrical connections to the motor assembly.

14. Apply sealant, install a gasket, then replace the left side access panel. Tighten the sixteen mounting BHCS.

15. Perform the necessary adjustments in accordance with "H-frame alignment" and "Pallet Rotation Hardstop Adjustment" sections.

ROTARY TABLE DRAWBAR

REMOVAL-

1. Remove the pallet, in accordance with the "Pallet Replacement" section.

2. Loosen the four mounting SHCS and remove the air blast manifold from the rotary table top.

3. Loosen the eight mounting SHCS and remove a pallet nut from one of the pallets. Screw the pallet nut onto the drawbar. This will provide a way of removing the drawbar assembly.

4. Loosen the six SHCS that mount the nut housing to the rotary table.

5. Pull the pallet nut and drawbar up and remove them from the center of the rotary table.

6. Unscrew the drawbar from the nut housing and pallet nut.

INSTALLATION -

7. Lubricate (using Molybdenum disulfide grease) the threads of the new drawbar, and its two thrust washers and the splines.

8. Screw the drawbar into the nut housing. Lower the drawbar (and nut housing) into the splines of the drive shaft in the center of the rotary table.

9. Secure the nut housing to the rotary table top with six SHCS.

10. Replace the pallet nut into the pallet and tighten the six SHCS.

11. Replace the air blast manifold onto the rotary table top and tighten the four mounting SHCS.

12. Replace the pallet according to the appropriate section.

13. Execute continuous pallet change cycles to check for any faults.

ROTARY TABLE DRAWBAR (PULL STUD TYPE)

REMOVAL-

1. Remove the pallet, in accordance with the "Pallet Replacement" section. Check for proper operation of drawbar collet balls. Make note of any wear or damage to drawbar collet and balls.

2. Loosen the four mounting SHCS and remove the air blast manifold from the rotary table top.

3. Once the air blast manifold is removed, remove the 12 rubber plugs that cover the upper draw bar mounting hardware and remove the 10 mounting SHCS that retain the upper draw bar assembly.

CAUTION! Do not remove yellow marked SHCS fasteners. Marked SHCS are used to retain drawbar assembly.

4. On the mounting surface of the upper draw bar assembly, gently pry the unit upwards (the housing return spring will cause the assembly to lift, once the retaining screws are removed) until there is enough surface area to grab and lift entire assembly out. Check for any wear or damages to assembly. Keep in upright position so oil does not leak out.

INSTALLATION -

1. Lubricate (using Red-i grease) the splines of the new drawbar.

2. Apply grease to the contact surfaces to ease the installation of the assembly.

3. Carefully place drawbar assembly into mounting location. Apply a drop of blue Loctite to assembly mounting SHCS. Depress the unit against the housing spring and screw the 10 SHCS into the assembly. Torque assembly mounting SHCS to **15 FT-LBS**.

4. Replace the O-Ring for the air blast manifold and re-install. Apply a drop of blue Loctite to the air blast manifold SHCS and screw them into the manifold. Torque air blast manifold SHCS to **15 FT-LBS**.

5. Replace the pallet according to the "Pallet Replacement" section.

6. Execute continuous pallet change cycles to check for any faults.

DRAWBAR INSERT (PULL STUD TYPE)

REMOVAL-

1. Remove the pallet, in accordance with the "Pallet Replacement" section.

2. Command the drawbar into its clamp position. E-Stop the machine.

3. Loosen the three mounting BHCS that retain the insert into the drawbar assembly.

4. Insert a socket extension tool into the pull-stud area of the drawbar assembly. (For steps 4 through 9, refer to Figure 3.12-4)

5. Place a standard flat head screwdriver into the annular groove at the top of the drawbar insert and position it to rest against the protruding socket extension tool.

6. Using the screwdriver as a lever arm, pivot it on the socket tool and gently pry out the insert. Alternate the position of screwdriver to evenly remove the insert.

7. Inspect the inside surface of the insert for galling marks and excessive wear.

8. Using a machinist *Hook and Pick* tool, carefully remove the v-seal that resides directly beneath the insert. Check for wear and damage. Replace if necessary.

9. Carefully clean out any debris or residue left in the insert and v-seal area. Remove the 10 mounting SHCS and two yellow marked SHCS on the upper drawbar assembly. Remove upper ball collet housing and check for proper oil level. Replace upper ball collet housing. Torque SHCS to **15 FT-LBS.**

INSTALLATION-

1. Install a new O-ring on to the drawbar insert and V-seal in the drawbar assembly.

2. Place the new insert into drawbar assembly and gently press into place. Be careful not damage insert.

3. Apply a drop of blue Loctite to the insert 3 BHCS and secure them to the drawbar assembly.

4. Power up machine. Execute clamp and unclamp cycles and check for proper operation of drawbar. Observe and check for proper movement of the collet balls.

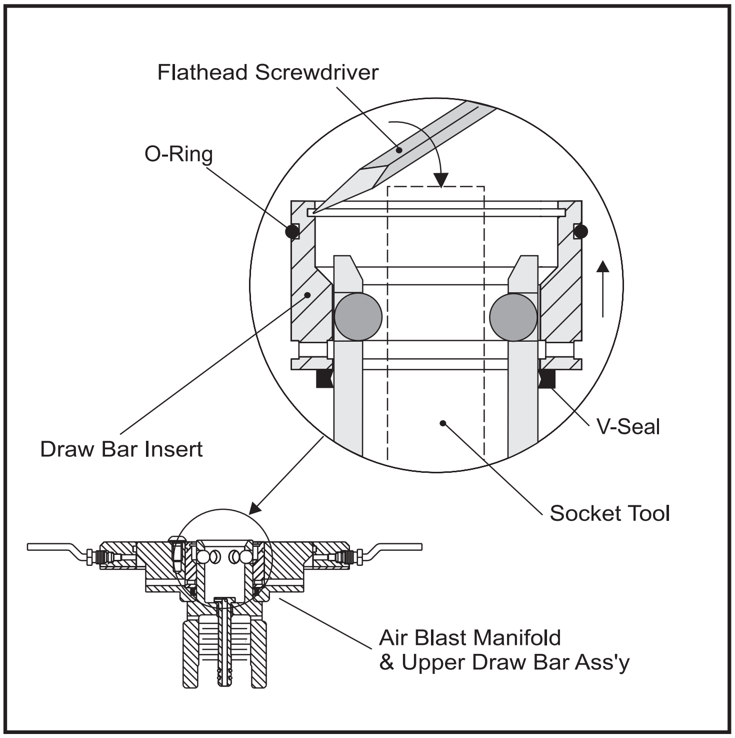


Figure 3.12-4

LOAD STATION DRAWBAR

NOTE: This only applies to machines up to serial number 50477.

REMOVAL-

1. Remove the pallet according to the appropriate section.

2. Loosen the hex nut that tightens the indexing handle onto the load station and remove the handle.

3. Loosen the four BHCS that attach the load station bottom cover to the load station and remove.

4. Disconnect the load station motor power supply cord (beneath the load station).

5. Loosen the four mounting SHCS and remove the load station motor from the bottom of the load station. Remove the drive shaft and woodruff key with the motor.

6. Remove the drawbar from the center of the load station by unscrewing it and pulling it out below the pallet turntable.

INSTALLATION-

NOTE: When threading the drawbar into the load station, ensure both drawbars are in the same location (clamped **or** unclamped).

7. Lubricate (using Molybdenum disulfide grease) the splines of the drawbar and screw it into the center of the load station.

8. Put the woodruff key and drive shaft back into place in the motor splines.

9. Mount the load station motor on the bottom of the load station with four SHCS.

10. Reconnect the load station motor power supply cord.

11. Replace the load station bottom cover onto the load station and tighten the six BHCS.

12. Replace the indexing handle into the actuator yoke, and tighten the hex nut.

13. Replace the pallet in accordance with the appropriate section.

14. Execute 50 continuous pallet change cycles to check for any faults.

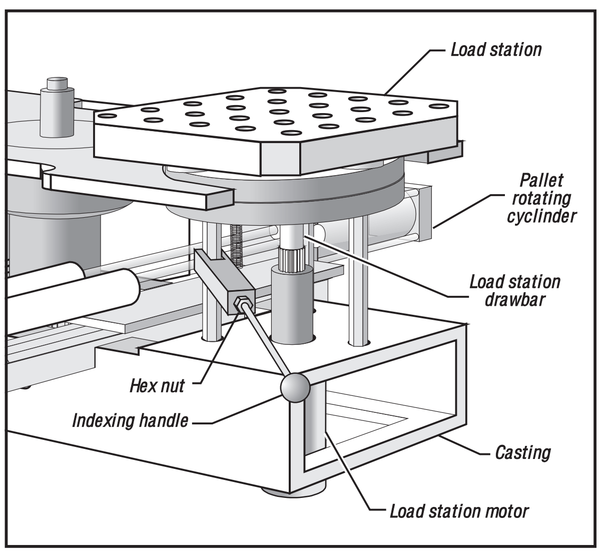


Figure 3.12-5 Pallet changer load station.

PALLET REPLACEMENT

REMOVAL-

The normal sequence of the pallet changer is:

1. Unclamp the pallets,
2. Raise the pallets,
3. Rotate the pallets,
4. Lower the pallets,
5. Clamp the pallets.

1. Execute a single M50 command from MDI, then interrupt the sequence by pressing RESET as the pallets start to rotate. Do not wait until the pallets are fully down on the stations.

2. Mark the front of the pallet to clarify orientation for when it is to be placed back on the machine.

3. Remove the pallet from the load station using some type of overhead lift, such as a hoist or crane.

CAUTION! Do not attempt to remove the pallet from inside the machine.

4. Check that the pads under the pallet are clean, and the V-ring seal is intact around the pallet nut.

5. After removing, set the pallet down on a clean surface, preferably wood, cardboard, or masonite for storage (even for temporary storage).

6. To remove the second pallet from the pallet changer, simply repeat the above procedure.

NOTE: It is not necessary for the pallet change sequence to begin from a "PALLETS CLAMPED" condition.

INSTALLATION-

1. Execute a single M50 command from MDI, then interrupt the sequence by pressing RESET as the lift mechanism starts to rotate. Do not wait until the lifting mechanism is fully down on the stations.

2. Check that the pads under the pallet are clean, and the V-ring seal is intact around the pallet nut.

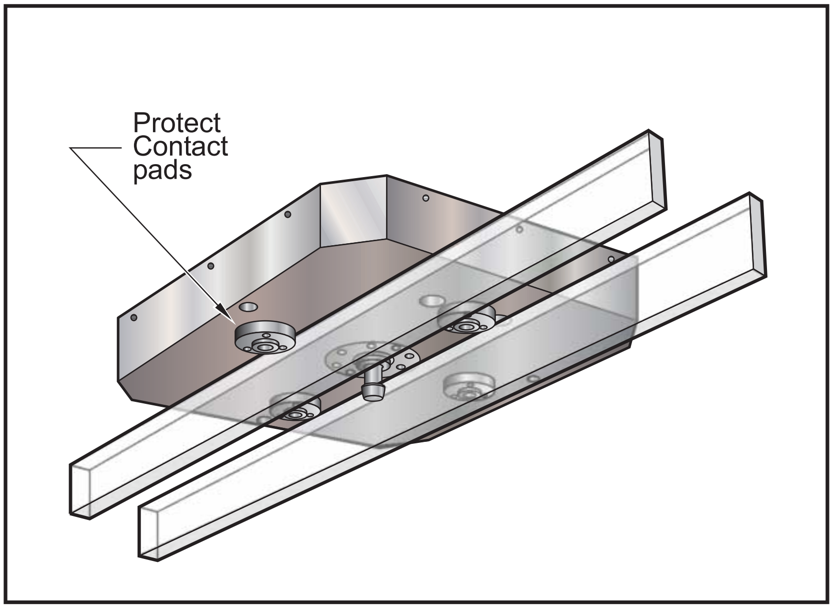
3. Ensure the load station is at the correct index position for proper pallet change operation before loading the pallet onto the load station. The correct position is defined as the position where the load station indexing handle is able to come to the fully up position.

4. **IMPORTANT!** When aligning the pallet and the load station locating pins, ensure that the three holes in the bottom of the pallet that mate to the lifting mechanism are properly oriented (the front of the pallet is facing the right direction).

5. Place the pallet onto the load station using some type of overhead lift, such as a hoist or crane.

CAUTION! Do not attempt to install the pallets from inside the machine.

PALLET STORAGE



CAUTION! Great care should be given to the storage and transfer of pallets. In order to properly store the pallets, place two supports between the locating pads so that the bottom of the pads do not touch anything.

AIR BLAST ADAPTER

REMOVAL-

1. Remove one pallet in accordance with the previous section.

2. Execute one more M50 in MDI, to put the empty pallet position inside the machine.

3. Remove the thirteen SHCS that attach the Z-axis way cover to the rotary table bottom cover.

4. Collapse the Z-axis way cover so the linear guides are exposed. The air blast adapter, beneath the rotary table, can be accessed from the side of the linear guides.

5. Disconnect the main air line to the machine.

6. Disconnect the air and oil lines from the air blast adapter.

7. Remove the rotary table drawbar in accordance with the appropriate section.

8. Remove the two shoulder bolts that secure the air blast adapter to the mounting bracket, and remove the air blast adapter.

INSTALLATION-

9. Attach the new air blast adapter (with O-rings installed) to the mounting bracket.

10. Replace the rotary table drawbar in accordance with "Rotary Table Drawbar" section.

11. Reconnect the oil and air lines to the air blast adaptor.

12. Reconnect the main air line to the machine.

13. Replace the pallet in accordance with the previous section.

14. Apply sealant and install a gasket where the Z-axis way cover meets the rotary table bottom cover.

15. Extend the Z-axis way cover and secure it to the rotary table bottom cover with the nine SHCS.

AIR BLAST MANIFOLD

REMOVAL-

1. Remove one pallet in accordance with the previous section.

2. Execute one more M50 in MDI, to put the empty pallet position inside the machine.

3. Loosen the four SHCS that mount the air blast manifold to the rotary table top and remove.

INSTALLATION-

4. Place the new air blast manifold, ensuring the O-ring is installed, onto the rotary table top and mount with the four SHCS.

5. Replace the pallet in accordance with the previous section.

PALLET ROTATION HARDSTOP ADJUSTMENT

1. Loosen the six BHCS and one SHCS that attach each of the front splash shields and remove the shields.

2. Slightly loosen the two SHCS that hold each of the hardstops (2) in place.

3. In MDI, execute an M50 (pallet change). Interrupt it by pressing RESET just as the pallets are lifted off the rotary table.

4. Execute an M12 to lower the pallets onto the rotary table without the drawbar clamping the pallets.

5. Rotate the cam screw inside the appropriate hardstop until the hardstop contacts the end of the roller mounting plate. Align the H-frame lifting pins with the holes in the bottom of the pallet, either by rotating the cam screw further in or backing it off.

6. Secure the hardstop by tightening the two SHCS.

NOTE: Clockwise rotation of the pallet changer is adjusted at the left hardstop (opposite side from the control panel), while counterclockwise rotation of the pallet changer is adjusted at the right hardstop (closest to control panel).

7. Replace the splash shields, and tighten the six BHCS and one SHCS on each shield.

PALLET ROTATION HARDSTOP ADJUSTMENT (DAMPER/SPRING & RETAINER PIN STYLE)

1. Remove any possible load(s) or fixtures from the pallets.

2. Loosen the nine BHCS that attach each of the front access panels and remove. The access panel removed should correspond to the rotation direction of the H-frame. To access the load station hardstop, remove the access panel to the left of the load station pallet. To access the rotary table hardstop, remove the access panel to the right of the rotary table pallet.

3. Execute a single M50 command from MDI, then interrupt the sequence by pressing RESET as the lift mechanism reaches maximum height. This will expose the access holes for the following step. Do not wait until the lifting mechanism starts to rotate the H-Frame.

4. Loosen the two SHCS that hold each of the hardstops (2) in place and remove hardstop(s). Manually rotate the H-frame to its full rotational swing and lower the lifting mechanism.

5. Remove the pallet (from the load station side) in accordance with the "Pallet Replacement" section.

6. Apply H-frame alignment tool to H-frame and pallet fixtures. (Refer to "A-axis Alignment to H-Frame" section). Using this as a reference, re-install the hardstops with the SHCS. Adjust the hardstop to mount flush against the surface of the H-frame strike. Tighten the SHCS and torque to **50 FT-LBS**.

7. Run pallet change commands and observe operation. (H-Frame full rotation shown in Figure 3.12-6.)

8. Replace pallet(s) in accordance to "Pallet Replacement" section. Replace the access panels.

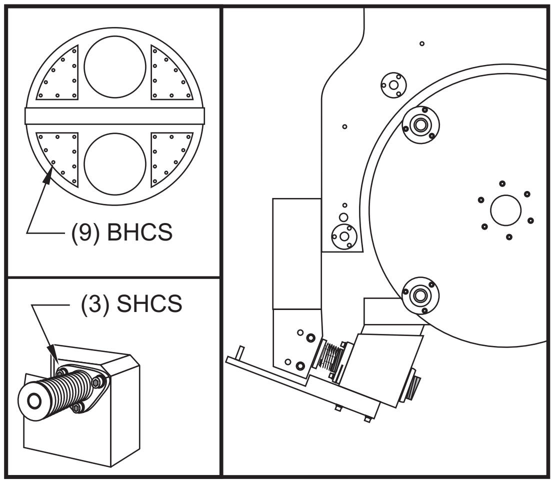


Figure 3.12-6.

A-Axis Alignment To H-Frame

TOOLS REQUIRED

H-frame alignment tool (T-1516)

NOTE: This adjustment must also be done if machine parameters are lost, or the A-axis rotary table is replaced.

1. Remove the pallet (from the load station side) in accordance with the "Pallet Replacement" section.

2. Execute a pallet change to bring the empty side of the H-frame into the machine. Press RESET as the H-frame is lowering, before the drawbar screws in.

3. Remove the pads from the rotary table (three SHCS each). Clean the pads and platter, and check for any scratches or high spots. Stone smooth if necessary.

4. Press the ALARM/MESGS key, type "Debug", then press the WRITE key.

5. Go to Parameter 224, write down the current value in Parameter 224 for reference, then enter zero (0) in its place.

6. Press the ZERO RET key, the A key, then the ZERO SINGL AXIS key. This will zero return the A-axis only.

7. Handle jog the A-axis counterclockwise until the rotary table pins are aligned with the center pin on the H-frame.

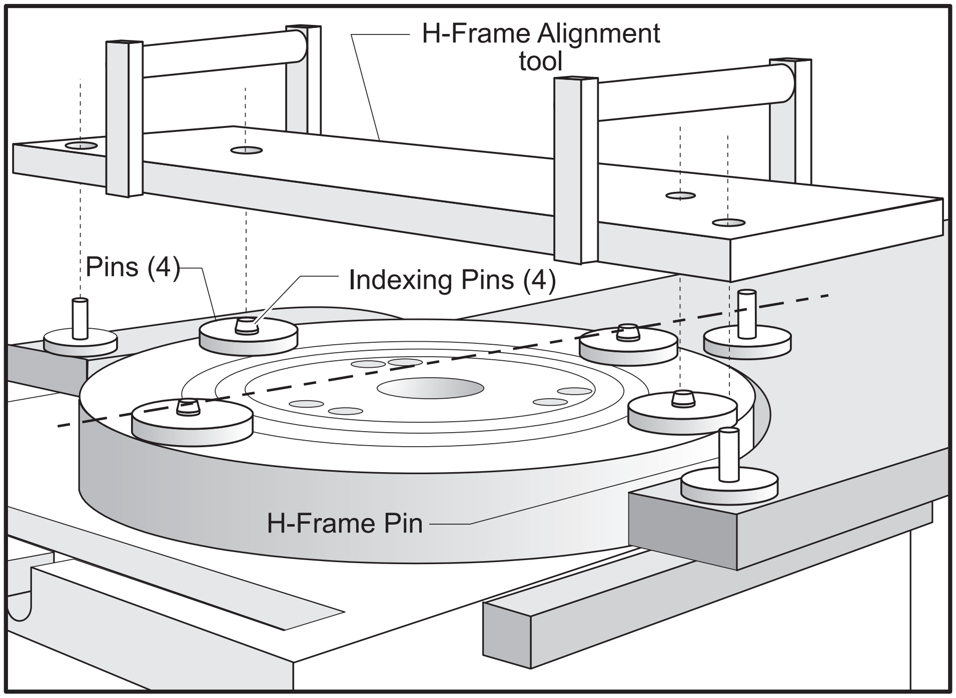


Figure 3.12-7. Use of the H-frame alignment tool.

8. Set the H-frame alignment tool in place on the pins. Using the jog handle, rotate the table until the alignment tool seats flat on the rotary table.

9. Press the POSIT key, then PAGE UP once. Take the actual number of encoder counts for the A-axis, disregard the decimal point and negative sign, and enter that number in Parameter 224. For example, the number -6.9347 would be entered as 69347.

10. Remove the alignment tool, zero return the A-axis (only), and check the value by replacing the alignment tool on the pins. Repeat the procedure if necessary.

11. Replace the pads on the rotary table platter with three SHCS each.

12. Replace the pallet in accordance with the "Pallet Replacement" section.

Rotary Top Cover Modifications

The instructions describes the steps necessary to modify the Rotary Top Cover (P/N 25-6486) on the HS-1RP pallet changer. These modifications are designed to eliminate coolant from contaminating the internal components of the pallet changer assembly. This will be accomplished by adding flanges (dams) at key locations to block coolant intrusion and the addition of several drain holes to redirect the coolant to the existing gutters.

NOTE: If the machine has openings, as shown in figure 3.12-9, it does not need this modification.

Tools Needed:

Drill, 9/32" and 1/2" bits

Required Hardware:

Included in Retrofit Kit P/N 93-0076.

1. Remove both pallets from the machine and carefully set aside. Make sure that the bottom surfaces are protected from damage and contamination.

2. Mark the pallet changer rotating door to indicate the side of the door that faces the pallet. This may eliminate the need to make adjustments when the door is reattached. Remove the pallet changer rotating door from the machine and set aside.

3. Mark the Rotary Top Cover position on the H-Frame assembly. Remove the eight 1/4-20 SHCS attaching the Rotary Top Cover to the H-Frame assembly. Remove the Rotary Top Cover from the machine and place on a suitable work surface. Provide protection against abrasion.

4. Thoroughly clean and prepare the area surrounding the 3.00" dia. center pivot hole of the Rotary Top Cover from below. Prep using alcohol or similar agent. See Figure 3.12-8.

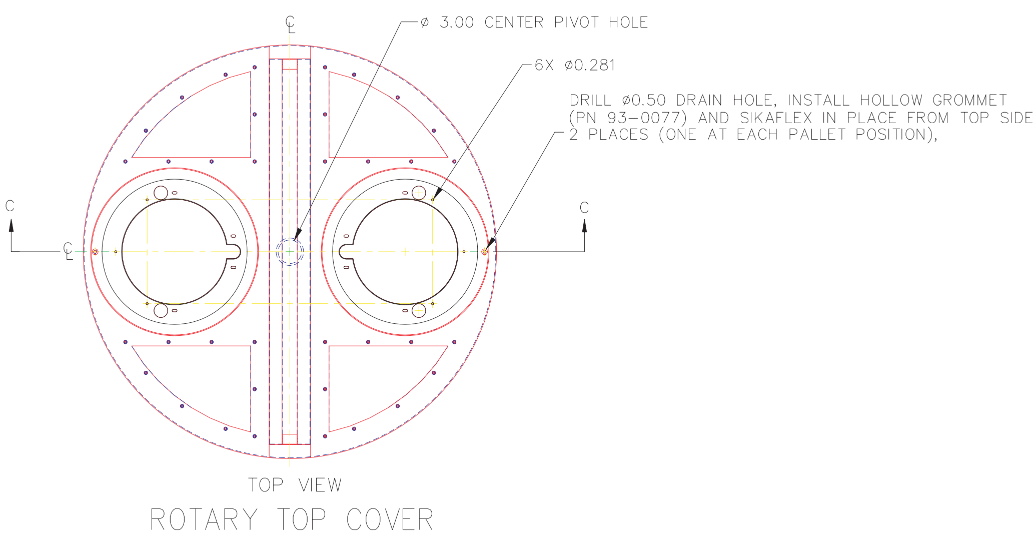


Figure 3.12-8 - Rotary Cover, Top View

5. Squeeze a bead of Sikaflex on the flange of the Flange Ring Cover, P/N 93-1099. Install the Flange Ring Cover from below so that the part protrudes up into the center pivot hole. Press firmly to create a watertight seal.

6. Place one Ring Dam HS-1RP, P/N 93-1098 onto one of the pallet locations on the Rotary Top Cover. Place the remaining Ring Dam onto the remaining pallet location. Line up all the existing perimeter holes and slots to ensure that the Ring Dams are centered over the openings. Using the Ring Dams as a guide, mark and match drill the three 0.281 dia. holes that do not yet exist in the Rotary Top Cover, as shown in Figure 3.12-8. Use a 9/32 (0.281) diameter drill bit and ensure the Ring Dams do not shift during drilling.

7. Remove the Ring Dams and debur the newly drilled holes top and bottom.

8. Drill a 1/2" diameter hole in the pallet location of the Rotary Top Cover as shown in Figure 3.12-8. Squeeze a bead of Sikaflex onto the hollow metal grommet (P/N 93-0077) and press into place from above. Repeat for the remaining pallet location.

9. Drill a 1/2" diameter hole centered on the end of the door guide shroud on the Rotary Top Cover. The hole should be as close to the intersection of the bottom of the shroud and the top cover as possible, as shown in Figure 3.12-9.

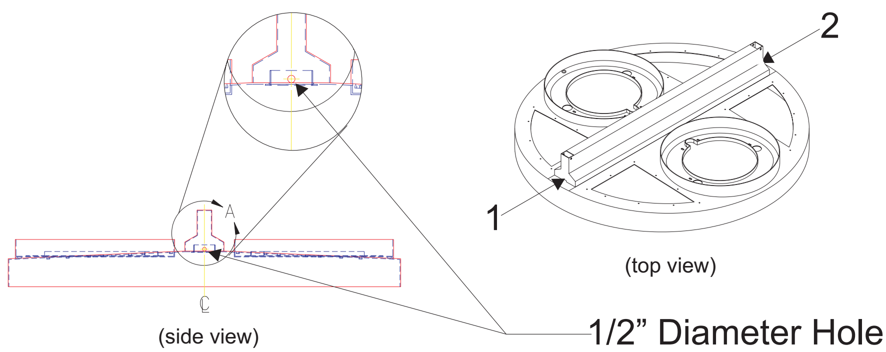


Figure 3.12-9

10. Repeat Step 9 on the opposite side of the Rotary Top Cover door guide shroud. See Figure 3.12-9.

11. Install the Gasket, Top Cover, P/N 57-0064 using one gasket for each end of the H-Frame. See Figure 3.12-10.

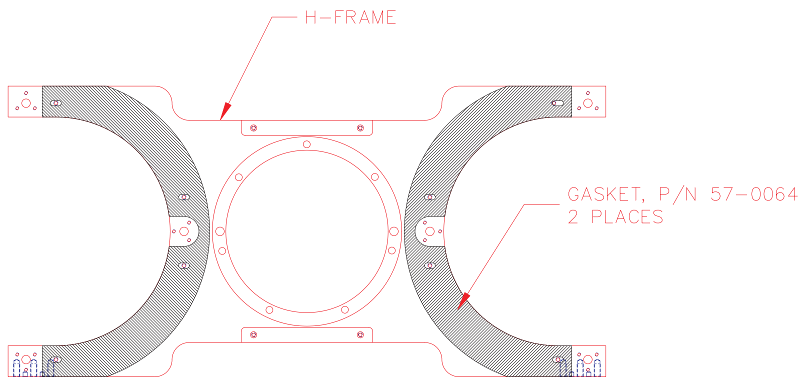


Figure 3.12-10 - Gasket Placement

12. Squeeze a small bead of Sikaflex around the bottom of both Ring Dams and mount to the Rotary Top Cover at the pallet locations. Center each Ring Dam over the large opening and attach using three 1/4-20 x 1/2" socket head cap screws inserted through the holes drilled in Step 6. Fasten to the Rotary Top Cover from below using lock-washers and 1/4-20 nuts.

13. Place the Rotary Top Cover assembly in position, centered on the H-Frame. Do not shift the gaskets. Reattach using eight 1/4-20 3/4" SHCS to allow for the added thickness of installed parts. Do not reuse the eight SHCS removed in Step 3. Some adjustments may be required to center the sheet metal on rotation.

14. Seal around the pallet spacers with Sikaflex.

15. Reinstall the pallet changer rotating door assembly. Adjust to center if required.

16. Before reinstalling the pallets, clean the pallet, load station, and rotary table locating pads and pins with alcohol.

3.14 Hydraulic Counterbalance

TOOLS REQUIRED

- **Hydraulic Counter Balance Service Kit consists of :**
  Pressure tank with manifold assembly, prefilled with (2) Quarts DTE-25 Hydraulic Oil
  Hydraulic cylinder with hose not attached (if necessary)

Hydraulic Tank Replacement

REMOVAL -

1. Remove the rear enclosure panel (seven SHCS).

2. Jog the X-axis until the hydraulic tank can be easily accessed from the rear.

3. Jog the Y-axis until the upper two holes in the column and the corresponding holes in the spindle head are aligned. Place two of the original shipping lockbolts (5/8-11 x 4" SHCS) through the two holes and tighten. **CAUTION!** This step must be followed to keep the spindle head from crashing down during service. If this is not done, serious injury could occur.

4. EMERGENCY STOP the machine. POWER OFF the machine.

5. Disconnect the two-pin end of the pressure sensor cable from the pressure sensor located on the tank manifold.

6. Remove cap to Schrader filler valve, attach discharging hose (finger tight only), and release any remaining pressure from the tank.

NOTE: Oil may drain out with releasing gas, so it is necessary to **slowly** discharge the system into a container.

7. Disconnect hydraulic hose from the tank assembly.

8. Remove tank assembly from the column by removing the four SHCS from tank box cover.

INSTALLATION -

1. Connect the hose to the tank, before inverting the tank for mounting. This prevents hydraulic oil from spilling.

2. Place the tank assembly in the tank mounting box. Secure the box lid with four SHCS. Ensure the hydraulic hose is not twisted.

3. Connect the two-pin end of the pressure sensor cable to the pressure sensor.

4. Connect the charging system to the Schrader filling valve. **Slowly** pressurize system with dry nitrogen gas (welding grade is acceptable).

NOTE: Do not use compressed air, oxygen or flammable gas. Verify the end of the cylinder rod is seated in the counterbore in the back of the spindle head.

5. **IMPORTANT!** Remove the two shipping lockbolts from the column and spindle head.

CAUTION! Serious machine damage will occur if the axes are moved with the lockbolts in place.

6. POWER ON the machine and zero return (ZERO RET) the **Y-axis only**. Check for any leaks or abnormal noises. Verify tank pressure (600 psi) at top of travel. Remove charging system and replace valve cap. Zero return all axes.

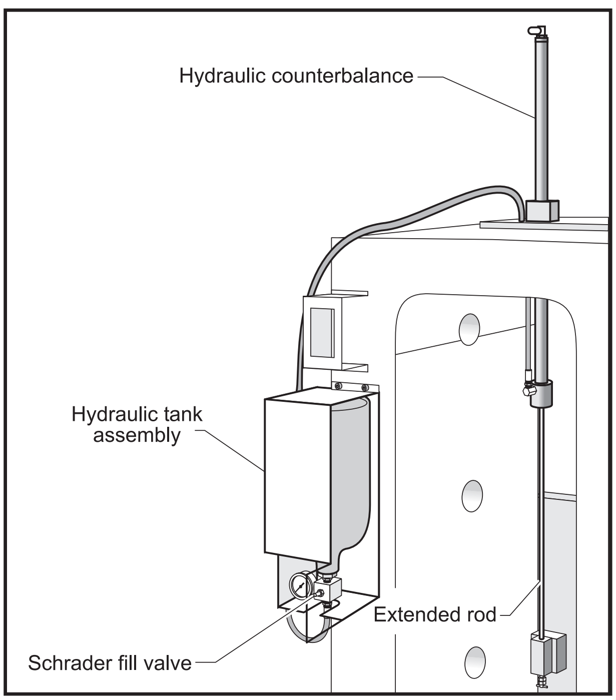


Figure 3.13-1. View of hydraulic counterbalance.

NOTE: If there is an Emergency Stop alarm that will not reset, check for correct system pressure, loose electrical connections, or the correct tank assembly.

HYDRAULIC CYLINDER REPLACEMENT

REMOVAL -

1. Remove the hydraulic tank as described in previous section.

2. To gain access to the cylinder rod, remove the rear enclosure panel (seven SHCS).

3. Insert the two shipping lockbolts into the column and spindle head, as in the previous section.

CAUTION! This step must be followed to keep the spindle head from crashing down during service. If this is not done, serious injury could occur.

4. EMERGENCY STOP the machine. POWER OFF the machine.

5. Remove the cotter pin and lock nuts from the threaded end of the cylinder rod. These are located on the back of the spindle head, towards the control panel side of the machine.

6. Loosen the two SHCS holding the cylinder clamp to the top of the column.

7. Remove the hydraulic cylinder from the top of the column.

8. Disconnect the hose from the cylinder body.

9. Return the hose and cylinder to HAAS Automation.

INSTALLATION-

1. Install cylinder (with cylinder rod extended) through the large hole (closest to front) on top of the column. The cylinder rod should pass through spindle head mounting hole.

2. Orient cylinder body with hydraulic hose fitting facing toward the back of the machine. Secure cylinder to column using two shoulder bolts through the block on the cylinder.

3. Install washer and lock nuts (wrench tight) at threaded end of cylinder rod. Install safety cotter pin through cylinder rod.

4. Install the hydraulic tank as described in the previous section, but **DO NOT POWER UP the machine**.

5. Install the new hose through the smaller of the two holes on the top of the column, and attach to the cylinder body.

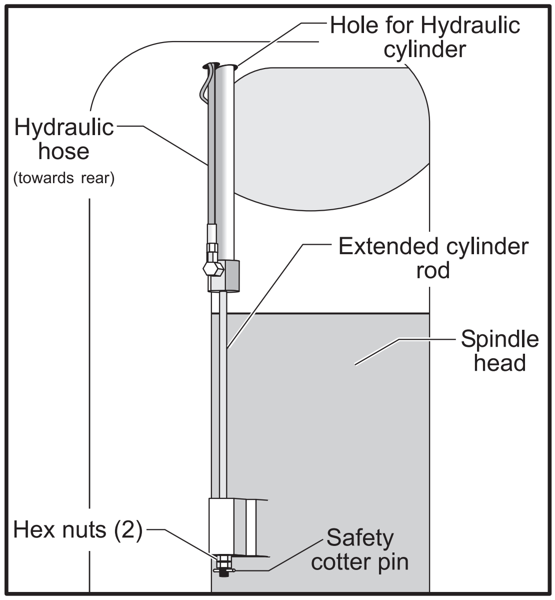


Figure 3.13-2. Hydraulic cylinder rod installation.

6. **IMPORTANT!** Remove the two shipping lockbolts from the column and spindle head.

CAUTION! Serious machine damage will occur if the axes are moved with the lockbolts in place.

---

7. POWER ON the machine and zero return (ZERO RET) **Y-axis only**. Observe the cylinder body for motion or abnormal noises. Check for fluid at manifold, cylinder hose connection and cylinder rod. Verify tank pressure at top of travel (600 psi). Remove charging system and replace valve cap.

8. Zero return (ZERO RET) the machine. HANDLE JOG the Y-axis in 0.1 increments. Verify full Y travel.

9. Cycle the Y-axis, using the following program, for five minutes and check for oil leaking at top of cylinder and cylinder rod:

   G28, G54, Y-14.
   M99
   50% Rapid

10. If a Y-axis overcurrent alarm occurs during travel, verify and correct system pressure.

NOTE: At top of machine travel (HS-1/R/RP/HCE-400/400P), the correct pressure for the hydraulic counterbalance is 600 psi.

NOTE: If Y-axis overcurrent alarm is received at top or bottom of travel, call HAAS Automation Service Department immediately for assistance. If fluid leaks from hydraulic fittings, check that fittings are tight. If leaking continues, call HAAS Automation Service Department for assistance.

11. Replace the rear enclosure panel with seven SHCS.

3.15 Through the Spindle Coolant System - Adjustments

TOOLS REQUIRED

Tool holder with small through coolant drill or small orifice tool (#T-1461).
TSCHP Gauge Kit (P/N 93-9011), includes:
0-15 PSI gauge
0-600 PSI coolant gauge
Ball valve

The old TSC system must be serviced with TSC gauge kit 93-9010. The fittings on the 0-150 psi coolant gauge and on the ball valve fit the old system. The precharge gauge is the same as the new system.

Precharge Regulator Adjustment

CAUTION! Extreme care must be taken in making this delicate adjustment.

1. Insert a short piece of 1/4" plastic tubing (for HS-2, use 3/8" tubing) into the 0-15 psi pressure gauge. Insert the short tube into the precharge pressure regulator (located on top of the transmission) and connect the plastic precharge tube (leading to the TRP) to the pressure gauge.

2. Manually turn on the precharge air by pushing the plunger on the precharge solenoid valve.

3. Hold down the precharge solenoid valve for at least 20 seconds to allow the pressure reading to stabilize, then set the precharge pressure to 6.0 psi (±0.4 psi). Release the solenoid and hold it down again for 20 seconds and re-check the precharge pressure. Repeat this a few times to ensure the pressure setting remains stable. Be sure the regulator adjustment knob is securely locked in place.

4. Remove the pressure gauge and the short piece of tubing. Reattach the precharge tube to the regulator.

Priming the TSC System

NOTE: When machine is ready to operate, with coolant in the coolant tank, prime the Through the Spindle Coolant (TSC) system according to the following procedure.

1. With no tool in the spindle, switch to MDI mode.

2. Press the AUX CLNT button to turn on TSC. Wait for coolant to flow from the spindle.

3. Run TSC system for at least one minute.

4. Press the AUX CLNT button again to turn off TSC.

NOTE: If the "Low Tool Coolant" alarm is received, press RESET and turn TSC on again. If the "Low Tool Coolant" alarm still does not clear, check the pump pressure and coolant pressure switch settings as described below. If the pump pressure is less than 60 psi with no tool in the spindle, replace the pump head.

NOTE: On old TSC system, If the drawbar was replaced, check that the ID of the drawbar is 0.156 dia, and not 0.190 dia. Replace it with the correct one if it is 0.190 dia.

Checking Pump Pressure

NOTE: If the coolant pressure with no tool in the spindle is 60 psi or less, replace the pump assembly (30-3281A). Old TSC system uses pump head (93-3280B).

1. Insert the 0-600 psi coolant pressure gauge into the coolant line between the machine enclosure and the TSC pump hose. Use wrenches to tighten the fittings snug. DO NOT OVERTIGHTEN !!

2. With no tool in the spindle, prime the TSC system as described above.

3. Insert a standard (no through hole in pull stud) tool holder into the spindle.

4. Turn on TSC.

5. Check for leaks while TSC is still running. Shut off TSC.

6. Remove pressure gauge and reconnect the pump to the machine.

If the pump relief valve has been changed, adjust the relief valve in the following manner:

1. Remove the sealing cap from the pump relief valve. Loosen the lock nut.

2. Start with the pressure below 300 psi. Adjust the pressure relief valve until the pressure on the gauge rises to 300 psi. Tighten the lock nut, and replace the sealing cap. Setting range is 280-300psi.

3. Mark across the pump and sealing cap with a paint marker. This will indicate tampering.

Testing the Coolant Pressure Switch

1. Insert the ball valve and pressure gauge into the coolant line between the machine enclosure and the TSC pump hose. The ball valve must be *between* the pump and pressure gauge. Tighten the fittings snugly with wrenches. DO NOT OVERTIGHTEN !!

2. Run TSC system for one minute to purge air.

3. Insert a TSC type tool holder (with a TSC drill or restrictor) in the spindle.

CAUTION! Changing tools after running TSC can cause coolant to spray out. Wear safety glasses.

4. Set Parameter 236 to 100.

5. Turn on TSC. Test low coolant pressure switch by slowly shutting off the ball valve in the coolant line (pump should shut off at 40 psi ± 10 psi). If the switch is outside this range, replace the switch.

NOTE: Test the electrical continuity of the switch cable and the control function by monitoring the "LO CLNT" bit on the Diagnostics page. Shorting the leads should cause the bit to switch from 1 to 0. Check this before replacing the pressure switch.

6. Reset Parameter 236 to the default value (1000).

3.16 Grid Offset Calculation

Please read this section in its entirety before attempting to set the grid offset.

GUIDELINES -

The encoder Z channel signal must occur between 1/8 and 7/8 revolution from where the home switch is released. If DISTANCE TO GO is less than 1/8 (.0295) or greater than 7/8 (.2065) of a revolution, it will alarm to "Zero Return Margin Too Small".

In ZERO RETURN mode, the DISTANCE TO GO is the amount the encoder rotated from when the switch was released until it found the Z channel signal. The ideal amount for the DISTANCE TO GO is .118 (This equals ½ of a revolution of the encoder).

SETTING THE OFFSET -

1. Set the grid offset to zero. (Parameter 125,126, 127, 128, or 170, depending on the axis being set.) Setting #7 (PARAMETER LOCK) must be OFF to reset grid offset.

2. Press ZERO RET and ZERO SINGL AXIS the axis you are setting (X, Y, Z, A, or B).

3. Calculate the grid offset using the following formula, and write the result in Parameter 125,126, 127, 128, or 170 (depending on the axis being set).

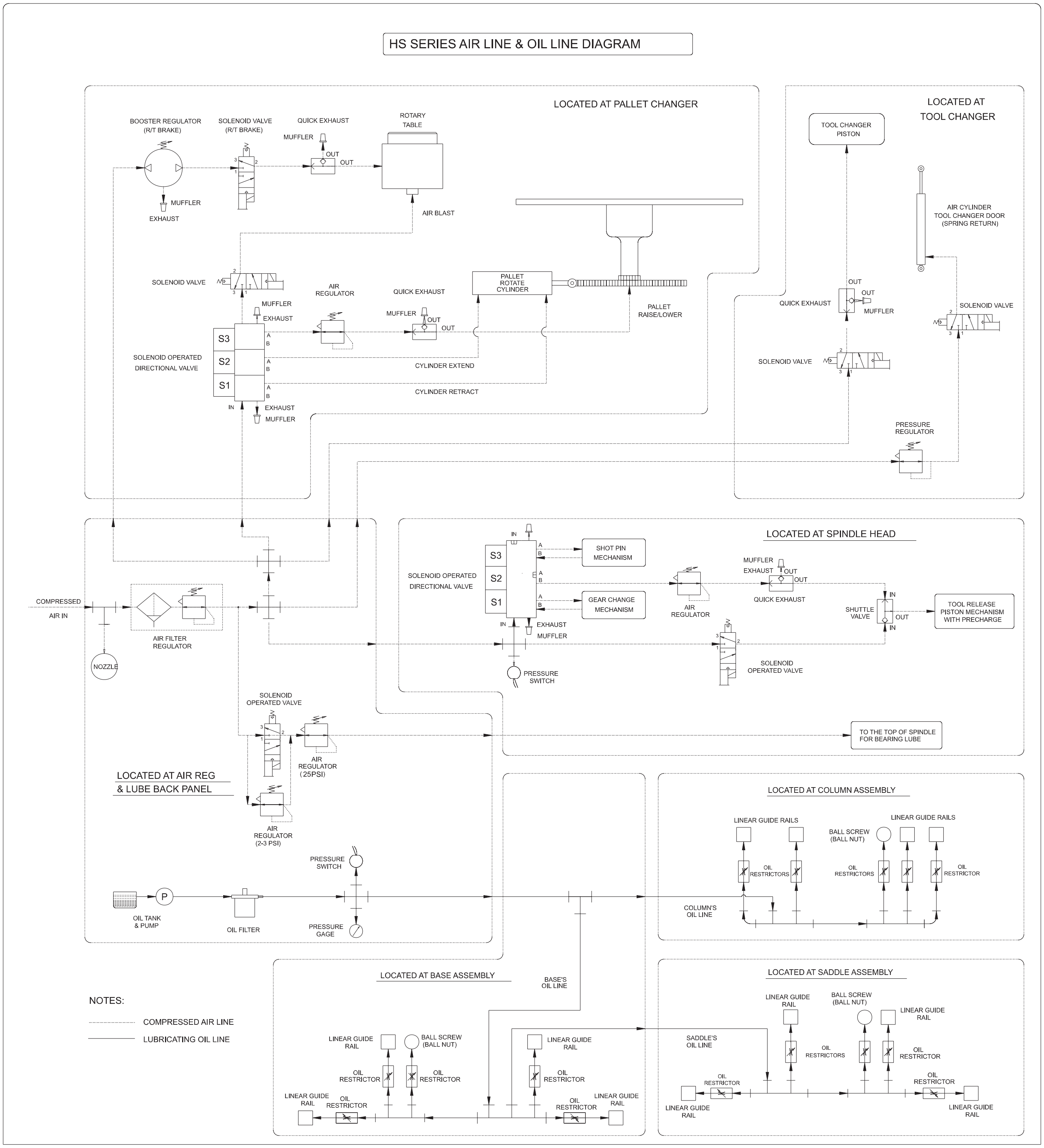
(DISTANCE TO GO - .118) x Ratio = Grid Offset

The Ratio (steps/unit) for the X, Y, Z, A, and B axes are the values in Parameters 5, 19, 33, 47, and 155, respectively.

4. ZERO RET the axis again to use this offset.

NOTE: If Z-axis grid offset is reset, Parameter 64 should be checked and adjusted accordingly.

3.17 Air / Oil Line Diagram



THROUGH THE SPINDLE COOLANT

SYSTEM FLOW DIAGRAM

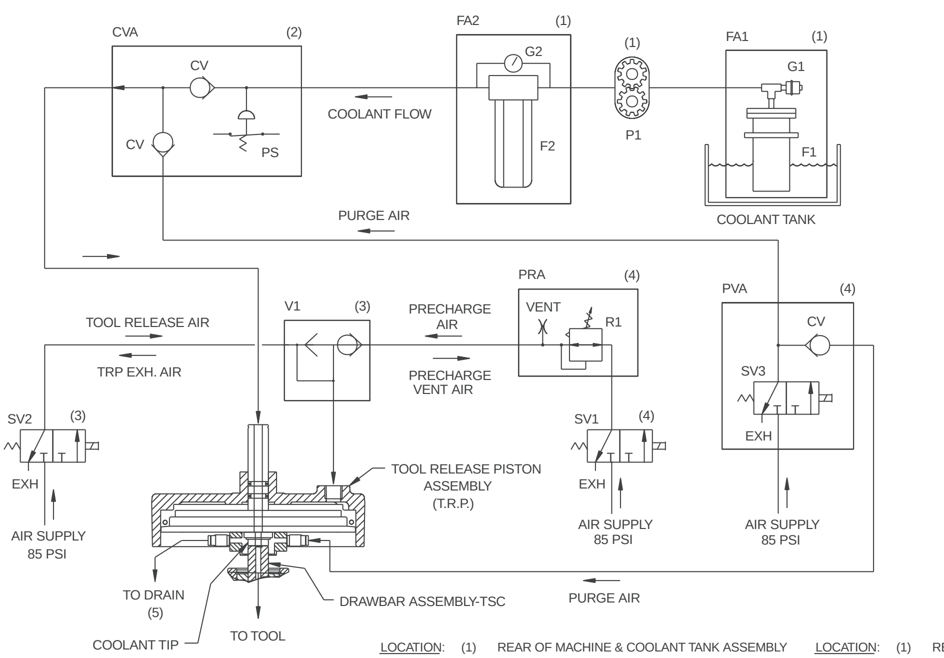
TSC SYSTEM WARNING!

THE TSC PUMP IS A PRECISION GEAR PUMP AND WILL WEAR OUT FASTER AND LOSE PRESSURE IF ABRASIVE PARTICLES ARE PRESENT IN THE COOLANT.

SHORTENED PUMP LIFE, REDUCTION OF PRESSURE AND INCREASED MAINTENANCE ARE NORMAL AND TO BE EXPECTED IN ABRASIVE ENVIRONMENTS AND ARE NOT COVERED BY WARRANTY.

WHEN MACHINING CASTINGS, SAND FROM THE CASTING PROCESS AND THE ABRASIVE PROPERTIES OF CAST ALUMINUM AND CAST IRON WILL SHORTEN PUMP LIFE UNLESS A SPECIAL FILTER IS USED IN ADDITION TO THE 100 MESH SUCTION FILTER. CONTACT HAAS FOR RECOMMENDATIONS.

MACHINING OF CERAMICS AND THE LIKE VOIDS ALL WARRANTY CLAIMS FOR WEAR AND IS DONE ENTIRELY AT CUSTOMER'S RISK. INCREASED MAINTENANCE SCHEDULES ARE ABSOLUTELY REQUIRED WITH ABRASIVE SWARF. THE COOLANT MUST BE CHANGED MORE OFTEN AND THE TANK THOROUGHLY CLEANED OF SEDIMENT ON THE BOTTOM. AN AUXILIARY COOLANT TANK IS RECOMMENDED.



CV	CHECK VALVE
CVA	CHECK VALVE ASSY - TSC
F1	INTAKE FILTER, 100 MESH
F2	TSC FILTER, 100 MICRON
FA1	INTAKE FILTER ASSEMBLY
FA2	TSC FILTER ASSEMBLY
G1	DIRT INDICATOR, INTAKE FILTER
G2	DIRT INDICATOR, 100 MICRON FILTER
P1	TSC PUMP
R1	PRECHARGE REGULATOR SET AT 3.6 - 4.4 PSI
PRA	PRECHARGE REGULATOR ASSY (30-3270A)
PS	PRESSURE SWITCH SET AT 40 PSI
PVA	PURGE VALVE ASSEMBLY (30-3276)
SV1	SOLENOID VALVE (PRECHARGE) 2 POSITION, 3 WAY, SP. RET.
SV2	SOLENOID VALVE (TOOL RELEASE) 2 POSITION, 3 WAY, SP. RET.
SV3	SOLENOID VALVE (PURGE) 2 POSITION, 3 WAY, SP. RET.
V1	SHUTTLE VALVE

THROUGH SPINDLE COOLANT SYSTEM FLOW DIAGRAM

LOCATION: HMC
(1) REAR OF MACHINE & COOLANT TANK ASSEMBLY
(2) REAR SIDE OF TRANSMISSION ASSEMBLY
(3) ON TOOL RELEASE PISTON ASSEMBLY
(4) TOP & SIDE OF TRANSMISSION ASSEMBLY
(5) AT REAR INSIDE OF ENCLOSURE PAN

LOCATION: VMC
(1) REAR OF MACHINE & COOLANT TANK ASSEMBLY
(2) SIDE OF GEAR BOX/SPINDLE MOTOR ASSEMBLY
(3) ON TOOL RELEASE PISTON ASSEMBLY
(4) REAR OF GEAR BOX/SPINDLE MOTOR ASSEMBLY
(5) AT BOTTOM REAR OF SPINDLE HEAD

THROUGH SPINDLE COOLANT (TSC) WARNINGS!!

1. TSC REQUIRES TOOL HOLDER WITH THROUGH HOLE IN PULL STUD AND TOOL. FAILURE TO DO SO CAN FLOOD SPINDLE HEAD WITH COOLANT.
2. DO NOT RUN TSC WITH LOW COOLANT LEVEL IN TANK.
3. WEAR SAFETY GLASSES WHEN MANUALLY CHANGING TSC TOOLS. COOLANT CAN SPRAY OUT.

THROUGH SPINDLE COOLANT ALARMS

1. LOW THRU SPINDLE COOLANT (ALARM 151):
CAUSE: COOLANT PRESSURE IN SYSTEM FELL BELOW 40 PSI.
A) CHECK FOR LOW COOLANT IN TANK, B) CHECK DIRT INDICATORS ON BOTH FILTERS,
C) PRESS RESET AND RUN TSC AGAIN TO PURGE AIR FROM SYSTEM.
2. PRE-CHARGE FAILURE (ALARM 198):
CAUSES: TOOL RELEASE PISTON DID NOT MOVE DOWN WHEN COMMANDED OR IT MOVED UP DURING TSC OPERATION, OR ANOTHER ALARM OCCURED DURING TSC OPERATION.
A) CHECK FOR LOW AIR SUPPLY PRESSURE, B) CHECK FOR T.R.P. FAILURE.

THROUGH SPINDLE COOLANT (TSC) MAINTENANCE SCHEDULE

1. TOP-OFF COOLANT TANK DAILY (EVERY 8 HOUR SHIFT) DURING HEAVY TSC USAGE.
2. CHECK GAGE (G2) ON 100 MICRON FILTER WITH TSC SYSTEM RUNNING AND NO TOOL IN SPINDLE. CHANGE ELEMENT WHEN THE INDICATOR REACHES THE RED ZONE. USE 100 MICRON FILTER ELEMENT (58-6045) OR COMMERCIALLY AVAILABLE EQUIVALENT.
3. CLEAN PUMP INTAKE FILTER WHEN INDICATOR (G1) IS IN RED ZONE. RESET WITH BUTTON.

SPECIAL INSTRUCTIONS: AFTER CHANGING OR CLEANING FILTER ELEMENTS, RUN TSC SYSTEM WITH NO TOOL IN SPINDLE FOR AT LEAST ONE MINUTE TO PURGE AIR.

ADJUSTABLE TSC PARAMETER: PARAMETER 237 (TSC CLNT LINE PURGE) MINIMUM (DEFAULT) VALUE IS 2500, NO MAXIMUM LIMIT.

3.18 HS-3R Harmonic Drive Components

The Harmonic Drive unit is used to drive the HS-3R Rotary Table.

The Harmonic Drive Assembly is made up of the following components:

Housed Harmonic Drive
- O-Ring Pack (included in package)
- Wave Generator (included in package)

Yaskawa Sigma Motor
Gearbox Adapter
Pinion Gear, 22 Tooth
Cam Backlash Adjuster

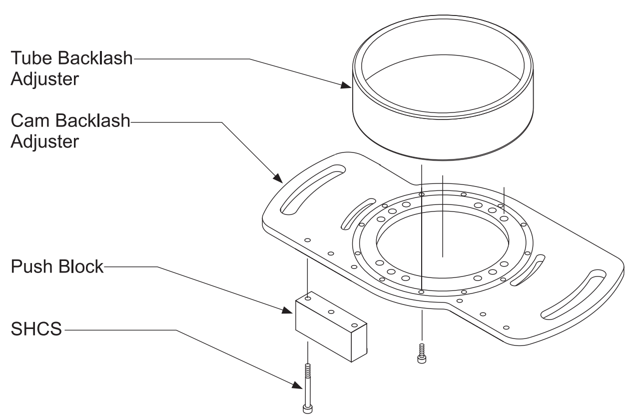
The Housed Harmonic Drive is prepacked with appropriate grease. It is a self-greasing unit, requiring no maintenance.

Assembly - Backlash Tube and Plate

1. Place the Tube Backlash Adjuster onto the Cam Backlash Adjuster plate. Turn the Tube so that the holes line up with the holes in the Plate. This is an interference-fit item. Insert the 12 SCHS into the Tube and thread into the Plate. Tighten the SCHS in a star-pattern to ensure proper positioning of the Tube.

2. Attach one Push Block to each side of the Plate, using existing drilled holes and 6 supplied SCHS.

NOTE: The Backlash Plate assembly is not attached to the Motor at this point to ease assembly into the table during installation.



Assembly - Motor / Wave Generator

1. Sweat the Pinion Gear (positioned so the groove is away from the flange) over the shaft of the Sigma Adapter and set aside.

2. Examine the spindle of your Yaskawa Sigma Motor. If your Motor has the Motor Shaft Spacer already sweated onto the shaft, skip to Step 4.

3. Sweat the Motor Shaft Spacer over the shaft of the Motor. Ensure the chamfer on the inner diameter spacer faces the motor.

4. Turn the Motor so that the shaft faces upward. Place the Gearbox Adapter over the Motor shaft. Insert the four SHCS through the tabs of the Motor case into the Gearbox Adapter and tighten.

5. Place the Wave Generator over the Motor shaft. Align the keyway in the Wave Generator with the keyway in the Motor's shaft.

6. Insert the Yaskawa Motor Key into the combined keyway. Use a press to fit the key into the keyway. Do not use the HAAS Motor Key.

CAUTION! Do not use a hammer or other forceful method of inserting the key. You will damage the fragile bearings and components of the Wave Generator.

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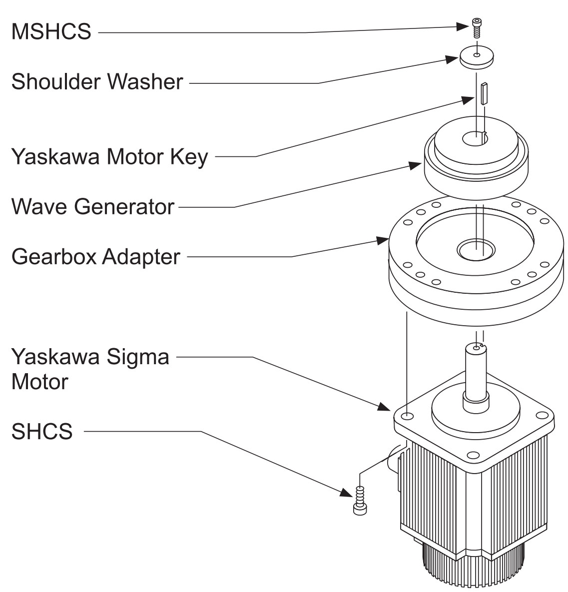
7. Place the Shoulder Washer over the Motor shaft. Apply Loctite, insert the MSHCS and tighten.



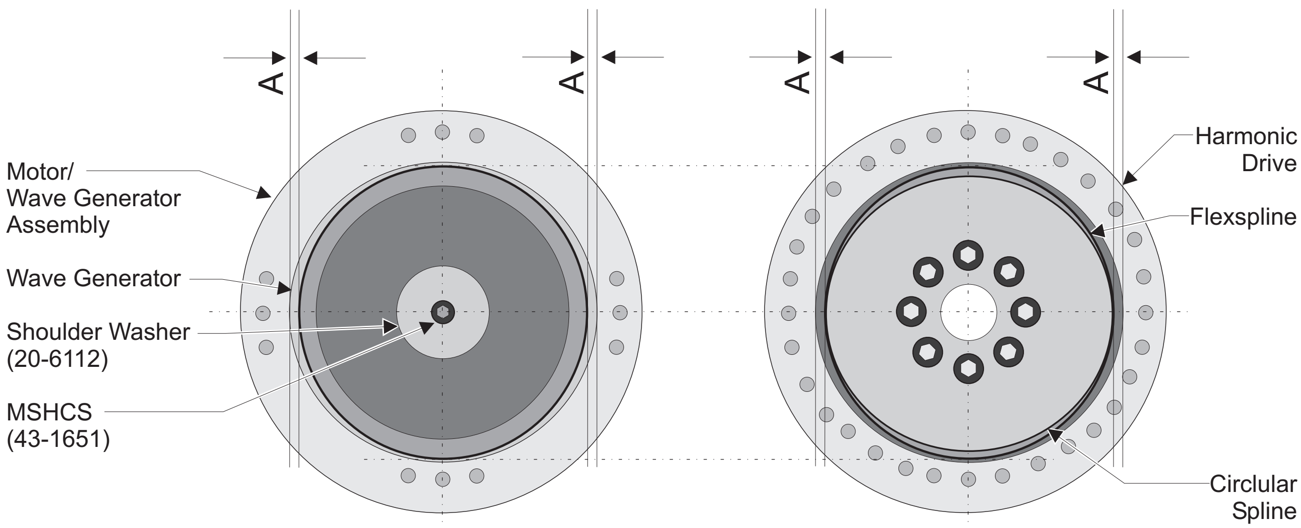
ASSEMBLY - HARMONIC DRIVE

1. Cover your work area with a clean shop rag and place the Harmonic Drive with the smaller-diameter end down on the work surface. You should see the grease cavity of the Harmonic Drive.

2. Remove the large O-Ring from the included package and lightly grease. Place in the groove in the face of the Harmonic Drive.

NOTE: For proper operation of an HDC Gear Set, it is essential that the ring of the Wave Generator be concentric with the ring of the Harmonic Drive. The rings of the Wave Generator and Harmonic Drive are ellipses; they are not circular. Incorrect assembly will result in an off-center or "dedoidal" condition, resulting in **poor performance** and **reduced service life**.

3. Place the Motor/Wave Generator assembly next to the Harmonic Drive. Turn the Harmonic Drive elliptical ring until the ring is closest to the front of the Harmonic Drive. Orient the Wave Generator elliptical ring until it matches the positioning of the Harmonic Drive exactly.



Phasing the Wave Generator to the Harmonic Drive (view from above)

4. Turn the Motor/Wave Generator assembly over and set lightly on the Harmonic Drive. If the two elliptical rings are in phase, they will mesh. If they do not mesh easily, remove the Motor/Wave Generator assembly and verify correct alignment of the elliptical rings and repeat this Step.

5. Bolt the Gearbox Adapter to the Harmonic Drive by inserting four SHCS into the countersunk holes in the Gearbox Adapter.

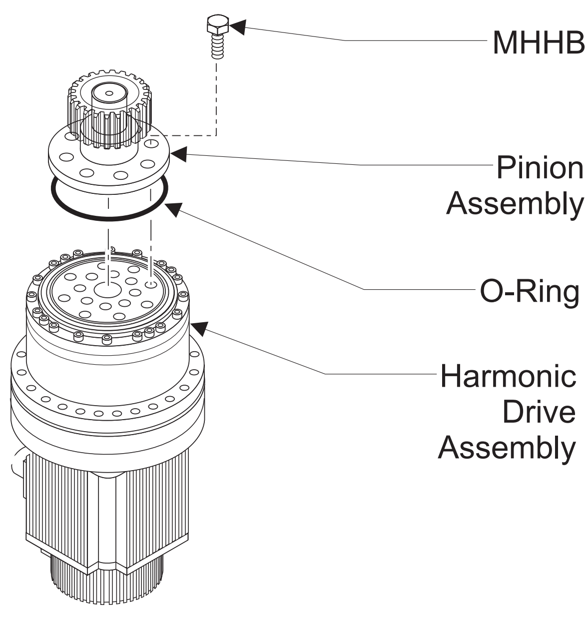
NOTE: To test for a dedoidal (out of phase) condition, perform the following operation:

Turn the Harmonic Drive/Motor assembly over and set it on the Motor casing, Harmonic Drive up. Insert a 5mm hex wrench through the center hole in the Harmonic Drive into the MSCHS installed in **Assembly - Motor / Wave Generator Step 7**. Turn the hex wrench with a drill. For one complete revolution of the input there should be two equal deflections, or pulses, felt through the drill.

6. Turn the complete assembly over to expose the Harmonic Drive. Keep this free of contaminents. Lightly grease and install the remaining O-Ring into the groove. This O-Ring seals the Harmonic Drive from coolant during machine operation.

7. Install the Pinion Assembly (from **Assembly - Motor / Wave Generator Step 1**) onto the Harmonic Drive. Be sure to orient the Pinion Assembly so that the bolt holes line up with the holes in the Harmonic Drive. This is an interference-fit item.

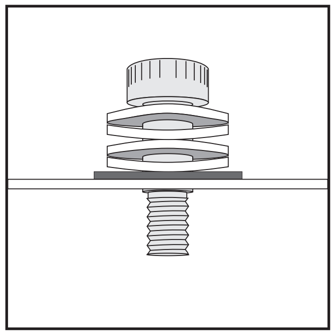
8. Place sealer on the 8 MHHB and thread into the holes of the Pinion Assembly. Tighten in a star pattern.



INSTALLATION - BACKLASH TUBE AND PLATE

1. Apply grease to the outer side of the Tube and top side (as installed) of the Plate. Also apply grease to the counterbore for the Tube and the machined surface underneath the Table the Plate will move against.

2. Assemble four Spring Washers in series and one 3/8" Hard Washer onto each Shoulder Screw. They should be assembled so that a small space appears between the top and bottom pairs of washers.



3. Orient the Backlash Plate so that the Push Blocks face the access holes of the Table. Insert the Backlash Tube/Plate assembly into the counterbore from beneath the Table. Use caution to avoid marring the surface of the Tube.

4. Insert the Shoulder Screws through the slots in the Plate closest to the Tube (place the Hard Washer against this Plate) and thread into the Table. Tighten with a hex wrench to standard torque.

5. Place a Flat Washer (45-1725) and a Lock Washer (45-1720) onto each HHB. Thread the HHB up into the Table through the outer slots of the Plate. Leave loose until final adjustment.

INSTALLATION - HARMONIC DRIVE

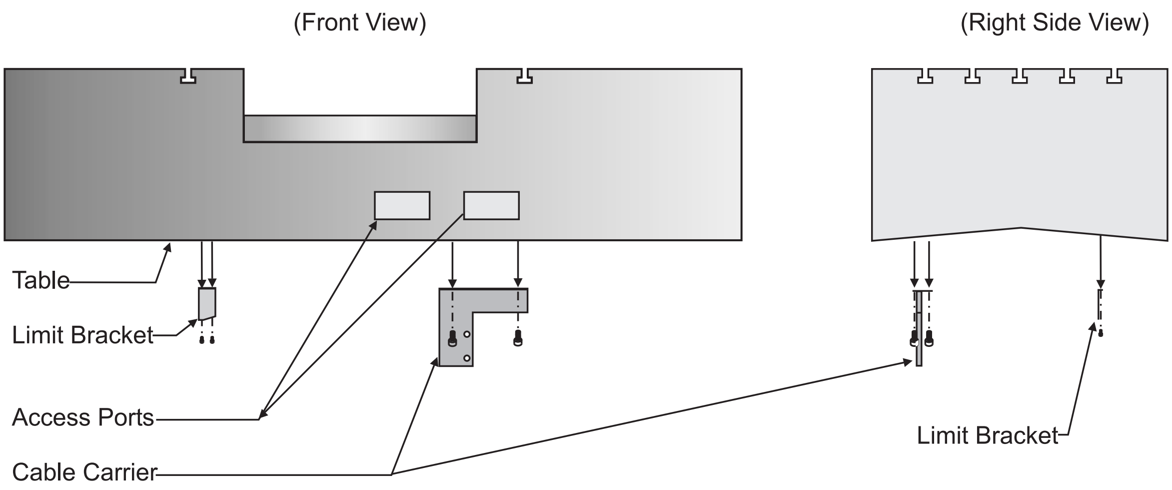
1. Thread an eye-bolt into the pilot hole in the shaft of the Harmonic Drive assembly.

2. Connect a rope or hoist line to the eye-bolt. Have an assistant lift the rope up through the counterbore and raise the Harmonic Drive.

3. Orient the Harmonic Drive so that the motor connectors can be accessed from the right of the Table. Insert (8) 70mm SHCS through the Gearbox Adapter into the Table. Torque to 35 ft/lbs.

Installation - Carrier Mount Bracket

1. Orient the Carrier Mount bracket so the edge side faces forward and the flush side is toward the center of the Table. Turn the Carrier bracket so that the mounting holes face the bottom surface of the Table. See the Figure below:



Cable Carrier and Bracket Installation

2. Place the Carrier bracket against the bottom side of the Table where indicated and insert the (4) SHCS through the bracket and thread into the Table. Tighten.

3. Orient the limit bracket so that the angled bottom edge faces to the right and the mounting tab faces toward the rear of the Table as shown in the Figure above. Mount using two SHCS.

Installation - Cable Box Encoder

1. Place the Cable Box Encoder into the left rear corner of the accessory box of the Table. Orient the Cable Box with the open sides against the casting of the Table for the Encoder cable.

2. Install the three SHCS and insert through the Cable Box into the Table. Tighten.

3. Apply Sikaflex around any gaps to prevent the Encoder cable from popping out when it is pushed down into the box after installation.

3.19 HS-3R Brake Assembly

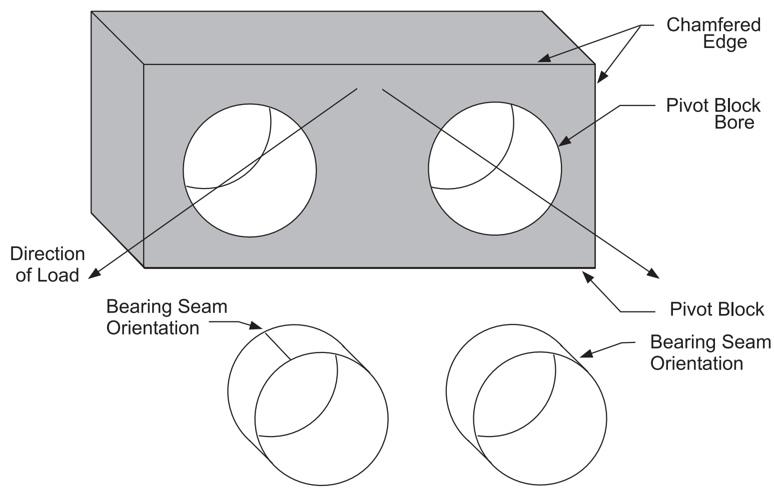
The Brake Assembly has five main components:

Brake Ring
Pivot Block
Bearing
Brake Arm
Pivot Pin

Assembly

1. Orient the Pivot Block so that you will be inserting the Bearings (Step 2) from the 20-degree chamfered side.

2. Insert one Bearing into each bore of the Pivot Block. When installing the Bearings, orient the seam in the bearing out of phase of the direction of load.



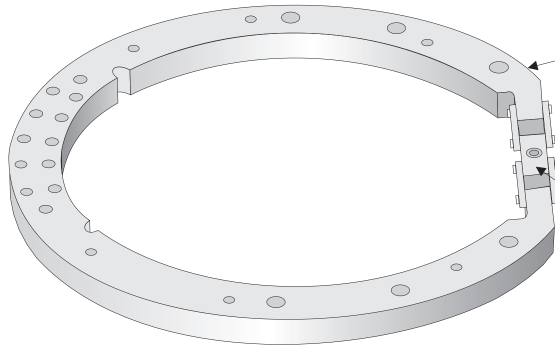
Proper Bearing Orientation

3. Clean the Pivot Pin with alcohol and a lint-free rag. Insert one Pivot Pin through each Bearing.

4. Place one Brake Arm over each end of the Pivot Pins. Secure each Pivot Pin with supplied E-Clips.

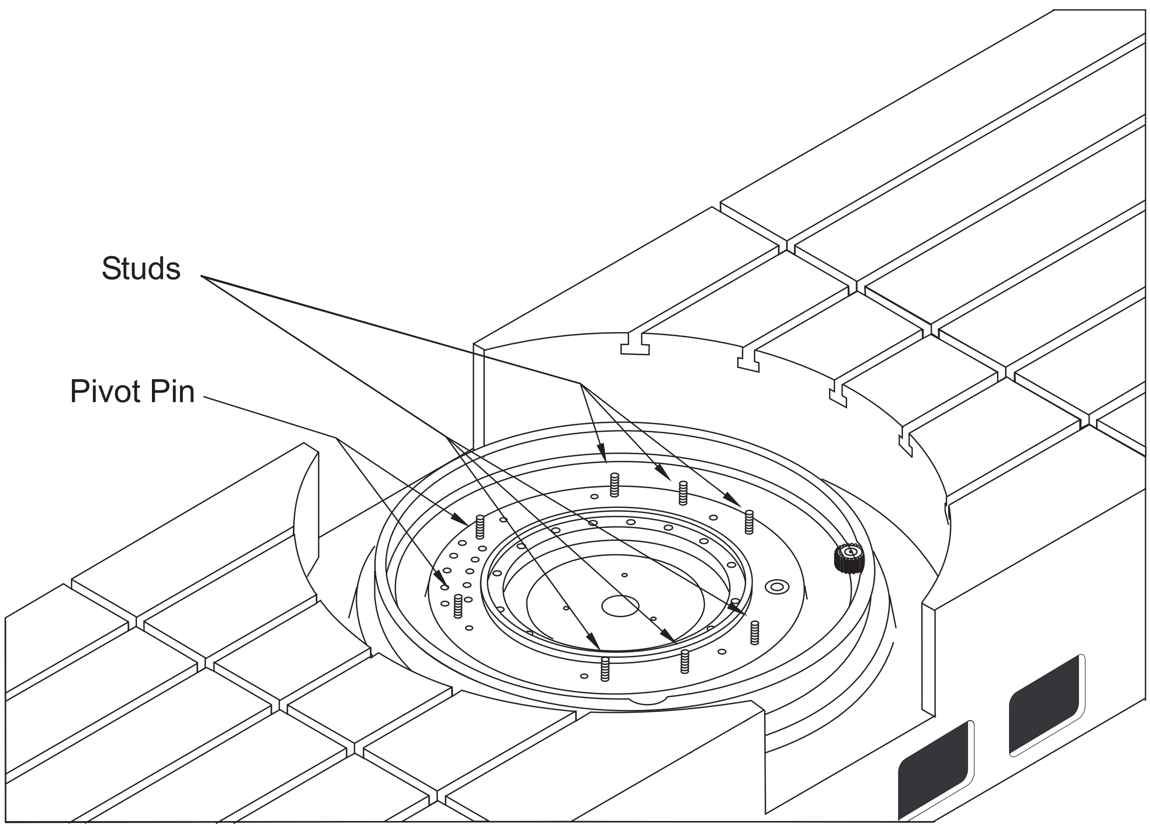
5. Insert the remaining two Bearings into the legs of the Brake Ring. Clean the remaining two Pivot Pins.

6. Place the Pivot Block assembly between the legs of the Brake Ring. Insert the Pivot Pins through the Brake Arms of the Pivot Block assembly. Secure each Pivot Pin with supplied E-Clips. See the following figure:



Installation - Brake Assembly

1. Clean the threaded holes in the table to remove all oil. Apply Red Loctite onto the (6) Studs (49-0024) and thread into the Stud holes indicated below. Install to a height of 2.175".



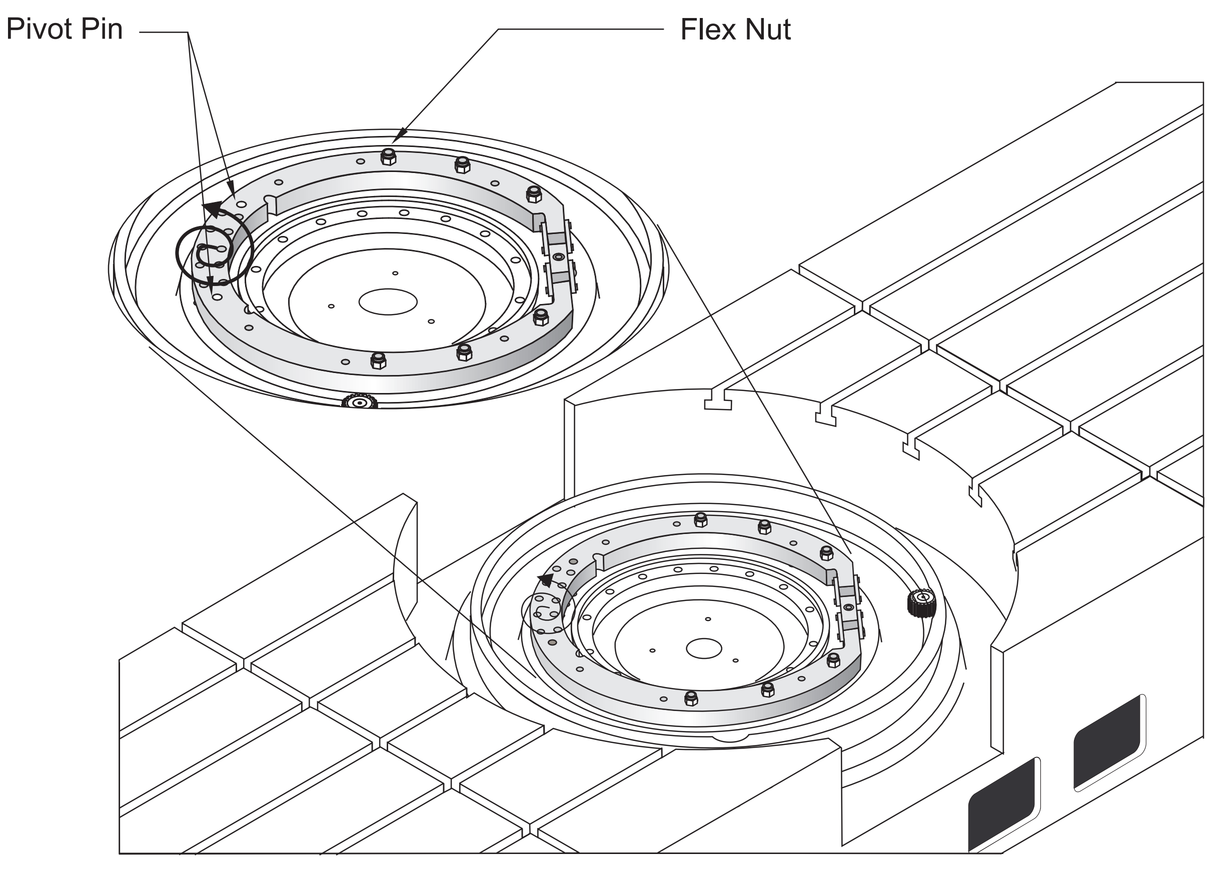
2. Use a brass hammer or punch to insert the (2) Pivot Pins into the table as shown in the figure on the previous page.

3. Clean the Brake Ring mounting surface with alcohol and a lint-free rag. Apply a coating of grease to the cleaned surface. Do not grease the area immediately surrounding the hole for the Hydraulic Cylinder shaft.

4. Place the Stop Block into the hole for the Hydraulic Cylinder shaft. Insert the two SHCS and tighten.

5. With an assistant, lift and lower the Brake Ring Assembly onto the Table. Fit the Brake Ring over the Pivot Pins and Studs. The Brake Ring should rest against the Table. If there is interference, make sure the Pivot Block is in the fully retracted position.

6. Place a drop of Loctite onto each of the (10) SHCS and insert into the machined holes in the area between the Pivot Pins. Tighten the SHCS in a circular pattern from the center outward as shown. The torque value is 80 ft./lbs.



Torque Sequence, Brake Ring SHCSs

7. Grease the counterbores machined into the Stud holes along the legs of the Brake Ring. Place a Thrust Washer and a Flex Nut onto each Stud and tighten completely. Back off each Flex Nut slightly (approximately 1-3°). Check the actuation of the brake after completion of Hydraulic Cylinder installation procedure. The Flex Nuts should be as tight as possible while still allowing the brake to actuate smoothly.

Installation - Ring Gear

1. Lubricate and stone the mating surfaces of the Platter and Ring Gear. Wipe clean to remove grease and contaminents.

2. Clean the mating surfaces of the Platter and Ring Gear with alcohol.

CAUTION! The Ring Gear is a precision-machined piece. Take care in handling the Ring Gear. Do not drop the Ring Gear or set it heavily on the teeth.

3. Install eye-bolts into the top of the Ring Gear. With an assistant, lift the Ring Gear by the eye-bolts and place over the Platter.

4. The Ring Gear is an interference-fit item and will need to be clocked properly prior to the next Step. If necessary, adjust the position of the Ring Gear so that all the bolt holes line up exactly.

5. Apply a drop of Loctite to each of the (16) SHCS and insert into the holes in the Ring Gear. Start each SHCS by hand to ensure proper alignment of the Ring Gear and to prevent crossthreading the tapped holes.

6. Tighten the SHCS incrementally in a star pattern to slowly pull the gear down onto the platter. Do not tighten each SHCS completely in one attempt. This will foul the location of the Ring Gear.

7. When the Ring Gear is fully seated on the Platter, tighten the SHCS to full torque value.

3.20 HS-3R Air Valve Assembly

The Air Valve Assembly has three main components:

3-Way Air Valve
High-Pressure Regulator
Low-Pressure Regulator

Theory of Operation

The Air Valve Assembly actuates the HS-3R's Rotary Table brake. Supplied air flows though the high-pressure regulator (70 PSI) to supply the high-side of the Brake Valve Pressure Booster. This supplies 12:1 hydraulic pressure boost to pull down on the Brake Assembly. When the Brake Ring is released, a valve switches the supplied air into the low-side of the Pressure Booster. This action returns the Pressure Booster piston to its original position and refills the hydraulic cylinder from the reservoir.
This is a closed hydraulic system. A 70/20 PSI pressure differential is used to prevent air leaking into the Pressure Booster.

Assembly

Individual assembly of the 3-Way Air Valve, the High-Pressure Regulator, and the Low-Pressure Regulator component parts is necessary and is not detailed in this Service Manual.

1. Apply a small amount of thread sealant to the threads of the High-Pressure Regulator Assembly and attach to the 3-Way Air Valve. Orient the Regulator to match the position of the part removed.

2. Apply a small amount of thread sealant to the threads of the Low-Pressure Regulator Assembly and attach to the 3-Way Air Valve. Orient the Regulator to match the position of the part removed.

3. Attach this assembly to the Mounting Plate using Loctite and supplied SHCS.

Installation

1. Position the Air Valve Assembly near its mounting location at the Air Lube Panel. Route all air tubing to the Air Valve.

2. Cut each air tubing line to fit and insert into the appropriate regulator/outlet on the Air Valve Assembly.

3. Position the Air Valve Assembly properly, then thread (4) SHCS into the mounting holes and tighten.

3.21 HS-3R Brake Cylinder Pressure Booster

The Brake Cylinder Pressure Booster has two main components:

Pressure Booster
Hydraulic Cylinder

Theory of Operation

The Pressure Booster gives the ability to develop and use high hydraulic pressure without incurring the cost of an on-board HPU. The Pressure Booster has a high-pressure side, a low-pressure side, and a fluid fill-port on the front of the unit. The Pressure Booster Assembly is located in the bottom of the HS-3R Rotary Table. There is a cut-out underneath the Rotary Table to provide access for service and replacement of the Pressure Booster and component parts.

Assembly - Pressure Booster

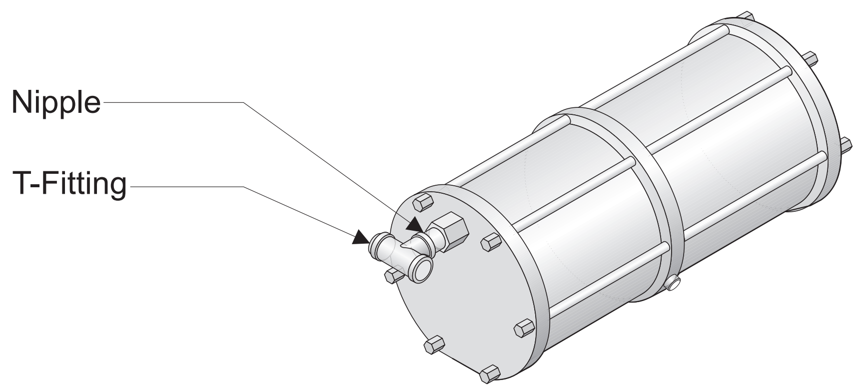
The Pressure Booster comes packaged with extra components not needed for its proper operation in this application. Where applicable in the following steps, use a small amount of thread sealer on all pipe threads.

1. The Pressure Booster is shipped full of hydraulic oil. Tilt the Pressure Booster on end before removing the plug from the container.

2. Thread Adapter into the Pressure Booster and tighten.

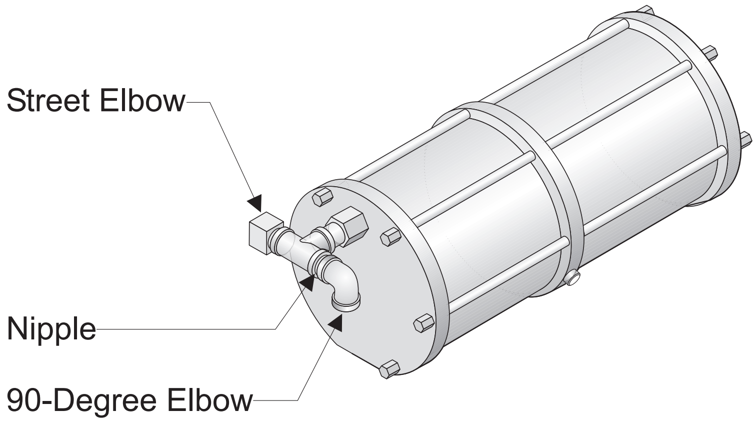
3. Thread the Nipple (new part) into the Adapter.

4. Thread the T-Fitting onto the Nipple and tighten so that it is oriented as shown in the following figure:

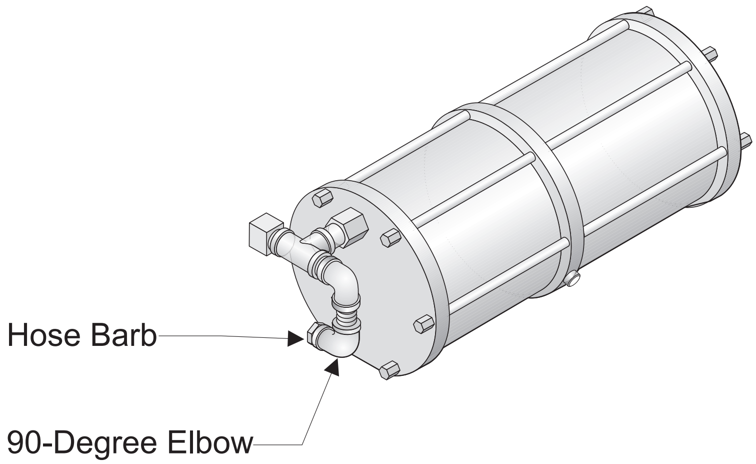


5. Thread the Nipple into the right side of the T-Fitting. Thread the Street Elbow into the left side of the T-Fitting as shown below. Tighten all parts.

6. Thread 90-Degree Elbow onto the Nipple. Thread Nipple into the Elbow. Tighten to orient as shown in the following figure:



7. Thread the Hose Barb into the remaining 90-Degree Elbow and attach to the Pressure Booster assembly. Orient as shown in the following figure:

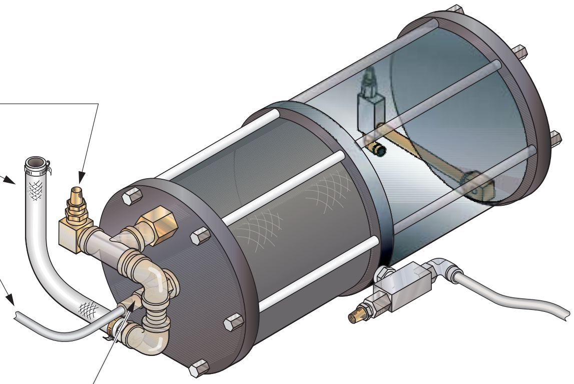


8. Attach the Braided Hose to the Hose Barb using the supplied hose clamp. Use caution when moving the Pressure Booster Assembly as the internal hydraulic fluid can spill from the Braided Hose.

9. Remove the plug in the center hole of the Pressure Booster. Thread a #4 SAE to NPT-female Adapter (new part) into the center hole.

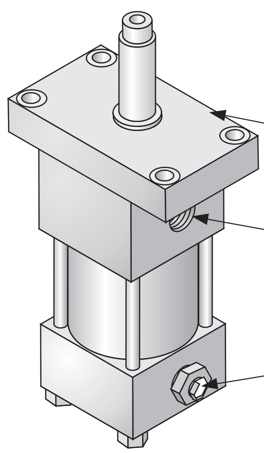
10. Thread the Hydraulic Hose into the Adapter.

11. Thread the Reducer into the Street Elbow. Thread the Muffler and Reducer together, then attach to the Street Elbow. Tighten all parts. This will act as a snorkle for the system.



Assembly - Hydraulic Cylinder

1. Turn the Hydraulic Cylinder so that the two ports are facing up. Remove the two caps. The Hydraulic Cylinder is shipped with oil; take caution to avoid spillage.



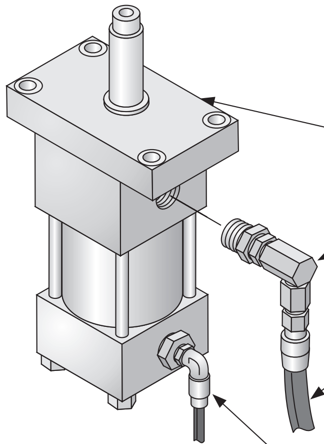
Hydraulic Cylinder (top view)

CAUTION! Do not press the Hydraulic Cylinder Piston in. Hydraulic oil will escape from the open port.

2. Using the correct hydraulic oil, fill the hydraulic port to remove any remaining air.

3. Thread a Reducer into the hydraulic port. Thread the Swivel Elbow into the Reducer. Thread the Hydraulic Hose from the Pressure Booster into the Swivel Elbow. Orient the Swivel Elbow as shown below and tighten.

4. Thread Elbow into the air port. Orient the Elbow as shown below:



Hydraulic Cylinder (side view)

5. Cut the Tubing to fit once installed in the Table. Insert one end of one piece of Tubing into the Elbow on the air side of the Hydraulic Cylinder.

6. Thread one of the two remaining Elbows into the low-pressure port of the Pressure Booster, located in the middle of the Pressure Booster. Insert one end of one piece of Tubing into the low-pressure Elbow. Coil the Tubing and mark with masking tape. See Figure.

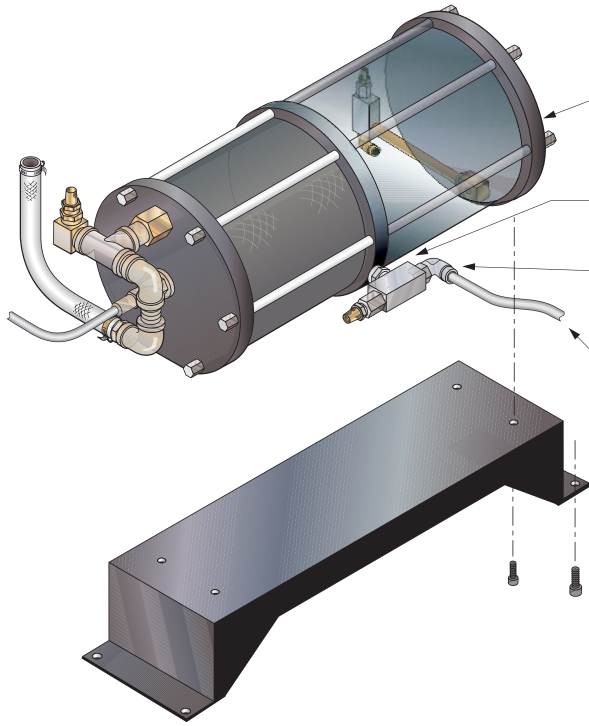
7. Place the Pressure Booster flat on the work surface. Route the Braided Hose upward and use caution to avoid fluid spillage.

8. Thread the remaining Elbow into the high-pressure port, located on the rear of the Pressure Booster cylinder. Insert one end of one piece of Tubing into the high-pressure Elbow. Coil the Tubing and mark with masking tape. See Figure.

9. Use wire ties to secure the Tubing lines to follow the Hydraulic Hose out.

Final Assembly

Orient the Plate as shown and attach to the bottom of the Pressure Booster.



Pressure Booster Final Assembly (bottom view)

Pressure Booster Assembly Bench Test

Prior to installation of the Pressure Booster Assembly, a test of the entire system should be performed. This will identify leaks and allow for the system to be bled while it is still easily accessible. Set the Air Valve Assembly and the Hydraulic Cylinder on top of the Table or other high work surface. Set the Pressure Booster Assembly onto the floor.

1. Identify the low-pressure Tubing line coming from the low-pressure side of the Pressure Booster. Connect this Tubing line to the Low-Pressure Regulator of the Air Valve Assembly.

2. Identify the high-pressure Tubing line coming from the high-pressure side of the Pressure Booster. Connect this Tubing line to the High-Pressure Regulator of the Air Valve Assembly.

3. Connect the Tubing line from the air port of the Hydraulic Cylinder to the unregulated source on the Air Valve Assembly.

4. Attach a supplied air line to the Air Valve Assembly. Supplied air should be set to 85 PSI.

5. Using the appropriate regulator adjuster on the Air Valve Assembly, set the Low-Pressure regulator to 20 PSI.

6. Make sure that the Swivel Elbow connected to the Hydraulic Cylinder is at the highest point of the entire assembly.

CAUTION! During the following Steps, spillage of hydraulic oil may occur. Wear eye protection and have sufficient rags on hand to clean up any purged oil.

7. Set the High-Pressure regulator to approximately 5-10 PSI. Remember that the Pressure Booster will still provide 12:1 pressure boost.

8. Break the mating of the Hydraulic Hose and the Swivel Elbow. Loosen this joint only enough to let air escape.

9. Apply air pressure to the Pressure Booster by pressing the yellow pin-button on the Air Valve Assembly. Do not activate the Pressure Booster for more than a second at a time.

10. When all air has escaped the hydraulic system, tighten the Hydraulic Hose. Readjust the High-Pressure regulator to 70 PSI.

11. If any air leaks have been noticed during this operation, take appropriate measures to fix them before installing the assembly.

Installation - Pressure Booster

Position the Pressure Booster, Air Valve, and Hydraulic Cylinder assemblies near the working areas.

1. Thread the 3/4 NPT Elbow (new part) into the Fill Port machined into the right side of the Table. The Elbow must be installed from the inside. Orient the Elbow so that it points down.

2. Thread a Hose Barb into the Elbow. Tighten with a 1-1/16” socket.

3. Lift the Pressure Booster Assembly into the cavity machined underneath the right front of the Table. See the Figure on the following page for the approximate location. Route the Hydraulic Hose and High- and Low-Pressure Tubing through the mouse hole. Secure to the Table with (4) 1/2” SHCS using the outermost holes in the Plate.

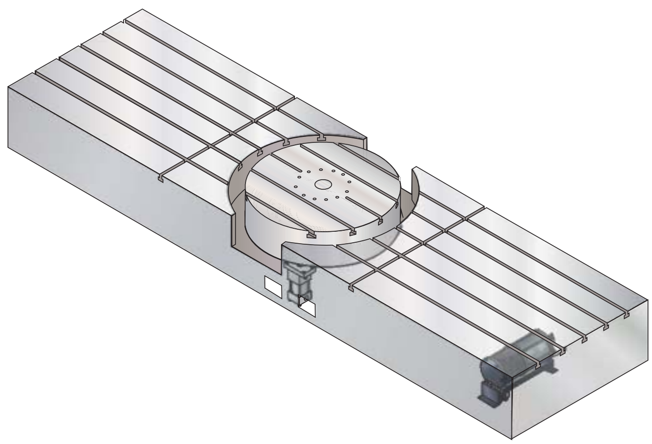
4. Cut the Braided Hose to length and attach to the Hose Barb with a clamp.

Installation - Hydraulic Cylinder

1. Lift the Hydraulic Cylinder into its area beneath the Table. See the Figure below for the approximate location. The hose connections should face the left of the table (away from the Pressure Booster) to prevent kinks in the lines when routed.

2. Thread (4) 1-1/4" SHCS through the mounting tabs of the Hydraulic Cylinder into the Table. Leave these loose for final alignment of the Hydraulic Cylinder (see **Final Alignment - Hydraulic Cylinder**).

3. Route the Hydraulic Hose and air port Tubing beneath the Hydraulic Cylinder and through the mouse holes machined to the right. Install Cable Plates using BHCS to retain the lines. Fit the plastic tabs over the Cable Plates to prevent damage to cables during operation.



Locations of Brake Cylinder Pressure Booster Components (installed from beneath)

Final Alignment - Hydraulic Cylinder

The following Steps are performed from above the Table.

1. Apply air pressure to the Hydraulic Cylinder. This will cause the piston in the Hydraulic Cylinder to extend. When the piston has extended, thread an SHCS into the pilot hole in the piston shaft and tighten. This will properly align the Hydraulic Cylinder to the Brake Assembly.

2. Tighten the four SHCS that mount the Hydraulic Cylinder to the Table. Relieve the hydraulic pressure.

INSTALLATION - BEARING

1. Place the Bearing Retainer Ring onto the rotary table, flat side down. Orient the holes in the Ring so that they line up with the threaded holes in the rotary table.

2. Stone the Table mating surface. Clean with a lint-free rag.

3. With an assistant, lift and place the Bearing onto the Table, on top of the Spacer.

4. Align the bolt holes in the Table with the countersunk holes in the outer Bearing race. Make sure the Spacer will pull up into the inner Bearing diameter. There should be no interference-fit problems.

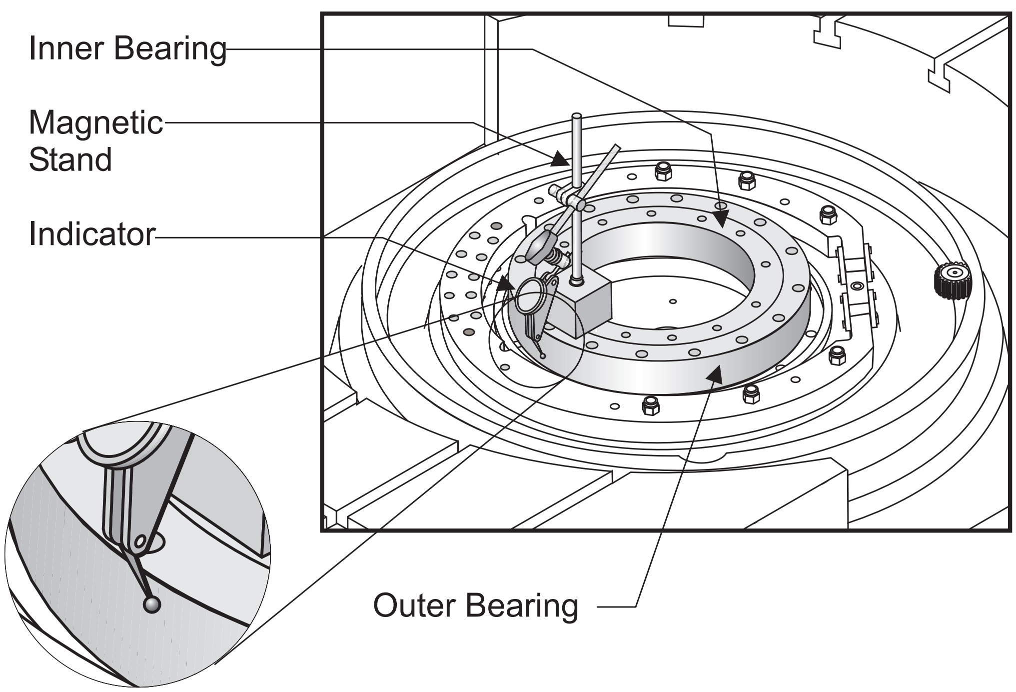
5. Insert the SHCS by hand through the Bearing and into the Table.

6. Tighten the SHCS in a star pattern until the screws are snug. Evenly tighten the screws to seat the Bearing, then back off each SHCS 1/16 turn.

NOTE: If you are installing the Bearing by yourself, it will be useful to have a mirror positioned to see the indicator when it is on the far side of you.

7. Remove four of the SHCS that lie along the X- and Y-axis.

8. Attach a Magnetic Indicator Stand (MIS) to the inner Bearing race. Adjust the indicator to point to the side of the outer Bearing surface as shown in the following figure.



9. Turn the inner race to find high and low spots. To ease this procedure, place a long bolt into one of the holes in the inner race. Do not use the MIS to rotate the Bearing.

NOTE: The acceptable tolerance for the Bearing is .0002". This is due to the 3:1 distance differential between the Platter diameter and the Bearing diameter.

NOTE: During the following adjustment procedure, keep these guidelines in mind:
1. Adjust the Bearing runout only from the high spots.
2. Adjust out only 1/2 of needed measurement. The high side will shrink by half, the low side will grow by half.
3. Periodically rotate the Bearing completely to realign the bearing rollers after adjustment.

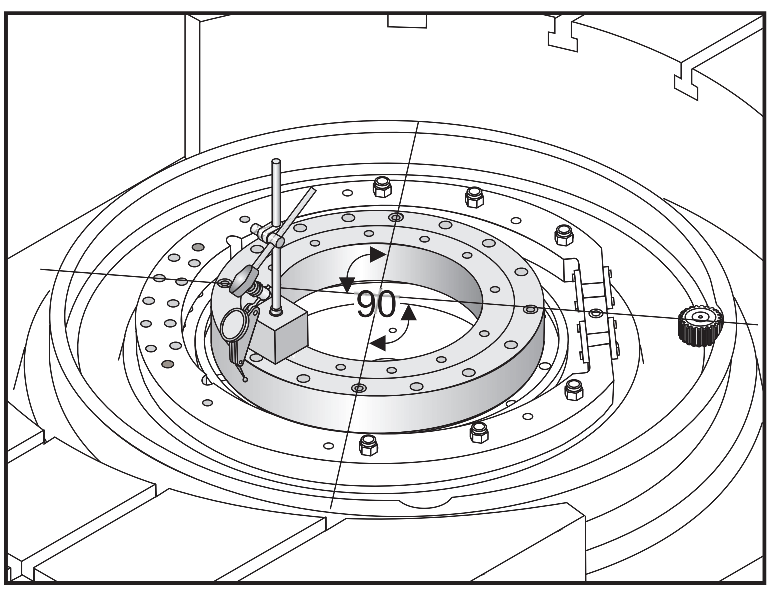
10. Turn the Bearing until the lowest spot is encountered. Zero the Indicator. Turn the Bearing until the high spot is encountered (this should be 180 degrees opposite the low spot).

11. Insert a long T-Handle hex wrench into the bolt hole in the outer Bearing nearest the high spot. Place pressure on the hex wrench towards the low side to adjust the Bearing.

NOTE: Adjusting the Bearing in this manner will move the top part of the outer bearing in the direction pressed, placing leverage against the bottom part of the outer bearing.

NOTE: During this procedure, it will be necessary to tighten selected bolts in the outer race to keep your adjustments. This is not exactly defined, depending upon adjustments necessary during this process.

12. Perform Steps 9 through 11 until the Bearing reads within .0002" of true. Torque the SHCS to 20 ft./lbs. in a star pattern (there should be very little effort needed to reach this value if you have tightened bolts during the previous Steps). Torque the SHCSs in sets of four, rotating the Bearing between each screw. Each SHCS of the set should be 90 degrees from each other.



13. Recheck Bearing runout. Ensure the Bearing remains within at least .0002” of true. If the Bearing has slipped out of true, repeat Steps 9 through 11.

14. Torque the SHCS in 5 ft/lbs. increments. Recheck Bearing runout after each torque sequence. The final torque value is 45 ft/lbs.

15. Recheck Bearing runout. Make sure the Bearing has not shifted after the final torque sequence.

ROTARY TABLE PLATTER REMOVAL AND INSTALLATION

Removal

1. Remove the Encoder cover plate

2. Remove the encoder shaft plate. Important: There are two set screw in the encoder shaft plate.

3. Remove the plastic bolt cover plugs and the bolts that secure the table to the bearing.

4. Fasten lifting plates to the platter. Do not use T-nuts and eyebolt; slippage can occur and the platter could fall. Use chains to lift the rotary table. **Do not** use synthetic lifting straps as these have a tendency to stretch which will cause the platter to be lifted off unevenly. An unevely lifted platter may cause damage to the components beneath it.

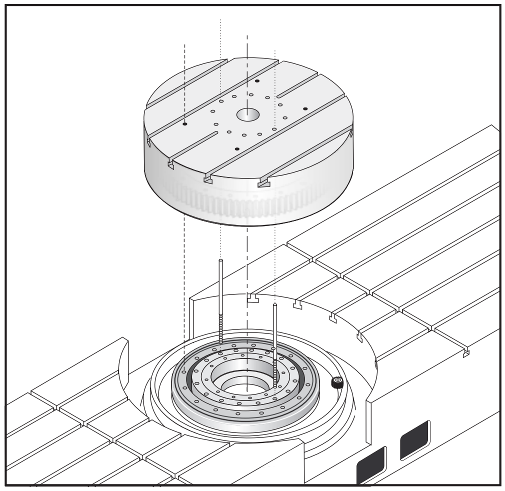
Installation

1. Generously apply red grease to the outer ring of the Brake, completely filling the two grooves. Apply Moly grease around the Stud Flex Nuts filling the counterbores on the Brake Ring, **horse shoe brake only**. Apply moly grease to the Pinion Gear and Ring Gear.

2. Stone and clean the Platter where it will mate with the Bearing. Rotate the inner Bearing holes so they line up on the X- and Y-axis.

3. Use the Backlash Adjusting screws to fully retract the Pinion Gear/Harmonic Drive Assembly.

4. Cut the heads off of two 3/8-16 x 7” threaded rods (40-0021). Insert each through a bearing mounting hole in the Platter so that they are 180° apart. Use these to rotate the Platter to align it with the holes in the inner Bearing. Install the threaded rods into the bearing, use them as a guide when lowering the platter.



5. Hoist the Platter over the Table using a chain fall. Do not use synthetic lifting straps to move or position the Platter.

6. Carefully lower the Platter over the pilot rods and onto the bearing. Thread the rods (from Step 4) into the Bearing Retaining Ring. Ensure the bolt holes in the Platter line up with the bolt holes in the Bearing.

7. When the Ring Gear attached to the Platter contacts the Pinion Gear, manually jog the A-axis so that the teeth mesh and the Pinion Gear does not force the Platter into position.

8. Slowly guide the Platter down the remaining distance.

CAUTION! Do not crash the Platter against the Table. These components are machined to very close tolerances and can be easily damaged by hard metal-to-metal contact.

9. Remove the threaded rods from Step 4.

10. Install the 12 3/8-16x4” (40-16430) SHCS to fasten the platter to the bearing.

NOTE: You will need a T-Handle wrench or a 6” long hex socket to tighten the SHCS in the Platter. Socket extensions will not fit.

11. Tighten the SHCS incrementally in a star pattern to avoid misaligning the Bearing. Torque the SHCS in stages up to a final torque of 45 ft./lbs.

12. Before replacing the encoder shaft plate, make sure the set screws ar ebacked off.

13. Tighten the screws securing the encoder shaft plate to the platter.

14. Tighten the set screws to clamp the shaft plate to the encoder shaft

15. Replace the encoder cover plate.

Installation - Encoder (New Style)

Pre-assembly Verification

Before assembling the encoder mounting parts, perform the following checks:

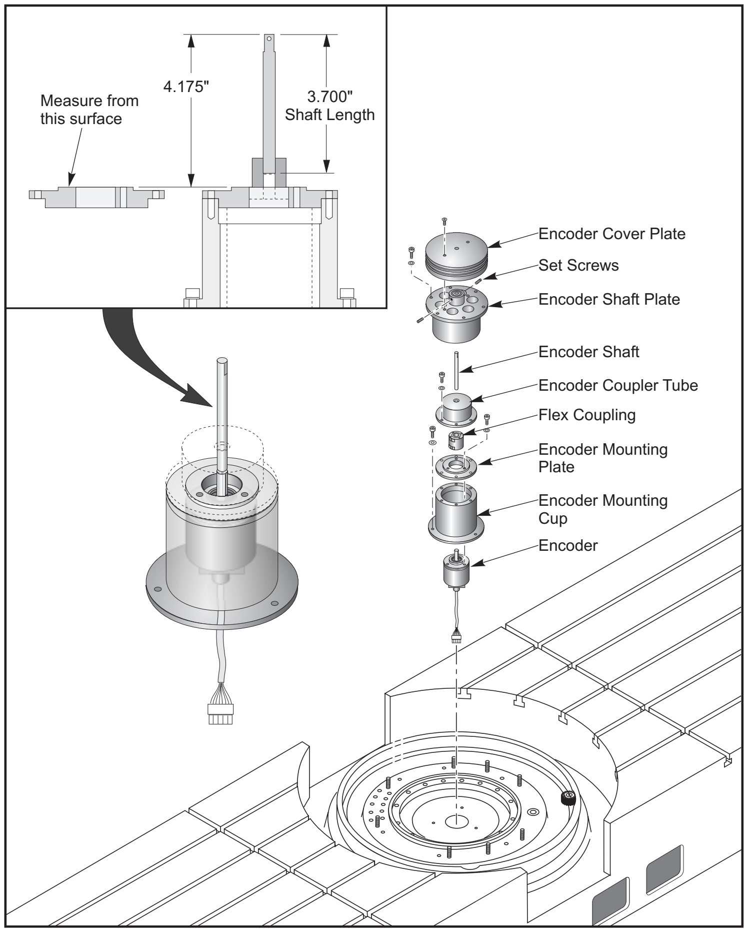
1. Verify that the encoder mounting plate can be inserted into the encoder mounting cup without binding. The contacting surfaces must be burr-free.

2. Verify that the encoder shaft has no detectable side-to-side play. Perform this test by hand.

3. Verify that the encoder boss can be inserted into the encoder mounting plate without binding. The contacting mating surfaces must be flat and free of burrs.

4. Verify that the encoder shaft can be inserted into the encoder shaft plate to the full depth of the bore in the encoder shaft plate without binding.

5. Verify that the encoder shaft plate can be inserted into the platter bore without binding. The contacting surfaces must be flat and burr-free.



Assembly

1. Install the encoder mounting cup with 0.010 shim washers under each screw location.

2. Attach a magnetic base and indicator to the inner race of the cross-roller bearing and indicate off the top face of the encoder mounting cup. Add or subtract shims to adjust the face run-out of the top face of the encoder mounting cup, flatness NTE 0.0005”.

3. Adjust the indicator to indicate off the inner diameter bore of the encoder mounting cup. Sweep the inner diameter bore of the encoder mounting cup concentric to the cross-roller bearing, concentricity NTE 0.0005”.

4. Verify that the top face flatness did not change during Step 3.

5. Install the rotary table platter and indicate its bore concentric with the cross-roller bearing, concentricity NTE 0.0005”.

6. When installing the encoder shaft plate, ensure that the flats on the encoder shaft are lined up with the set screw holes in the shaft plate. Set screws must be removed before performing this operation.

7. After seating the encoder shaft plate, tighten the screws securing the encoder shaft plate to the platter. Then install and tighten the set screws.

8. Grease o-rings. Install o-rings onto the encoder cover plate. Install the encoder cover plate into the platter bore.

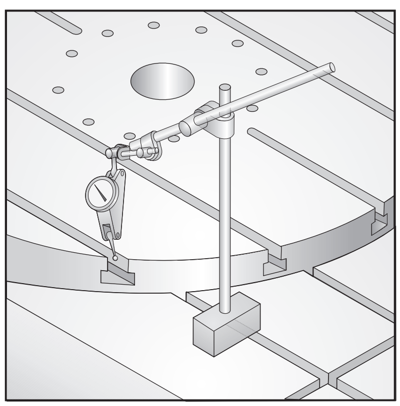
Checking A-axis Backlash

1. Command the A-axis brake to disengage. To do this enter MDI and command an M11. Do not disconnect the air to the machine.

2. Disable the A-axis encoder by setting the parameter 43 bit 3 to 1. Note: This will disable the rotary table position encoder and enable the drive motor encoder. The drive motor gear will now hold position allowing backlash to be measured between the ring and pinion gear.

3. Verify the brake is disengaged, by ensuring the platter can be rotated a slight amount.

4. Set up an indicator on the non-rotary part of the table and set the indicator needle against a T-slot. See figure.



5. Manually rotate the platter back and forth. At times additional force is required to overcome the frction. Use platter lifting plates or a fixture on the platter with a cheater bar between them, if necessary, to move the platter.

6. Take readings from the indicator every 10° for 360°. Note: the indicator must be repositioned each time. Backlash should be between .0005” and .0007”. If it is not within this range perform the following adjustment procedure.

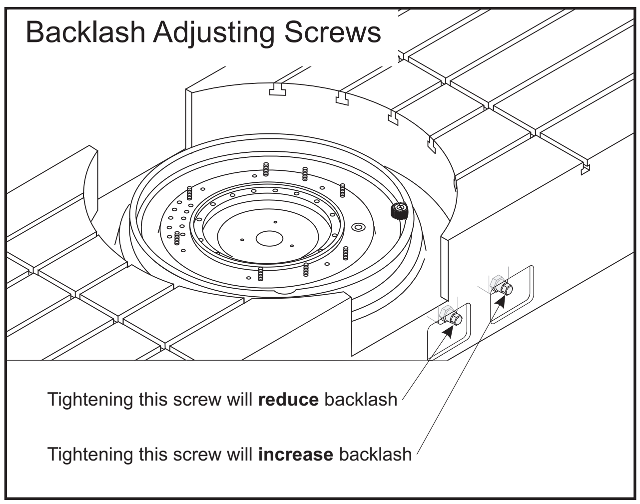
A-axis Backlash adjustment

1. Command the A-axis brake to disengage. To do this enter MDI and command an M11. Do not disconnect the air to the machine.

2. Disable the A-axis encoder by setting the parameter 43 bit 3 to 1. Note: This will disable the rotary table position encoder and enable the drive motor encoder. The drive motor gear will now hold position allowing backlash to be measured between the ring and pinion gear.

3. Loosen the 3/4-11 hex head bolts that secure the cam backlash adjuster (motor plate) to the underside of the table. It is not required to remove these bolts completely, only loosen them. The 2 SHCS that bolt through the plate are shoulder bolts and do not need to be loosened.

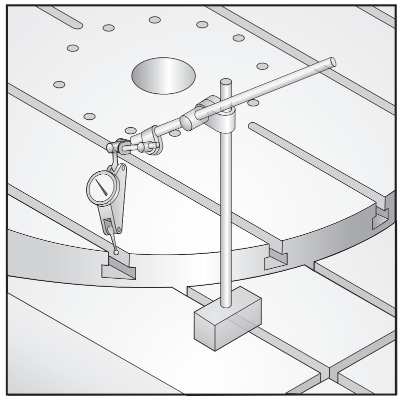
4. Loosen the backlash adjusting screw lock nuts on both of the adjusting screws. See the following figure. Loosen the left adjusting bolt and thread it back away from the plate. Tighten the right bolt three turns. This will increase the backlash between the drive and ring gear. Note: As this bolt is driven in it may start to bind. If this happens back the bolt off slightly and then continue tightening.



5. Verify the brake is disengaged and that backlash exists by manually moving the platter back and forth. At times additional force is required to overcome friction. Use platter lifting plates or a fixture on the platter with a cheater bar between them, if necessary, to move the platter within the allowable backlash.

6. Back the right bolt all the way out.

7. Set up an indicator on the non-rotary part of the table and set the indicator needle against a T-slot. See figure.



8. Begin tightening the left adjusting bolt and check the backlash. Using the cheater bar between the lifting plates or fixtures, nudge the table CW and CCW. Take readings from the indicator. Once the readings come close to .003", rotate the table and take readings every 10° for 360°. Find the tightest of these spots and set the indicator up as in the previous step.

9. Tighten the left adjusting bolt until the backlash is between .0005" and .0007"

10. Snug the right adjusting bolt against the bracket.

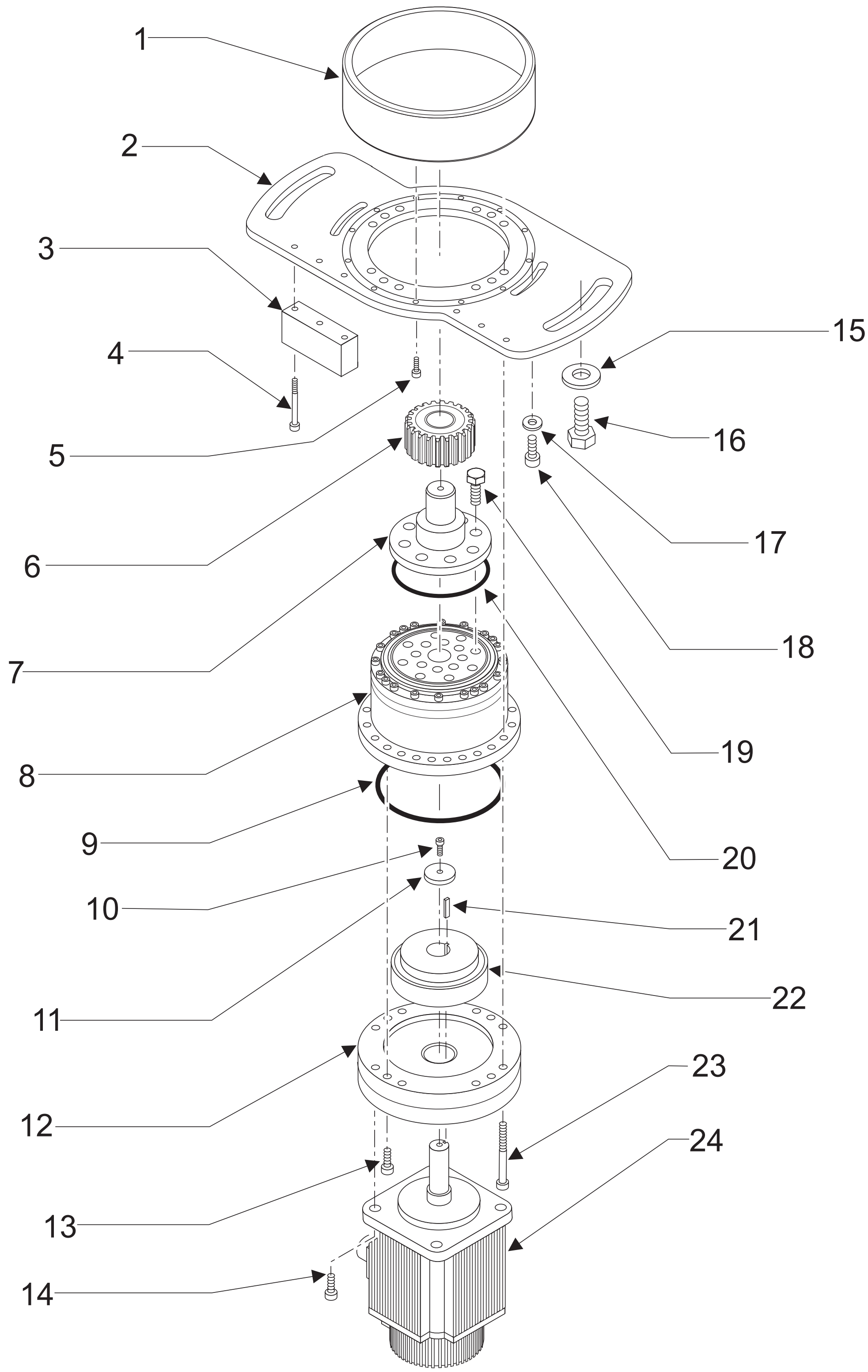
11. Tighten the 3/4-11 hex bolts that mount the cam backlash adjuster (motor plate).

12. Tighten the adjusting screw lock nuts.

13. Recheck the backlash. If adjustment is necessary, loosen the plate's hex bolts and adjusting screw's lock nuts before making adjustments.

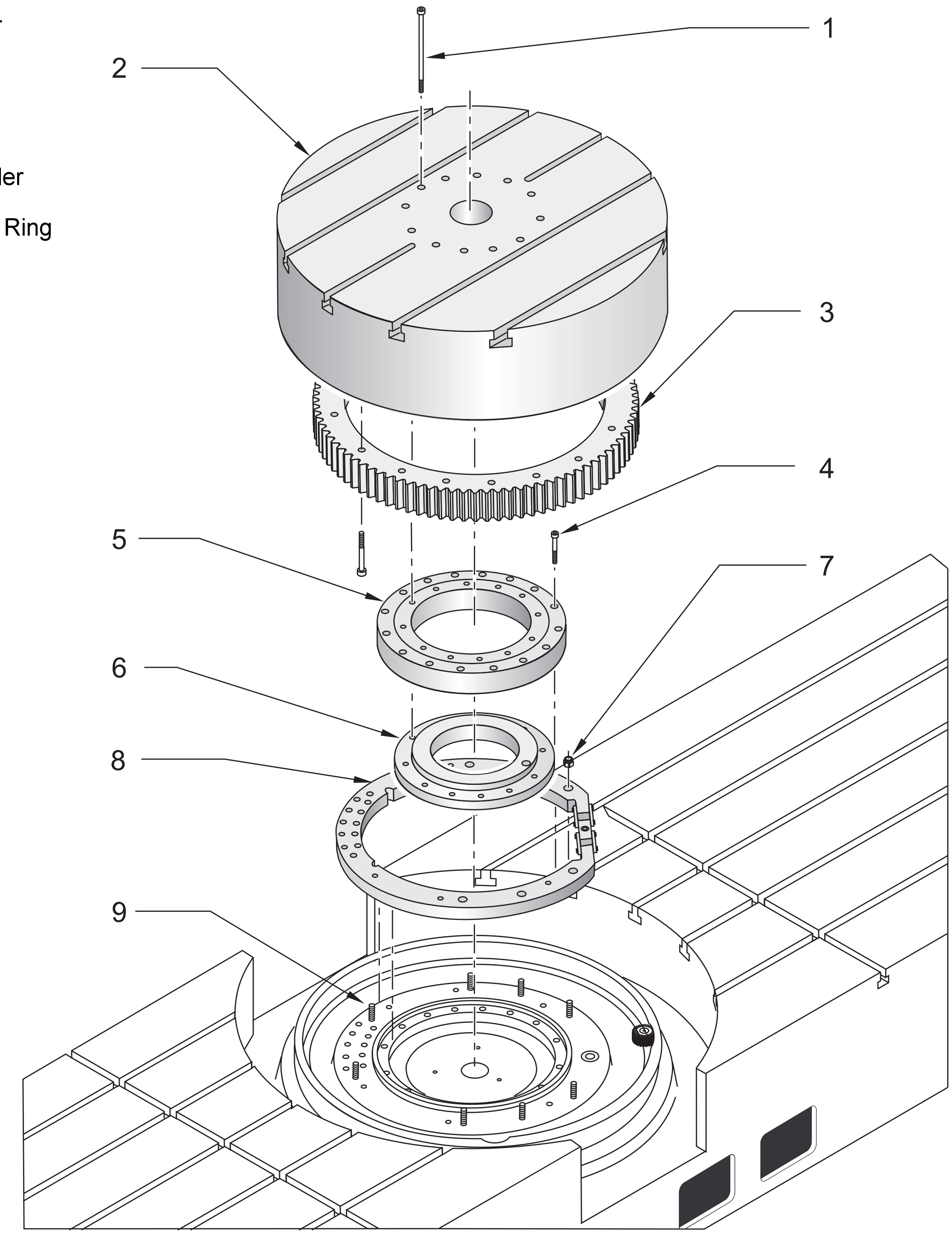
3.22 HS-3R Harmonic Drive Assembly - Exploded Parts List

1 Tube Backlash Adjuster
2 Cam Backlash Adjuster
3 Push Block
4 SCHS
5 SHCS
6 Pinion Gear
7 Sigma Adapter
8 Harmonic Drive
9 O-Ring
10 MSHCS
11 Shoulder Washer
12 Gearbox Adapter
13 SHCS
14 SHCS
15 Flat Washer
16 HHB
17 Spring Washer
18 Shoulder Screw
19 MHHB
20 O-Ring
21 Yaskawa Motor Key
22 Wave Generator
23 SHCS
24 Yaskawa Sigma Motor

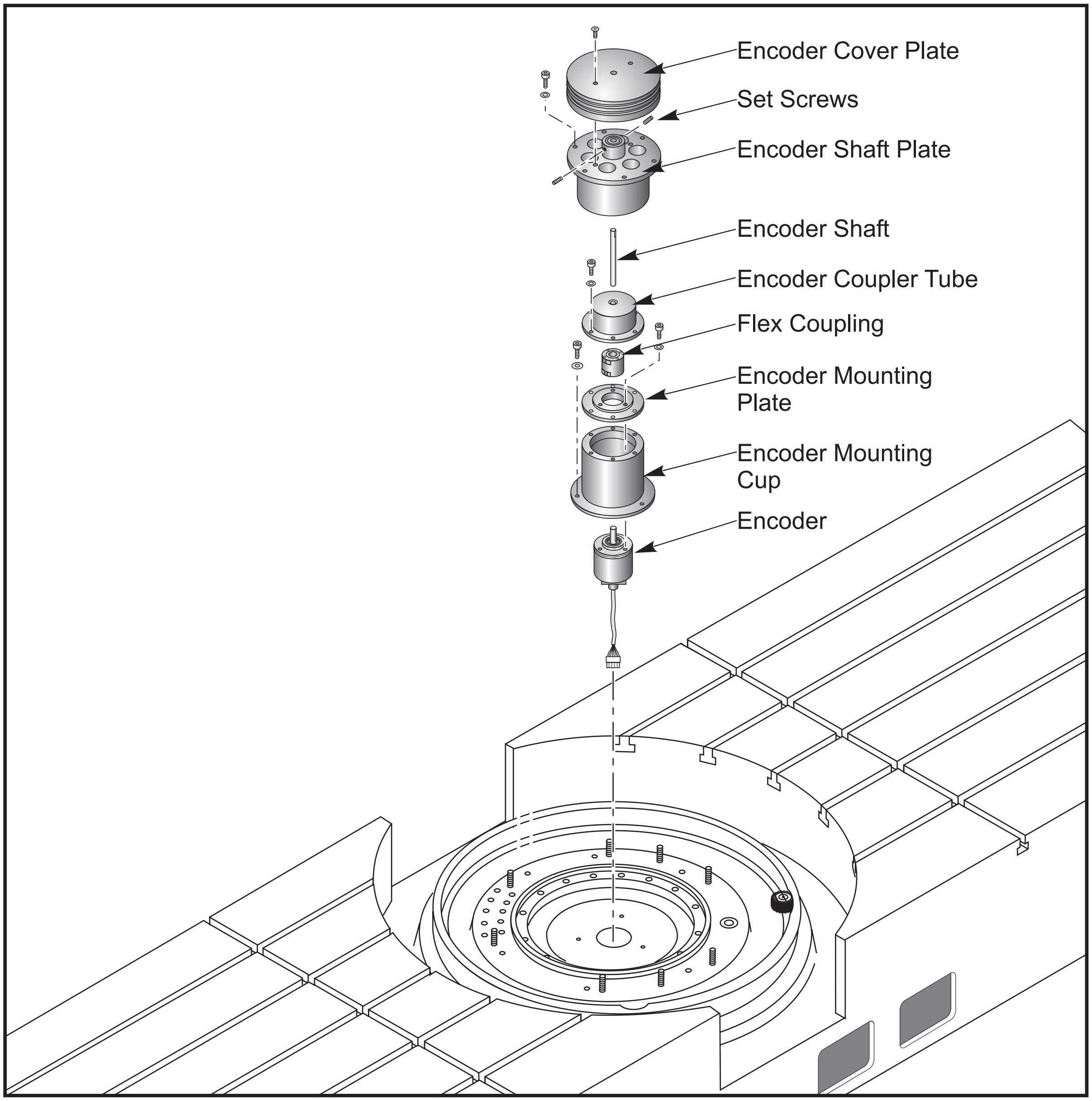


3.23 HS-3R Table Assembly - Exploded Parts List

1 SHCS
2 Machined Platter
3 Ring Gear
4 SHCS
5 Bearing Crossroller
6 Bearing Retainer Ring
7 Flex Nut
8 Brake Assembly
9 Stud



3.24 HS-3R Encoder Assembly - Exploded Parts List



4. ELECTRICAL SERVICE

4.1 SOLENOIDS

Please read this section in its entirety before attempting to replace any solenoid assemblies.

AIR SOLENOID ASSEMBLY

REMOVAL -

1. Turn machine power ON and lower spindle head to the lowest position. Turn power OFF.

2. Remove the rear enclosure panel (seven SHCS).

3. Remove air supply from machine.

4. Disconnect all air lines going to and from the air solenoid assembly on the top front of the solenoid bracket. Do not remove the fittings --- remove the lines from the fittings.

5. Disconnect the two leads to the low air pressure sensor.

6. Unplug the wiring leading to the plug marked on the solenoid bracket as "880 FROM I/O PCB TO SOLENOID VALVES" and the plug marked "SPARE".

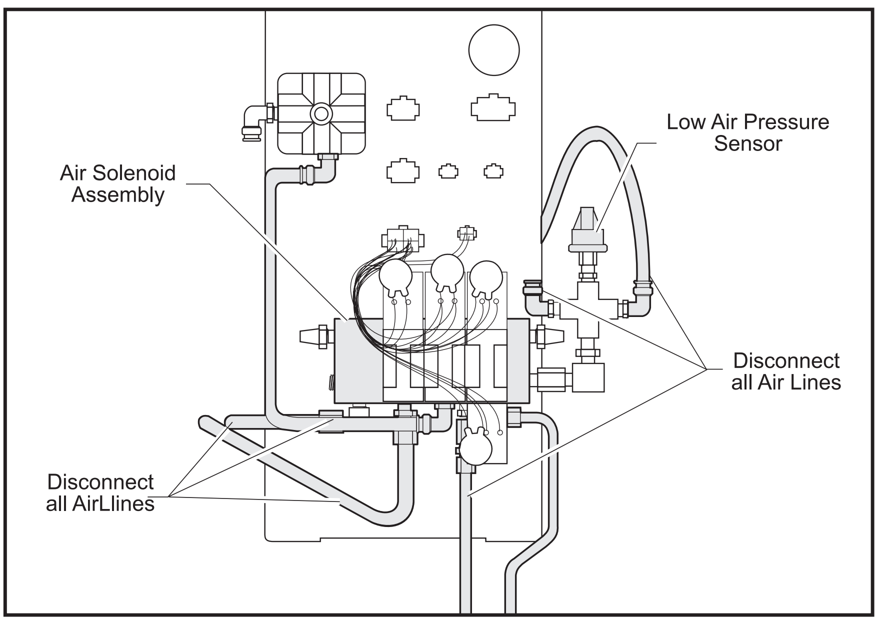


Figure 4.1-1. Air solenoid assembly.

7. Remove the SHCS holding the assembly to the bracket and remove the assembly.

INSTALLATION -

8. Replace the air solenoid assembly and attach to the bracket with the SHCS previously removed. Tighten securely.

9. Reconnect all air lines at this time, ensuring that all connections are tight and do not leak.

10. Reconnect the two leads to the low air pressure sensor.

11. Reconnect the wiring to the plugs on the solenoid bracket (See step 6).

12. Reconnect air supply to the machine.

13. Replace the rear enclosure panel (seven SHCS).

TOOL RELEASE PISTON ASSEMBLY AIR SOLENOID

1. Turn machine power ON and raise spindle head to uppermost position. Turn power OFF.

2. Remove air supply from machine.

3. Remove the tool release piston assembly (Mechanical Service).

4. Unscrew the air solenoid assembly from the tool release piston assembly, taking care to not disturb the position of the clamp/unclamp switches.

5. Unscrew the air solenoid from the air solenoid assembly.

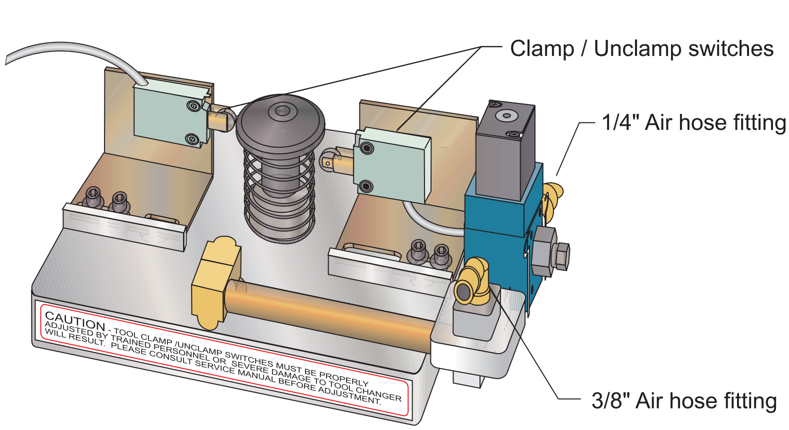


Figure 4.1-2. Tool release piston assembly with air solenoid assembly.

6. Install the new air solenoid on the air solenoid assembly. Reinstall the air solenoid assembly onto the tool release piston assembly. Take care to not disturb the position of the clamp/unclamp switches.

7. Reinstall the tool release piston assembly (Mechanical Service).

IMPORTANT! Ensure all air lines are reconnected to their proper fitting!

Spindle Lube Air Solenoid

1. Turn the machine power off and remove the air supply from the machine.

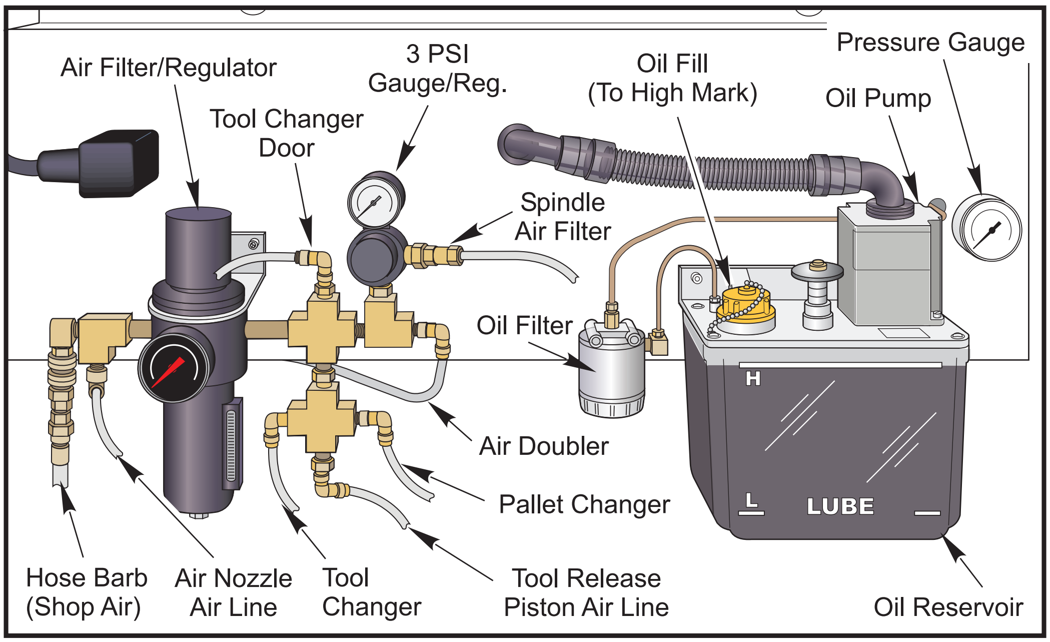


Figure 4.1-3. Front side of lube/air panel.

2. Disconnect the air lines from the spindle lube air solenoid assembly.

3. Unplug the electrical leads at the quick-disconnect. You will have to slide the wiring channel cover back to disconnect the leads.

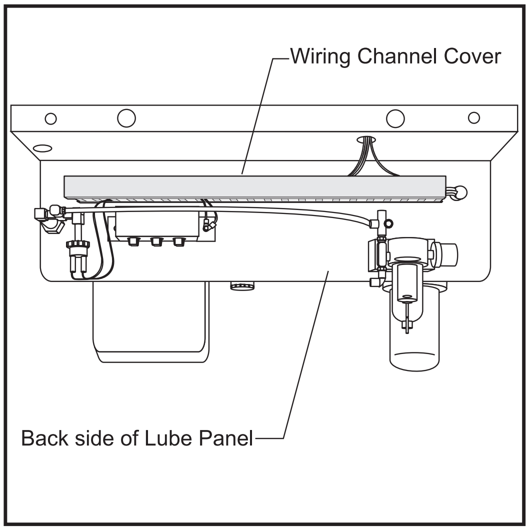


Figure 4.1-4. Top view of spindle lube/air solenoid assembly.

4. Unscrew the assembly from the T-fitting.

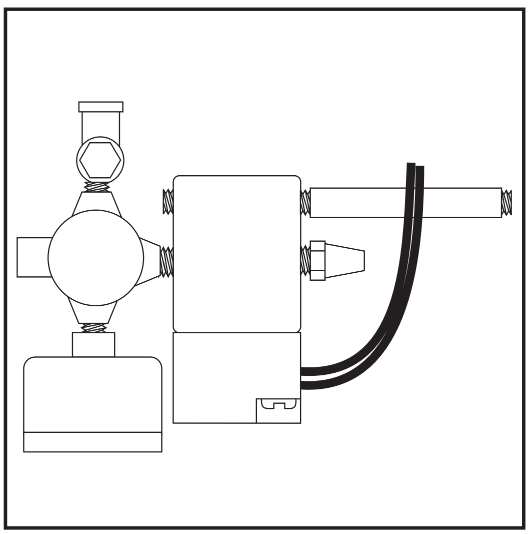


Figure 4.1-5. Top view of spindle lube/air solenoid assembly.

5. Replace the assembly, ensuring it is approximately horizontal to the floor, and tighten fittings securely.

6. Reconnect all air lines.

7. Reconnect wiring leads at the quick-disconnect in the wiring channel. Slide cover back into place.

8. Restore air supply to the machine.

4.2 Line Voltage Adjustments

Please read this section in its entirety before attempting to adjust the line voltage.

TOOLS REQUIRED

- Large flat tip screwdriver
- Digital voltmeter

ADJUSTING VOLTAGE

NOTE: The machine must have air pressure at the air gauge, or a "Low Air Pressure" alarm will be present on power up.

CAUTION! Working with the electrical services required for the Horizontal mill can be extremely hazardous. The electrical power must be off and steps must be taken to ensure that it will not be turned on while you are working with it. In most cases this means turning off a circuit breaker in a panel and then locking the panel door. However, if your connection is different or you are not sure how to do this, check with the appropriate personnel in your organization or otherwise obtain the necessary help BEFORE you continue.

WARNING!

The electrical panel should be closed and the three screws on the door should be secured at all times except during installation and service. At those times, only qualified electricians should have access to the panel. When the main circuit breaker is on, there is high voltage throughout the electrical panel (including the circuit boards and logic circuits) and some components operate at high temperatures. Therefore extreme caution is required.

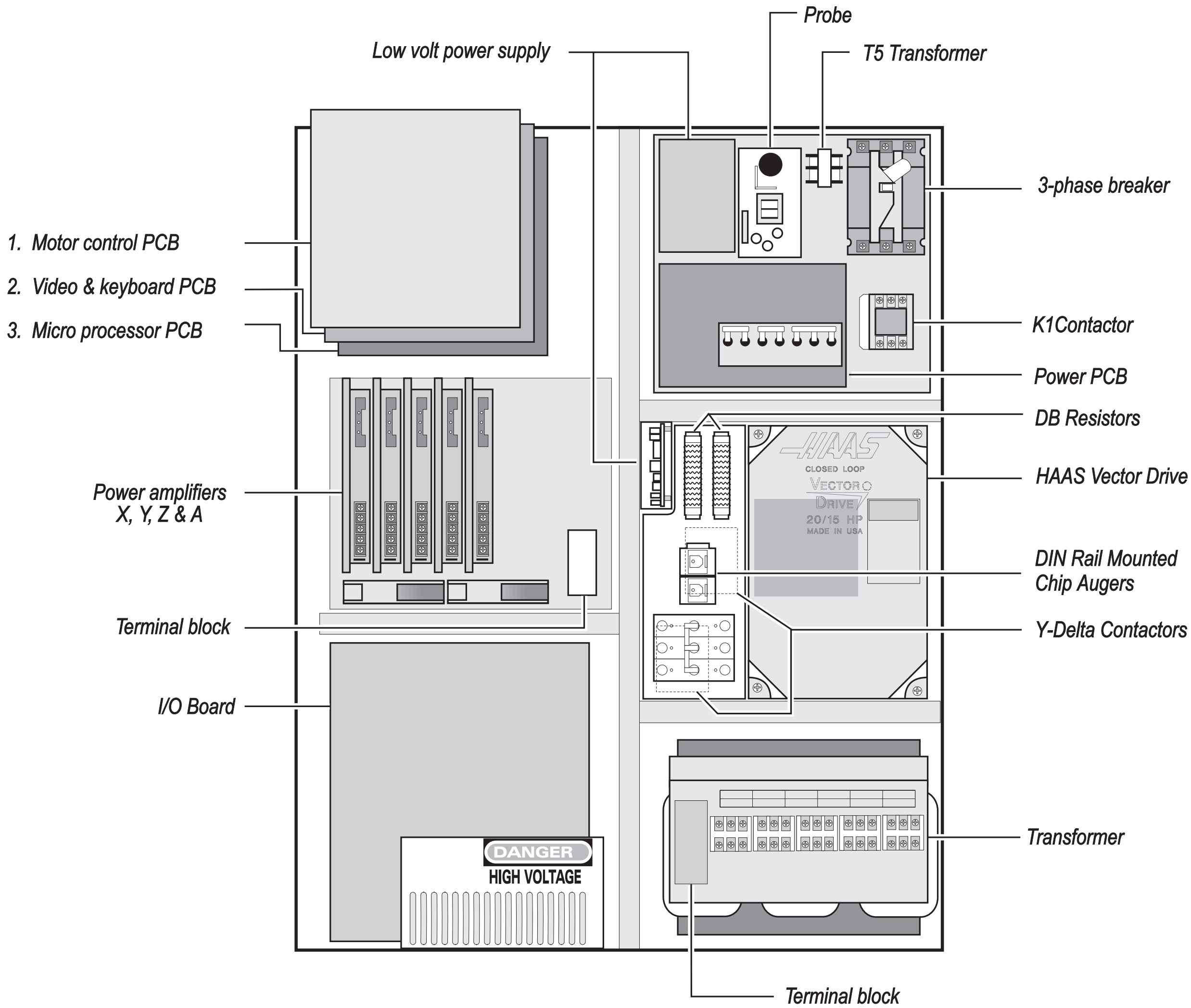


Figure 4.2-1. Control panel general overview.

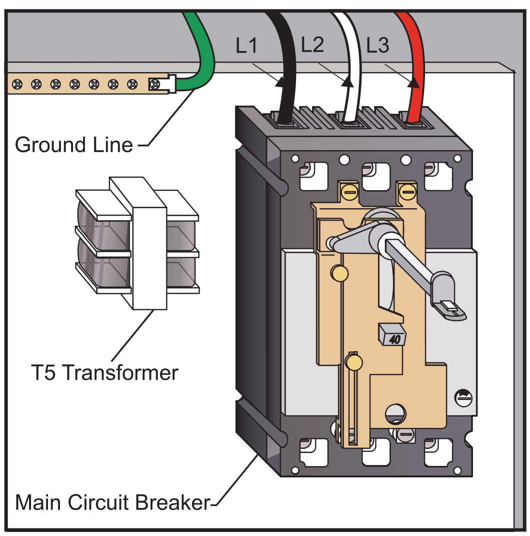
Electrical Connections

NOTE: The machine must have air pressure at the air gauge, or a "Low Air Pressure" alarm will be present on power up.

CAUTION! Working with the electrical services required for the Horizontal mill can be extremely hazardous. The electrical power must be off and steps must be taken to ensure that it will not be turned on while you are working with it. In most cases this means turning off a circuit breaker in a panel and then locking the panel door. However, if your connection is different or you are not sure how to do this, check with the appropriate personnel in your organization or otherwise obtain the necessary help BEFORE you continue.

WARNING!

The electrical panel should be closed and the three latches on the door should be secured at all times except during installation and service. At those times, only qualified electricians should have access to the panel. When the main circuit breaker is on, there is high voltage throughout the electrical panel (including the circuit boards and logic circuits) and some components operate at high temperatures. Therefore, extreme caution is required.



1. Hook up the three power lines to the terminals on top of the main switch at upper right of electrical panel and the separate ground line to the ground bus to the left of the terminals.

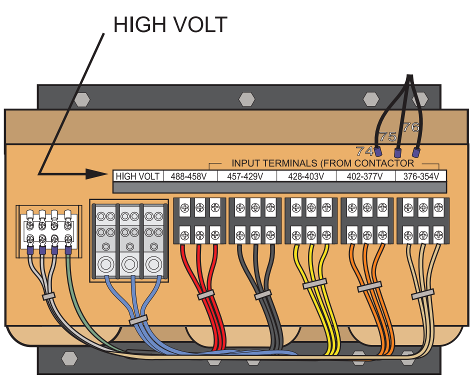
NOTE: Make sure that the service wires actually go into the terminal-block clamps. (It is easy to miss the clamp and tighten the screw. The connection looks fine but the machine runs intermittently or has other problems, such as servo overloads.) To check, simply pull on the wires after the screws are tightened.

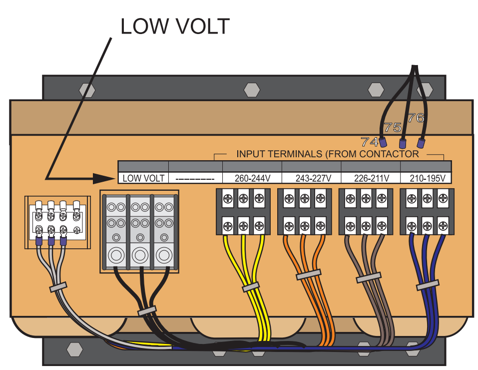
2. After the line voltage is connected to the machine, make sure that main circuit breaker (at top-right of rear cabinet) is OFF (rotate the shaft that connects to the breaker counterclockwise until it snaps OFF). Turn ON the power at the source. Using an accurate digital voltmeter and appropriate safety procedures, measure the voltage between all three pair phases at the main circuit breaker and write down the readings. The voltage must be between 195 and 260 volts (360 and 480 volts for high voltage option).

NOTE: Wide voltage fluctuations are common in many industrial areas; you need to know the minimum and maximum voltage which will be supplied to the machine while it is in operation. U.S. National Electrical Code specifies that machines should operate with a variation of +5% to -5% around an average supply voltage. If problems with the line voltage occur, or low line voltage is suspected, an external transformer may be required. If you suspect voltage problems, the voltage should be checked every hour or two during a typical day to make sure that it does not fluctuate more than +5% or -5% from an average.

CAUTION! Make sure that the main breaker is set to OFF and the power is off at your supply panel BEFORE you change the transformer connections. Make sure that all three black wires are moved to the correct terminal block and that they are tight.

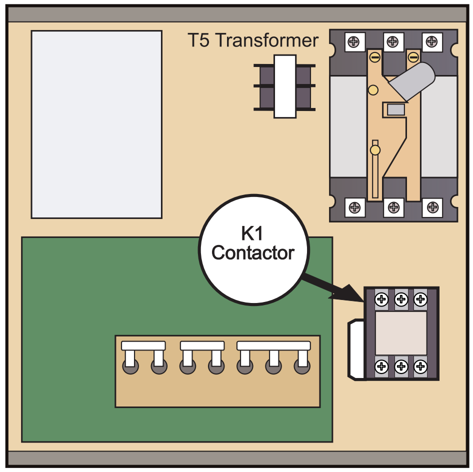
3. Check the connections on the transformer at the bottom-right corner of the rear cabinet. The three black wires labeled **74, 75,** and **76** must be moved to the terminal block triple which corresponds to the average voltage measured in **step 2** above. There are four positions for the input power for the 260 volt transformer and five positions for the 480 volt transformer. The labels showing the input voltage range for each terminal position are as shown in the following illustrations:





4. Transformer T5 supplies 24VAC used to power the main contactor. There are two versions of this transformer for use on 240 and 400V machines (32-0964B and 32-0965B, respectively). The 240V transformer has two input connectors located about two inches from the transformer, which allow it to be connected to either 240V or 200V. Users that have 220V-240V RMS input power should use the connector labeled 200V. Users with the External High Voltage Option should use the 240V connector if they have 420V-510V 60Hz power or the 200V connector if they have 50Hz power. Failure to use the correct input connector will result in either overheating of the main contactor or failure to reliably engage the main contactor.

5. Set the main switch to ON (rotate the shaft that engages the handle on the panel door clockwise until it snaps into the ON position). Check for evidence of problems, such as the smell of overheating components or smoke. If such problems are indicated, set the main switch to OFF immediately and call the factory before proceeding.



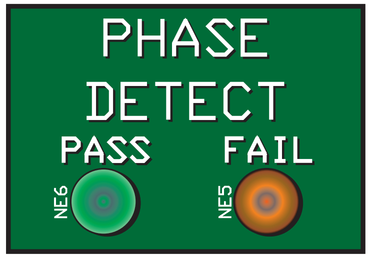
WARNING!

Through the Spindle Coolant (TSC) pump is a three phase pump and must be phased correctly! Improper phasing will cause damage to the TSC pump and void the warranty. Refer to the TSC start up section IF YOUR MACHINE IS EQUIPPED WITH tsc.

6. After the power is on, measure the voltage across the upper terminals on the contactor K1 (located below the main circuit breaker). It should be the same as the measurements where the input power connects to the main breaker. If there are any problems, check the wiring.

7. Apply power to the control by pressing the Power-On switch on the front panel. Check the high voltage buss on the Vector Drive (pin 2 with respect to pin 3 on the terminal bus at the bottom of the drive). It must be between 310 and 360 volts. If the voltage is outside these limits, turn off the power and recheck steps 2 and 3. If the voltage is still outside these limits, call the factory. Next, check the DC voltage displayed in the second page of the Diagnostic data on the CRT. It is labeled DC BUS. Verify that the displayed voltage matches the voltage measured at pins 2 and 3 of the Vector Drive +/- 7 VDC.

8. Electrical power must be phased properly to avoid damage to your equipment. The Power Supply Assembly PC board incorporates a "Phase Detect" circuit with neon indicators, shown below. When the orange neon is lit (NE5), the phasing is incorrect. If the green neon is lit (NE6), the phasing is correct. If both neon indicators are lit, then you have a loose wire. Adjust phasing by swapping L1 and L2 of the incoming power lines at the main circuit breaker.



WARNING!

ALL POWER MUST BE TURNED OFF AT THE SOURCE PRIOR TO ADJUSTING PHASING.

9. Turn off the power (rotate the shaft that engages the handle on the panel door counterclockwise until it snaps into the OFF position). Also, set the main switch handle on the panel door to OFF. (Both the handle and the switch must be set to OFF before the door can be closed). Close the door, lock the latches, and turn the power back on.

10. Remove the key from the control cabinet and give it to the shop manager.

Installation Procedure for External 480V Transformer

Introduction

The external transformer adds to overall machine reliability and performance, however it does require extra wiring and a place to locate it. The external transformer provides electrostatically shielded isolation. This type of transformer acts to isolate all common mode line transients and improve EMI conducted emissions.

The external transformer has a 45 KVA rating.

Installation

The transformer should be located as close to the machine as possible. The input and output wiring of the transformer should conform to the local electrical codes and should be performed by a licensed electrician. The following is for guidance only, and should not be construed to alter the requirements of local regulations.

The input wire should not be smaller than the 6AWG for the 45KVA transformer. Cable runs longer than 100” will require at least one size larger wire. The output wire size should be 4 AWG.

The transformer is 480V to 240V isolation transformers with delta wound primary and secondary windings. The primary windings offer 7 tap positions, 2 above and 4 below the nominal input voltage of 480V.

For domestic installations and all others using 60Hz power, the primary side should be wired as follows:

Input Voltage Range	Tap
493-510	1 (504)
481-492	2 (492)
469-480	3 (480)
457-468	4 (468)
445-456	5 (456)
433-444	6 (444)
420-432	7 (432)

This should produce a voltage on the secondary side of 234-243 V RMS L-L. Verify this and readjust the taps as required. At the machine, connect the cables at the input of the internal 230V transformer to the 227-243V taps. Apply power to the machine and verify that the DC voltage between pins 2 and 3 of the Vector Drive (2nd and 3rd pins from the left) is 329-345VDC. If not, return to the 480V isolation transformer and readjust the taps as required. Do not use the taps on the internal 230V transformer to adjust the voltage.

50Hz Installations

The external transformers are 60Hz rated, and cannot be used at 50Hz without derating the input voltage. For these applications, the internal 230V transformer should be tapped on the lowest setting (195-210V RMS). The external transformer should be tapped according to the table shown below. If these tap setting do not produce a DC bus voltage between pins 2 and 3 on the Vector Drive between 320 and 345VDC, readjust the taps on the external transformer as required. DO NOT move the taps on the internal transformer from the lowest position.

Input Voltage Range	Tap
423-440	1 (504)
412-422	2 (492)
401-411	3 (480)
391-400	4 (468)
381-390	5 (456)
371-380	6 (444)
355-370	7 (432)

4.3 Fuse Replacement

Please read this section in its entirety before attempting to replace any fuses.

Overvoltage Fuses

WARNING!

The electrical panel will have residual voltage, even after power has been shut off and/or disconnected . Never work inside this cabinet until the small red CHARGE light on the servo drive assembly goes out. The servo drive assembly is on the left side of the main control cabinet and about halfway down. This light is at the top of the circuit card at the center of the assembly. Until this light goes out, there are dangerous voltages in the assembly EVEN WHEN POWER IS SHUT OFF.

1. Turn machine power off.

2. Turn the main switch (upper right of electrical cabinet) to the off position.

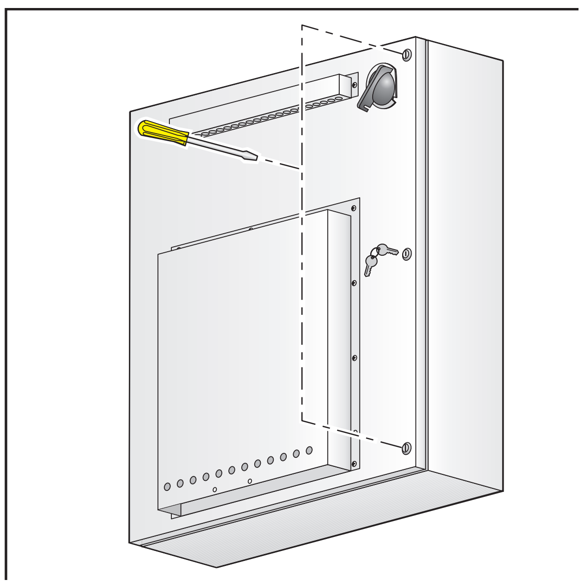


Figure 4-3.1 Unscrew the three screws to open the cabinet door. (Newer control cabinets require a key)

3. Open the cabinet door and wait until the red CHARGE light on the servo drive assembly goes out before beginning any work inside the electrical cabinet.

4. On the POWER SUPPLY board there are three fuses located in a row at the upper right of the board; these are the overvoltage fuses. An orange light will be on to indicate the blown fuse(s).

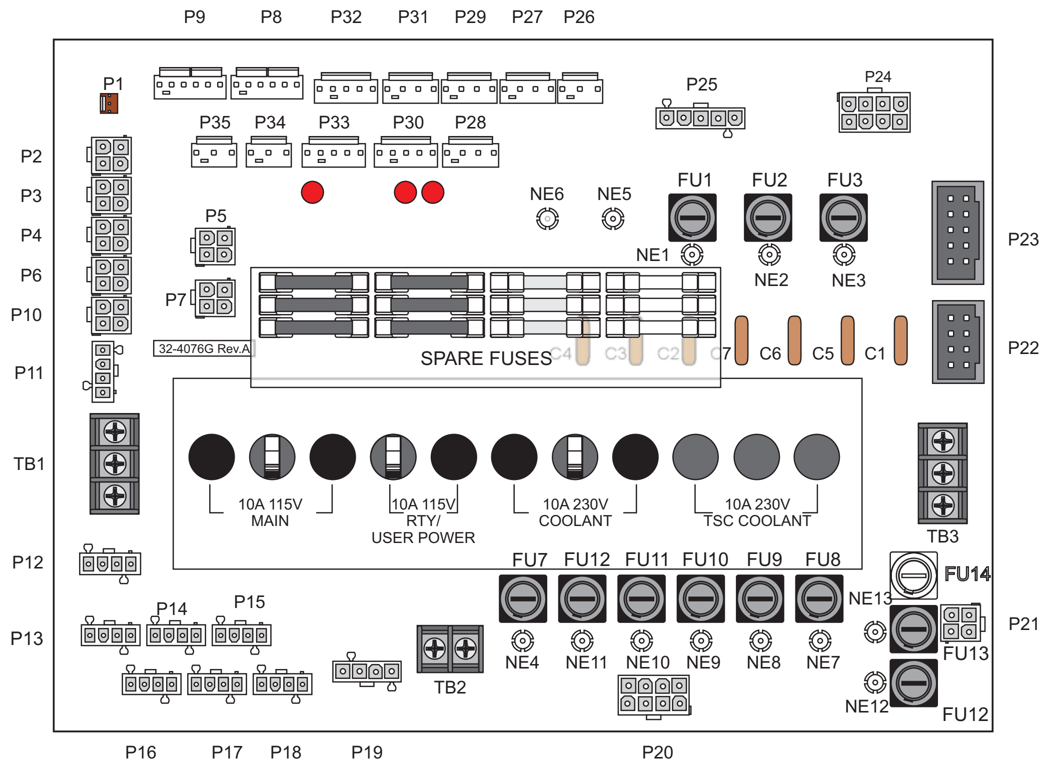


Figure 4.3-2 Power supply board; fuse locations.

5. Using a flat tip screwdriver, turn the fuse(s) counterclockwise to remove and replace the blown fuse(s) with ones having the same type and rating (½ amp, type AGC, 250V).

CAUTION! When the left fuse is blown, it is still possible to operate the machine, thereby making an overvoltage situation possible. VERIFY absolute voltage to the machine does not exceed 260 volts.

4.4 PCB Replacement

Please read this section in its entirety before attempting to replace any PCBs.

Microprocessor, Mocon & Video / Keyboard

WARNING!

The electrical panel will have residual voltage, even after power has been shut off and/or disconnected . Never work inside this cabinet until the small red CHARGE light on the servo amplifiers go out. The servo amplifiers are on the left side of the main control cabinet and about halfway down. This light is at the top of the circuit card at the center of the assembly. Until this light goes out, there are dangerous voltages in the assembly EVEN WHEN POWER IS SHUT OFF.

GROUND STRAPS MUST BE USED WHEN HANDLING BOARDS

NOTE: The arrangement of these boards may differ from the order of replacement that follows. The steps for replacement will only differ in which board may need to be removed before getting to the necessary board.

MOCON BOARD -

NOTE: Refer to "Cable Locations" for a diagram of this board.

1. Turn machine power off.

2. Turn the main switch (upper right of electrical cabinet) to the off position.

3. Open the cabinet door and wait until the red CHARGE light(s) on the servo amplifiers go out before beginning any work inside the electrical cabinet.

4. Disconnect all leads to the Motor Controller (MOCON) board. Ensure all cables are properly labeled for reconnecting later.

5. After all cables have been disconnected, unscrew the standoffs, taking care to hold the board in place until all standoffs have been removed.

NOTE: If the VIDEO / KEYBOARD or PROCESSOR boards need replacing, please skip the next step.

6. Replace the MOCON board, attaching it to the VIDEO / KEYBOARD (beneath the MOCON board) with the standoffs.

7. Reconnect all leads (previously removed) to their proper connections.

VIDEO / KEYBOARD -

NOTE: Refer to "Cable Locations" for a diagram of this board.

8. Remove the MOCON board as described in Steps 1-5.

9. Disconnect all leads to the Video / Keyboard. Ensure all cables are properly labeled for reconnecting later. The following illustration shows all cable numbers and the locations on the Video / Keyboard.

10. After all cables have been disconnected, unscrew the standoffs, taking care to hold the board in place until all standoffs have been removed.

NOTE: If the PROCESSOR board need replacing, please skip the next step.

11. Replace the Video / Keyboard, attaching it to the PROCESSOR board (beneath the Video / Keyboard) with the standoffs.

12. Reconnect all leads (previously removed) to their proper connections.

PROCESSOR BOARD -

NOTE: Refer to "Cable Locations" for a diagram of this board.

13. Remove the MOCON board as described in Steps 1-7, and the Video / Keyboard as described in Steps 8-9.

14. Disconnect all leads to the Processor board. Ensure all cables are properly labeled for reconnecting later. The following illustration shows all cable numbers and the locations on the Processor board.

15. After all cables have been disconnected, unscrew the standoffs, taking care to hold the board in place until all standoffs have been removed.

16. Replace the Processor board, attaching it to the electrical cabinet (beneath the Processor board) with the standoffs.

17. Reconnect all leads (previously removed) to their proper connections.

I/O Board

NOTE: Refer to "Cable Locations" for a diagram of this board.

1. Follow all precautions noted previously before working in the electrical cabinet.

2. Turn the main switch (upper right of electrical cabinet) to the off position.

3. Using a large flat tip screwdriver, loosen the three screws on the cabinet door and then open the door enough to safely work on the electrical panel.

4. Disconnect all leads to the Input/Output board and move aside for removal. Ensure all cables are properly labeled for reconnecting later. The following illustration shows all cable numbers and the locations on the I/O board.

5. Remove the board by first removing the twelve screws that fasten it to the cabinet. Take care to hold the board in place until all screws have been removed.

6. Replace the I/O board, attaching it to the cabinet with the twelve screws previously removed.

7. Reconnect all leads to the I/O board at this time.

Power & Low Voltage Supply

POWER BOARD -

NOTE: Refer to "Cable Locations" for a diagram of this board.

1. Follow all precautions noted previously before working in the electrical cabinet

2. Turn the main switch (upper right of electrical cabinet) to the off position.

3. Using a large flat tip screwdriver, loosen the three screws on the cabinet door and then open the door enough to safely work on the electrical panel.

4. Disconnect all leads to the Power Distribution board and move aside for removal. Ensure all cables are properly labeled for reconnecting later. The illustration on the following page shows all cable numbers and the locations on the POWER board.

5. After all cables have been disconnected, remove the seven screws holding the POWER board to the cabinet and remove the board. Take care to hold the POWER board in place until all screws have been removed.

NOTE: If you need to replace the LOW VOLTAGE POWER SUPPLY board, please skip the next step.

6. Replace the POWER board, attaching it with the seven screws previously removed. Do not forget to use the lower left screw for a ground connection.

7. Reconnect all cables to the POWER board at their proper location.

LOW VOLTAGE POWER SUPPLY -

NOTE: Refer to "Cable Locations" for a diagram of this board.

8. Remove the Power Distribution (POWER) board as described in steps 1-5.

9. Disconnect all leads to the Low Voltage Power Supply (LVPS) board. Ensure all cables are properly labeled for reconnecting later. The following illustration shows all cable numbers and the locations on the LVPS board.

10. After all cables have been disconnected, unscrew the two standoffs at the bottom of the board. Unscrew the remaining two screws at the top of the LVPS board, taking care to hold the board in place until all screws have been removed.

11. Replace the LVPS board, attaching it to the cabinet with the two screws and two standoffs previously removed.

12. Replace the POWER board as described in Steps 6-7.

RS-232 PCB

NOTE: Refer to "Cable Locations" for a diagram of this board.

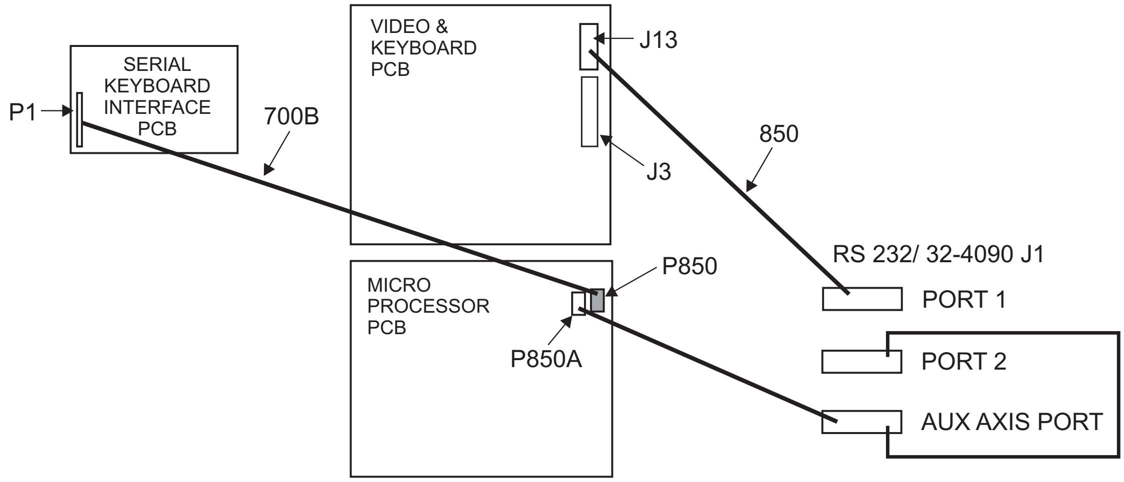
1. Follow all precautions noted previously before working in the electrical cabinet (See warning at beginning of "Servo Driver & SDIST" section).

2. Turn the main switch (upper right of electrical cabinet) to the off position.

3. Using a large flat tip screwdriver, loosen the three screws on the cabinet door and then open the door enough to safely work on the electrical panel.

NOTE: It is suggested to make use of a step ladder high enough to allow you to work from the top of the electrical cabinet. It will be necessary, when replacing the RS-232 board, to work from the inside and outside of the cabinet at the same time.

4. On the left side of the cabinet, at the top of the side panel are two serial port connections labeled "SERIAL PORT #1" and "SERIAL PORT #2", SERIAL PORT #1 being the upper connection.



* Serial interface replaces cable 700 with cable 700B.

Figure 4.4-1. RS-232 wiring pictorial (with serial keyboard).

5. To remove the RS-232 board, unscrew the two hex screws (on the exterior of the cabinet) holding the connector to the cabinet. From the inside of the cabinet, pull the connector through the panel, and disconnect the cable.

6. Replace the RS-232 board by first connecting the appropriate cable to the board (850 to SERIAL PORT #1, 850A to SERIAL PORT #2, then inserting the board (cable side up) through the left side panel. Attach with the two hex screws previously removed. Ensure the board for Serial Port #1 is the upper connector and the board for Serial Port #2 is the lower connector.

7. Replace the Serial Keyboard Interface (KBIF) board, using the four screws previously removed, starting at the top right. Attach the screw and standoff loosely, then all other screws and standoffs, until all are mounted. Tighten down completely.

8. Reconnect all cables to the Serial KBIF board at their proper locations.

RS-232 Serial Interface

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

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

The RS-232 interface sends and receives **seven data bits, even parity, and two stop bits**. The interface must be set correctly. 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 is 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.

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, remote unattended operation is thus possible.

RS-232 Line Noise

To minimize line noise on the serial port, reroute the cables; route them straight up the left-hand side of the control to the processor stack. Do not run them above the I/O PCB or up the center wire channel to the processor.

Also, disconnect both shield connections on the RS-232 ribbon cables. One connection is at the red-box to the chassis, the second connection is at the processor stack with the shields for the active circuitry.

These two adjustments make a very big difference in the signals and will minimize and possibly eliminate RS-232 communications problems.

4.5 Front Panel

Please read this section in its entirety before attempting to replace any component of the control panel.

CRT Assembly Replacement

1. Turn the power off and disconnect power to the machine.

2. Remove the screws holding the cover panel on the back of the control panel. Take care to hold the cover panel in place until all screws have been removed.

3. Unplug the white cable from the black cable at the connection in the control panel. It may be necessary to cut straps off the black cable's connector to unplug.

4. Unscrew the four hex nuts on the bottom row of the CRT bracket and remove, along with the washers. Set aside in a safe place.

5. While holding up the CRT assembly, remove the four hex nuts on the top row of the CRT bracket, along with the washers.

CAUTION! Take extreme care to not drop or damage the CRT assembly when removing from the control panel.

6. CAREFULLY pull the CRT assembly out toward the rear until it is clear of the control panel and all wiring. Set CRT assembly down in a safe place so as not to damage.

7. Replace by sliding the new assembly onto the eight bolts (four each on top and bottom). Starting with the bottom right, place the washers and hex nuts on the bolts to hold in place. Refer to Fig. 4.5-1 for the order of replacement. Once all washers have been attached and nuts have been hand-tightened, tighten down completely with the socket.

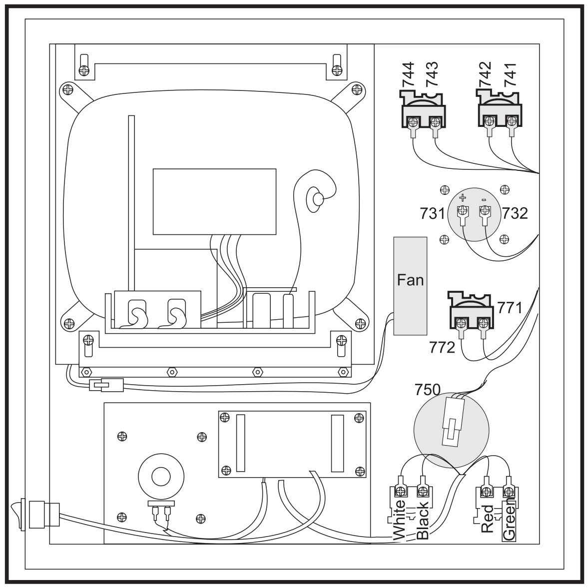


Figure 4.5-1. Interior of control panel (rear).

8. Plug the black cable and white cable into the matching cables. Feed the white cable through the opening in the top of the control panel.

9. Replace the back cover panel and attach with the four screws previously removed.

Jog Handle Replacement

The JOG handle is actually a 100-line-per-revolution encoder. We use 100 steps per revolution to move one of the servo axes. If no axis is selected for jogging, turning of the crank has no effect. When the axis being moved reaches its travel limits, the handle inputs will be ignored in the direction that would exceed the travel limits.

NOTE: Parameter 57 can be used to reverse the direction of operation of the handle.

1. Turn the machine power off.

2. Remove the screws holding the cover panel on the back of the control panel. Take care to hold the cover panel in place until all screws have been removed.

3. Unplug the cable leading to the jog handle encoder. IMPORTANT! The blank pin side of the connector must face as shown in Fig. 4.5-2 when reconnecting; otherwise, damage may occur to the machine.

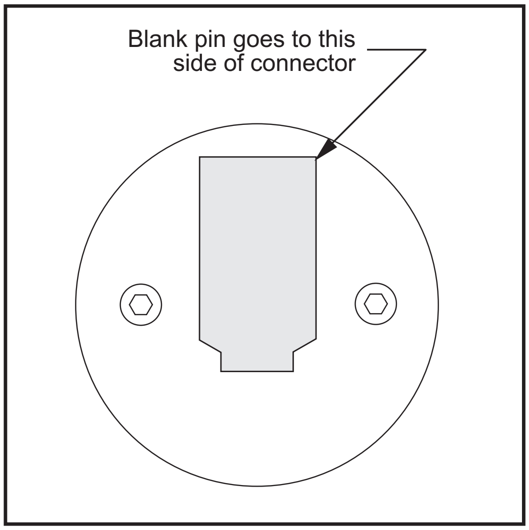


Figure 4.5-2. Jog handle encoder.

4. Using the 5/64" allen wrench, loosen the two screws holding the knob to the control panel and remove.

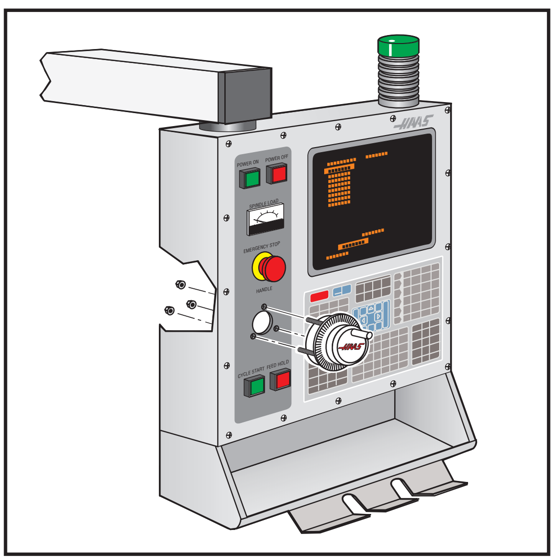


Figure 4.5-3. Jog Handle removal.

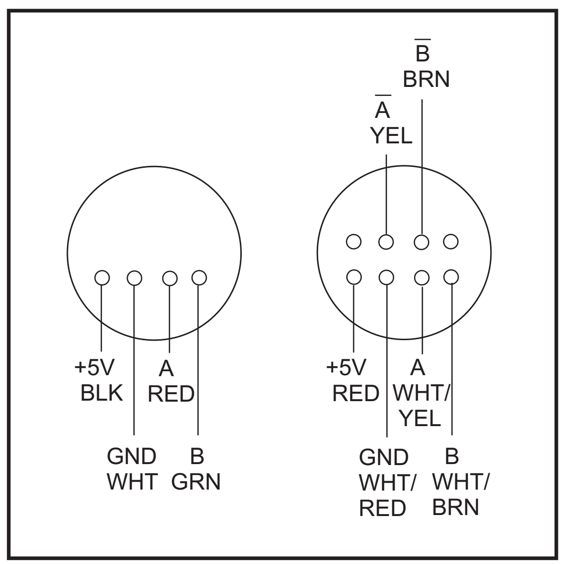


Figure 4.5-4. Jog Handle wiring diagram

5. Remove the three screws holding the jog handle encoder to the control panel and remove.

6. Replacement is reverse of removal. Keep in mind the important notice in Step 3.

Switch Replacement

NOTE: This section is applicable for the POWER ON, POWER OFF, EMERGENCY STOP, CYCLE START, and FEED HOLD switches.

1. Turn the machine power off.

2. Remove the four screws holding the cover panel on the back of the control panel. Take care to hold the cover panel in place until all screws have been removed.

3. Disconnect all leads to the switch's connectors. Ensure all leads are properly marked for reconnecting later. Refer to Fig. 4.5-1 for proper locations.

4. Unscrew the two small set screws, one on top and one on the bottom, and turn the switch counter clockwise to loosen. Separate from the front portion and pull out.

5. For replacement, screw the front and rear portions together (reverse of removal) and tighten down the two small set screws when the switch is properly positioned.

NOTE: The POWER ON, POWER OFF, and EMERGENCY STOP switches must all have the connectors on the bottom of the switch.

6. Reconnect all leads to the correct switch.

Spindle Load Meter Replacement

1. Turn the power off and disconnect power to the machine.

2. Remove the four screws holding the cover panel on the back of the control panel. Take care to hold the cover panel in place until all screws have been removed.

3. Disconnect the two leads at the back of the spindle load meter assembly. Ensure the two leads are properly marked for reconnecting later.

4. Unscrew the four screws that hold the spindle load meter assembly to the control panel. Take care to hold the assembly in place until all screws have been removed. Remove the assembly.

5. Installation is reverse of removal. Ensure leads go the correct location.

Keypad Replacement

1. Turn the power off and disconnect power to the machine.

2. Remove the four screws holding the rear cover panel to the back of the control panel. Take care to hold the cover panel in place until all screws have been removed.

3. Unplug the keypad's 24-pin ribbon cable from the Keyboard Interface board.

4. Remove the screws from the front of the control panel. Take care to hold the front cover panel in place until all screws have been removed. Remove the pieces and set aside in a safe place.

5. Using a flat, blunt tool, such as putty knife, pry the keypad away from the control panel. Pull the ribbon cable through the opening in the control to remove.

6. To replace, first put the bezel spacer in place and fasten temporarily with screws in the top corners.

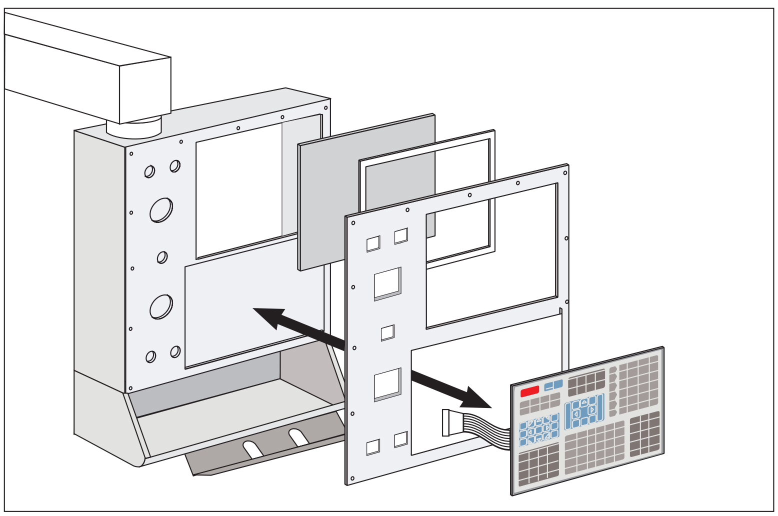


Figure 4.5-5. Keypad installation.

7. Insert the ribbon cable through the opening in the control panel. Expose the adhesive strip on the back of the keypad and press the keypad in place in the upper right corner of the keypad recess. Press to the control panel to mount. Plug the ribbon cable into the Keyboard Interface board, taking care to not bend the pins on the board.

8. Replace the front and rear cover panels and fasten with the screws that were previously removed.

Serial Keyboard Interface

NOTE: Refer to "Cable Locations" for a diagram of this board.

1. Follow all precautions noted previously before working in the control cabinet (See warning at beginning of Section 5).

2. Turn the main switch (upper right of electrical cabinet) to the off position.

3. Remove the four screws on the back of the control box, then remove the cover panel. Take care to hold the panel in place until all screws have been removed.

4. Disconnect all leads to the Serial Keyboard Interface (KBIF) board. Ensure all cables are properly labeled for reconnecting later.

5. After all cables have been disconnected, unscrew the four screws holding the Serial KBIF board to the control box. Take care to hold the board in place until all screws have been removed. Place the screws and standoffs aside for later use.

6. Replace the Serial KBIF board, using the four screws previously removed, starting at the top right. Attach the screw and standoff loosely, then all other screws and standoffs, until all are mounted. Tighten down completely.

7. Reconnect all cables to the Serial KBIF board at their proper locations.

4.6 Spindle Encoder Replacement

Please read this section in its entirety before attempting to remove or replace encoder.

REMOVAL -

1. Turn machine power on. Lower the spindle head to a position that will allow you to easily work on the encoder. Turn machine off.

2. Disconnect the encoder cable at the top of the encoder.

3. Unscrew and remove the four screws holding the encoder to the standoffs . Remove the encoder, leaving the belt on the pulley at the orient ring.

INSTALLATION -

NOTE: If you wish to install an encoder on a machine start at Step 5; if this is just a replacement, skip to Step 13.

4. Place some blue Loctite on the threads of the four set screws and screw approximately halfway into the standoffs. Screw the hex end of the set screws into the standoffs.

5. Screw the standoffs into the four holes located at the rear of the transmission's top plate.

6. Place the 18- tooth pulley onto the pulley bushing and tighten down. Place the SHCS through the center axis of the pulley.

7. Screw this assembly into the spindle orientation ring.

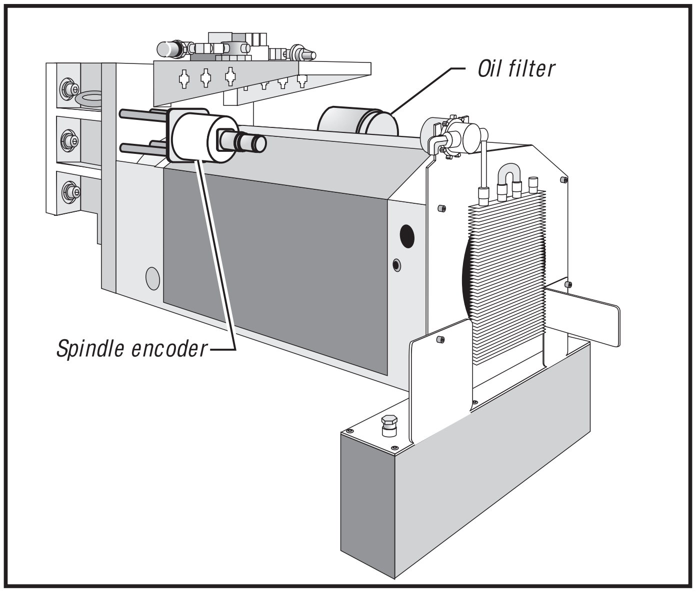


Figure 4.6-1. Spindle encoder installation.

8. Place the 36-tooth pulley onto the encoder, making the top of the pulley flush with the end of the shaft. Tighten down with the hex wrench.

9. Unscrew the four screws and remove the cover panel on the box at the base of the flexible tube.

10. Feed the encoder cable through the flexible tube and connect at the plug in the box on top of the electrical cabinet.

11. Place the 18 tooth belt on the pulley, then loop the 36 tooth pulley over the 18-tooth pulley. Place the encoder assembly on the four standoffs and attach with the four 10-32 SHCS, placing the #10 lock washers between the socket head and the encoder base.

12. Connect the encoder cable to the encoder assembly.

5. TECHNICAL REFERENCE

5.1 Tool Changer

Tool Weight and Size

CAUTION! Do not exceed the Maximum Specifications given below!

	HS-1, HS-1R, HS-1RP	HS 60/120 SMTC	HS-2RP
MAXIMUM TOOL DIAMETER WITH ALL POCKETS FULL	3.5”	3.0”	3.4”
MAXIMUM TOOL WEIGHT	12 lbs.	12 lbs.	12 lbs.
NUMBER OF TOOL POCKETS	24	60/120	40

CAUTION!
- Extremely heavy tool weights should be distributed evenly
- Ensure there is adequate clearance between tools in the tool changer before running an automatic operation.

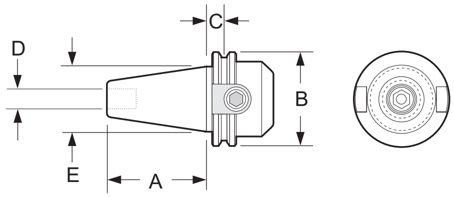
Tools are always loaded through the spindle and should never be installed directly in the carousel in order to avoid crashes. The pocket open to the spindle must always be empty in the retracted position. All wiring to the tool changer goes through connector P8 on the side of the control cabinet.

Pull Studs

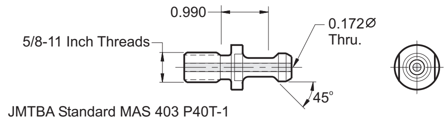
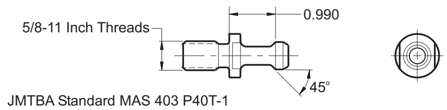
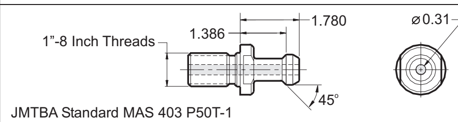
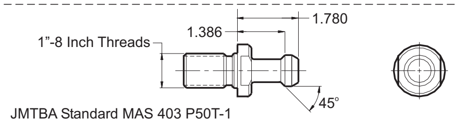
The tool holders used are CT #40 taper, V flange, commonly called “CT 40”. Use A 45 Degree, P40T Type 1, inch threads pull stud built to JMTBA standard MAS 403-1982. This pull stud is characterized by a long shaft and a 45˚ shoulder under the head. Do not use the short shaft or pull studs with a sharp right angle (90˚) head as they will not work and will cause serious damage.

Tool Holders/Pull Studs

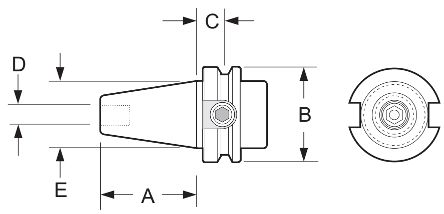
CT CAT V-Flange



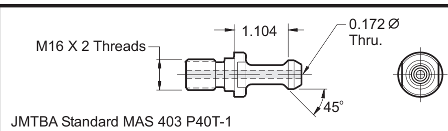
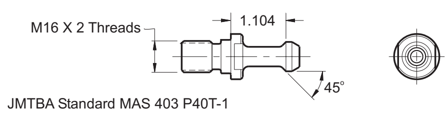
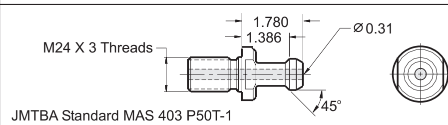
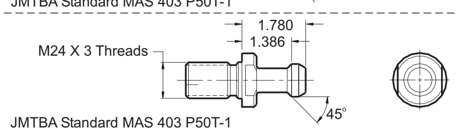
	A	B	C	D	E
40T	2.69	2.50	.44	5/8"-11	1.75
50T	4.00	3.87	.44	1"-8	2.75

Taper	Part #	Pull Stud	Kit #
40T	20-7594 (TSC)	 0.990; 0.172Ø Thru.; 5/8-11 Inch Threads; 45° JMTBA Standard MAS 403 P40T-1	TPS24CT
40T	20-7164 (non-TSC)	 0.990; 5/8-11 Inch Threads; 45° JMTBA Standard MAS 403 P40T-1	PS24CT
50T	22-0075 (TSC)	 1.780; 1.386; Ø0.31; 1"-8 Inch Threads; 45° JMTBA Standard MAS 403 P50T-1	TPS24CT50
50T	22-0039 (non-TSC)	 1.780; 1.386; 1"-8 Inch Threads; 45° JMTBA Standard MAS 403 P50T-1	PS24CT50

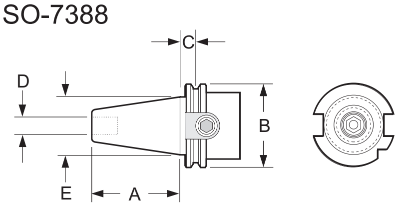
BT MAS 403



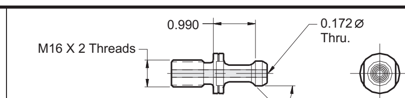
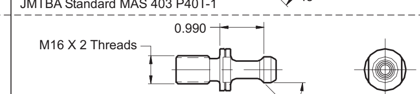
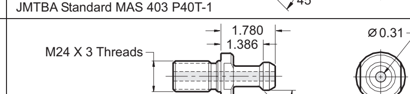
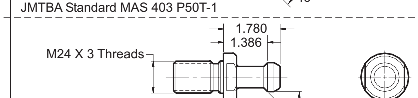
	A	B	C	D	E
40T	2.57	2.48	.65	M16X2	1.75
50T	4.00	3.94	.91	M24X3	2.75

Taper	Part #	Pull Stud	Kit #
40T	20-7595 (TSC)	 1.104; 0.172Ø Thru.; M16 X 2 Threads; 45° JMTBA Standard MAS 403 P40T-1	TPS24BT
40T	20-7165 (non-TSC)	 1.104; M16 X 2 Threads; 45° JMTBA Standard MAS 403 P40T-1	PS24BT
50T	22-7171 (TSC)	 1.780; 1.386; Ø0.31; M24 X 3 Threads; 45° JMTBA Standard MAS 403 P50T-1	TPS24E50
50T	22-7170 (non-TSC)	 1.780; 1.386; M24 X 3 Threads; 45° JMTBA Standard MAS 403 P50T-1	PS24E50

DIN-69871 (MIKRON) ISO-7388



	A	B	C	D	E
40T	2.69	2.50	.44	M16X2	1.75
50T	4.00	3.84	.44	M24X3	2.75

Taper	Part #	Pull Stud	Kit #
40T	20-7556 (TSC)	 0.990; 0.172Ø Thru.; M16 X 2 Threads; 45° JMTBA Standard MAS 403 P40T-1	TPS24E
40T	20-7164A (non-TSC)	 0.990; M16 X 2 Threads; 45° JMTBA Standard MAS 403 P40T-1	PS24E
50T	22-7171 (TSC)	 1.780; 1.386; Ø0.31; M24 X 3 Threads; 45° JMTBA Standard MAS 403 P50T-1	TPS24E50
50T	22-7170 (non-TSC)	 1.780; 1.386; M24 X 3 Threads; 45° JMTBA Standard MAS 403 P50T-1	PS24E50

NOTE: CT 40T Pullstud = One Identification Groove
BT 40T Pullstud = Two Identification Grooves
MIKRON 40T Pullstud = Three Identification Grooves

Tool holders and pull studs must be in good condition and tightened together with wrenches or they may stick in the spindle taper. Clean the tool tapers with a lightly-oiled rag to leave a film to prevent rusting. Tools that make a loud bang when being released indicate a problem and should be checked before serious damage occurs. When the TOOL RELEASE button (on the keypad) is pressed, the tool should be pushed out of the spindle by a small amount (approximately .07"). This is an indication that the pull stud is correctly touching the release mechanism.

Low air pressure or insufficient volume will reduce the pressure applied to the tool unclamp piston and will slow down tool change time or will not release the tool. The air pressure is now checked prior to moving the carousel on a mill with a side mount tool changer and alarm 120 LOW AIR PRESSURE is generated if such a problem exists.

If the tool changer should crash, the control will automatically come to an alarm state. To correct this, press the TOOL CHANGER RESTORE key. The control will then ask questions and provide instruction to help restore the tool changer.

CAUTION! Never put your hands near the tool changer when powered unless the EMERGENCY STOP button is pressed.

Operation of the tool changer can also be interrupted by problems with the tool clamp/unclamp and the spindle orientation mechanism. Problems with them can be caused by low air pressure or a blown solenoid circuit breaker CB4.

WARNING

AN INADEQUATE AIR SUPPLY
WILL CAUSE TOOL CHANGER FAULTS

FOLLOW THESE GUIDELINES:

MINIMUM AIR SUPPLY PRESSURE TO MACHINE IS 100 PSI.
OBSERVE GAGE DURING TOOL CHANGE - 10 PSI MAX. DROP.
USING THE AIR GUN DURING TOOL CHANGES MAY CAUSE FAULTS IF THE AIR SUPPLY TO THE MACHINE IS MARGINAL.
ALLOW 2 HP OF AIR COMPRESSOR PER MACHINE, (I.E., 5 MACHINES REQUIRE A 10 HP AIR COMPRESSOR).
USE MINIMUM 3/8 ID HOSE FOR 40 TAPER MACHINES,
MINIMUM 1/2 ID HOSE FOR 50 TAPER & HS MACHINES.
AVOID QUICK DISCONNECTS IN SUPPLY LINES - THEY ARE RESTRICTIVE.

The tool changer is controlled with a single axis control mounted inside the control.

When a tool change operation is performed, the following sequence of events occurs:

1. Z axis moves to machine zero,
2. If the spindle is turning, it is commanded to stop,
3. Y moves to machine zero as spindle is oriented,
4. TSC pump turns off, (optional)
5. Y moves up to deposit the tool in the carousel,
6. Tool unclamps,
7. Carousel shuttles out,
8. Carousel rotates,
9. Carousel shuttles in,
10. Tool clamps,
11. Y moves to machine zero,
12. TSC pump turns on (optional)

Carousel Rotation Motor

A DC brush motor is used to rotate the carousel between tool changes. The motor has an encoder and is driven by the single axis control mounted inside the control.

NOTE: This motor should never be disassembled.

Tool Changer Position Switches

TOOL CHANGER IN/OUT SWITCHES

Two switches are used to sense the position of the tool changer carousel. One switch is activated when the carousel is moved full travel inward and one is activated when it is full travel outward. These switches are normally closed so that both will be closed between in and out. The diagnostic display will show this status of this input switch. A “1” indicates the associated switch is activated or open.

5.2 Tool Clamp/Unclamp

The tool holder draw bar is held clamped by spring pressure. Air pressure is used to release the tool clamp. When the tool is unclamped, air is directed down the center of the spindle to clear the taper of water, oil, or chips. Tool unclamp can be commanded from a program (but this is quite dangerous), or from the keyboard. The manual button only operates in MDI or JOG modes.

Tool Clamp/Unclamp Air Solenoids

A single solenoid controls the air pressure to release the tool clamp. This corresponds to relay K15. When the relay is activated, 115V AC is applied to the solenoid. This applies air pressure to release the tool. Relay K15 is on the I/O PCB. Circuit breaker CB4 will interrupt power to this solenoid.

Tool Clamp/Unclamp Sense Switches

There are two switches, located on the tool release piston assembly, that are used to sense the position of the tool clamping mechanism. They are both normally closed and one will activate at the end of travel during unclamping and the other during clamping. When both switches are closed, it indicates that the draw bar is between positions.

A tool change operation will wait until the unclamped switch is sensed before the Z-axis pulls back from the tool. This prevents any possibility of breaking the tool changer or its support mounts.

The diagnostic display can be used to display the status of the relay outputs and the switch inputs.

The Precharge and Through the Spindle Coolant system applies low air pressure and releases the clamped switch.

5.3 Spindle Operation

Spindle speed functions are controlled primarily by the **S** address code. The **S** address specifies RPM in integer values from 1 to maximum spindle speed (Parameter 131). NOT TO BE CHANGED BY USER! When using the Through the Spindle Coolant option, the maximum spindle speed is 7500 RPM for all spindles.

Speeds from S1 to the Parameter 142 value (usually 1200) will automatically select low gear and speeds above Parameter 142 will select high gear. Two **M** codes, M41 and M42 can be used to override the gear selection. M41 for low gear and M42 for high gear. Low gear operation above S1250 is not recommended. High gear operation below S100 may lack torque or speed accuracy. Spindle speed accuracy is best at the higher speeds and in low gear.

The spindle is hardened and ground to the precise tool holder dimensions providing an excellent fit to the holder.

Spindle Warm-Up Program

All spindles, which have been idle for more than 4 days, must be thermally cycled prior to operation above 6,000 RPM. This will prevent possible overheating of the spindle due to settling of lubrication. A 20-minute warm-up program has been supplied with the machine, which will bring the spindle up to speed slowly and allow the spindle to thermally stabilize. This program may also be used daily for spindle warm-up prior to high-speed use. The program number is O02020 (Spindle Warm-Up).

```
O02020 (Spindle Warm-Up)
S500M3;
G04 P200.;
S1000M3;
G04 P200.;
S2500M3;
G04 P200.;
S5000M3;
G04 P200.;
S7500M3;
G04 P200.;
S10000M3;
G04 P200.;
M30;
```

Spindle Run-In Program

All spindles must go through a run-in cycle at the time of machine installation prior to operating the spindle at speeds above 1,000 RPM. A program has been supplied with the machine that will run-in the spindle during machine installation and should also be used after long periods of machine down-time (two weeks or more). The program number is O02021 (Spindle Run-In). Cycle Time: 2 hours. See Installation Section for copy of the program.

These programs can be used for all spindle types. Adjust spindle speed override depending on maximum spindle speed of machine: Set override at 50% for 5,000 RPM machines; Set at 100% for 7,500 and 10,000 RPM machines; Set at 150% for 15,000 machines.

Spindle Orientation

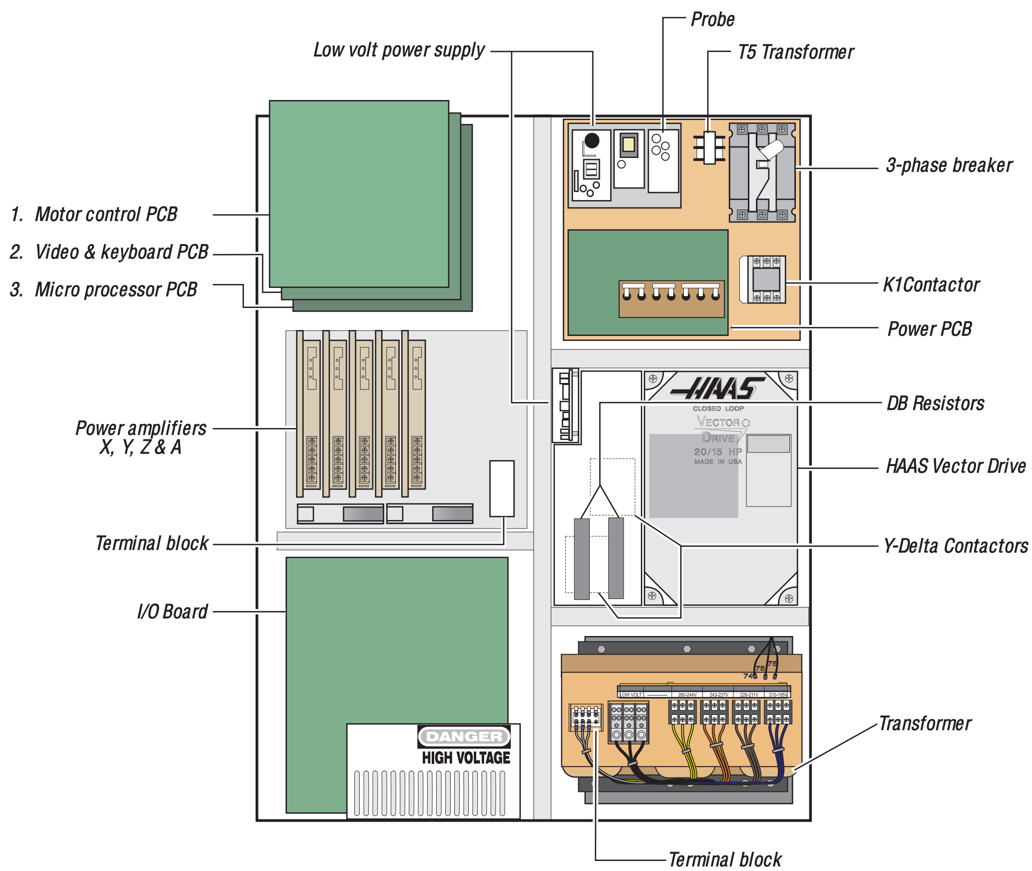
Orientation is performed electrically and no shot pin or solenoid is required for locking the motor in place. Orientation of the spindle is automatically performed for tool changes and can be programmed with M19 commands. Orientation is performed by turning the spindle until the encoder reference is reached , the spindle motor holds the spindle locked in position. If the spindle is orientated and locked, commanding spindle forward or reverse will release the lock.

Spindle Orientation Sequence

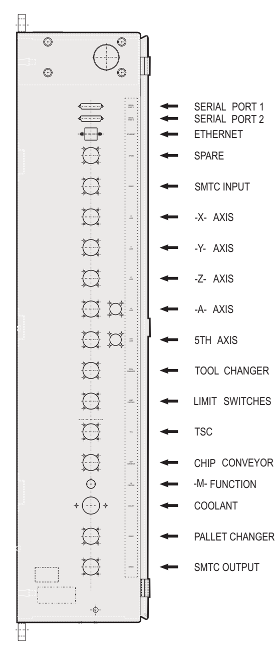
When spindle orientation is commanded, the following sequence of operations occurs:

1. If the spindle is turning, it is commanded to stop,
2. Pause until spindle is stopped,
3. Spindle orientation speed is commanded forward,
4. Pause until spindle is at orientation speed,
5. Spindle encoder rotates past a reference mark,
6. The spindle drive stops and holds the spindle position at a parameter distance from the reference mark,
7. Command spindle lock air solenoid active,
8. Pause until spindle locked status is active and stable,
9. If not locked after time-out time, alarm and stop.

5.4 Control Cabinet



Control cabinet general overview.



Connectors on side of control cabinet.

5.5 SERVOS (BRUSHLESS)

SERVO ENCODERS (BRUSHLESS)

Haas machines are equipped with brushless motors, which provide for better performance, and no maintenance. In addition to the performance differences, these machines differ from brush type machines, in the following areas:

The brushless motors have 8192 line encoders built in, which result in differences a resolution of 32768 parts per revolution.

The motor controller board has a dedicated processor which does all the servo control algorithm.

There is no servo distribution board, therefore there is no CHARGE light present. Care should still be taken however, since there are high voltages present on the amplifiers, even when power is shut off. The high voltage comes from the spindle drive, which does have a CHARGE light.

The servo drive cards are replaced by Brushless Servo Amplifiers, and are controlled differently.

A low voltage power supply card is added to the servo drive assembly to supply the low voltage requirement to the amplifiers.

The user interface and motion profiling have not changed, however, and the user should not see any functional differences between a brush type machine and a brushless machine.

SERVO AMPLIFIERS (BRUSHLESS)

NOTE: Refer to "Cable Locations" section for a diagram of the amplifiers.

The brushless servo amplifier is a PWM based current source. The PWM outputs control the current to a three phase brushless motor. The PWM frequency is either 12.5 KHz or 16 KHz. The amplifiers are current limited to 30 amps peak (45A peak for a medium amplifier). However there are fuse limits both in hardware and software to protect the amplifiers and motors from over current. The nominal voltage for these amplifiers is 320 volts. Therefore the peak power is about 9600 watts or 13 H.P. The amplifiers also have short circuit, over temperature and over voltage protection.

There is a 10 amp (20A for a medium amplifier) supply fuse for failure protection. This fuse is relatively slow, therefore it can handle the 30 amp peak. Actual continues current limit to the motor is controlled by software.

The user should never attempt to replace these fuses.

Commands to the amplifier are +/-5 volts current in two legs of the motor and a digital enable signal. A signal from the amplifier indicates drive fault or sustained high current in stalled motor.

The connectors on the amplifiers are:

+H.V.	+ 320 volts DC
-H.V.	320 volts return
A	motor lead phase A
B	motor lead phase B
C	motor lead phase C
J1	Three pin Molex connector used for +/-12 and GND.
J2	Eight pin Molex connector used for input signals.

5.6 Input/Output Assembly

The IOPCB contains a circuit for electronically turning the drawbar motors* power on and off. This prevents any arcing of the drawbar motor* relays and increases their life tremendously. This includes an adjustable current limit to the tool changer. Potentiometer R45 adjusts the current limit to the drawbar motors* motors. R45 should be set to limit current to between 9 and 11 amps.

The IOPCB also contains a circuit for sensing a ground fault condition of the servo power supply. If more than 1.75 amps is detected flowing through the grounding connection of the 160V DC buss, a ground fault alarm is generated and the control will turn off servos and stop.

Relay K6 is for the coolant pump 230V AC. It is a plug-in type and is double-pole. Relays K9 through K12 are also plug in types for controlling the drawbar motors*.

The Input/Output Assembly consists of a single printer circuit board called the IOPCB.

* Indicates HS-1RP and HS 2RP

5.7 Two-Speed Gear Transmission

The spindle head contains a two-speed gear transmission. The spindle motor is directly coupled to the transmission and the transmission is cog belt-coupled to the spindle.

Gear Box Lubrication

The transmission requires 5 quarts of Mobil DTE 25 oil. The level should be checked monthly with a dipstick (5 quarts = $4^{3}/_{4}$" deep).

The gear box uses an oil sump and is cooled by gear oil.

Gear Box Air Solenoids

There is a double solenoid valve controlling air to the gear box. This solenoid sends air to select either the high gear or the low gear. When power is removed from the solenoids, the valve remains in its last state. Air is always required to ensure the gears are held in either high or low gear. Circuit breaker CB4 will interrupt power to these solenoids. Power is left on the solenoid which is commanded last.

Gear Box Sense Switches

There are two switches in the gear box used to sense the position of the gears. One switch indicates HIGH by opening and the other indicates LOW by opening. Between gears, both switches are closed indicating a between-gear condition. The diagnostic display shows the status of these switches and the CURNT COMDS display shows which gear is selected. If the switches indicate that the gear box is between gears, the display will indicate "No Gear".

NOTE: The transmission high/low gear position switches are located at the bottom of the gearbox assembly and are extremely difficult to reach. Removal of this assembly is necessary to replace these switches.

Gear Change Sequence

When a gear change is performed, the following sequence of events occurs:

1. If the spindle is turning, it is commanded to stop,
2. Pause until spindle is stopped,
3. Gear change spindle speed is commanded forward,
4. Pause until spindle is at speed,
5. Command high or low gear solenoid active,
6. Pause until in new gear or reversal time,
7. Alarm and stop if max gear change time elapsed,
8. If not in new gear, reverse spindle direction,
9. Turn off high and low gear solenoids

5.8 Control Pendant

Jog Handle

The JOG handle is actually a 100-line-per-revolution encoder. We use 100 steps per revolution to move one of the servo axes. If no axis is selected for jogging, turning of the crank has no effect. When the axis being moved reaches its travel limits, the handle inputs will be ignored in the direction that would exceed the travel limits.

Parameter 57 can be used to reverse the direction of operation of the handle.

Power On/Off Switches

The POWER ON switch engages the main contactor. The on switch applies power to the contactor coil and the contactor thereafter maintains power to its coil. The POWER OFF switch interrupts power to the contactor coil and will always turn power off. POWER ON is a normally open switch and POWER OFF is normally closed. The maximum voltage on the POWER ON and POWER OFF switches is 24V AC and this voltage is present any time the main circuit breaker is on.

Spindle Load Meter

The load meter measures the load on the spindle motor as a percentage of the rated continuous power of the motor. There is a slight delay between a load and the actual reflection of the meter. The eighth A-to-D input also provides a measure of the spindle load for cutter wear detection. The second page of diagnostic data will display % of spindle load. The meter should agree with this display within 5%. The spindle drive display #7 should also agree with the load meter within 5%.

There are different types of spindle drive that are used in the control. They are all equivalent in performance but are adjusted differently.

Emergency Stop Switch

The EMERGENCY STOP switch is normally closed. If the switch opens or is broken, power to the servos will be removed instantly. This will also shut off the tool changer, spindle drive, and coolant pump. The EMERGENCY STOP switch will shut down motion even if the switch opens for as little 0.005 seconds.

Be careful of the fact that Parameter 57 contains a status switch that, if set, will cause the control to be powered down when EMERGENCY STOP is pressed.

You should not normally stop a tool change with EMERGENCY STOP as this will leave the tool changer in an abnormal position that takes special action to correct.

Note that tool changer alarms can be easily corrected by first correcting any mechanical problem, pressing RESET until the alarms are clear, selecting ZERO RETURN mode, and selecting “AUTO ALL AXES”.

If the tool changer should crash, the control will automatically come to an alarm state. To correct this, push the EMERGENCY STOP button. Push the RESET key to clear any alarms. Push the ZERO RETURN and the AUTO ALL AXES keys to reset the Z-axis and tool changer. Never put your hands near the tool changer when powered unless the EMERGENCY STOP button is pressed.

KEYBOARD BEEPER

There is a beeper inside the control panel that is used as an audible response to pressing keyboard buttons and as a warning beeper. The beeper is a 2.3 kHz signal that sounds for about 0.1 seconds when any keypad key, CYCLE START, or FEED HOLD is pressed. The beeper also sounds for longer periods when an auto-shut down is about to occur and when the “BEEP AT M30” setting is selected.

If the beeper is not audible when buttons are pressed, the problem could be in the keypad, keyboard interface PCB or in the beeper. Check that the problem occurs with more than one button and that the beeper volume control is not closed.

5.9 Microprocessor Assembly

The microprocessor assembly is in the rear cabinet at the top left position. It contains three large boards. They are: microprocessor, the keyboard and the MOCON. All three boards of the processor assembly receive power from the low voltage power supply. The three PCB's are interconnected by a local buss on dual 50-pin connectors. At power-on of the control, some diagnostic tests are performed on the processor assembly and any problems found will generate alarms 157 or 158. In addition, while the control is operating, it continually tests itself and a self test failure will generate Alarm 152.

Microprocessor PCB (68ECO30)

The Microprocessor PCB contains the 68ECO30 processor running at 40 MHz, one 128K EPROM; between 1MB and 16MB of CMOS RAM and betwen 512K and 1.5MB of FAST STATIC RAM. It also contains a dual serial port, a five year battery to backup RAM, buffering to the system buss, and eight system status LED's.

Two ports on this board are used to set the point at which an NMI* is generated during power down and the point at which RESET* is generated during power down.

The eight LED's are used to diagnose internal processor problems. As the system completes power up testing, the lights are turned on sequentially to indicate the completion of a step. The lights and meanings are:

+5V — **+5V logic power supply is present. (Normally On)**
If this light does not come on, check the low voltage power supply and check that all three phases of 230V input power are present.

HALT — **Processor halted in catastrophic fault. (Normally Off)**
If this light comes on, there is a serious problem with the processor PCB. Check that the EPROM is plugged in. Test the card with the buss connectors off.

POR — **Power-on-reset complete. (Normally On)**
If this light does not come on, there is a serious problem with the processor PCB. Check that the EPROM is plugged in. Test the card with the buss connectors off.

SIO — **Serial I/O initialization complete. (Normally On)**
If this light does not come on, there is a problem with the serial ports. Disconnect anything on the external RS-232 and test again.

MSG — **Power-on serial I/O message output complete. (Normally On)**
If this light does not come on, there is a problem with serial I/O or interrupts. Disconnect anything on the external RS-232 and test again.

CRT — **CRT/VIDEO initialization complete. (Normally On)**
If this light does not come on, there is a problem communicating with the VIDEO PCB. Check the buss connectors and ensure the VIDEO PCB is getting power.

PGM **Program signature found in memory. (Normally On)**
If this light does not come on, it means that the main CNC program package was not found in memory or that the auto-start switch was not set. Check that switch S1-1 is on and the EPROM is plugged in.

RUN **Program running without fault exception. (Normally On)**
If this light does not come on or goes out after coming on, there is a problem with the microprocessor or the software running in it. Check all of the buss connectors to the other two PCB's and ensure all three cards are getting power.

There 1 two-position DIP switch on the processor PCB labled S1. Switch S1-1 must be ON to auto-start the CNC operational program. If S1-1 is OFF, the PGM light will remain off.

Switch S2-1 is used to enable FLASH. If it is disabled it will not be possible to write to FLASH.

The processor connectors are:

J1	Address buss
J2	Data buss
J4	Serial port #1 (for upload/download/DNC) (850)
J5	Serial port #2 (for auxiliary 5th axis) (850A)
J3	Power connector
J6	Battery

Memory Retention Battery

The memory retention battery is initially soldered into the processor PCB. This is a 3.3V Lithium battery that maintains the contents of CMOS RAM during power off periods. Prior to this battery being unusable, an alarm will be generated indicating low battery. If the battery is replaced within 30 days, no data will be lost. The battery is not needed when the machine is powered on. Connector J6 on the processor PCB can be used to connect an external battery.

Video Keyboard with Floppy

The VIDEO and KB PCB generates the video data signals for the monitor and the scanning signals for the keyboard. In addition, the keyboard beeper is generated on this board. There is a single jumper on this board used to select inverse video. The video PCB connectors are:

P1	Power connector
J3	Keyboard (700)
J4	Address bus
J5	Data
J10	Floppy V+
J11	SPARE
J12	Floppy
J13	Video (760)
J14	RS422 B
J15	RS422 A

MOTOR CONTROLLER (MOCON) BRUSHLESS

The brushless machining centers are equipped with a microprocessor based brushless motor controller board (MOCON)that replaces the motor interface in the brush type controls. It runs in parallel with the main processor, receiving servo commands and closing the servo loop around the servo motors.

In addition to controlling the servos and detecting servo faults, the motor controller board (MOCON) is also in charge of processing discrete inputs, driving the I/O board relays, commanding the spindle and processing the jog handle input. Another significant feature is that it controls 6 axes, so there is no need for an additional board for a 5 axis machine.

5.10 Spindle Drive Assembly

The spindle drive is located in the main cabinet on the right side and halfway down. It operates from three-phase 200 to 240V AC. It has a 7.5 (or 10) H.P. continuous rating, and a 11.25 (or 15) H.P. one-minute rating. The spindle drive is protected by CB1 at 40 amps (20 for High Voltage option). Never work on the spindle drive until the small red CHARGE light goes out. Until this light goes out, there are dangerous voltages inside the drive, even when power is shut off.

For all other data on the spindle drive, refer to the documentation with your drive.

Haas Vector Drive

The Haas vector drive is a current amplifier controlled by the MOCON software, using the C axis output. The vector drive parameters are a part of the machine parameters and are accessible through the Haas front panel. The spindle encoder is used for the closed loop control and spindle orientation, as well as rigid tapping if the option is available. Spindle speed is very accurate, since this is a closed loop control, and the torque output at low speeds is to non vector drive spindles.

5.11 Resistor Assembly

The Resistor Assembly is located on top of the control cabinet. It contains the servo and spindle drive regen load resistors.

Spindle Drive Regen Resistor

A resistor bank is used by the spindle drive to dissipate excess power caused by the regenerative effects of decelerating the spindle motor. If the spindle motor is accelerated and decelerated again in rapid succession repeatedly, this resistor will get hot. In addition, if the line voltage into the control is above 255V, this resistor will begin to heat. This resistor is overtemp protected at 100^0 C. At that temperature, an alarm is generated and the control will begin an automatic shutdown. If the resistor is removed from the circuit, an alarm may subsequently occur because of an overvoltage condition inside the spindle drive. A functional resistor will have a reading of 8 ohms.

Servo Drive Regen Resistor (brush motors only)

A 25-ohm, 300-watt resistor bank is used by the servo drives to dissipate excess power caused by the regenerative effects of decelerating the servo motors. If the servo motors are accelerated and decelerated again in rapid succession repeatedly, this resistor will get hot. In addition, if the line voltage into the control is above 255V, this resistor will begin to heat. This resistor is overtemp protected at 100^0 C. At that temperature, an automatic control shutdown is begun. If that resistor is removed from the circuit, an alarm may subsequently occur because of an overvoltage condition for the servo buss.

Overheat Sense Switch

There is an overtemperature sense switch mounted near the above-mentioned regen resistors. This sensor is a normally-closed switch that opens at about 100^0 C. It will generate an alarm and all motion will stop. After the time period, specified ny parameter 297, of an overheat condition, an automatic shutdown will occur in the control.

5.12 Power Supply Assembly

All power to the control passes through the power supply assembly. It is located on the upper right corner of the control cabinet.

Main Circuit Breaker CB1

Circuit breaker CB1 is rated at 40 amps (20 for High Voltage option) and is used to protect the spindle drive and to shut off all power to the control. The locking On/Off handle on the outside of the control cabinet will shut this breaker off when it is unlocked. A trip of this breaker indicates a SERIOUS overload problem and should not be reset without investigating the cause of the trip. The full circuit breaker rating corresponds to as much as 15 horsepower.

CIRCUIT BREAKER (CB1) AMP RATING		
HP RATING	195-260 VAC	354-488 VAC
20 - 15	40 AMP	20 AMP
40 - 30	80 AMP	40 AMP

Main Contactor K1

Main contactor K1 is used to turn the control on and off. The POWER ON switch applies power to the coil of K1 and after it is energized, auxiliary contacts on K1 continues to apply power to the coil. The POWER OFF switch on the front panel will always remove power from this contactor.

When the main contactor is off, the only power used by the control is supplied through two ½ amp fuses to the circuit that activates the contactor. An overvoltage or lightning strike will blow these fuses and shut off the main contactor.

The power to operate the main contactor is supplied from a 24V AC control transformer that is primary fused at ½ amp. This ensures that the only circuit powered when the machine is turned off is this transformer and only low voltage is present at the front panel on/off switches.

Low Voltage Power Supply

The low voltage power supply provides +5V DC, +12V DC, and -12V DC to all of the logic sections of the control. It operates from 115V AC nominal input power. It will continue to operate correctly over a 90V AC to 133V AC range.

POWER PCB (PSUP)

The low voltage power distribution and high voltage fuses and circuit breakers are mounted on a circuit board called the POWER PCB.

POWER-UP LOW VOLTAGE CONTROL TRANSFORMER (T5)

The low voltage control transformer, T5, supplies power to the coil of the main contactor K1. It guarantees that the maximum voltage leaving the Power Supply assembly when power is off is 12V AC to earth ground. It is connected via P5 to the POWER PCB.

SECONDARY CIRCUIT BREAKERS

The following circuit breakers are located on the Power supply assembly:

CB2 Controls the 115 V power from the main transformer to the servo transformers and, if tripped, will turn off the servo motors and air solenoids. CB2 could be blown by a severe servo overload.

CB3 Controls the power to coolant pump only. It can be blown by an overload of the coolant pump motor or a short in the wiring to the motor.

CB5 Controls power to the TSC coolant pump only. It can be tripped by an overload of the TSC coolant pump motor or a short in the wiring to the motor.

CB6 Is a single phase 115V protected output for the user.

OPERATOR'S WORK LIGHT

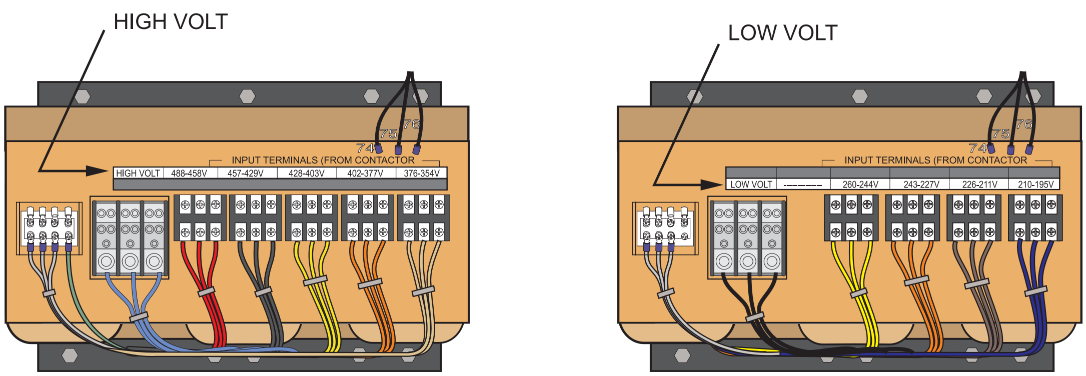
Main transformer (T1) outputs 115 VAC to the work light.

5.13 Power Transformer Assembly (T1)

The power transformer assembly is used to convert three-phase input power (50/60Hz) to three phase 230V and 115V power. Two different transformers are used depending on the input voltage range. The low voltage transformer has four different input connections to allow for a range of voltages from 195 V RMS to 260 V RMS. The high voltage transformer has five different input connections and will accept a range of voltages from 354V RMS to 488 V RMS.

The 230 V is used to power the spindle drive, which also develops the 325 VDC power for the axis servo amplifiers. The 115 V is used by the video monitor, solenoids, fans and pumps, in addition to supplying power to the main LVPS used by the control electronics.

The transformer assembly is located in the lower right hand corner of the main cabinet. Besides the high/low voltage variations, two different power levels are available depending on the spindle motor used. The small and large transformers have power ratings of 14 KVA and 28 KVA, respectively. They are protected by the main circuit breaker to the levels shown in the preceding table.



Polyphase bank transformer.

Primary Connection To T1

Input power to T1 is supplied through CB1, the 40 amp three-phase main circuit breaker. Three-phase 230 to T1 is connected to the first three terminals of TB10.

Voltage Selection Taps

There are four labeled plastic terminal blocks. Each block has three connections for wires labeled 74, 75, and 76. Follow the instructions printed on the transformer.

Secondary Connection To T1

The secondary output from T1 is 115V AC three-phase CB2 protects the secondary of transformer T1 and is rated at 25 amps.

Optional 480V 60Hz Transformer

All machines will get the 45KVA transformer.

For domestic installations and all others using 60Hz power, the primary side should be wired as follows:

Input Voltage Range	Tap
493-510	1 (504)
481-492	2 (492)
469-480	3 (480)
457-468	4 (468)
445-456	5 (456)
433-444	6 (444)
420-432	7 (432)

Optional 480V 50Hz Transformer

Input Voltage Range	Tap
423-440	1 (504)
412-422	2 (492)
401-411	3 (480)
391-400	4 (468)
381-390	5 (456)
371-380	6 (444)
355-370	7 (432)

5.14 Fuses

The brushless amplifier has one fuse, F1 15 amps. This fuse protects the amplifier itself from drastic damage. If this fuse is ever blown, the associated motor will stop. This will only happen if there is a failure of the amplifier card. **The user should never attempt to replace these fuses.**

The POWER PCB contains three ½-amp fuses located at the top right (FU1, FU2, FU3). If the machine is subject to a severe overvoltage or a lightning strike, these fuses will blow and turn off all of the power. Replace these fuses only with the same type and ratings.

FU 4, 5 and 5A protect the chip conveyor (FU6 is only used with 3 phase motors). FU7-12 are ultra fast 20A fuses. They will only blow in the case of cable short for either the TSC or the coolant pump. Spare fuses for the power card are located above the breakers on the spare fuse PCB.

SIZE	FUSE NAME	TYPE	RATING (amps)	VOLTAGE	LOCATION
5mm	FU1	Slo-Blo	½	250V	PSUP pcb, upper right
5mm	FU2	AGC	½	250V	" "
5mm	FU3	AGC	½	250V	" "
1/4	FU1	Ultra fast	10	250V	I/O PCB
1/4	F1	Ultra fast	15	250V	Amplifier (X,Y,Z,A,B)
5mm	FU4,5	Fast blow	5A	250V	PSUP, bottom right corner
1/4	FU7-12	Ultra fast	20A	250V	PSUP, bottom

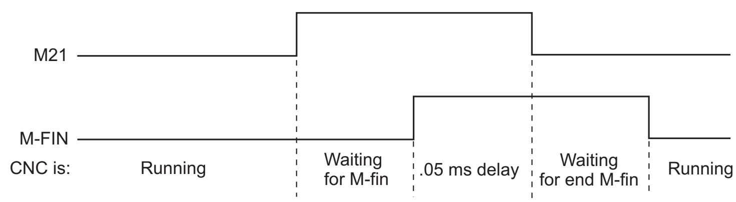
FU2 on the IOPCB is a spare.

5.15 Spare User M code Interface

The M code interface uses outputs M21-25 and one discrete input circuit. M codes M21 through M25 will activate relays labeled M21-25. These relay contacts are isolated from all other circuits and may switch up to 120V AC at three amps. The relays are SPDT. **WARNING!** Power circuits and inductive loads must have snubber protection.

The M-FIN circuit is a normally open circuit that is made active by bringing it to ground. The one M-FIN applies to all of the user M codes.

The timing of a user M function must begin with all circuits inactive, that is, all circuits open. The timing is as follows:



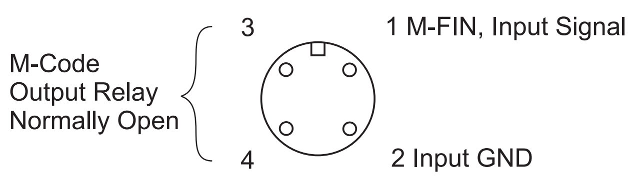
The Diagnostic Data display page may be used to observe the state of these signals.

NOTE: See the 8M option section for more details.

M Function Relays

The M code relay board has five relays (M21-25) that may be available to the user. M21 is already wired out to P12 at the side of the control cabinet. This is a four-pin DIN connector and includes the M-FIN signal.

NOTE: Refer to the Diagnostic section in the manual for specific machine Inputs and Outputs.



NOTE: Some or all of the M21-25 on the I/O PCB may be used for factory installed options. Inspect the relays for existing wires to determine which have been used. Contact the Haas factory for more details.

M-FIN Discrete Input

The M-FIN discrete input is a low voltage circuit. When the circuit is open, there is +12V DC at this signal. When this line is brought to ground, there will be about 10 milliamps of current. M-FIN is discrete input #10 and is wired from input #10 on the I/O PCB. The return line for grounding the circuit should also be picked up from that PCB. For reliability, these two wires should be routed in a shielded cable where the shield is grounded at one end only. The diagnostic display will show this signal a "1" when the circuit is open and a "0" when this circuit is grounded.

Turning M Functions On And Off

The M code relays can also be separately turned on and off using M codes M51-M55 and M61-M65. M51 to M55 will turn on one of the eight relays and M61 to M65 will turn the relays off. M51 and M61 correspond to M21, etc.

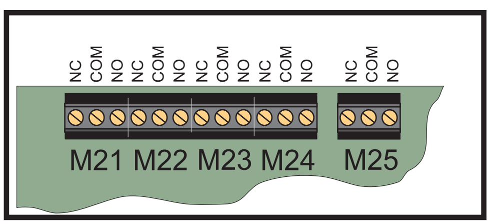
NOTE: Refer to the Diagnostic section in the manual for specific machine Inputs and Outputs.

Wiring the Relays

The relays are marked on the IOPCB, with their respective terminals forward of them. If the optional 8M relay board is installed then the connections on the IOPCB are to be left unused as they are replaced by the relays on the optional board. Refer to the figure, and the Probe Option figure in the Electrical Diagrams section for the terminal labeling.

WARNING!

Power circuits and inductive loads must have snubber protection.



IOPCB Relays

CAUTION! If a screw terminal is already in use **DO NOT** connect anything else to it. Call you dealer.

5.16 Lubrication System

The lubrication system is a resistance type system which forces oil through metering units at each of the 16 lubricating points within the machine. The system uses one metering unit at each of the lubricating points: one for each linear guide pad, one for each lead screw and one for spindle lubrication. A single oil pump is used to lubricate the system. The pump is powered only when the spindle and/or an axis moves. Once powered the pump cycles approximately 3.0 cc of oil every 30 minutes throughout the oil lines to the lube points. Every lube point receives approximately 1/16 of oil. The control monitors this system through an internal level switch in the reservoir and and external pressure switch on the lube panel.

Low Lubrication and Low Pressure Sense Switches

There is a low lube sense switch in the oil tank. When the oil is low, an alarm will be generated. This alarm will not occur until the end of a program is reached. There is also an lube pressure switch that senses the lube pressure. Parameter 117 controls the lube pressure check. If Parameter 117 is not zero, the lube pressure is checked for cycling high within that period. Parameter 117 has units of 1/50 seconds; so 30 minutes gives a value of 108000. Parameter 57, bit "Oiler on/off", indicates the lube pump is only powered when the spindle fan is powered. The lube pressure is only checked when the pump is on.

5.17 Switches

Door Open Sense Switch

The DOOR OPEN sense switch is a magnetic reed switch type and consists of two switches; one on each half of the enclosure front doors. These switches are normally closed and wired in series. When the doors open, one or both of these switches will open and the machine will stop with a “Door Hold” function. When the door is closed again, operation will continue normally.

Each side door also has a limit switch. When open, these switches will also stop the machine with a "Door Hold" function.

If the doors are open, you will not be able to start a program. Door Hold will not stop a tool change operation or a tapping operation, and will not turn off the coolant pump. Also, if the doors are open, the spindle speed will be limited to 750 RPM.

The Door Hold function can be temporarily disabled with by turning Setting 51 **on**, if Parameter 57 bits DOOR STOP SP and SAFETY CIRC are set to zero, but this setting will return to OFF when the control is turned off.

Limit Switches

NOTE: There are many limit switches located on the Horizontal mill, and some are difficult to reach. There are also seven (7) limit switches associated with the pallet changer. Ensure the problem is the switch *before* beginning removal procedures. The following is a list of all X, Y, and Z switches, their general location, and a functional description:

X, Y, Z TRAVEL LIMIT SWITCHES

X - Left side of saddle by X-axis motor
Y - Top of column by Y-axis motor
Z - Rear of base by Z-axis motor

The machine zero position is defined by a limit switch for each of the X, Y, and Z axes. After the search for machine zero has been completed, these switches are used to limit travel in the positive direction. In addition, travel in the negative direction is limited by stored stroke limits. It is not normally possible to command the servo axes past the machine zero as servo travel lookahead will decelerate and stop each motor prior to exceeding the stroke limits. All limit switches are wired through connector P5 on the side of the control cabinet. P5 also contains the wiring to the lubrication pump and an alternate connection to the DOOR OPEN switches.

Prior to performing an AUTO ALL AXES operation, there are no travel limits. Thus, you can jog into the hard stops in either direction for X, Y, or Z. After a ZERO RETURN has been performed, the travel limits will operate unless an axis hits the limit switch. When the limit switch is hit, the zero returned condition is reset and an AUTO ALL AXES must be done again. This is to ensure that if you hit the limit switch, you can still move the servo back away from it.

The limit switches are normally closed. When a search for zero operation is being performed, the X, Y, and Z axes will move towards the limit switch unless it is already active (open); then they will move away from the switch until it closes again; then they will continue to move until the encoder Z channel is found. This position is machine zero.

What Can Go Wrong With Limit Switches?

If the machine is operated without connector P5, a LOW LUBE and DOOR OPEN alarm will be generated. In addition, the Home search will not stop at the limit switch and will instead run into the physical stops on each axis.

If the switch is damaged and permanently open, the zero search for that axis will move in the negative direction at about 0.5 in/min until it reaches the physical travel stops at the opposite end of travel.

If the switch is damaged and permanently closed, the zero search for that axis will move at about 10 in/min in the positive direction until it reaches the physical stops.

If the switch opens or a wire breaks after the zero search completes, an alarm is generated, the servos are turned off, and all motion stops. The control will operate as though the zero search was never performed. The RESET can be used to turn servos on but you can jog that axis only slowly.

5.18 Y-Axis Brake Motor

The servo brake motor compensates for the weight of the spindle head on machines without a counterbalance. The brake is released when the servo motors are activated, however the disk brake engagement spline may produce a small noise when the head is in motion, **this is normal**.

A parameters governs the ability of the brake motor, therefore mills **without** counterbalances must have parameter 25, Y-Axis Torque Preload, set correctly. Check the parameters sections for the correct value.

5.19 Hydraulic Counterbalance

The spindle head weight is balanced by the upward pull of a hydraulic cylinder. The hydraulic oil forces the piston to retract into the cylinder body. The oil is then pressurized by a nitrogen resevoir. The system is self contained and passive (no pump is required to maintain the lift). Normal Y-axis of the gas/oil counter balance has the initial pressure to balance the weight at full system volume, plus an additional 50-75 psi overcharge for longevity.

The CNC controls senses a normally closed status from the hydraulic counterbalance at all times. If this switch opens for any reason the control will alarm as an E-Stop.

5.20 Pallet Changer for the HS-1

Rotary Table (HRT310HRPA)

The rotary table is a standard HAAS 310 equipped with a special platter compatible with the pallet operation. The table is mounted on the pallet changer casting, and a drive shaft bearing assembly is inserted into its spindle (on the brake side). A nut housing is inserted into spindle of the table (on the platter side), and an air blast manifold is mounted onto the table platter.

Main Drawbar Assembly

The main drawbar's primary function is to hold the pallet tightly to the rotary table. On older machines (S/N 50477 and earlier), the main drawbar is rotated by the drawbar drive assembly so that it screws into the pallet nut of the pallet, securing it to the table. It also provides a path for lubrication to the threads of the main drawbar and pallet nut, and a flowpath for the air blast from beneath the rotary table to the working area of the machine. The main drawbar assembly consists of five components: the main drawbar, air blast tube, air blast plug, lubrication tube, and a retaining clip. The main drawbar, air blast tube, and air blast plug are pressed together, and the lubrication tube is inserted through the drawbar and held in place by the retaining clip.

Mounted beneath the rotary table is a bracket that mounts the lube tube adaptor. The lubrication for the drawbar and the supply for the air blast both enter the drawbar assembly through the lube tube adaptor. Oil from the lube oil system fills the lower part of the air blast plug, which is attached to the bottom of the drawbar assembly. The lubrication tube extends into the air blast plug, below the level of the oil. When a pallet change is performed, the air blast system is activated, and oil is forced up the lubrication tube as a mist. The main volume of the air blast, however, is directed up the air blast tube around the outside of the lubrication tube, to the drawbar. The air is then directed from the interior of the drawbar, through the nut housing, and into the air blast manifold.

Main Drawbar Drive Assembly

The drawbar drive assembly provides the torque required to clamp and unclamp the pallet to the rotary table platter. The system includes a gearmotor, a drive pulley, a drive belt, and a drive shaft/driven pulley. The gearmotor turns a drive pulley, which drives the belt. This belt drives the pulley on the drive shaft of the main drawbar. The torque is transferred to the main drawbar from the drive shaft by means of a splined interface. The drawbar is then either raised or lowered through the floating nut, which is in the nut housing assembly. A one-way slip clutch pulley prevents the drawbar from overtightening into the pallet nut. This clutch allows a preset torque to be acheived when tightening the drawbar, and assures the ability of the system to free itself on command of a pallet change. If the drawbar were to be overtightened, no damage to either component would occur; unless it was left in this condition for too long, where it may become so tightly engaged that the system may not be able to free itself.

NOTE: Refer to the Diagnostic section in the manual for specific switch status and other machine Inputs and Outputs.

Air Blast System

The main components of the air blast system are the lube tube adaptor and air blast manifold. The air blast system, along with the chip shroud, keeps metal chips from accumulating at the rotary table pallet locating pins and the H-frame locating pins, ensuring the pallets will be able to rest squarely on these pins.

The air blast moves up the center of the drawbar assembly, and into the nut housing. The air then moves into the air blast manifold, where it is directed to the rotary table pallet locating pins.

Lifting Assembly

The pallet lifting assembly consists of a large guided pneumatic cylinder and an H-frame. Pins are mounted in the H-frame to engage the pallets from below and to give aid in stabilizing the load during rotation of the pallets. The H-frame itself is attached to the top of the lifting cylinder in order to lift and lower the load. The rotation pinion is mounted on the lifting cylinder (near the bottom), and interlock pins are attached to the bottom of the pinion. These pins are intended as a protective feature, as well as a means to trip the two switches that sense the lift cylinder up or down position.

NOTE: Refer to the Diagnostic section in the manual for specific switch status and other machine Inputs and Outputs.

Weight Recommendation for the HS-2RP

NOTE: The HS-1RP does not have a Maximum Weight Difference. A weight differential up to the maximum weight will not cause operational problems.

ROTATION / RACK ASSEMBLY

The rotation/rack assembly provides the motive force to rotate the pallets clockwise and counter clockwise during the pallet change sequence. A rack is attached a double-acting pneumatic cylinder, and engages the pinion of the lifting cylinder assembly. The pneumatic cylinders are mounted to a support plate, so when this rod extends, the rack exerts a force on the pinion and causes rotation of the lifting cylinder. The rack moves along a V-guide assembly, consisting of rollers on V-guides. A switch is mounted at each end of the V-guide support bar, to sense the rotational position of the pallet changer after a pallet change sequence. A check valve/orifice restrictor assembly located on each cylinder put along with precharging the cylinder limits erratic motion and excessive speed of the H-Frame.

NOTE: Refer to the Diagnostic section in the manual for specific switch status and other machine Inputs and Outputs.

LOAD STATION

NOTE: This only applies to machines with serial numbers up to 50477.

The load station is a 90 degree manual indexing station that holds a pallet securely into place while maintaining the ability to index freely. The load station holds the pallet by means of two large pins that engage the pallet bottom. A manual indexing handle withdraws an indexing pin from the load station, which makes it possible to rotate the turntable (and the load) by hand. Four positions are available, at 90 degree increments, and at each increment the indexing pin will lock into position.

NOTE: Refer to the Diagnostic section in the manual for specific switch status and other machine Inputs and Outputs.

PALLET CHANGER SWITCHES

The pallet changer uses nine (9) switches to provide feedback for the pallet change sequence.

NOTE: Refer to the Diagnostic section in the manual for specific switch status and other machine Inputs and Outputs.

MAIN DRAWBAR UP/DOWN SWITCHES

[Switch bracket beneath rotary table (2)]
The main drawbar has two switches that sense drawbar position. The Drawbar ‘up’ switch is tripped when the Drawbar assembly is unclamped (ready to recieve or release the pullstud). The Drawbar ‘down’ switch is only tripped if the pallet is lowered onto a Drawbar assembly that has sticky balls. H-Frame misalignment, excessive debris, or worn pullstuds will also cause the Drawbar ‘down’ switch to trip. The switches are actuated directly by the drawbar.

PALLET UP/DOWN SWITCHES

[Switch bracket on lifting assembly mounting plate (2)]
The lift cylinder has two switches that sense the cylinder lifted position (pallet up) or cylinder lowered position (pallet down). Both switches are tripped when the cylinder is in the lowered position, and both switches are not tripped when the cylinder is in the lifted position. The switches are directly actuated by the two interlock pins on the rotation pinion.

On machines S/N 50477 and earlier, rotary pallet drawbar up will always be a "1" and will not change.

CW/CCW SWITCHES

[V-guide support bar (2)]
The rack has two switches, one to sense full clockwise rotation, and one to sense full counterclockwise rotation. The switches are mounted on the V-guide support bar, and are actuated by two trip brackets mounted at each end of the rack.

LOAD STATION LOCKED LIMIT SWITCH

[Base of indexing handle (1)]
The load station has a switch to sense proper orientation of the load station, which is required before a pallet change will be permitted to occur.

Power Supply Cables

The load station drawbar gearmotor and the main drawbar gearmotor each have a power supply cable. The load station motor is equipped with an extension cable to aid in motor replacement. The connector is about 12 inches from the gearmotor. Both power supplies are routed to their respective mounting locations from the central point of the solenoid mounting bracket (at the rear of the machine), where the disconnects are located.

Air Supply Lines

The lifting cylinder has one large air supply line for lifting the pallets and their loads. No return line is required because the cylinder is vented to the atmosphere and the weight of the assembly and load will cause the cylinder to lower.

The rotation cylinder is double-acting and has two smaller air supply lines for clockwise and counterclockwise rotation.

The air blast system has one large air supply line, which is connected to the lube tube adapter.

Each of the four air supply lines are routed to the solenoid mounting bracket (at the rear of the Horizontal), where the air solenoid assembly is located. Four solenoid valves are used to provide the responses required for the pallet change operation.

Lubrication Supply Lines

An oil supply line from the lube/air panel (on the right side of the machine) attaches to the lube tube adaptor. It provides lubrication to the rotary table drawbar, which carries oil mist from the air blast plug up the center of the main drawbar, to the drawbar and pallet nut.

5.21 DIAGNOSTIC DATA

The ALARM MSGS display is the most important source of diagnostic data. At any time after the machine completes its power-up sequence, it will either perform a requested function or stop with an alarm. Refer to the Alarms section for a complete list of alarms, their possible causes, and some corrective action.

If there is an electronics problem, the controller may not complete the power-up sequence and the CRT will remain blank. In this case, there are two sources of diagnostic data; these are the audible beeper and the LED's on the processor PCB. If the audible beeper is alternating a ½ second beep, there is a problem with the main control program stored in EPROM's on the processor PCB. If any of the processor electronics cannot be accessed correctly, the LED's on the processor PCB will or will not be lit.

If the machine powers up but has a fault in one of its power supplies, it may not be possible to flag an alarm condition. If this happens, all motors will be kept off and the top left corner of the CRT will have the message "POWER FAILURE ALARM", and all other functions of the control will be locked out.

DISCRETE INPUTS / OUTPUTS

When the machine is operating normally, a second push of the **PARAM/DGNOS** key will select the diagnostics display page. The PAGE UP and PAGE DOWN keys are then used to select one of two different displays. These are for diagnostic purposes only and the user will not normally need them. The diagnostic data consists of 32 discrete input signals, 32 discrete output relays and several internal control signals. Each can have the value of 0 or 1. In addition, there are up to three analog data displays and an optional spindle RPM display. Their number and functions are listed below.

NOTE: Inputs/Outputs that are **BOLD** pertain only to the pallet changer.

The inputs/outputs that are followed by an asterick (*) are active when equal to zero (0).

DISCRETE INPUT

#	Name	#	Name
1000	TC Changer In	1016	Spare
1001	TC Changer Out	1017	Spare
1002	R.P. Drawbar Dn.	1018	Spare
1003	Low TSC Pressure	1019	Spare
1004	R.P. Collet Down	1020	Low Trans Oil Prs
1005	Spindle Hi Gear	1021	Tool Door Open*
1006	Spindle Low Gear	1022	Rotary Pallet CW
1007	Emergency Stop	1023	Rotary Pallet CCW
1008	Door Switch	1024	Oper. Sta Locked
1009	M Code Finish*	1025	Low Phasing 115V
1010	Over Voltage	1026	Rotary Pallet Up
1011	Low Air Pressure	1027	Rotary Pallet Dn
1012	Low Lube Press	1028	Ground Fault
1013	Regen. Over Heat	1029	G31 Block Skip
1014	Draw Bar Open	1030	Spigot Position
1015	Draw Bar Closed	1031	Conveyr Overcrnt

DISCRETE OUTPUTS

#	Name	#	Name
1100	Power Servos	1120	Unclamp Pre-Chrg
1101	Spare	1121	HTC Shuttle Out
1102	Spare	1122	Rotary Pallet Up
1103	Spare	1123	CE Door Lock
1104	Brake 4th Axis	1124	R.P. Main DB Enabl
1105	Coolant Pump On	1125	R.P. Oper DB Enabl
1106	Auto Power Off	1126	Air Door
1107	Spind. Motor Fan	1127	TSC Coolant
1108	R.P. Main Clamp	1128	Green Beacon On
1109	R.P. Main Unclamp	1129	Red Beacon On
1110	R.P. Sta. Clamp	1130	Enable Conveyor
1111	R.P. Sta. Unclamp	1131	Reverse Conveyor
1112	Spindle Hi Gear	1132	M-fin
1113	Spindle Low Gear	1133	Probe
1114	Unclamp Tool	1134	spare
1115	Spare	1135	Beeper
1116	Move Spigot CW	1136	Pallet CW
1117	Move Spigot CCW	1137	Pallet CCW
1118	R.P. Ready Light	1138	Air Blast
1119	TSC Purge	1139	spare

1110	RPOCLA	*SHUTTLE IN	1121 HTC SH	*NOT USED
1111	RPOUNC	*SHUTTLE OUT		

* Specified **DISCRETE OUTPUTS** for **HS-2RP** Machine

The inputs are numbered the same as the connections on the inputs printed circuit board.

The following eight discrete outputs are present on the HS-1RP only, which is equipped with the M-Code relay board, and are displayed on page 3 of the Diagnostics display.

Name	Description	Name	Description
M21	spare	RP CW	Pallet Rotate CW
M22	spare	RP CCW	Pallet Rotate CCW
M23	spare	RPAIRB	Air blast
RPWARN	Audible alarm	M28	spare

The second page of diagnostic data is displayed using the PAGE UP and PAGE DOWN keys. It contains:

INPUTS 2

Name	Name	Name
X Axis Z Channel	X Over heat	X Cable Input
Y Axis Z Channel	Y Over heat	Y Cable Input
Z Axis Z Channel	Z Over heat	Z Cable Input
A Axis Z Channel	A Over heat	A Cable Input
B Axis Z Channel	B Over heat	B Cable Input
X Home Switch	X Drive Fault	Spindle Z Channel
Y Home Switch	Y Drive Fault	
Z Home Switch	Z Drive Fault	
A Home Switch	A Drive Fault	
B Home Switch	B Drive Fault	

The following inputs and outputs pertain to the Haas Vector Drive. If it is not enabled, these will display a value of *. Otherwise, it will display a 1 or 0.

Spindle Forward
Spindle Reverse
Spindle Lock
Spindle at Speed*
Spindle Stopped*
Spindle Fault
Spindle Locked
Spindle Over heat
Spindle Cable Fault

The following Discrete Inputs / Outputs 2 are available when parameter 278 SMNT BIT 1,2 or 3 (Side Mount Tool Changer) is set and parameter 209 MCD RLY BRN (M-Code relay board) is ON

DISCRETE INPUTS 2

Name	Name
Spare Input 4A	Spare Input 8A
Spare Input 4B	Serp. Shot Pin*
Spare Input 5A	Motor Stop
Spare Input 15B	Origin
Spare Input 6A	Clamp / Unclamp
Spare Input 6B	Serp. Cam Count
Spare Input 7A	Spare Input 11A
Spare Input 7B	Spare Input 11 B

DISCRETE OUTPUTS 2

Name	Name
Spare Output 32	Spare Output 48
Spare Output 33	Spare Output 49
Spare Output 34	Spare Output 50
Rot.Pal. Beeper	Spare Output 51
Move Rot Pal CW	Spare Output 52
Move Rot Pal CCW	Spare Output 53
R.P. Air Blast	Spare Output 54
Spare Output 39	Spare Output 55
M21	
M22	
M23	
M24	
M25	
M26	
M27	
M28	

ANALOG DATA

Name	Description
DC BUSS	Voltage from Haas Vector Drive (if equipped)
uP TEMP	Microprocessor enclosure temperature (dis played only when Parameter 278 bit "uP ENCL TEMP" is set to 1)
SP LOAD	Spindle load in %
SP SPEED	Spindle RPM CW or CCW
RUN TIME	Machine total run time
TOOL CHANGES	Number of tool changes
VER X.XXX	Software version number
MOCON	MOCON software version
YY/MM/DD	Today's date
MDL HS__	Machine model

Num	Circuit #	IOPCB	MACHINES BEFORE #50149 (EXCEPT #50132 AND #50139)					MACHINE W/HAAS VECTOR DRIVE		
			HS-1 NO Air Door NO Tsc	**HS-1 W/Air Door NO Tsc**	**HS-1 W/Air Door W/Tsc**	**HS-1RP NO Air Door NO Tsc**	**HS-1RP W/Air Door NO Tsc**	**HS-1RP W/Air Door W/Tsc**	**HS-1/R**	**HS-1RP**
1000	820	P13	TC In	TC In	TC In	TC In	TC In	TC In	TC In	TC In
1001	820	P13	TC Out	TC Out	TC Out	TC Out	TC Out	TC Out	TC Out	TC Out
1002	820	P13	spare *	spare *	spare *	spare *	spare *	1 DB Down	spare *	1 DB Down
1003	900	P14	spare *	spare *	2 Lo Clnt	1 DB Down	1 DB Down	2 Lo Clnt	2 Lo Clnt	2 Lo Clnt
1004	820	P13	spare *	spare *	spare *	spare *	spare *	spare *	spare *	1 DB up
1005	890	P15	spare *	spare *	spare *	spare *	spare *	spare *	4 High Gear	4 High Gear
1006	890	P15	spare *	spare *	spare *	spare *	spare *	spare *	4 Low Gear	4 Low Gear
1007	770	P16	E-Stop	E-Stop	E-Stop	E-Stop	E-Stop	E-Stop	E-Stop	E-Stop
1008	1050	P38	Side Door Open	Side Door Open	Side Door Open	Side Door Open	Side Door Open	Side Door Open	Door Open	Door Open
1009	100	P22	M-Fin	M-Fin	M-Fin	M-Fin	M-Fin	M-Fin	M-Fin	M-Fin
1010	970	P18	Over Volt	Over Volt	Over Volt	Over Volt	Over Volt	Over Volt	Over Volt	Over Volt
1011	950	P19	Low Air	Low Air	Low Air	Low Air	Low Air	Low Air	Low Air	Low Air
1012	950	P19	Low Lube	Low Lube	Low Lube	Low Lube	Low Lube	Low Lube	Low Lube	Low Lube
1013	830	P20	Overheat	Overheat	Overheat	Overheat	Overheat	Overheat	Overheat	Overheat
1014	890	P15	SP DB Open	SP DB Open	SP DB Open	SP DB Open	SP DB Open	SP DB Open	Spare	Spare
1015	890	P15	SP DB Closed	SP DB Closed	SP DB Closed	SP DB Closed	SP DB Closed	SP DB Closed	Spare	Spare
1016	890	P15	SP Locked	SP Locked	SP Locked	Spare	Spare	Spare	Spare	Spare
1017	780	P21	SP Drive Fault	SP Drive Fault	SP Drive Fault	Spare	Spare	Spare	Spare	Spare
1018	780	P21	SP Stopped	SP Stopped	SP Stopped	Spare	Spare	Spare	SP Stopped	SP Door Open
1019	780	P21	SP At Speed	SP At Speed	SP At Speed	Spare	Spare	Spare	SP At Speed	SP DB CLS
1020	960	P17	spare *	spare *	spare *	Spare	Low Oil	Low Oil	4 Low Oil	4 Low Oil
1021	410	P52	Front Door Open	Front Door Open	Front Door Open	TC Door Open	TC Door Open	TC Door Open	TC Door Open	TC Door Open
1022	790	P24	spare *	spare *	spare *	1 Pallet CW	1 Pallet CW	1 Pallet CW	spare *	1 Pallet CW
1023	790	P24	spare *	spare *	spare *	1 Pallet CCW	1 Pallet CCW	1 Pallet CCW	spare *	1 Pallet CCW
1024	190	P23	spare *	spare *	spare *	1 Operator station locked	1 Operator station locked	1 Operator station locked	spare *	1 Operator station locked
1025			Lo Phase	Lo Phase	Lo Phase	Lo Phase	Lo Phase	Lo Phase	Lo Phase	Lo Phase
1026	240	P25	spare *	spare *	spare *	1 Pallet Up	1 Pallet Up	1 Pallet Up	spare *	1 Pallet Up
1027	240	P25	spare *	spare *	spare *	1 Pallet Down	1 Pallet Down	1 Pallet Down	spare *	1 Pallet Down
1028	1060	P43	Grnd Fault	Grnd Fault	Grnd Fault	Grnd Fault	Grnd Fault	Grnd Fault	Grnd Fault	Grnd Fault
1029	1070	P47	Skip	Skip	Skip	Skip	Skip	Skip	Skip	Skip
1030	180	P53	spare *	spare *	spare *	spare *	spare *	spare *	3 Spigot	3 Spigot
1031	140		Chip Conveyor	Chip Conveyor	Chip Conveyor	Chip Conveyor	Chip Conveyor	Chip Conveyor	Chip Conveyor	6 Chip Conveyor

Num	Circuit #	IOPCB	MACHINES BEFORE #50149 (EXCEPT #50132 AND #50139)					MACHINE W/HAAS VECTOR DRIVE		
			HS-1 NO Air Door NO Tsc	HS-1 W/Air Door NO Tsc	HS-1 W/Air Door W/Tsc	HS-1RP NO Air Door NO Tsc	HS-1RP W/Air Door NO Tsc	HS-1RP W/Air Door W/Tsc	HS-1/R	HS-1RP
1100	110	P5	Servo Power	Servo Power	Servo Power	Servo Power	Servo Power	Servo Power	Servo Power	Servo Power
1101	710	P9	Spindle Forward	Spindle Forward	Spindle Forward	Spindle Forward	Spindle Forward			
1102	710	P9	Spindle Reverse	Spindle Reverse	Spindle Reverse	Spindle Reverse	Spindle Reverse			
1103	710	P9	Spindle Reset	Spindle Reset	Spindle Reset	Spindle Reset	Spindle Reset			
1104	390	P29	4'th axis brake	4'th axis brake	4'th axis brake	4'th axis brake	4'th axis brake	4'th axis brake	4'th axis brake	4'th axis brake
1105	940	P7	Coolant	Coolant	Coolant	Coolant	Coolant	Coolant	Coolant	Coolant
1106	170	P8	Auto Off	Auto Off	Auto Off	Auto Off	Auto Off	Auto Off	Auto Off	Auto Off
1107	300	P10	Sp Fan/Oil pump/luber	Sp Fan/Oil pump/luber	Sp Fan/Oil pump/luber	Sp Fan/Oil pump/luber	Sp Fan/Oil pump/luber	Sp Fan/Oil pump/luber	Sp Fan/Oil pump/luber	Sp Fan/Oil pump/luber
1108	810A	P30	spare *	spare *	spare *	1 Main DB forward	1 Main DB forward	1 Main DB forward	spare *	1 Main DB forward
1109	810A	P30	spare *	spare *	spare *	1 Main DB reverse	1 Main DB reverse	1 Main DB reverse	spare	1 Main DB reverse
1110	810	P39	spare *	spare *	spare *	1 Operator DB forward	1 Operator DB forward	1 Operator DB forward	spare *	1 Operator DB forward
1111	810	P39	spare *	spare *	spare *	1 Operator DB reverse	1 Operator DB reverse	1 Operator DB reverse	spare *	1 Operator DB reverse
1112	880A	P12	spare *	spare *	spare *	spare *	spare *	1 Pallets up	4 High Gear	4 High Gear
1113	880A	P12	spare *	spare *	spare *	spare *	spare *	spare *	4 Low Gear	4 Low Gear
1114	880A	P12	Tool Unclamp	Tool Unclamp	Tool Unclamp	Tool Unclamp	Tool Unclamp	Tool Unclamp	Tool Unclamp	Tool Unclamp
1115	880A	P12	Spindle Lock	Spindle Lock	Spindle Lock	Spindle Lock	Spindle Lock	Spindle Lock	Wye-Delta Cntcrs	Wye-Delta Cntcrs
1116	200	P50	spare *	spare *	spare *	1 Warning sounder	1 Warning sounder	1 Warning sounder	3 Spigot CW	3 Spigot CW
1117	200	P50	spare *	spare *	spare *	1 Warning sounder	1 Warning sounder	1 Warning sounder	3 Spigot CCW	3 Spigot CCW
1118	270	P49	spare *	spare *	spare *	1 Pallets CW	1 Pallets CW	1 Pallets CW	Pallet Ready light	Pallet Ready light
1119	260	P48	spare *	spare *	spare *	1 Pallets CCW	1 Pallets CCW	1 Pallets CCW	2 Purge	2 Purge
1120	880A	P12	Pre-charge	Pre-charge	Pre-charge	Pre-charge	Pre-charge	Pre-charge	Pre-charge	Pre-charge
1121	250	P45	HTC Shuttle	HTC Shuttle	HTC Shuttle	HTC Shuttle	HTC Shuttle	HTC Shuttle	HTC Shuttle	HTC Shuttle
1122	230	P44	5'th axis brake	5'th axis brake	5'th axis brake	5'th axis brake	1 Air blast	1 Air blast	5'th axis brake	1 Pallet Up
1123		P27	Pallet Ready light	Pallet Ready light	Pallet Ready light	Pallet Ready light	Pallet Ready light	Pallet Ready light	5 Door Interlock	5 Door Interlock
1124		P26	M21 spare *	M21 spare *	spare *	1 Main DB enable	1 Main DB enable	1 Main DB enable	spare *	1 Main DB enable
1125		P26	M22 spare *	M22 spare *	spare *	1 Operator DB enable	1 Operator DB enable	1 Operator DB enable	M22 Probe Option	1 Operator DB enable
1126		P26	M23 spare *	M23 spare *	M23 Air door	M23 1 Pallet up	M23 1 Pallet up	M23 Air door	M23 Air door	Air door
1127	/940A	P26/P6	M24 spare *	M24 Air door	xtra contacts * + 2 Aux Clnt	M24 Air blast	M24 Air door	xtra contacts * + 2 Aux Clnt	xtra contacts * + 2 Aux Clnt	xtra contacts * + + 2 Aux Clnt
1128	280	P55	Green beacon	Green beacon	Green beacon	Green beacon	Green beacon	Green beacon	Green beacon	Green beacon
1129	280	P55	Red beacon	Red beacon	Red beacon	Red beacon	Red beacon	Red beacon	Red beacon	Red beacon
1130	140	P46	Chip Conv Power	Chip Conv Power	Chip Conv Power	Chip Conv Power	Chip Conv Power	Chip Conv Power	Chip Conv Power	6 Chip Conv Power
1131	140	P46 P58	Chip Conv Rev.	Chip Conv Rev.	Chip Conv Rev.	Chip Conv Rev.	Chip Conv Rev.	Chip Conv Rev. Wye-Delta Cntcrs	Chip Conv Rev. Wye-Delta Cntcrs	6 Chip Conv Rev. Wye-Delta Cntcrs

NOTES: 1 Pallet Changer 2 Through Spindle Coolant 3 Programmable Coolant Spigot 4 Transmission 5 CE Safety Interlocks 6 Chip Conveyor

									MACHINE W/HAAS VECTOR DRIVE
Num	Circuit #	RLYBRD	HS-1 NO Air Door NO Tsc	HS-1 W/Air Door NO Tsc	HS-1 W/Air Door W/Tsc	HS-1RP NO Air Door NO Tsc	HS-1RP W/Air Door NO Tsc	HS-1RP W/Air Door W/Tsc	HS-1	HS-1RP
1132	M21	P4 -1,2,3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M21 M-Function
1133	M22	P4 -4,5,6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M22 Probe Option
1134	M23	P4 -7,8,9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M23 spare *
1135	M24	P4 -10,11,12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M24 1 Warning Sounder
1136	M25	P5 -1,2,3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M25 1 Pallet CW
1137	M26	P5 -4,5,6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M26 1 Pallet CCW
1138	M27	P5 -7,8,9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M27 1 Air Blast
1139	M27	P5 -10,11,12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M28 spare *

NOTES: 1 Pallet Changer 2 Through Spindle Coolant 3 Programmable Coolant Spigot 4 Transmission 5 CE Safety Interlocks 6 Chip Conveyor

5.22 The Equations of Motion

An analysis of the physics of motion of a machine tool can give some important insights into the "blocks per second" issue. The following mathematics calculates the block per second requirement in order to achieve a worst case chordal deviation error while moving around a curve made up of a series of points:

Let:

a = acceleration,
v=speed (or feed rate),
r = radius of curvature,
e = error from chordal deviation
l = block length (or travel length from point to point)
b = blocks per second

The following are known:
For a circular motion:

a = v*v/r (1)

and in motion:

v = b * l (2)

which gives:

b = v / l (3)

and

e = r – sqrt(r*r-l*l/4) (4)

which gives:

r*r – 2*r*e + e*e = r*r – l*l/4 (5)

and:

l= sqrt(8*r*e – 4*e*e) (6)

Since r>>e, e*e is small compare to r*e and we can assume:

l = sqrt(8*r*e) (7)

And combining we get:

b = sqrt(a*r) / sqrt (8*r*e) (8)

Or

b = sqrt(a / (8*e)) (9)

Thus, block per second is dependent only on the machine acceleration and the maximum chordal error allowed. For a Haas VF-1, acceleration is about 60 inches per second per second. This means that if the maximum error is 0.00005 (one half of one ten-thousandth), the block per second required is 380 blocks per second. For a VF-9, an acceleration of 30 inches/sec/sec, it would be 269 blocks per second.

Note also that an important equation (7) above is the relationship between radius of curvature (r), chordal error (e) and block length (l). If you have a radius or curvature close to 1/4 inch and your maximum chordal error is 0.00005 inch, the recommended block length is 0.01 inch. This shows that it is not always required to use very short blocks.

5.23 Formulas

TO FIND:

S.F.M

TO FIND THE SFM OF A CUTTER OR WORKPIECE

EXAMPLE: To find the SFM of a cutter rotating at 600 RPM with a diameter of 10 inches.

$$SFM = \frac{3.1416 \times d \times RPM}{12} = .262 \times d \times RPM$$

R.P.M.

TO FIND THE RPM OF A CUTTER OR WORKPIECE

EXAMPLE: To find the RPM of a cutter rotating at 150 SFM with a diameter of 8 inches.

$$SFM = \frac{12 \times SFM}{3.1416 \times d} = \frac{3.82 \times SFM}{d}$$

I.P.M.

TO FIND THE FEED (table travel in inches per minute)

EXAMPLE: To find the feed of a 10 tooth cutter rotating at 200 RPM with a feed per tooth of 0.012".

IPM = F.P.T. x T x RPM

TO FIND:

F.P.R.

TO FIND THE FEED PER REVOLUTION (in inches) OF A CUTTER.

EXAMPLE: To find the feed per revolution of a cutter rotating at 200 RPM with a table travel of 22 inches per minute.

$$F.P.R. = \frac{I.P.M.}{R.P.M.}$$

F.P.T.

TO FIND THE FEED PER TOOTH OF A CUTTER.

EXAMPLE: To find the feed per tooth of a cutter rotating at 200 RPM with a table travel of 22 inches per minute.

$$F.P.T. = \frac{I.P.M.}{T \times R.P.M.}$$

D = Depth of cut
d = diameter of cutter
I.P.M. = Feed (table travel in inches per minute)
K = Constant (cubic inches per minute per HPc). Power required to remove 1 cubic inch per minute.
HPc = Horsepower at the cutter
F.P.R. = Feed per revolution
R.P.M. = Revolutions per minute
T = Number of teeth in cutter
W = Width of cut (in inches)

6. PARAMETERS

Parameters are seldom-modified values that change the operation of the machine. These include servo motor types, gear ratios, speeds, stored stroke limits, lead screw compensations, motor control delays and macro call selections. These are all rarely changed by the user and should be protected from being changed by the parameter lock setting. If you need to change parameters, contact HAAS or your dealer. Parameters are protected from being changed by Setting 7.

The Settings page lists some parameters that the user may need to change during normal operation and these are simply called "Settings". Under normal conditions, the parameter displays should not be modified. A complete list of the parameters is provided here.

The PAGE UP, PAGE DOWN, up and down cursor keys , and the jog handle can be used to scroll through the parameter display screens in the control. The left and right cursor keys are used to scroll through the bits in a single parameter.

Parameter List

Parameter 1 X SWITCHES

Parameter 1 is a collection of single-bit flags used to turn servo related functions on and off. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0	REV ENCODER	Used to reverse the direction of encoder data.
1	REV POWER	Used to reverse direction of power to motor.
2	REV PHASING	Used to reverse motor phasing.
3	DISABLED	Used to disable the X-axis.
4	Z CH ONLY	With **A** only, indicates that no home switch.
5	AIR BRAKE	With **A** only, indicates that air brake is used.
6	DISABLE Z T	Disables encoder **Z** test (for testing only).
7	SERVO HIST	Graph of servo error (for diagnostics only).
8	INV HOME SW	Inverted home switch (N.C. switch).
9	INV Z CH	Inverted **Z** channel (normally high).
10	CIRC. WRAP.	With **A** only, causes 360 wrap to return to 0.
11	NO I IN BRAK	With **A** only, removes **I** feedback when brake is active.
12	LOW PASS +1X	Adds 1 term to low pass filter.
13	LOW PASS +2X	Adds two terms to low pass filter.
14	OVER TEMP NC	Selects a normally closed overheat sensor in motor.
15	CABLE TEST	Enables test of encoder signals and cabling.
16	Z TEST HIST	History plot of Z channel test data.
17	SCALE FACT/X	If set to 1, the scale ratio is interpreted as divided by X; where X depends on bits SCALE/X LO and SCALE/XHI.
18	INVIS AXIS	Used to create an invisible axis.
19	ROT ALM LMSW	Rotary alarms at the limit switch.
20	ROT TRVL LIM	Rotary travel limits are used.

22	D FILTER X8	Enables the 8 tap FIR filter. Used to eliminate high frequency vibrations, depending on the axis motor.
23	D FILTER X4	Enables the 4 tap FIR filter. Used to eliminate high frequency vibrations, depending on the axis motor.
24	TORQUE ONLY	For HAAS diagnostic use only.
25	3 EREV/MREV	For HAAS diagnostic use only.
26	2 EREV/MREV	For HAAS diagnostic use only.
27	NON MUX PHAS	For HAAS diagnostic use only.
28	BRUSH MOTOR	Enables the brushless motor option.
29	LINEAR DISPL	This bit changes the display from degrees to inches (or millimeters) on the A and B axes.
30	SCALE/X LO	With SCALE/X HI bit, determines the scale factor used in bit SCALE FACT/X,
31	SCALE/X HI	With SCALE/X LO bit, determines the scale factor used in bit SCALE FACT/X. See below:

HI	**LO**	
0	0	3
0	1	5
1	0	7
1	1	9

Parameter 2 X P GAIN
Proportional gain in servo loop.

Parameter 3 X D GAIN
Derivative gain in servo loop.

Parameter 4 X I GAIN
Integral gain in servo loop.

Parameter 5 X RATIO (STEPS/UNIT)
The number of steps of the encoder per unit of travel. Encoder steps supply four (4) times their line count per revolution. Thus, an 8192 line encoder and a 6mm pitch screw give:

8192 x 4 x 25.4 / 6 = 138718
(5 steps per unit inch/mm ratio)

Parameter 6 X MAX TRAVEL (STEPS)
Max negative direction of travel from machine zero in encoder steps. Does not apply to A-axis. Thus a 20 inch travel, 8192 line encoder and 6 mm pitch screw give:

20.0 x 138718 = 2774360

Parameter 7 X ACCELERATION
Maximum acceleration of axis in steps per second per second.

Parameter 8 X MAX SPEED
Max speed for this axis in steps per second.

Parameter 9 X MAX ERROR
Max error allowed in servo loop before alarm is generated. Units are encoder steps. This is the maximum allowable error in Hz between the commanded speed and the actual speed. The purpose of this parameter is to prevent "motor runaway" in case of phasing reversal, or bad parameters. If this parameter is set to 0, it defaults to 1/4 of parameter 183 Max Frequency.

Parameter 10 X FUSE LEVEL
Used to limit average power to motor. If not set correctly, this parameter can cause an “overload” alarm.

Parameter 11 X TORQUE PRELOAD
TORQUE PRELOAD is a signed number that should be set to a value from 0 to 4095 where 4095 is the maximum motor torque. It is applied at all times to the servo in the same direction. It is used to compensate, in the vertical direction, for gravity on a machine with an axis brake instead of a counterbalance. Normally, the brake is released when the servo motors are activated. However, when an axis with the brake has been disabled, the brake must not be released at all. This feature takes care of that situation. Normally, this parameter should be set to zero on all axes. Exceptions are:
Mini-mills with the axis brake instead of a counterbalance, parameter 39 Z axis TORQUE PRELOAD must be set to 300. The TORQUE PRELOAD parameter for the remaining axes must be set to zero.
Vertical mills with the axis brake instead of a counterbalance, parameter 39 Z axis TORQUE PRELOAD must be set to 600. The TORQUE PRELOAD parameter for the remaining axes must be set to zero.
Horizontal mills with the axis brake instead of a counterbalance, parameter 25 Y axis TORQUE PRELOAD must be set to 500. The TORQUE PRELOAD parameter for the remaining axes must be set to zero.

Parameter 12 X STEPS/REVOLUTION
Encoder steps per revolution of motor. Thus, an 8192 line encoder gives:

8192 x 4 = 32768

Parameter 13 X BACKLASH
Backlash correction in encoder steps.

Parameter 14 X DEAD ZONE
Dead zone correction for driver electronics. Units are 0.0000001 seconds.

Parameter 15 Y SWITCHES
See Parameter 1 for description.

Parameter 16 Y P GAIN
See Parameter 2 for description.

Parameter 17 Y D GAIN
See Parameter 3 for description.

Parameter 18 Y I GAIN
See Parameter 4 for description.

Parameter 19 Y RATIO (STEPS/UNIT)
See Parameter 5 for description.

Parameter 20 Y MAX TRAVEL (STEPS)
See Parameter 6 for description.

Parameter 21 Y ACCELERATION
See Parameter 7 for description.

Parameter 22 Y MAX SPEED
See Parameter 8 for description.

Parameter 23 Y MAX ERROR
See Parameter 9 for description.

Parameter 24 Y FUSE LEVEL
See Parameter 10 for description.

Parameter 25 Y TORQUE PRELOAD
See Parameter 11 for description.

Parameter 26 Y STEPS/REVOLUTION
See Parameter 12 for description.

Parameter 27 Y BACKLASH
See Parameter 13 for description.

Parameter 28 Y DEAD ZONE
See Parameter 14 for description.

Parameter 29 Z SWITCHES
See Parameter 1 for description.

Parameter 30 Z P GAIN
See Parameter 2 for description.

Parameter 31 Z D GAIN
See Parameter 3 for description.

Parameter 32 Z I GAIN
See Parameter 4 for description.

Parameter 33 Z RATIO (STEPS/UNIT)
See Parameter 5 for description.

Parameter 34 Z MAX TRAVEL (STEPS)
See Parameter 6 for description.

Parameter 35 Z ACCELERATION
See Parameter 7 for description.

Parameter 36 Z MAX SPEED
See Parameter 8 for description.

Parameter 37 Z MAX ERROR
See Parameter 9 for description.

Parameter 38 Z FUSE LEVEL
See Parameter 10 for description.

Parameter 39 Z TORQUE PRELOAD
See Parameter 11 for description.

Parameter 40 Z STEPS/REVOLUTION
See Parameter 12 for description.

Parameter 41 Z BACKLASH
See Parameter 13 for description.

Parameter 42 Z DEAD ZONE
See Parameter 14 for description.

Parameter 43 A SWITCHES
See Parameter 1 for description AND make sure that this parameter is se to enable the fourth axis before you try to enable the fourth axis from settings.

Parameter 44 A P GAIN
See Parameter 2 for description.

Parameter 45 A D GAIN
See Parameter 3 for description.

Parameter 46 A I GAIN
See Parameter 4 for description.

Parameter 47 A RATIO (STEPS/UNIT)
This parameter defines the number of encoder steps required to complete one full rotation of the platter. For example an HRT 210 with a 90:1 gear ratio, a final drive ratio of 2:1, and an encoder count of 2000 lines would be:

2000 x 4 x (90 x 2) / 360 = 2000 steps

for a brushless HRT 210 with a 90:1 gear ratio, a final drive ratio of 2:1 and an encoder count of 8192 the formula would be:

8192 x 4 x (90 x 2) / 360 = 16384 steps

If for example 16384 ended up being 13107.2 (non integer) the user must make sure the single bits SCALE FACT/X and the COMBINATION OF SCALE/X LO and SCALE/X HI are turned on in parameter 43. When the scale factor/x bit is 1 the scale ratio is interpreted as divide by X: where X depends on scale/ x lo and scale/ x hi (see parameter 1 for scale/ x lo and scale x hi values). For example:

8192 x 4 x (72 x 2) / 360 = 13107.2

You would then turn on the scale fact/x bit and the scale/ x lo bit which would give you a factor of 5 thus:

13107.2 x 5 = 65536 encoder steps

Parameter 48 A MAX TRAVEL (STEPS)
See Parameter 6 for description. Normally this parameter would not apply to the A axis, however this parameter is used on mills with a gimbaled spindle (5-axis mills). On a VR-series mill this parameter is used to limit the amount of angular movement of the spindle (A and B axes). The A and B axes are limited in movement to a distance between negative MAX TRAVEL, and positive TOOL CHANGE OFFSET. On 5-axes mills A and B axes ROT TRVL LIM must be set to 1, MAX TRAVEL and TOOL CHANGE OFFSET must be calibrated and set correctly.

Parameter 49 A ACCELERATION
See Parameter 7 for description.

Parameter 50 A MAX SPEED
See Parameter 8 for description.

Parameter 51 A MAX ERROR
See Parameter 9 for description.

Parameter 52 A FUSE LEVEL
See Parameter 10 for description.

Parameter 53 A BACK EMF
See Parameter 11 for description.

Parameter 54 A STEPS/REVOLUTION
See Parameter 12 for description

Parameter 55 A BACKLASH
See Parameter 13 for description.

Parameter 56 A DEAD ZONE
See Parameter 14 for description.

Parameters 57 through 128 are used to control other machine dependent functions. They are:

Parameter 57 COMMON SWITCH 1
Parameter 57 is a collection of general purpose single bit flags used to turn some functions on and off. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0	REV CRANK	Reverses direction of jog handle.
1	DISABLE T.C.	Disables tool changer operations.
2	DISABLE G.B.	Disables gear box functions.
3	POF AT E-STP	Stops spindle then turns the power off at EMERGENCY STOP
4	RIGID TAP	Indicates hardware option for rigid tap.
5	REV SPIN ENC	Reverses sense direction of spindle encoder.
6	REPT RIG TAP	Selects repeatable rigid tapping.
7	EX ST MD CHG	Selects exact stop in moves when mode changes.

8	SAFETY CIRC.	This enables safety hardware, if machine is so equipped.
9	SP DR LIN AC	Selects linear deceleration for rigid tapping. 0 is quadratic.
10	PH LOSS DET	When enabled, will detect a phase loss.
11	COOLANT SPGT	Enables coolant spigot control and display.
12	OVER T IS NC	Selects Regen over temp sensor as N.C.
13	SKIP OVERSHT	Causes Skip (G31) to act like Fanuc and overshoot sense point.
14	NONINV SP ST	Non-inverted spindle stopped status.
15	SP LOAD MONI	Spindle load monitor option is enabled.
16	SP TEMP MONI	Spindle temperature monitor option is enabled.
17	ENA ROT & SC	Enables rotation and scaling.
18	ENABLE DNC	Enables DNC selection from MDI.
19	ENABLE BGEDT	Enables BACKGROUND EDIT mode.
20	ENA GRND FLT	Enables ground fault detector.
21	M19 SPND ORT	This bit makes the P and R codes a protected feature which can only be enabled with an unlock code. The unlock code will be printed on the parameter listing of all new machines. If this bit is set to 0, an M19 will orient the spindle to 0 degrees regardless of the value of any P or R code in the same block. If this is set to 1, a P code in the block will cause the spindle to be oriented to the specified angle such as P180. Alternately, a decimal R code can be used, such as R180.53. Note that the P and R codes only work on a vector drive machine.
22	ENABLE MACRO	Enables macro functions.
23	INVERT SKIP	Invert sense of skip to active low=closed.
24	HANDLE CURSR	Enable use of jog handle to move cursor.
25	NEG WORK OFS	Selects use of work offsets in negative direction.
26	TRANS OIL	Enables transmission low oil pressure detection.
27	ENA QUIKCODE	Enables conversational programming.
28	OILER ON/OFF	Enables oiler power when servos or spindle is in motion.
29	NC OVER VOLT	Inverts sense of over voltage signal.
31	DOOR STOP SP	Enables functions to stop spindle and manual operations at door switch.

Parameter 58 LEAD COMPENS SHIFT

Shift factor when applying lead screw compensation. Lead screw compensation is based on a table of 256 offsets; each +\-127 encoder steps. A single entry in the table applies over a distance equal to two raised to this parameter power encoder steps.

Parameter 59 MAXIMUM FEED
Maximum feed rate in inches per minute.

Parameter 60 TURRET START DELAY
Maximum delay allowed in start of tool turret. Units are milliseconds. After this time, an alarm is generated.

On Horizontal mills with a side mount tool changer, this parameter is used to specify the time (in milliseconds) allowed for motor driven motions of the shuttle and arm. If the motion has not completed within the time allowed by this parameter, alarm 696 ATC MOTOR TIME OUT is generated. This parameter should be set to 2000.

Parameter 61 TURRET STOP DELAY
Maximum delay allowed in motion of tool turret. Units are milliseconds. After this time, an alarm is generated.

On Horizontal mills with a side mount tool changer, this parameter is used to specify the time (in milliseconds) allowed for air-pressure driven arm in/arm out moves. If the motion has not completed within the time allowed by this parameter, alarm 695 ATC AIR CYLINDER TIME OUT is generated. This parameter should be set to 10000.

Parameter 62 SHUTTLE START DELAY
This parameter is used to specify the time (in milliseconds) needed to allow the tool pocket to settle (stop bouncing) after being lowered in preparation for a tool change.

Parameter 63 SHUTTLE STOP DELAY
This parameter is also used for vertical mills with a Side Mount Tool Changer. It is used to specify the time allowed (in milliseconds) for the tool arm motor to stop. If the arm has not stopped after the allowed time alarm 627 ATC ARM POSITION TIMEOUT is generated.

Parameter 64 Z TOOL CHANGE OFFSET
On Vertical mills: For Z-axis; displacement from home switch to tool change position and machine zero. About 4.6 inches, so for an 8192 line encoder this gives:

4.6 x 138718 = 638103

On Horizontal mills, this parameter is not used. It should be set to zero.

Parameter 65 NUMBER OF TOOLS
Number of tool positions in tool changer. This number must be set to the configuration machine. The maximum number of tool positions is 32, except Horizontal mills with a side mount tool changer. This parameter must be 60 for the HS 60 SMTC and 120 for the HS 120 SMTC.

Parameter 66 SPINDLE ORI DELAY
Maximum delay allowed when orienting spindle. Units are milliseconds. After this time, an alarm is generated.

Parameter 67 GEAR CHANGE DELAY
Maximum delay allowed when changing gears. Units are milliseconds. After this time, an alarm is generated.

Parameter 68 DRAW BAR MAX DELAY
Maximum delay allowed when clamping and unclamping tool. Units are milliseconds. After this, time an alarm is generated.

Parameter 69 A AIR BRAKE DELAY
Delay provided for air to release from brake on A-axis prior to moving. Units are milliseconds.

Parameter 70 MIN SPIN DELAY TIME
Minimum delay time in program after commanding new spindle speed and before proceeding. Units are milliseconds.

Parameter 71 DRAW BAR OFFSET
Offset provided in motion of Z-axis to accommodate the tool pushing out of the spindle when unclamping tool. Units are encoder steps.

Parameter 72 DRAW BAR Z VEL UNCL
Speed of motion in Z-axis to accommodate tool pushing out of the spindle when unclamping tool. Units are encoder steps per second.

Parameter 73 SP HIGH G/MIN SPEED
Command speed used to rotate spindle motor when orienting spindle in high gear. Units are maximum spindle RPM divided by 4096. This parameter is not used in machines equipped with a Haas vector drive.

Parameter 74 SP LOW G/MIN SPEED
Command speed used to rotate spindle motor when orienting spindle in low gear. Units are maximum spindle RPM divided by 4096. This parameter is not used in machines equipped with a Haas vector drive.

Parameter 75 GEAR CHANGE SPEED
Command speed used to rotate spindle motor when changing gears. Units are maximum spindle RPM divided by 4096.

Parameter 76 LOW AIR DELAY
Delay allowed after sensing low air pressure before alarm is generated. Alarm skipped if air pressure returns before delay. Units are 1/50 seconds.

Parameter 77 SP LOCK SETTLE TIME
Required time in milliseconds that the spindle lock must be in place and stable before spindle orientation is considered complete.

Parameter 78 GEAR CH REV TIME
Time in milliseconds before motor direction is reversed while in a gear change.

Parameter 79 SPINDLE STEPS/REV
Sets the number of encoder steps per revolution of the spindle. Applies only to rigid tapping option.

Parameter 80 MAX SPIN DELAY TIME
The maximum delay time control will wait for spindle to get to commanded speed or to get to zero speed. Units are milliseconds.

Parameter 81 M MACRO CALL O9000

M code that will call O9000. This parameter can contain a value from 1 through 98, inclusive, zero causes no call. However it is best to use a value that is not already in use (see current M code list). Using M37 the value 37 would be entered in parameter 81 (for example). A program would be written to include the M37, such as:

```
G X0...
M37
.
.
M30
```

The control would run the program until it got to the M37, It would call program O9000, run that, and then return to the point that it left, and continue the main program.

Be aware that, if program O9000 contains another M37, it will call itself, and keep calling until it fills the stack (9 times) and then alarm out with 307 SUBROUTINE NESTING TOO DEEP.

Note that if M33 (for example) is used, it would override the normal M33 Conveyor Stop function.

Parameter 82 M MACRO CALL O9001

See parameter 81 for description

Parameter 83 M MACRO CALL O9002

See parameter 81 for description

Parameter 84 M MACRO CALL O9003

See parameter 81 for description

Parameter 85 M MACRO CALL O9004

See parameter 81 for description

Parameter 86 M MACRO CALL O9005

See parameter 81 for description

Parameter 87 M MACRO CALL O9006

See parameter 81 for description

Parameter 88 M MACRO CALL O9007

See parameter 81 for description

Parameter 89 M MACRO CALL O9008

See parameter 81 for description

Parameter 90 M MACRO CALL O9009

See parameter 81 for description

Parameter 91 G MACRO CALL O9010

G code that will call O9010. This parameter can contain a value from 1 through 98, inclusive, zero causes no call. However it is best to use a value that is not already in use (see current G code list). Using G45 the value 45 would be entered in parameter 91 (for example). A program would be written to include the G45, such as:

```
G X0...
G45
.
.
M30
```

The control would run the program until it got to the G45, It would call program O9010, run that, and then return to the point that it left, and continue the main program.

Be aware that, if program O9010 contains another G45, it will call itself, and keep calling until it fills the stack (4 times) and then alarm out with 531 MACRO NESTING TOO DEEP.

Note that if G84 (for example) is used, it would override the normal G84 Tapping Canned Cycle.

Parameter 92 G MACRO CALL O9011

See parameter 91 for description

Parameter 93 G MACRO CALL O9012

See parameter 91 for description

Parameter 94 G MACRO CALL O9013

See parameter 91 for description

Parameter 95 G MACRO CALL O9014

See parameter 91 for description

Parameter 96 G MACRO CALL O9015

See parameter 91 for description

Parameter 97 G MACRO CALL O9016

See parameter 91 for description

Parameter 98 G MACRO CALL O9017

See parameter 91 for description

Parameter 99 G MACRO CALL O9018

See parameter 91 for description

Parameter 100 G MACRO CALL O9019

See parameter 91 for description

Parameter 101 IN POSITION LIMIT X

How close motor must be to endpoint before any move is considered complete when not in exact stop (G09 or G61). Units are encoder steps. This parameter does not apply to feeds.

Parameter 102 IN POSITION LIMIT Y

See Parameter 101 for description

Parameter 103 IN POSITION LIMIT Z
See Parameter 101 for description

Parameter 104 IN POSITION LIMIT A
See Parameter 101 for description

Parameter 105 X MAX CURRENT
Fuse level in % of max power to motor. Applies only when motor is stopped.

Parameter 106 Y MAX CURRENT
See Parameter 105 for description

Parameter 107 Z MAX CURRENT
See Parameter 105 for description

Parameter 108 A MAX CURRENT
See Parameter 105 for description

Parameter 109 D*D GAIN FOR X
Second derivative gain in servo loop.

Parameter 110 D*D GAIN FOR Y
Second derivative gain in servo loop.

Parameter 111 D*D GAIN FOR Z
Second derivative gain in servo loop.

Parameter 112 D*D GAIN FOR A
Second derivative gain in servo loop.

Parameter 113 X ACC/DEC T CONST
Acceleration time constant. Units are 1/10000 seconds. This parameter provides for a constant ratio between profiling lag and servo velocity at the endpoint of a rapid motion.

Parameter 114 Y ACC/DEC T CONST
See Parameter 113 for description

Parameter 115 Z ACC/DEC T CONST
See Parameter 113 for description

Parameter 116 A ACC/DEC T CONST
See Parameter 113 for description

Parameter 117 LUB CYCLE TIME
If this is set nonzero, it is the cycle time for the lube pump and the Lube pressure switch option is checked for cycling in this time. It is in units of 1/50 seconds.

Parameter 118 SPINDLE REV TIME
Time in milliseconds to reverse spindle motor.

Parameter 119 SPINDLE DECEL DELAY
Time in milliseconds to decelerate spindle motor.

Parameter 120 SPINDLE ACC/DECEL
Accel/decel time constant in 200ths of a step/ms/ms for spindle motor.

Parameter 121 X PHASE OFFSET
The motor phase offset for **X** motor. This is arbitrary units.

Parameter 122 Y PHASE OFFSET
See Parameter 121 for description.

Parameter 123 Z PHASE OFFSET
See Parameter 121 for description.

Parameter 124 A PHASE OFFSET
See Parameter 121 for description.

Parameter 125 X GRID OFFSET
This parameter shifts the effective position of the encoder **Z** pulse. It can correct for a positioning error of the motor or home switch.

Parameter 126 Y GRID OFFSET
See Parameter 125 for description.

Parameter 127 Z GRID OFFSET
See Parameter 125 for description.

Parameter 128 A GRID OFFSET
See Parameter 125 for description.

Parameter 129 GEAR CH SETTLE TIME
Gear change settle time. This is the number of one millisecond samples that the gear status must be stable before considered in gear.

Parameter 130 GEAR STROKE DELAY
This parameter controls the delay time to the gear change solenoids when performing a gear change.

Parameter 131 MAX SPINDLE RPM
This is the maximum RPM available to the spindle. When this speed is programmed, the D-to-A output will be +10V and the spindle drive must be calibrated to provide this.

Parameter 132 Y SCREW COMP. COEF.
This is the coefficient of heating of the lead screw and is used to decrease or shorten the screw length.

Parameter 133 Z SCREW COMP. COEF.
This is the coefficient of heating of the lead screw and is used to decrease or shorten the screw length.

Parameter 134 X EXACT STOP DIST.

Parameter 135 Y EXACT STOP DIST.

Parameter 136 Z EXACT STOP DIST.

Parameter 137 A EXACT STOP DIST.
These parameters control how close each axis must be to its end point when exact stop is programmed. They apply only in G09 and G64. They are in units of encoder steps. A value of 34 would give 34/138718 = 0.00025 inch.

NOTE: To change the values of parameters 134-137 permanently the machine must be rebooted.

Parameter 138 X FRICTION COMPENSATION

Parameter 139 Y FRICTION COMPENSATION

Parameter 140 Z FRICTION COMPENSATION

Parameter 141 A FRICTION COMPENSATION
These parameters compensate for friction on each of the four axes. The units are in 0.004V.

Parameter 142 HIGH/LOW GEAR CHANG
This parameter sets the spindle speed at which an automatic gear change is performed. Below this parameter, low gear is the default; above this, high gear is the default.

Parameter 143 DRAW BAR Z VEL CLMP
This parameter sets the speed of the Z-axis motion that compensates for tool motion during tool clamping. Units are in encoder steps per second.

Parameter 144 RIG TAP FINISH DIST
This parameter sets the finish tolerance for determining the end point of a rigid tapping operation. Units are encoder counts.

Parameter 145 X ACCEL FEED FORWARD

Parameter 146 Y ACCEL FEED FORWARD

Parameter 147 Z ACCEL FEED FORWARD

Parameter 148 A ACCEL FEED FORWARD
These parameters set the feed forward gain for the axis servo. They have no units.

Parameter 149 Precharge DELAY
This parameter sets the delay time from precharge to tool release. Units are milliseconds.

Parameter 150 MAX SP RPM LOW GEAR
Max spindle RPM in low gear.

Parameter 151 B SWITCHES
See Parameter 1 for description.

Parameter 152 B P GAIN
See Parameter 2 for description.

Parameter 153 B D GAIN
See Parameter 3 for description.

Parameter 154 B I GAIN
See Parameter 4 for description.

Parameter 155 B RATIO (STEPS/UNIT)
See Parameter 47 for description.

Parameter 156 B MAX TRAVEL (STEPS)
See Parameter 6 for description. Normally this parameter would not apply to the A axis, however this parameter is used on mills with a gimbaled spindle (5-axes mills). On a VR-series mill this parameter is used to limit the amount of angular movement of the spindle (A and B axes). The A and B axes are limited in movement to a distance between negative MAX TRAVEL, and positive TOOL CHANGE OFFSET. On 5-axes mills A and B axes ROT TRVL LIM must be set to 1, MAX TRAVEL and TOOL CHANGE OFFSET must be calibrated and set correctly.

Parameter 157 B ACCELERATION
See Parameter 7 for description.

Parameter 158 B MAX SPEED
See Parameter 8 for description.

Parameter 159 B MAX ERROR
See Parameter 9 for description.

Parameter 160 B FUSE LEVEL
See Parameter 10 for description.

Parameter 161 B BACK EMF
See Parameter 11 for description.

Parameter 162 B STEPS/REVOLUTION
See Parameter 12 for description.

Parameter 163 B BACKLASH
See Parameter 13 for description.

Parameter 164 B DEAD ZONE
See Parameter 14 for description.

Parameter 165 IN POSITION LIMIT B
Same definition as Parameter 101.

Parameter 166 B MAX CURRENT
Same definition as Parameter 105.

Parameter 167 D*D GAIN FOR B
Second derivative gain in servo loop.

Parameter 168 B ACC/DEC T CONST
Same definition as Parameter 113.

Parameter 169 B PHASE OFFSET
See Parameter 121 for description.

Parameter 170 B GRID OFFSET
See Parameter 125 for description.

Parameter 171 B EXACT STOP DIST.
See Parameters 134 for description.

Parameter 172 B FRICTION COMPENSATION
See Parameter 138 for description.

Parameter 173 B ACCEL FEED FORWARD
Same description as Parameter 145.

Parameter 174 B SCREW COMP. COEF.
This is the coefficient of heating of the lead screw and is used to decrease or shorten the screw length.

Parameter 175 B AIR BRAKE DELAY
Delay provided for air to release from brake on B-axis prior to moving. Units are milliseconds.

NOTE: The C-axis parameters (176-200) are used to control the Haas Vector Drive. Parameter 278 bit HAAS VECT DR must be set to 1 for these parameters to be available.

Parameter 176 C SWITCHES
See Parameter 1 for description.

Parameter 177 C P GAIN
See Parameter 2 for description.

Parameter 178 C D GAIN
See Parameter 3 for description.

Parameter 179 C I GAIN
See Parameter 4 for description.

Parameter 180 C SLIP GAIN
The slip rate calculated depends on two other variables: speed and current.

Slip rate = slip gain x (speed/max speed) x (current/max current)

The slip gain value is the value that slip rate would assume at maximum speed, and maximum current (16.384=1 Hz).

Parameter 181 C MIN SLIP

The minimum value allowed from the slip rate. From the equation:

Slip rate = slip gain x (speed/max speed) x (current/max current)

It can be seen that at a zero speed, the slip rate would become zero. Therefore a minimum value for slip rate is required. (16.384 =1Hz).

Parameter 182 C ACCELERATION

Maximum acceleration of axis. The value is the units of encoder steps / second / second at the motor.

Parameter 183 C MAX FREQ

The frequency at which the motor will be run when maximum spindle RPM is commanded. Units: 0.01 Hz (two implied decimal places).

Parameter 184 C MAX ERROR

The maximum allowable error (in Hz) between commanded spindle speed and actual speed. If set to zero, it will default to 1/4 of Parameter 183.

Parameter 185 C FUSE LEVEL

See Parameter 10 for description.

Parameter 186 C DECELERATION

Maximum deceleration of axis in encoder steps per second per second.

Parameter 187 C HIGH GEAR STEPS/REV

The value is the number of encoder steps per revolution of the motor when the transmission is in high gear. If the machine does not have a transmission, this is simply the number of encoder steps per revolution of the motor.

Parameter 188 C ORIENT GAIN

The value is the proportional gain used in the position control loop when performing a spindle orientation.

Parameter 189 C BASE FREQ

This is the rated frequency of the motor.

Parameter 190 C HI SP CURR LIM

At speeds higher than the base frequency, the maximum current that is applied to the motor must be reduced. This is done linearly from base frequency to max frequency. This value is the max current at the max frequency.

Parameter 191 C MAX CURRENT

See Parameter 105 for description

Parameter 192 C MAG CURRENT

This is the magnetization component of the current in the motor, also called the flux or field current.

Parameter 193 C SPIN ORIENT MARGIN
When a spindle orientation is done, if the actual position of the spindle is within this value (plus or minus), the spindle will be considered locked. Otherwise, the spindle will not be locked.

Parameter 194 SPINDLE STOP FREQ
The spindle is considered to be stopped (discrete input SP ST*=0) when the speed drops below this value. Units are encoder steps/millisecond.

Parameter 195 C START/STOP DELAY
This delay is used at the start of motion to magnetize the rotor before acceleration starts. When the motor comes to a stop it remains energized for this amount of time. Units are in milliseconds.

Parameter 196 C ACCEL LIMIT LOAD
This parameter is used when a Vector Drive is installed. This is the % load limit during acceleration. If the load reaches this limit during acceleration the control slows down the acceleration. If a Vector Drive is not installed, this parameter is called C axis EXACT STOP DISTANCE, and is not used.

Parameter 197 SWITCH FREQUENCY. Unit:Hz.
This is the frequency at which the spindle motor windings are switched. Note that there is a hysteresis band around this point, defined by parameter 198.

Parameter 198 SWITCH HYSTERESIS. UNIT:Hz.
This defines the ± hysteresis band around parameter 197. For example if parameter 197 is 85 Hz, and parameter 198 is 5Hz, the switching will take place at 90Hz when the spindle is speeding up, and at 80 Hz when the spindle is slowing down.

Parameter 199 PRE-SWITCH DELAY. UNIT: ms.
This is the amount of time allowed for the current in the motor to drop before the winding change contactors are switched.

Parameter 200 POST- SWITCH DELAY. UNIT: ms
This is the amount of time allowed for the contactors to stabilize after a switch is commanded, before current is applied to the motor.

Parameter 201 X SCREW COMP. COEF.
This is the coefficient of heating of the lead screw and is used to shorten the screw length.

Parameter 205 A SCREW COMP. COEF.
This parameter should be set to 0.

Parameter 206 SPIGOT POSITIONS
Vertical mills only. Maximum number of spigot positions.

Parameter 207 SPIGOT TIMEOUT (MS)
Vertical mills only. Maximum timeout allowed for spigot to traverse one spigot location.

Parameter 208 SPIN. FAN OFF DELAY
Delay for turning the spindle fan off after the spindle has been turned off.

Parameter 209 COMMON SWITCH 2

Parameter 209 is a collection of general purpose single bit flags used to turn some functions on and off. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0	HORIZONTAL	When set to (1), the control identifies the machine as a horizontal mill. The control will then make the necessary adjustments, such as enabling the horizontal tool changer.
1	RST STOPS T.C.	Tool changer can be stopped with RESET button.
2	CHAIN TC	On all HS mills with the 60 or 120 pocket chain-style tool changer, it must be set to 1. On all other mills, it must be set to zero.
3	ENA CONVEYOR	Enables chip conveyor, if machine is so equipped.
4	50% RPD KBD	When (1) the control will support the new style keyboards with the 50% rapid traverse key. For controls without a 50% rapid keypad set this bit to (0).
5	FRONT DOOR	When enabled the control will look for an additional door switch and will generate an operator message.
6	TC Z NO HOME	In Horizontal mills only. This bit prevents Z-axis motion to machine zero prior to a tool change.
7	M36 AUTO MOT	In Horizontal only. When set to (1), an M36 rotates the A-axis after the PART READY button is pressed.
8	AUX AXIS TC	In Horizontal mills only. When enabled, means the tool changer carousel is driven by an aux. axis.
9	SPIGOT KEY INV	This bit controls the direction the spigot moves when the Coolant Up and Coolant Down buttons are pressed. Changing this bit reverses the direction the spigot moves when the buttons are pressed. It has no effect on the direction the spigot moves when commanded by the M34 and M35 codes.
12	REV CONVEYOR	Reverses the direction of the chip conveyor.
13	M27-M28 CONVYR	Usually the chip conveyor motor and direction relays are attached to the user relays M21 and M22. When this bit is set, the control expects to see the conveyor hooked up to M27 and M28.
15	GREEN BEACON	When (1) user relay M25 is used to flash a beacon. If the control is in a reset state, the beacon will be off. If the control is running normally, the beacon will be steadily on. If the control is in a M00, M01, M02, M30 feedhold, or single block state, then the beacon will flash.
16	RED BEACON	When (1) user relay M26 is used to flash a beacon. The beacon flashes if the control is experiencing an alarm or emergency stop condition.
17	CONVY DR OVRD	When (1) the conveyor will continue to run with the door open. When (0) the conveyor will stop when the door is open, but will resume when the door is closed. For safety it is recommended that the bit be set to (0).
18	DSBL CLNT IN	If set to 1 low coolant input will not be used.
19	DSC INP PR	Discrete pallet rotate/part ready; inputs enabled if set to 1.
20	RMT TOOLS RLS	If set to 1, allows use of remote tool release button on spindle head.

21	DISK ENABL	If set to 1, enables the optional disk drive.
22	TCR KEYPAD	If set to 1, enables tool changer restore button on keypad.
23	MCD RLY BRD	If set to 1, adds 8 additional relays, for a total of 40. These additional relays (M21-M28) become available on a secondary board, and are shown on the discrete outputs page.
24	TSC ENABLE	When set to 1, "DSBL CLNT IN" bit is ignored, M24, M54 and M64 are disabled, and TSC will operate. When set to zero, the control functions normally.
25	AUX JOG NACC	If the jog handle is moved rapidly the auxiliary axis will not develope extremely large lags.
26	ALISM PRGRST	Alias M codes during program restart.
27	DSBL JOG TST	Disables the encoder test for the jog handle.
28	AIR DR @ M24	Used on horizontal mills only.
29	PAL ENABLE	This parameter accommodates both the APC on the vertical mill the Rotary Pallet Changer on the Horizontal mill. This parameter bit should be set to 1 if an APC is present. Otherwise, it should be set to zero. Note that this bit should be zero on Horizontal Mills as it is intended for future pallet changer software that replaces the macro program.
30	P RDY @ Y160	Used on horizontal mills only.
31	SPNDL NOWAIT	When (1), the machine will not wait for the spindle to come up to speed immediately after an M03 or M04 command. Instead, it will check and/or wait for the spindle to come up to speed immediately before the next interpolated motion is initiated. This bit does not affect rigid tapping or the TSC option.

Parameter 210 X AXIS TOOL CHANGE OFFSET

Used on the HS-2RP mill for X axis displacement from the home position to tool change position.

If this parameter contains an incorrect value, a horizontal mill will crash when it does a tool change.

Parameter 211 Y AXIS TOOL CHANGE OFFSET

Used on the HS-2RP mill for Y axis displacement from the home position to tool change position.

If this parameter contains an incorrect value, a horizontal mill will crash when it does a tool change.

Parameter 212 A TOOL CHANGE OFFSET

This parameter sets the distance between the **A**-axis grid offset (Parameter 128) and the spindle home position. The **A**-axis will be limited in movement to the area between the positive value of this parameter and the negative MAX TRAVEL.

Parameter 213 B TOOL CHANGE OFFSET
This parameter sets the distance between the **B**-axis grid offset (Parameter 170) and the spindle home position. The **B**-axis will be limited in movement to the area between the positive value of this parameter and the negative MAX TRAVEL.
This parameter must be used on all mills with the 60 or 120 pocket chain-style tool changer, as opposed to parameter 215, CAROUSEL OFFSET, which is used on other side mount tool changers. Note that on a machine with a single mocon board, the Tt axis parameters are automatically copied to the B axis parameters and only the Tt axis parameters can be altered.

Parameter 214 D:Y CURRENT RATIO %. UNIT: %.
This defines the ratio between the two winding configurations. This default winding is Y, and the parameters are set for the Y winding. This number is used to adjust the parameters for the delta winding when the windings are switched.

Parameter 215 CAROUSEL OFFSET
Used on horizontal mills only. Parameter used to align tool 1 of tool changing carousel precisely. Units are encoder steps.

Parameter 216 CNVYR RELAY DELAY
Delay time in 1/50 seconds required on conveyor relays before another action can be commanded. Default is 50.

Parameter 217 CNVYR IGNORE OC TIM
Amount of time in 1/50 seconds before overcurrent is checked after conveyor motor is turned on. Default is 50.

Parameter 218 CONVYR RETRY REV TIM
Amount of time that the conveyor is reversed in 1/50 seconds after overcurrent is sensed. Default is 2000.

Parameter 219 CONVYR RETRY LIMIT
Number of times that the conveyor will cycle through the reverse/forward sequencing when an overcurrent is sensed before the conveyor will shut down. An overcurrent is sensed when chips jam the conveyor. By reversing and then forwarding the conveyor, the chip jam may be broken. Default is 5.

Parameter 220 CONVYR RETRY TIMEOUT
Amount of time in 1/50 seconds between consecutive overcurrents in which the overcurrents is considered another retry. If this amount of time passes between overcurrents, then the retry count is set to (0). Default is 1500, 30 seconds.

Parameter 221 MAX TIME NO DISPLAY
The maximum time (in 1/50 sec.) between screen updates.

Parameter 222 ROTARY AXIS INCRMNT
For Horizontal mills only. This parameter sets the degrees of rotation of the A-axis at an M36 or Pallet Rotate.

Parameter 223 AIR TC DOOR DELAY
For Horizontal mills only. This parameter sets the delay to open the tool changer door (in milliseconds). If the tool changer does not have a pneumatic door, this parameter is set to zero.

Parameter 224 ROT AXIS ZERO OFSET
This parameter shifts the zero point of A for a wheel fixture or tombstone.

Parameter 225 MAX ROT AXIS ALLOW
For Horizontal mills with a wheel fixture only. This parameter sets the maximum rotation (in degrees) allowed before stopping at front door.

Parameter 226 EDITOR CLIPBOARD
This parameter assigns a program number (nnnnn) to the contents of the clipboard (for the advanced editor).

Parameter 227 DISK DIR NAME
When the disk drive is enabled and a directory is read the directory listing is placed into a program as comments. The program is then made the current program so the user can read the contents of the disk drive. This parameter designates where to write the directory listing. Program 08999 is the default value.

Parameter 228 QUICKCODE FILE
This parameter set the program numbers to store in the Quick Code definition program. Usually, this is 9999.

Parameter 229 X LEAD COMP 10E9
This parameter sets the X-axis lead screw compensation signed parts per billion.

Parameter 230 Y LEAD COMP 10E9
This parameter sets the Y-axis lead screw compensation signed parts per billion.

Parameter 231 Z LEAD COMP 10E9
This parameter sets the Z-axis lead screw compensation signed parts per billion.

Parameter 232 A LEAD COMP 10E9
This parameter sets the A-axis lead screw compensation signed parts per billion.

Parameter 233 B LEAD COMP 10E9
This parameter sets the B-axis lead screw compensation signed parts per billion.

Parameter 235 TSC PISTON SEAT
With the 50 TSC option, the amount of time given for the piston to seat during system start-up. The default is 500 milliseconds. If machine has a **50 Taper spindle** and the TSC option, this parameter **must be set to 0.**

Parameter 236 TSC LOW PR FLT
After the TSC system has stabilized following start-up, Alarm 151 is generated if coolant pressure falls below 40 psi for the amount of time set in this parameter. The default is 1000 milliseconds.

Parameter 237 TSC CLNT LINE PURGE
The amount of time given for the coolant to purge when the TSC system is shut off. This parameter may be increased by the user to a higher value to help purge coolant from small orifice tooling. The minimum (default) value is 2500 milliseconds.

Parameter 238 MAX TSC SPINDLE RPM
When TSC is enabled and in use, this parameter limits the maximum spindle speed. Default value is 10000 RPM. On 50 taper machines, the maximum spindle speed is 5000 RPM

Parameter 239 SPNDL ENC STEPS/REV
This parameter sets the number of encoder steps per revolution of the spindle encoder.

Parameter 240 1ST AUX MAX TRAVEL
This parameter sets the maximum travel of the first auxiliary (C) axis in the positive direction.

Parameter 241 2ND AUX MAX TRAVEL
This parameter sets the maximum travel of the second auxiliary (U) axis in the positive direction.

Parameter 242 3RD AUX MAX TRAVEL
This parameter sets the maximum travel of the third auxiliary (V) axis in the positive direction.

Parameter 243 4TH AUX MAX TRAVEL
This parameter sets the maximum travel of the fourth auxiliary (W) axis in the positive direction.

Parameter 244 1ST AUX MIN TRAVEL
This parameter sets the maximum travel of the first auxiliary (C) axis in the negative direction.

Parameter 245 2ND AUX MIN TRAVEL
This parameter sets the maximum travel of the second auxiliary (U) axis in the negative direction.

Parameter 246 3RD AUX MIN TRAVEL
This parameter sets the maximum travel of the third auxiliary (V) axis in the negative direction.

Parameter 247 4TH AUX MIN TRAVEL
This parameter sets the maximum travel of the fourth auxiliary (W) axis in the negative direction.

Parameter 248 SMTC RLY ON / OFF DLY
Vertical mills with sidemount tool changers only. It specifies the time needed (in milliseconds) between turning off one relay and turning on the other one, when reversing the carousel.

Parameter 249 TOOL CLAMP DELAY
This parameter provides a delay after the tool has been clamped and before retraction of the tool carousel at the end of a tool change. For most mills, this parameter should be set to zero. Units are milliseconds.

Parameter 250 TOOL UNCLAMP DELAY
This parameter provides a delay after the tool has been unclamped and before the spindle is backed away at the beginning of a tool change. For most mills, this parameter should be set to zero. Units are in milliseconds.

Parameter 251 A DOOR OPEN ERRTIME
This parameter supports the Auto-Door feature. It is used for several things:
1) It specifies the number of 50ths of a second for the motor to run to open the door.
2) The value of this parameter plus one second specifies the number of 50ths of a second for the motor to run to close the door.
3) If, at the end of the door-close time, the door has not yet reached the switch, alarm 238 DOOR FAULT is generated.
If an automatic door is installed, this parameter should be set to 5500 (5.5 seconds) nominally, otherwise it should be set to zero.

Parameter 252 GEAR MOTOR TIMEOUT
This parameter supports the Auto-Door feature. It specifies the length of time (in ms) that is allowed for the door to begin opening. If the door does not move off the door-closed switch within this amount of time, alarm 238 DOOR FAULT will be generated. This parameter should be set to 1000 (1.0 seconds) nominally.

Parameter 254 VB AIR DOOR CLEARANCE
This is a new parameter to support the VB-1 Bridge Mill tool carousel air door. The air door is a clamshell shaped door covering the tool carousel, which raises up at one side by air power to allow the spindle to access the tools. In order for it to open and close, there must be sufficient clearance between it and the spindle. This parameter must be set to the correct value (in encoder units), parameter 223 AIR TC DOOR DELAY must set to a non-zero value, parameter 267 ZERO AXIS TC must be set to 1 and parameter 278 TC DR SWITCH must be set to 1.
When a tool change is commanded, the following steps are performed:
1) The Y axis is moved to the position specified by parameter 254.
2) The air door is commanded to open.
3) There is a delay specified by parameter 223 to allow the door to open fully.
4) The Y axis is moved to zero and the tool change is performed.
5) The Y axis is moved to the position specified by parameter 254.
6) The air door is commanded to close.
7) There is a delay specified by parameter 223 to allow the door to close fully.

Parameter 255 CONVEYOR TIMEOUT
The number of minutes the conveyor will operate without any motion or keyboard action. After this time, the conveyor will automatically shut off. Note that this parameter value will cause the conveyor to turn off even if the intermittent feature is functioning. Note also that if this parameter is set to zero, the chip conveyor will shut off immediately, i.e., pressing CHIP FWD or CHIP REV will not turn it on.

Parameter 256 PALLET LOCK INPUT
This parameter selects the discrete input (0 to 31) that is to be used to monitor the pallet locked status. Used in horizontal mills only.

Parameter 257 SPINDL ORIENT OFSET
If the machine is equipped with a spindle vector drive (as set in bit 7 of Parameter 278), this bit sets the spindle orientation offset. The offset is the number of encoder steps between the Z pulse and the correct spindle orientation position. It is used to orient the spindle properly anytime it needs to be locked, such as prior to a tool change, or orient spindle command.

Parameter 258 COLD SPINDLE TEMP

The first time Cycle Start is pressed after the machine has been turned on, the control will compare the microprocessor temperature (in degrees Fahrenheit) against the value of this parameter. If the microprocessor is colder, the control will assume that the spindle is too cold or inadequately lubricated to be run safely at high speed and the following message will be displayed:

!!!WARNING!!!

YOUR MACHINE IS COLD, RUN A WARM-UP PROGRAM BEFORE RUNNING THE SPINDLE AT HIGH SPEED OR DAMAGE MAY RESULT PRESS 'CANCEL' TO CONTINUE

The user must press CANCEL before continuing. It is recommended that a spindle warm-up program be run immediately. This message will only appear once each time the machine has been turned on. The initial value for this parameter is 70 (degrees F). To disable this feature, change it to zero.

Parameter 259 COLD SPINDLE DAYS

The first time Cycle Start is pressed after the machine has been turned on, the control will compare the number of days that have passed since the machine was turned off against the value of this parameter. If the machine has been off longer, the control will assume that the spindle is too cold or inadequately lubricated to be run safely at high speed and the following message will be displayed:

!!!WARNING!!!

YOUR MACHINE IS COLD, RUN A WARM-UP PROGRAM BEFORE RUNNING THE SPINDLE AT HIGH SPEED OR DAMAGE MAY RESULT PRESS 'CANCEL' TO CONTINUE

The user must press CANCEL before continuing. It is recommended that a spindle warm-up program be run immediately. This message will only appear once each time the machine has been turned on. The initial value for this parameter is 3 (days). To disable this feature, change it to 999999.

Parameter 266 X SWITCHES

Parameter 266 is a collection of single-bit flags used to turn servo related functions on and off. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0	X LIN SCALE EN	Used to enable linear scales for the X axis.
1	X INVRT LN SCL	Used to invert the X-axis linear scale.
2	DSBL SCALE Z	Used to disable the linear scale Z test.
3	X ZERO AXIS TC	Used to return axis to zero prior to tool change (5-axes mills) .
4	X 2ND HOME BTN	Used to move axis to coordinate specified in Work Offset G129.
5	X NEG COMP DIR	Used to negate the direction of thermal compensation.
6	X DELAY AXIS 0	Used with an APL to ensure X axis is zeroed before A axis of APL
7	X MAX TRAVEL INP	This bit is set to 1 on five axes machines. This bit indicates that there is a switch (visible through MOCON) that detects if the axis has rotated all the way round. It is used to tell the control to skip the first zero switch when zeroing so it can unwrap the cables.

9 X TEMP SENSOR — This performs Lead Screw Thermal Compensation via a temperature sensor attached to the ball nut. When this bit is set to 1, the feature is activated for that axis. Note that this feature can only be used when temperature sensors are installed. The following parameters must be set appropriately:

201, 132, 133 XYZ SCREW COMP. COEF.	=-8000000
272, 273, 274 XYZ SCREW COMP. T. CONST.	=-28000
351 TEMP PROBE OFFSET	=450000

16 SCALE Z HIST — For HAAS diagnostic use only.

Parameter 267 Y SWITCHES

Parameter 267 is a collection of single-bit flags used to turn servo related functions on and off. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0 Y LIN SCALE EN — Used to enable linear scales for the Y axis.

1 Y INVRT LN SCL — Used to invert the Y-axis linear scale.

2 DSBL SCALE Z — Used to disable the linear scale Z test.

3 Y ZERO AXIS TC — Used to return axis to zero prior to tool change (5-axes mills).

4 Y 2ND HOME BTN — Used to move axis to coordinate specified in Work Offset G129.

5 Y NEG COMP DIR — Used to negate the direction of thermal compensation.

6 Y DELAY AXIS 0 — Used with an APL to ensure Y axis is zeroed before A axis of APL.

7 Y MAX TRAVEL INP — This bit is set to 1 on five axes machines. This bit indicates that there is a switch (visible through MOCON) that detects if the axis has rotated all the way round. It is used to tell the control to skip the first zero switch when zeroing so it can unwrap the cables.

9 Y TEMP SENSOR — This performs Lead Screw Thermal Compensation via a temperature sensor attached to the ball nut. When this bit is set to 1, the feature is activated for that axis. Note that this feature can only be used when temperature sensors are installed. The following parameters must be set appropriately:

201, 132, 133 XYZ SCREW COMP. COEF.	=-8000000
272, 273, 274 XYZ SCREW COMP. T. CONST.	=-28000
351 TEMP PROBE OFFSET	=450000

16 SCALE Z HIST — For HAAS diagnostic use only.

Parameter 268 Z SWITCHES

Parameter 268 is a collection of single-bit flags used to turn servo related functions on and off. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0 Z LIN SCALE EN — Used to enable linear scales for the Z axis.

1 Z INVRT LN SCL — Used to invert the Z-axis linear scale

2 DSBL SCALE Z — Used to disable the linear scale Z test.

3 Z ZERO AXIS TC — Used to return axis to zero prior to tool change (5-axes mills) .

4 Z 2ND HOME BTN — Used to move axis to coordinate specified in Work Offset G129.

5 Z NEG COMP DIR — Used to negate the direction of thermal compensation.

6 Z DELAY AXIS 0 — Used with an APL to ensure Z axis is zeroed before A axis of APL

7	Z MAX TRAVEL INP	This bit is set to 1 on five axes machines. This bit indicates that there is a switch (visible through MOCON) that detects if the axis has rotated all the way round. It is used to tell the control to skip the first zero switch when zeroing so it can unwrap the cables.
9	Z TEMP SENSOR	This performs Lead Screw Thermal Compensation via a temperature sensor attached to the ball nut. When this bit is set to 1, the feature is activated for that axis. Note that this feature can only be used when temperature sensors are installed. The following parameters must be set appropriately:

201, 132, 133 XYZ SCREW COMP. COEF.	=-8000000
272, 273, 274 XYZ SCREW COMP. T. CONST.	=-28000
351 TEMP PROBE OFFSET	=450000

16	SCALE Z HIST	For HAAS diagnostic use only.

Parameter 269 A SWITCHES

Parameter 269 is a collection of single-bit flags used to turn servo related functions on and off. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0	A LIN SCALE EN	Used to enable linear scales for the A axis.
1	A INVRT LN SCL	Used to invert the A-axis linear scale.
2	DSBL SCALE Z	Used to disable the linear scale Z test.
3	A ZERO AXIS TC	Used to return axis to zero prior to tool change (5-axes mills).
4	A 2ND HOME BTN	Used to move axis to coordinate specified in Work Offset G129.
5	A NEG COMP DIR	Used to negate the direction of thermal compensation.
6	A DELAY AXIS 0	Used with an APL to ensure A axis is zeroed before B axis of APL.
7	A MAX TRAVEL INP	This bit is set to 1 on five axes machines. This bit indicates that there is a switch (visible through MOCON) that detects if the axis has rotated all the way round. It is used to tell the control to skip the first zero switch when zeroing so it can unwrap the cables.
9	A TEMP SENSOR	This performs Lead Screw Thermal Compensation via a temperature sensor attached to the ball nut. When this bit is set to 1, the feature is activated for that axis. Note that this feature can only be used when temperature sensors are installed. The following parameters must be set appropriately:

201, 132, 133 XYZ SCREW COMP. COEF.	=-8000000
272, 273, 274 XYZ SCREW COMP. T. CONST.	=-28000
351 TEMP PROBE OFFSET	=450000

16	SCALE Z HIST	For HAAS diagnostic use only.

Parameter 270 B SWITCHES

Parameter 270 is a collection of single-bit flags used to turn servo related functions on and off. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0	B LIN SCALE EN	Used to enable linear scales for the B axis.
1	B INVRT LN SCL	Used to invert the B-axis linear scale.
2	DSBL SCALE Z	Used to disable the linear scale Z test.
3	B ZERO AXIS TC	Used to return axis to zero prior to tool change (5-axes mills). On HS mills with the 60 or 120 pocket chain-style tool changer, this bit must be set to 1. It will cause the TOOL CHANGE OFFSET parameter to be used for tool changes.
4	B 2ND HOME BTN	Used to move axis to coordinate specified in Work Offset G129.
5	B NEG COMP DIR	Used to negate the direction of thermal compensation.
6	B DELAY AXIS 0	Used with an APL to ensure B axis is zeroed before A axis of APL.
7	B MAX TRAVEL INP	This bit is set to 1 on five axes machines. This bit indicates that there is a switch (visible through MOCON) that detects if the axis has rotated all the way round. It is used to tell the control to skip the first zero switch when zeroing so it can unwrap the cables.
9	B TEMP SENSOR	This performs Lead Screw Thermal Compensation via a temperature sensor attached to the ball nut. When this bit is set to 1, the feature is activated for that axis. Note that this feature can only be used when temperature sensors are installed. The following parameters must be set appropriately:

201, 132, 133 XYZ SCREW COMP. COEF.	=-8000000
272, 273, 274 XYZ SCREW COMP. T. CONST.	=-28000
351 TEMP PROBE OFFSET	=450000

16	SCALE Z HIST	For HAAS diagnostic use only.

Parameter 271 C SWITCHES

Parameter 271 is a collection of single-bit flags used to turn servo related functions on and off. This parameter is not used when machine is equipped with a Haas vector drive. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0	C LIN SCALE EN	Used to enable linear scales for the C axis.
1	C INVRT LN SCL	Used to invert the C-axis linear scale.
2	DSBL SCALE Z	Used to disable the linear scale Z test.
3	C ZERO AXIS TC	Used to return axis to zero prior to tool change (5-axes mills).
4	C 2ND HOME BTN	Used to move axis to coordinate specified in Work Offset G129.
5	C NEG COMP DIR	Used to negate the direction of thermal compensation.
6	C DELAY AXIS 0	Used with an APL to ensure C axis is zeroed before A axis of APL.
16	SCALE Z HIST	For HAAS diagnostic use only.

Parameter 272 X SCREW COMP T. CONST.

This parameter is the thermal compensation time constant, and is the time constant governing the rate of cool down of the screw.

Parameter 273 Y SCREW COMP T. CONST.
This parameter is the thermal compensation time constant, and is the time constant governing the rate of cool down of the screw.

Parameter 274 Z SCREW COMP T. CONST.
This parameter is the thermal compensation time constant, and is the time constant governing the rate of cool down of the screw.

Parameter 275 A SCREW COMP T. CONST.
This parameter should be set to 0.

Parameter 276 B SCREW COMP T. CONST.
This parameter should be set to 0.

Parameter 278 COMMON SWITCH 3
Parameter 278 is a collection of general purpose single bit flags used to turn some functions on and off. This bit will cause the machine to use discrete outputs 21 and 26 to command the shuttle to move in and out. On mills with the Air Driven Shuttle it must be set to 1. On all other mills it must be set to 0. The left and right cursor arrows are used to select the function being changed. All values are 0 or 1 only. The function names are:

0	INVERT G.B.	This bit allows an alternate gearbox configuration. It inverts the sense of the gearbox inputs. Used for 50 taper option.
1	DPR SERIAL	Causes the main serial inputs/outputs to go through the disk video board.
2	CHECK PALLET IN	This bit is used on horizontal mills only.
3	CHECK HIDN VAR	This bit is used on horizontal mills only.
4	DISPLAY ACTUAL	When set to 1, displays the actual spindle speed on the Current Commands display page.
5	TSC PRG ENBL	Enables purge output on TSC option.
6	SNGL SW CLMP	This parameter enables the control to rely up on a single switch to detect the clamp position of the Side Mount Tool Changer arm. When this bit is set to zero, both the upper and the lower switches are used to detect the arm position. When it is set to one, only the lower switch will be used. This means that the control will not wait until the upper switch is tripped to conclude that the tool is clamped, so subsequent operations can begin immediately. This increases tool change speed.
7	SPND DRV LCK	This bit must be set to 1 if machine is equipped with a non-Haas vector spindle drive. This bit must be set to 1 if the machine has a 50 taper spindle or a non-Haas vector drive.
9	CNCR SPINDLE	(Concurrent Spindle) When set to 1, the spindle will be commanded to start concurrently with other commands in the same block. In the following example, with this bit set to 1, the spindle will start at the same time as the rapid move: **G0 X-1. S7500 M3;**
10	HS3 HYD TC	This parameter bit is used with the 38 tool SMTC on the HS-3. When this is set to zero, the mill will behave normally. When it is set to 1, the control will recognize that the toolchanger is a 38-Tool SMTC.

11	HAAS VECT DR	(Haas Vector Drive) This bit must be set to 1 if machine is equipped with a HAAS vector spindle drive. When set to 1, voltage to the Haas vector drive is displayed in the diagnostics display as DC BUSS.
12	UP ENCL TEMP	(Microprocessor Enclosure Temperature) When set to 1, the enclosure temperature will be displayed on INPUTS2 screen of the diagnostics display.
13	HAAS RJH	(Haas Remote Jog Handle) This bit must be set to 1 if the machine is equipped with a Haas 5-Axes Remote Jog Handle.
14	SPIN TEMP NC	(Spindle Temperature Sensor Normally Closed) This bit specifies the type (normally open or normally closed) of the spindle temperature sensor. This bit should be set to 1.
15	AIR DRV SHTL	This bit will cause the machine to use discrete outputs 21 and 26 to command the shuttle to move in and out. On mills with the Air Driven Shuttle it must be set to 1. On all other mills it must be set to 0.
16	GIMBAL SPNDL	Used on 5-axes mills. This bit will cause the machine to check that the Z,A and B axes are at zero before a tool change is started. If one is not, alarm 150 will be generated. On mills with the gimbaled Spindle it must be set to 1. On all other mills it must be set to 0.
17	NO MFIN CKPU	When this bit is set, it will prevent checking of MFIN at power-up. It should be set for 1 for all machines that have the new Haas Automatic Pallet Changer attached, and 0 for all other machines.
18	D:Y SW ENABLE	(Delta Wye switch enabled). This bit is used for the Vector Drive. The bit enables the switching of spindle motor windings, provided the hardware ENABLE is installed, and the proper parameters are set. If this switch is set, but bit 19 is not, then the winding switching will only be done when the spindle is at rest, depending on the target speed of the spindle.
19	D:Y SW ON FLY	This bit enables switching on the fly, as the spindle motor is accelerating or decelerating through the switch point. If bit 18 is not set, this switch will be ignored.
20	5 AX TOFS -X	This bit is used with the G143 (modal 5 axes tool length compensation) on machines with a Gimbaled Spindle. If it is set to 1, this means that when the corresponding rotary axes is moved, the sign of the X Position must be inverted. Normally, this bit should be set to 0.
21	5 AX TOFS -Y	This bit is used with the G143 (modal 5 axes tool length compensation) on machines with a Gimbaled Spindle. If it is set to 1, this means that when the corresponding rotary axes is moved, the sign of the Y Position must be inverted. Normally, this bit should be set to 0.
22	B+C 5 AXES	This bit is used with the G142 (modal 5 axes tool length compensation) on machines with a Gimbaled Spindle. The B-axis normally moves the A-axis, but if this is not true, this bit can be set to change which is the inner axis. Normally, this bit should be set to 0.

23 TC DR SWITCH — Horizontal tool carousel door configuration. This bit specifies the Horizontal Mill tool carousel door configuration. If it is set to 0, this indicates the old configuration where the door is driven open by a timed operation. If it is set to 1, this indicates the new configuration where the door is spring-loaded closed and is driven open by the timed operation against the door open switch. In open position, the door switch signal is 0 (low). The switch status is checked before and after commanding the door to open in order to be fail-safe.

For all horizontal mills that have the switch installed, this bit must be set to 1. For all other mills, this bit must be set to 0.

24 HS2 SDMTCRSL — This parameter bit is for the HS-2 sidemount tool changer. It must be set to 1 on all HS-2 mills, and 0 on all other mills.

25 HS3 SDMTCRSL — This parameter bit is for the HS-3 sidemount tool changer. It must be set to 1 on all HS-3 mills, and 0 on all other mills.

26 S MNT BIT 1 — Bits 26, 27, and 28 work together to specify the type of sidemount tool changer that is installed on a vertical mill. The following table shows the bit combinations that must be used:

Bit 26	27	28	
0	0	0	No side-mount tool changer installed
1	0	0	Serpentine 1
0	1	0	Serpentine 2
1	1	0	Serpentine 3
0	0	1	Disk 1
1	0	1	Disk 2
0	1	1	Disk 3
1	1	1	Disk 4

27 S MNT BIT 2 — Bits 26, 27, and 28 work together to specify the type of sidemount tool changer that is installed on a vertical mill.

28 S MNT BIT 3 — Bits 26, 27, and 28 work together to specify the type of sidemount tool changer that is installed on a vertical mill.

29 SAFETY INVERT — This bit supports the CE door interlock that locks when power is turned off. For machines that have the regular door lock that locks when power is applied, this bit must be set to 0. For machines that have the inverted door lock, this bit must be set to 1.

30 SWAP A & C — This parameter causes the A and C axes to be swapped internally. This parameter bit should be set to 1 for the bridge mill. All other mills should set this bit to 0.

31 INV SPD DCEL — Inverse Spindle Speed Deceleration. When this parameter is set to 1, the spindle decelerates faster at lower speeds, resulting in a shorter deceleration time.

Parameter 279 X SCALE GAIN MULT

This parameter is used on machines with linear scales. Linear scales are used to continuously correct any errors in the encoder position. The parameter determines the gain of the correction factor, that is, how fast it corrects. This parameter should be set to 40.

Parameter 280 Y SCALE GAIN MULT

See parameter 279 for description

Parameter 281 Z SCALE GAIN MULT
See parameter 279 for description

Parameter 282 A SCALE GAIN MULT
See parameter 279 for description

Parameter 283 B SCALE GAIN MULT
See parameter 279 for description

Parameter 284 RESERVED

Parameter 285 X LINEAR SCREW OFFS
This parameter is used on machines with linear scales. This parameters account for the unused portion of the lead screw between zero and the actual motor. This parameter should be a positive value (400000) unless the NEG COMP DIR bit for the axis is set, in which case this parameter should be a negative value (-400000.)

Parameter 286 Y LINEAR SCREW OFFS
See parameter 285 for description.

Parameter 287 Z LINEAR SCREW OFFS
See parameter 285 for description.

Parameter 288 A LINEAR SCREW OFFS
See parameter 285 for description.

Parameter 289 B LINEAR SCREW OFFS
See parameter 285 for description.

Parameter AUTO DOOR PAUSE
This parameter supports the Auto-Door feature. It specifies the length of a pause (in 50ths of a second) that occurs during the door close sequence. As the door closes and the switch is activated, the motor is turned off for this amount of time and the door coasts. This allows the door to close smoothly. This parameter should be set to 1 (0.02 seconds) nominally. It works in conjunction with parameter 293.

Parameter 293 AUTO DOOR BUMP
This parameter supports the Auto-Door feature. It specifies the length of time (in 50ths of a second) that the motor should be reactivated after the pause specified by parameter 292. This causes the motor to close the door fully and smoothly. This parameter should be set to 2 (0.04 seconds) nominally.

Parameter 294 MIN BUSS VOLTAGE
This parameter specifies the minimum Haas Vector Drive buss voltage. It should be set to 200 (the units are volts). Alarm 160 will be generated if the voltage falls below this value.

Parameter 295 SHTL SETTLE TIME
Used on mills with an air driven shuttle. This parameter allows settling time for the shuttle after it has moved toward the spindle and before a tool change is performed. It should be set to approximately half a second (500) on all mills with the Air Driven Shuttle. This may very. All other mills can be set to 0 as they are unaffected by it.

Parameter 296 MAX OVER VOLT TIME
Specifies the amount of time (in 50ths of a second) that an overvoltage condition (alarm 119 OVER VOLTAGE) will be tolerated before the automatic shut down process is started.

Parameter 297 MAX OVERHEAT TIME
Specifies the amount of time (in 50ths of a second) that an overheat condition (alarm 122 REGEN OVERHEAT) will be tolerated before the automatic shut down process is started.

Parameter 298 MAX FEED (DEG/MIN)
Used on 5-axes mills. This parameter specifies the maximum rotary feed rate in degrees per minute. Any attempt at cutting faster than this will result in "LIM" being displayed next to the FEED message on the Program Command Check screen.

On mills with a Gimbaled Spindle, this parameter must be set to 300. For all other mills, this bit should be set to 99999.

Parameter 299 AUTOFEED-STEP-UP
This parameter works with the AUTOFEED feature. It specifies the feed rate step-up percentage per second and should initially be set to 10.

Parameter 300 AUTOFEED STEP-DOWN
This parameter works with the AUTOFEED feature. It specifies the feed rate step-down percentage per second and should initially be set to 20.

Parameter 301 AUTOFEED-MIN-LIMIT
This parameter works with the AUTOFEED feature. It specifies the minimum allowable feed rate override percentage that the AUTOFEED feature can use and should initially be set to 1.

Parameter 302 FEED ACCELERATION
This parameter supports the motion control feature. This is the acceleration that applies to feed motion in encoder steps per second squared. For Vertical mill, 1/2 of the value of parameter 7 is a good starting point. For horizontal Mills, 1000000 is a good value to start with. This parameter can be further updated as necessary.

Parameter 303 FEED TIME CONSTANT
This parameter supports the motion control feature. It is the base 2 exponent of the feed time constant in milliseconds. It should be set to 3.

Parameter 305 SERVO PO BRK DLY
The SRV PO (Servo Power On) discrete output is used to engage and disengage an axis brake. This parameter is used to specify a time in milliseconds that the control should wait after activating the SRV PO output and turning off power to the servo motors via the MOCON. This parameter also specifies the time to wait after deactivating the SRV PO output and reactivating the servo motors via the MOCON.

Parameter 306 POCKET UP / DN DELAY
This parameter supports the side mount tool changers. It specifies the time allowed (in milliseconds) for the tool pocket to be raised or lowered. If the pocket does not move to its commanded position within the time allowed by this parameter and by parameter 62, alarm 626 TOOL POCKET SLIDE ERROR is generated. For mills without a side mount tool changer, this parameter should be set to 0.

Parameter 307 POCK UN / LOCK DELAY
This parameter supports the side mount tool changers. It specifies the time allowed (in milliseconds) to lock or unlock a tool pocket. For mills without a side mount tool changer, this parameter should be set to 0.

Parameter 308 ARM ROTATE TIME
This parameter supports the side mount tool changers. It specifies the time allowed (in milliseconds) for the arm to rotate to the next position. The positions are, Clamp, Unclamp, and Origin. If the arm does not move to the commanded position within the allowed time, alarm 622 TOOL ARM FAULT is generated. For mills without a side mount tool changer, this parameter should be set to 0.

Parameter 309 MOTOR COAST TIME
This parameter supports the side mount tool changers. It specifies the time allowed for the tool changer to start only. If the arm has not moved after the allowed time, alarm 627 ATC ARM POSITION TIMEOUT is generated. Units are milliseconds.

Parameter 310 CAM LOCK DELAY
This parameter supports the side mount tool changers. It specifies the time allowed (in milliseconds) to lock the cam by pushing the shot pin in, or to unlock the cam by pulling the shot pin out. If the shot pin has not moved to its commanded position within the allowed time, alarm 625 INVALID TC START CONDITION is generated.

Parameter 311 ARM BUMP TIME
This parameter supports the side mount tool changers. During tool change recovery, the arm may be moved a small amount by pressing the ATC FWD or ATC REV key. Each press of the key will cause the arm motors to run for the amount of time (in milliseconds) specified by this parameter. For mills without a side mount tool changer, this parameter should be set to 0.

On horizontal mills with a side mount tool chager, the arm may be rotated a small amount by pressing the END or PAGE DOWN keys. The shuttle may be moved by pressing the Left Arrow or Right Arrow keys. Each press of the key will cause the motor to run for the amount of time (in milliseconds) specified by this parameter. This parameter is most commonly set to 30.

Parameter 312 CAROUSEL BUMP TIME
This parameter supports the side mount tool changers. During tool change recovery, the carousel may be moved a small amount by pressing the Left Arrow or Right Arrow key. Each press of the key will cause the carousel motors to run for the amount of time (in milliseconds) specified by this parameter. For mills without a side mount tool changer, this parameter should be set to 0.

Parameter 313 POCKET INCREMENT
This is a parameter for the bridge mill. Under normal circumstances it should be set to 1. If it is set to 2, for example, the control will only recognize every other pocket. That is, it will treat the tools and pockets as follows:

Tool 1 is in pocket 1
Tool 2 is in pocket 3
Tool 3 is in pocket 5
Tool 4 is in pocket 7
etc...

If this parameter is set to 3 the control will only recognize every third pocket and so on. **It is the operator's responsibility to ensure that the total number of pockets in the tool changer is evenly divisible by this parameter value.** If not, the control will pick the wrong pocket after the carousel has exceeded a full revolution.

Parameter 314 FEED DELTA V

This parameter supports the motion control feature. It is the maximum change in velocity in encoder steps per millisecond.

Model	Basic Value
HS-1	8
HS-1R	8
HS-1RP	8
HS-15AXT	8
HS-2RP	8
HS-3	8
HS-3R	8
MM-1	32
VR-11	16
VB-1	8
VB-3	8
VS-3	8
G-1	8

Model	Basic Value
VF-0	32
VF-0E	32
VF-EC	32
VF-1	32
VF-2	32
VF-3	24
VF-3D	24
VF-4	24
VF-4D	24
VF-5	24
VF-6	16
VF-7	16
VF-8	16
VF-9	16
VF-10	8
VF-11	8

Parameter 315 COMMON SWITCH 4

0 ALIS M GRPHC When this bit is set to 0, all user defined M codes (such as M50 normally used to do a pallet change on a horizontal mill) will be ignored when a program is run in graphics mode. If it is necessary to have graphics recognize such M codes, this bit should be set to 1.

1 GANTRY

2 NO X MV NXTL This parameter only affects horizontal mills, and is intended for use primarily on the HS-3. If this bit is set to zero, it will have no effect. If it is set to one, the X-axis will not move following a NEXT TOOL button press. The reason for this is because after pressing NEXT TOOL on an HS-1 or HS-2, the spindle, which is mounted on the X-axis, is moved closer to the operator so the next tool can be manually installed. On an HS-3, the X-axis is on the table and there is no advantage to moving it. Setting this bit to one will save time.

3 XL TOOLS This parameter enables the user to specify that large tools are considered to be extra large, and allow the Tool Pocket table to get set up as shown below. This parameter bit should be set to 1 on all mills with the 50 Taper Side Mount Tool Changer. Note that when this parameter bit is set to 1, the following tool pocket configuration is not allowed (see alarm 422).
An example of a tool pocket table with extra large tools:

1	-
2	L
3	-
4	-
5	L
6	-

4	HIGH SPEED	This parameter bit enables the High Speed Machining feature. This parameter requires an unlock code in order to set the bit to 1. This option requires the Floating Point Co-Processor and Floating Point software. If this option is turned on when non-floating point software is installed the High Speed option will have no effect.
5	FAEMAT SPIN	This bit controls the tool clamp and unclamp sequence for different spindles. This bit should be set to 1 when the mill has a Faemat spindle installed. Otherwise the bit should be set to 0. This improvement is intended primarily for the VB-1 bridge mill.
7	RST STOP PAL	This parameter enables the RESET button to stop a pallet change. It is intended for use with the future hard-coded pallet changer macro program. It should be set to zero.
8	MINI MILL	When parameter 315 bit 8 MINI MILL is set to 1, the Over Voltage discrete input will be displayed as P.S. Fault. When it is set to 1: (a) The DC BUSS voltage that is normally displayed on the diagnostics screen for a Vector Drive machine will not be displayed. (b) The conditions that would normally generate alarm 119 OVER VOLTAGE and alarm 160 LOW VOLTAGE will instead generate alarm 292 320V POWER SUPPLY FAULT and this alarm will be added to the alarm history only after a 1 second delay to prevent false 292 alarms being added to the alarm history at the moment power is turned off. This parameter bit must be set to 1 on all Mini Mills.
9	DOOR OPEN SW	The bit allows the software to work with an optional door-open switch. This bit should be set to 1 on all machines fitted with the second door switch. If this bit is set to 1, the control will look for a second door switch when the door is opened automatically to the fully open position. If the switch is not found, alarm 238 DOOR FAULT will be generated. If this bit is set to zero, the control behaves as before.
10	PAL HARDCODE	This bit supports the hard-coded APC pallet changer function. It must be set to 1 when an APC is present that is wired for two APC door switches. On all other machines, it must be set to 0.

Parameter 316 APC PAL. CLAMP TIME

This is the time required to clamp the APC pallet to the receiver. It should be set to 4000. Units are milliseconds.

Parameter 317 APC UNCLAMP TIME

This is the time required to unclamp the APC pallet from the receiver. It should be set to 4000. Units are milliseconds.

Parameter 318 APC PAL. CHAIN TIME

This is the time required to cycle the chain. It should be set to 8000. Units are milliseconds.

Parameter 319 APC DOOR CLOSE TIME

This is the time required to close the door. It should be set to 6000. Units are milliseconds.

Parameter 320 RP DRAWBAR DOWN
This is the time required for the drawbar to move down. Units are milliseconds.

Parameter 321 RP DRAWBAR UP TIME
This is the time required for the drawbar to move up. Units are milliseconds.

Parameter 327 X SCALES PER INCH
This parameter is used on machines equipped with linear scales. This parameter should be set to 25,400 on mills fitted with linear scales. On all other mills, they should be set to zero.

Parameter 328 Y SCALES PER INCH
This parameter is used on machines equipped with linear scales. This parameter should be set to 25,400 on mills fitted with linear scales. On all other mills, they should be set to zero.

Parameter 329 Z SCALES PER INCH
This parameter is used on machines equipped with linear scales. This parameter should be set to 25,400 on mills fitted with linear scales. On all other mills, they should be set to zero.

Parameter 330 A SCALES PER INCH
This parameter is used on machines equipped with linear scales. This parameter should be set to 0 on mills with or without linear scales.

Parameter 331 B SCALES PER INCH
This parameter is used on machines equipped with linear scales. This parameter should be set to 0 on mills with or without linear scales.

Parameter 333 X SCALES PER REV
This parameter is used on machines equipped with linear scales. This parameter should be set to 50,000 on mills fitted with linear scales. On all other mills, they should be set to zero.

Parameter 334 Y SCALES PER REV
This parameter is used on machines equipped with linear scales. This parameter should be set to 50,000 on mills fitted with linear scales. On all other mills, they should be set to zero.

Parameter 335 Z SCALES PER REV
This parameter is used on machines equipped with linear scales. This parameter should be set to 50,000 on mills fitted with linear scales. On all other mills, they should be set to zero.

Parameter 336 A SCALES PER REV
This parameter is used on machines equipped with linear scales. This parameter should be set to 0 on mills with or without linear scales.

Parameter 337 B SCALES PER REV
This parameter is used on machines equipped with linear scales. This parameter should be set to 0 on mills with or without linear scales.

Parameter 339 X SPINDLE THERM COEF.
This parameter supports the Spindle Head Thermal Compensation feature, and should be set to 0.

Parameter 340 Y SPINDLE THERM COEF.
See parameter 339 for description.

Parameter 341 Z SPINDLE THERM COEF.
See parameter 339 for description.

Parameter 342 A SPINDLE THERM COEF.
See parameter 339 for description.

Parameter 343 B SPINDLE THERM COEF.
See parameter 339 for description.

Parameter 345 X SPINDLE THERM TIME.CONST.
This parameter supports the Spindle Head Thermal Compensation feature, and should be set to 0.

Parameter 346 Y SPINDLE THERM TIME.CONST.
See parameter 345 for description.

Parameter 347 Z SPINDLE THERM TIME.CONST.
See parameter 345 for description.

Parameter 348 A SPINDLE THERM TIME.CONST.
See parameter 345 for description.

Parameter 349 B SPINDLE THERM TIME.CONST.
See parameter 345 for description.

Parameter 351 THRML SENSOR OFFSET
This is a parameter used for Lead Screw Thermal Compensation via a temperature sensor attached to the ball nut.

Parameter 352 RELAY BANK SELECT
This parameter allows the user to change which bank of relays is to be used (Parameter 209 bit 23 MCD RLY BRD assumes that relay bank one is to be used). It may be set to a number from 0 to 3 (inclusive). M codes M21 through M28 will be switched to the selected bank. This parameter requires a revision "S" I/O board. If a previous board is installed (without the additional banks of relays), this parameter should be set to zero.

Parameter 588 X ENC. SCALE FACTOR

These are new axis parameters that work in place of the axis parameters called SCALE/X LO and SCALE/X HI. If SCALE FACT/X is set to 1, the scale ratio is determined by SCALE/X LO and SCALE/X HI as follows:

HI	LO	
0	0	3
0	1	5
1	0	7
1	1	9

If, however, SCALE FACT/X is set to zero, the value of ENC. SCALE FACTOR will be used for the scale ratio instead. Note that any value outside the range of 1 to 100 will be ignored and the scale ratio will remain unaffected. Note also that currently, these parameters are intended for use only on rotary axes (A and B).

Parameter 589 Y ENC. SCALE FACTOR

See parameter 588 for description

Parameter 590 Z ENC. SCALE FACTOR

See parameter 588 for description

Parameter 591 A ENC. SCALE FACTOR

See parameter 588 for description

Parameter 592 B ENC. SCALE FACTOR

See parameter 588 for description

Parameter 593 Sp ENC. SCALE FACTOR

See parameter 588 for description

Parameter 594 U ENC. SCALE FACTOR

See parameter 588 for description

Parameter 595 V ENC. SCALE FACTOR

See parameter 588 for description

Parameter 596 W ENC. SCALE FACTOR

See parameter 588 for description

Parameter 600 PEAK SPIN. PWR - KW

This is a new parameter that has been added to support the spindle kilowatt (KW) load display which appears on the current commands page, next to the spindle load percentage. This parameter should be set to the peak power output in KW for the spindle motor.

Lead Screw Compensation

Separate lead screw compensation is provided for each of the **X**, **Y**, and **Z** axes. The operator-entered compensation values are spaced at 0.5 inch intervals within the machine coordinate system. The compensation values are entered in inches with a resolution of 0.0001 inch. The operator entered values are used to interpolate into a table of 256 entries. The spacing between two entries in the table of 256 is defined by Parameter 58. The entered values are limited to +/-127 encoder steps; so the limit in inches is dependent on Parameters 5, 19, and 33.

Note that the first entry corresponds to machine position zero and subsequent entries are for increasingly negative positions in the machine coordinate system. The user should not ever need to adjust the lead screw compensation tables.

Electronic Thermal Compensation

When ballscrews rotate they generate heat. Heat causes the ballscrews to expand. In constant duty cycles as in mold making the resultant ball screw growth can lead to cutting errors on the next morning start up. The Haas ETC algorithm can accurately model this heating and cooling effect and electronically expand and contract the screw to give near glass scale accuracy and consistency.

This compensation is based on a model of the lead screw which calculates heating based on the distance traveled and the torque applied to the motor. This compensation does not correct for thermal growth due to changes in ambient temperature or due to part expansion.

Electronic thermal compensation works by estimating the heating of the screw based on the total amount of travel over its length and including the amount of torque applied to the screw. This heat is then turned into a thermal coefficient of expansion and the position of the axis is multiplied by the coefficient to get a correction amount.

If the machine is turned off when there is some compensation applied (due to motion and heating of screw), when the machine is turned back on, the compensation will be adjusted by the clock indicated elapsed time.

Spindle Head Thermal Compensation

This feature integrates spindle speed over time and builds a model of thermal growth. As the model shows the spindle head warming up, the control adjusts the Z axes to compensate for thermal growth.

7. MAINTENANCE SCHEDULE

The following is a list of required regular maintenance for the HAAS HS Series Horizontal Machining Centers. Listed are the frequency of service, capacities, and type of fluids required. These required specifications must be followed in order to keep your machine in good working order and protect your warranty.

INTERVAL — **MAINTENANCE PERFORMED**

DAILY

- ✓ Top off coolant level every eight hour shift (especially during heavy TSC usage).
- ✓ Check way lube lubrication tank level.
- ✓ Clean chips from way covers and bottom pan.
- ✓ Clean chips from tool changer.
- ✓ Wipe spindle taper with a clean cloth rag and apply light oil.

WEEKLY

- ✓ Check for proper operation of auto drain on filter regulator.
- ✓ On machines with the TSC option, clean the chip basket on the coolant tank. Remove the tank cover and remove any sediment inside the tank. Be careful to disconnect the coolant pump from the controller and POWER OFF the control before working on the coolant tank. **Do this MONTHLY for machines without the TSC option.**
- ✓ Check air gauge/regulator for 85 psi.
- ✓ For machines with the TSC option, place a dab of grease on the V-flange of tools. **Do this MONTHLY for machines without the TSC option.**
- ✓ Clean exterior surfaces with mild cleaner. **DO NOT** use solvents.
- ✓ Check the hydraulic counterbalance pressure according to the machine's specifications.
- ✓ Place a dab of grease on the outside edge of the fingers of the tool changer and run through all tools.

MONTHLY

- ✓ Check oil level in gearbox. Add oil until oil begins dripping from over flow tube at bottom of sump tank.
- ✓ Clean pads on bottom of pallets.
- ✓ Clean the locating pads on the A-axis and the load station. This requires removing the pallet.
- ✓ Inspect way covers for proper operation and lubricate with light oil, if necessary.

SIX MONTHS

- ✓ Replace coolant and thoroughly clean the coolant tank.
- ✓ Check all hoses and lubrication lines for cracking.

ANNUALLY

- ✓ Replace the gearbox oil. Drain the oil from the gearbox, and slowly refill it with 2 quarts of Mobil DTE 25 oil.
- ✓ Check oil filter and clean out residue at bottom of filter.
- ✓ **Replace air filter on control box every (2) years.**

7.1 Lubrication Chart

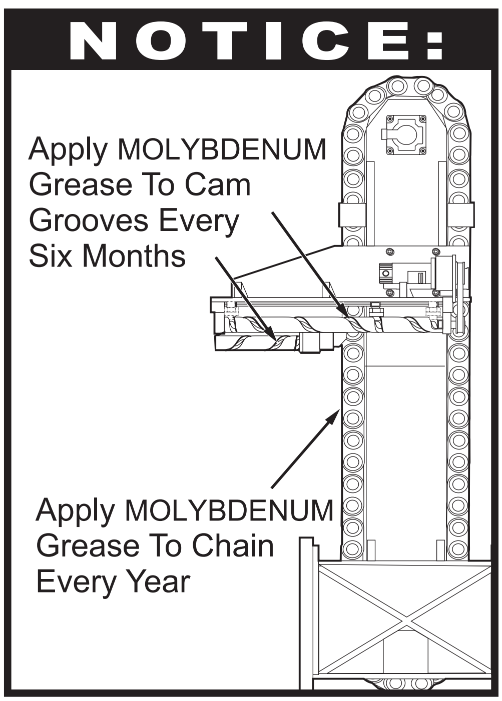
System	Way Lube and Pneumatics	Transmission	Coolant Tank
Location	Under the control panel on the right side of the machine	Rear of spindle head	Side of machine
Description	Piston pump with 30 minute cycle time. Pump is only on when spindle is turning or when axis is moving		
Lubricates	Linear guides, and ball nuts	Transmission only	
Quantity	2-2.5 Qts. depending on pump style	2 Qts.	80 gal.
Lubricant	Mobile Vactra #2	Mobile DTE 25	Water based coolant only*

***Mineral cutting oils will damage rubber based components throughout the machine.**

HS 60/120 SMTC Maintenance

To perform any maintenance tasks on the 60/120 SMTC, you must first remove the rear sheet metal. The following maintenance should be performed upon installation of the SMTC (if necessary), and every six-months thereafter:

- Lubricate the Shuttle Cam and Double Arm Cam grooves with black molybdenum grease. Apply grease to the chain using a brush.



TSC MAINTENANCE

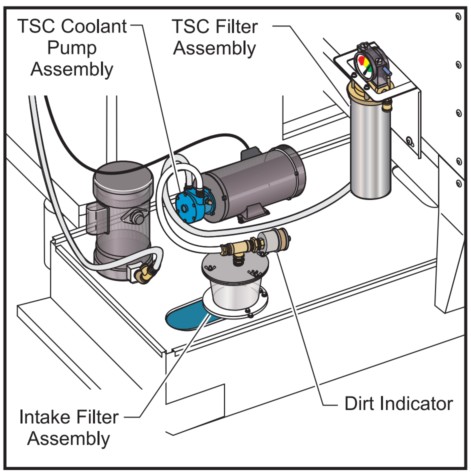
- Top off the coolant tank every eight hour shift during heavy TSC usage.
- Refer to the next section, and check gauge (G2) on 100 micron filter with TSC system running and no tool in the spindle. Change element when the indicator reaches the red zone. Use 100 micron filter element (58-6045) or commercially available equivalent.
- Clean pump intake filter when indicator (G1) is in red zone. Reset with button.

SPECIAL INSTRUCTIONS:

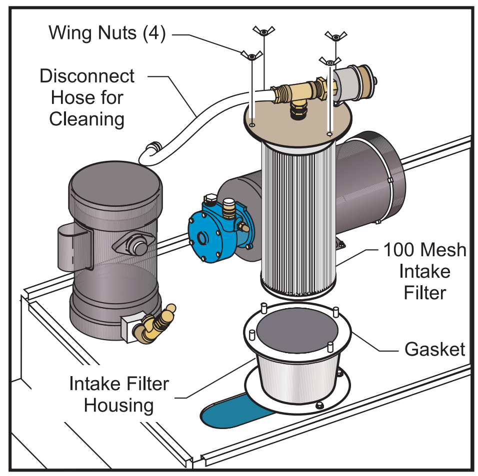
After changing or cleaning filter elements, run TSC system with no tool in spindle for at least one minute to purge air.

✓ Clean pump intake filter when indicator is in red zone. Reset indicator with button. All intake filters can be cleaned with a wire brush.

✓ After changing or cleaning filter elements, run TSC system with no tool in spindle for at least one minute to prime system.

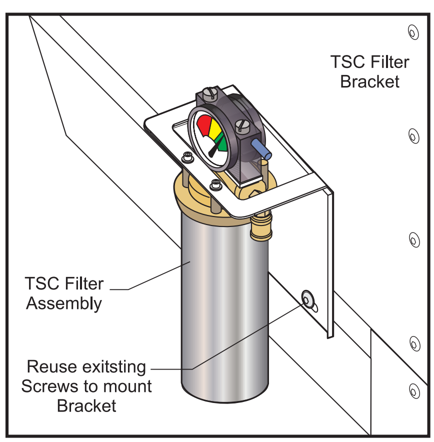


TSC coolant pump assembly.

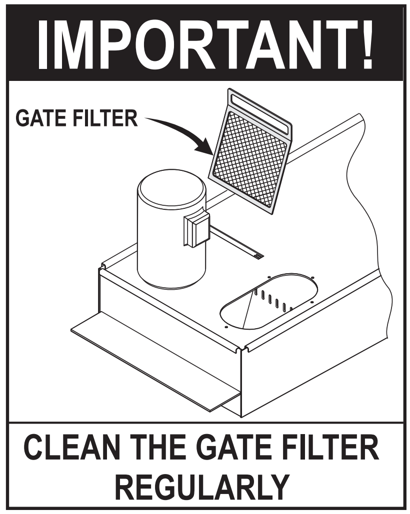


Cleaning the intake filter.

✓ Check dirt indicator on 100 micron filter (see the figure below) with TSC system running and no tool in the spindle. Change element when the indicator reaches the red zone.



100 Micron 1TSC filter.



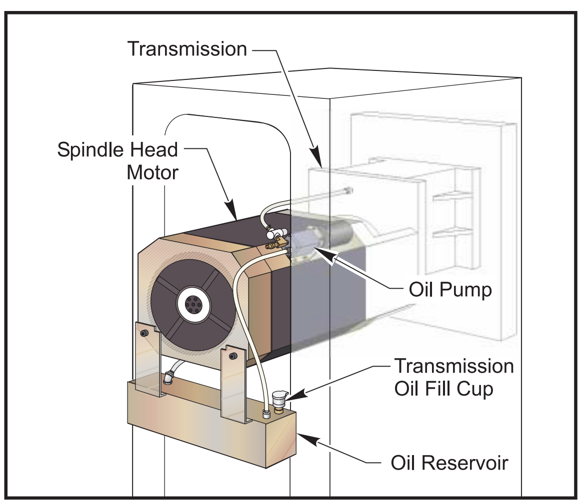
To clean the filter:

Turn off the coolant pump.
Remove the filter.
Clean and reinstall filter.

HS-1/2 - Transmission Oil

CAUTION! Power down the machine before performing any maintenance tasks.

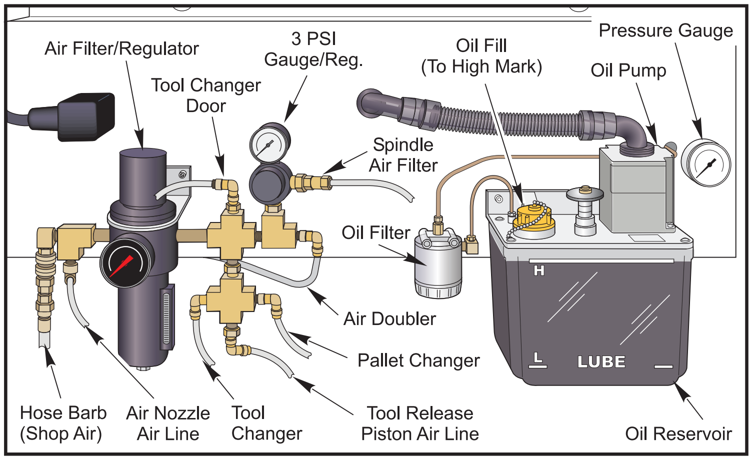
To access the Transmission Oil Fill Cup, remove the SHCS that secure the rear Spindle Motor Access panel to the machine. With this panel removed the motor and transmission are visible. The Transmission Oil Reservoir is the box beneath the Motor Fan (see Figure below). The Transmission Oil Fill Cup is located on the right side of the Oil Reservoir (as viewed from the rear). Flip open the spring-loaded cap and add needed oil. When full, the oil will overflow onto the Oil Reservoir, so use caution when pouring to avoid a large mess.



HS 1/2 Transmission Oil Reservoir

7.2 Lubrication System

All machine lubrication is supplied by the external lubrication system. The reservoir is located on the lower rear of the machine (see Figure below). Current lube level is visible in the reservoir. If additional lube needs to be added, remove the cap from the fill port and add lube to proper level.



External Lubrication System

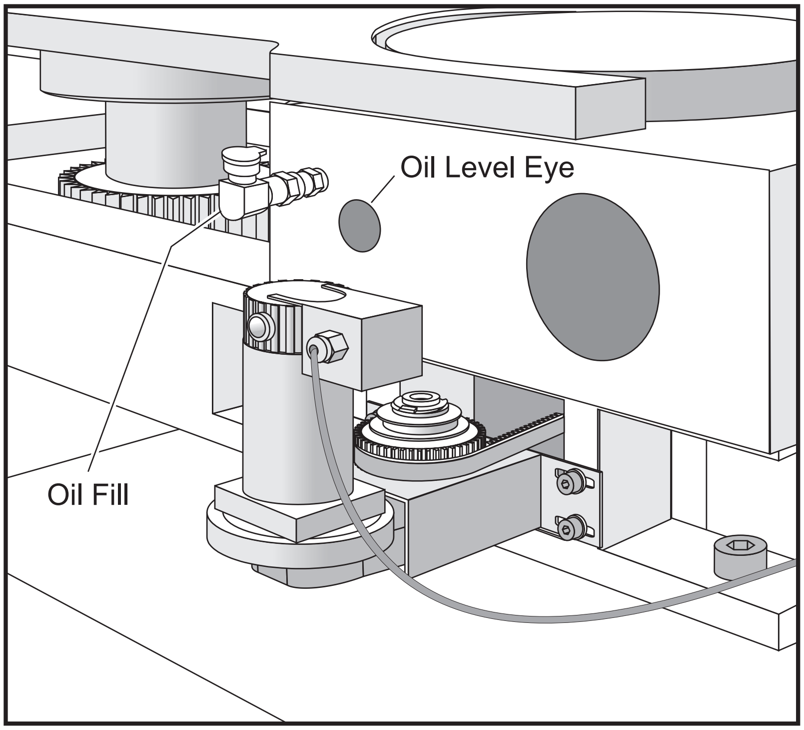
WARNING!

Do not add lube above the "high" line marked on the reservoir. Do not allow the lube level to go below the "low" line marked on the reservoir as machine damage could result.

To lubricate the system, pull up on the primer pull-tab located next to the fill port. The primer will automatically send 3cc of lube through the system.

7.3 Pallet Changer Rotary Table

Perform Every Six Months



1. To check and/or add lube to the Pallet Changer rotary table, remove the right-front Access Cover (nearest the control pendant). On HS-1R and HS-1RP models, remove the 9 BHCS. On HS-2RP models, remove the 14 BHCS.

2. View the lube level eye in the side of the rotary table. The lube level should completely cover this eye.

3. If necessary, add Mobile SHC 630 to the fill cup until lube can be seen in the fill cup spigot.

4. Apply sealant, install a gasket, and replace the Access Cover. Tighten the securing BHCS.

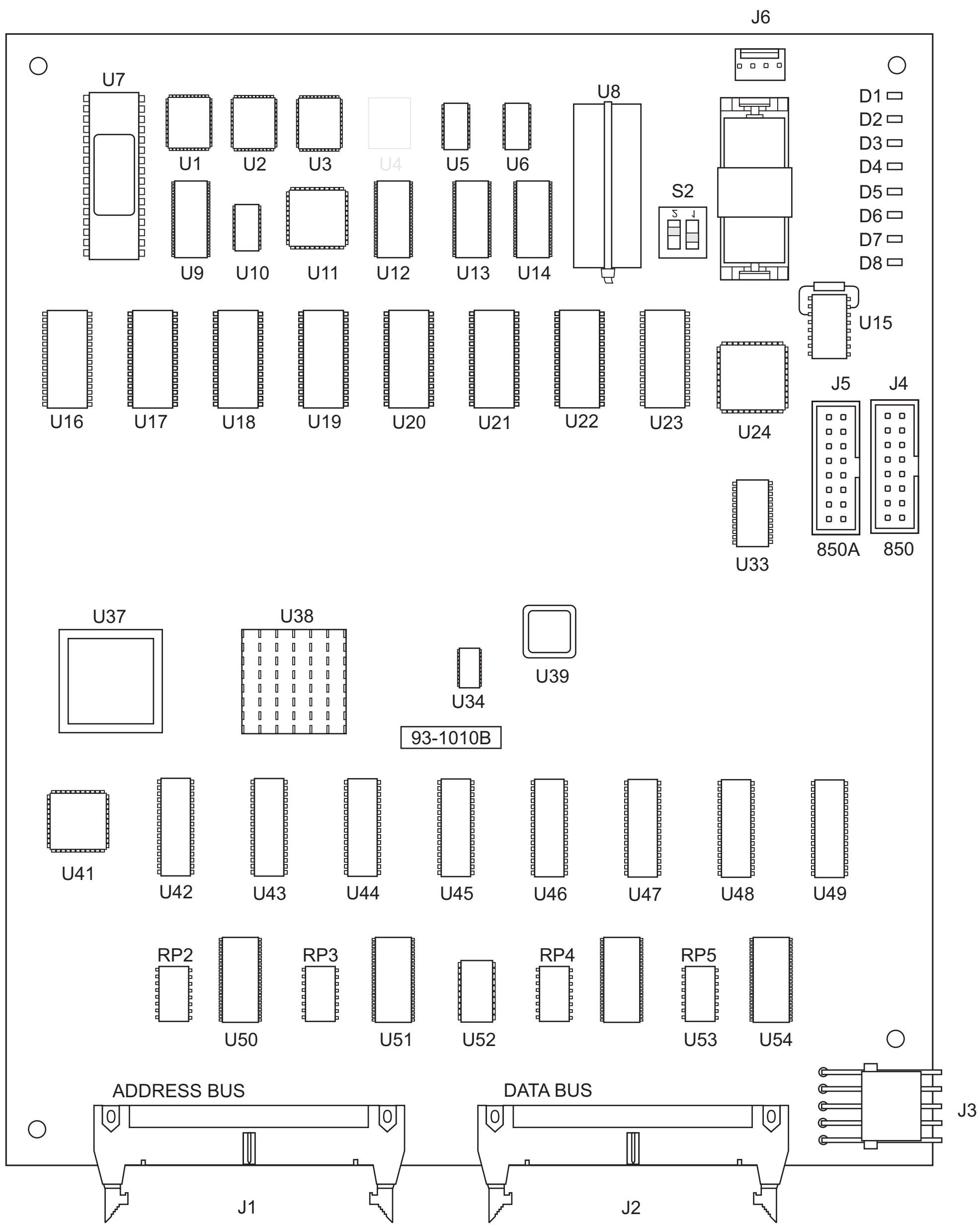
7.4 Chip Auger

MAINTENANCE

During normal operation, most chips are discharged from the machine at the discharge tube. However, very small chips may flow through the drain and collect in the coolant tank strainer. To prevent drain blockage, clean this trap regularly. Should the drain become clogged and cause coolant to collect in the machine's pan, stop the machine, loosen the chips blocking the drain, and allow the coolant to drain. Empty the coolant tank strainer, then resume operation.

8. PCB'S, CABLE LOCATIONS AND BOARD DIAGRAMS

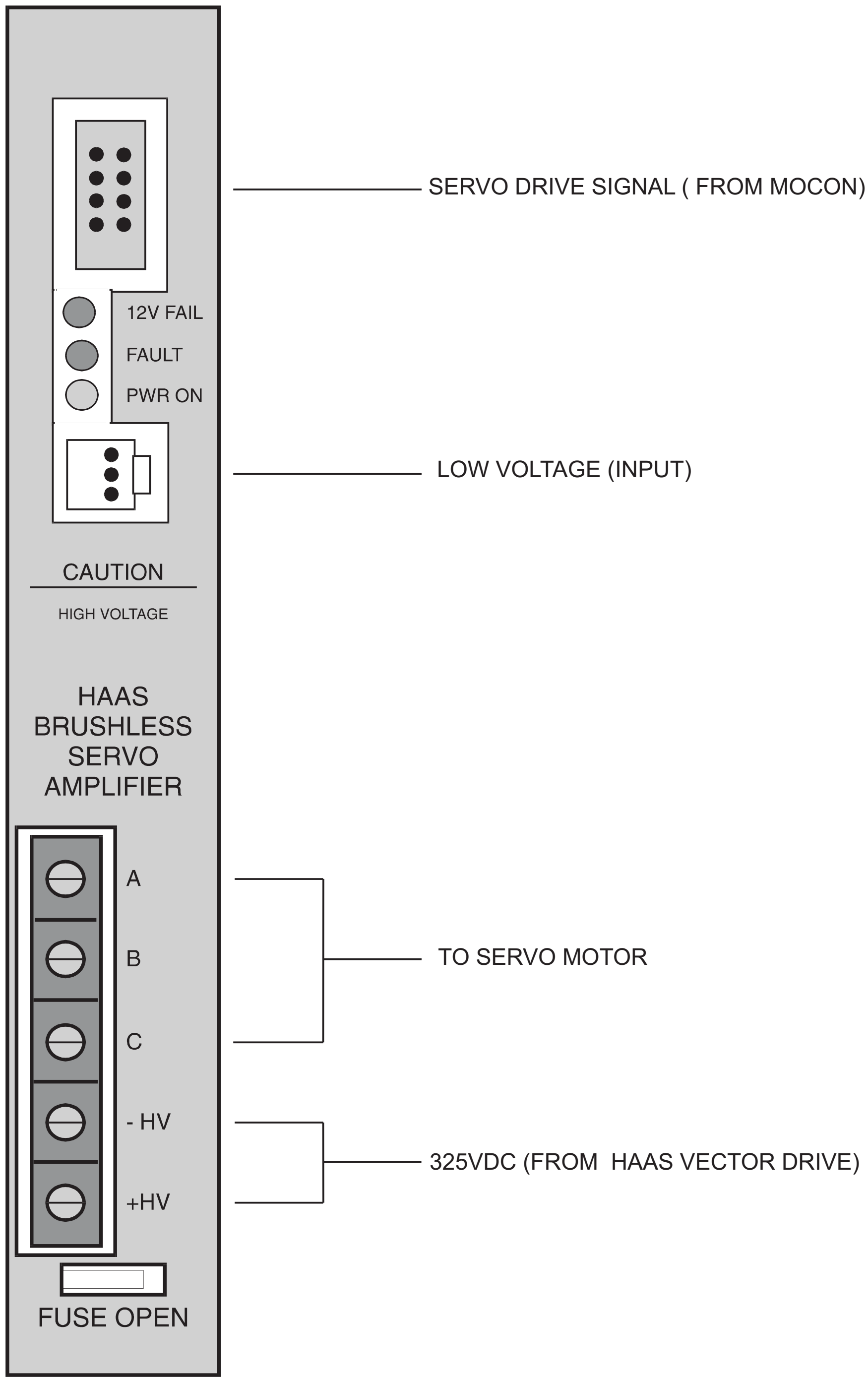
MICRO PROCESSOR PCB - P/N 93-1010B CABLE CONNECTIONS



MICRO PROCESSOR PCB - P/N 93-1010B CABLE CONNECTIONS

PROC. PLUG #	CABLE #	SIGNAL NAME ⇨ TO ⇨	LOCATION	PLUG #
J1 ADDRESS	ADDRESS BUSS		VIDEO	——
J2 DATA	DATA BUSS		MOTIF PCB	——
J3	860	LOW VOLTAGE	POWER SUPPLY PCB	——
J6	N/A	REPLACEMENT BAT. CONNECTION		——
PORT 1	850	SERIAL PORT #1	KEY. INTERFACE	——
PORT 2	850A	SERIAL PORT #2	SERIAL PORT #2	——

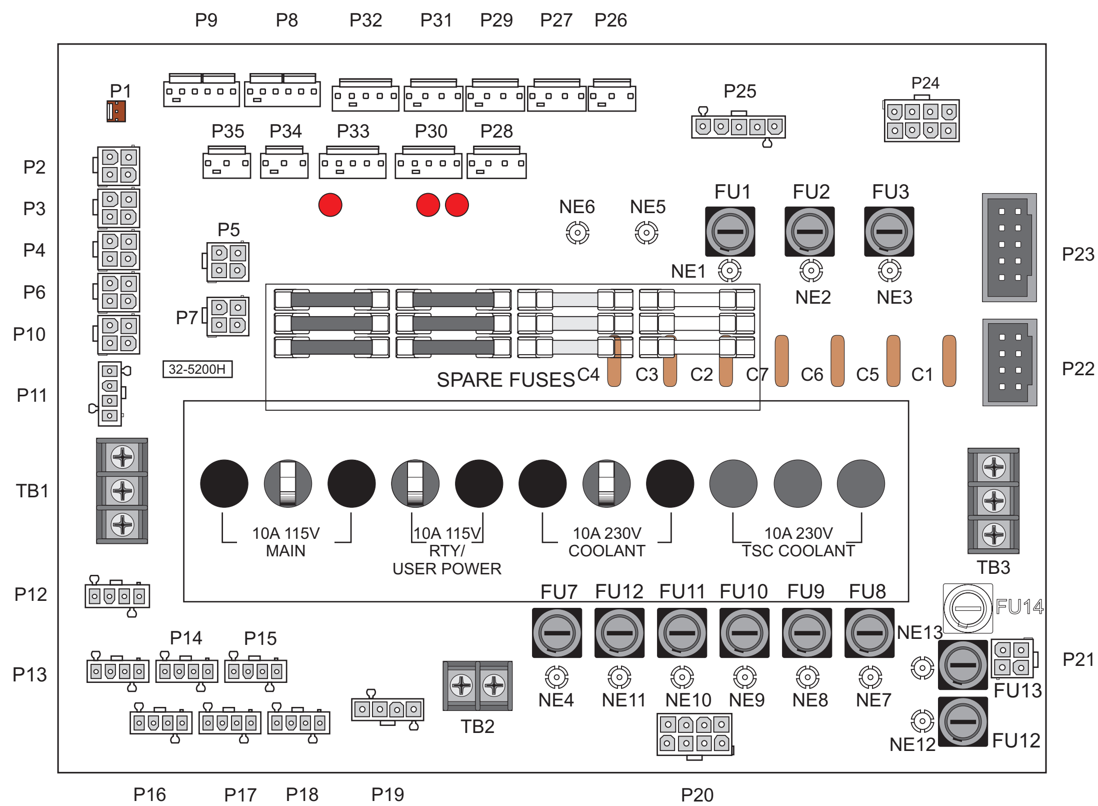
BRUSHLESS SERVO AMPLIFIER P/N 93-5550C



BRUSHLESS SERVO AMPLIFIER - P/N 93-5550C CABLE CONNECTIONS

MOCON PLUG #	CABLE #	SIGNAL NAME ⇨ TO ⇨	LOCATION	PLUG #
X AXIS AMP				
P	570	LOW VOLTAGE	L. V. POWER SUPPLY	——
TB A, B, C	——	MOTOR DRIVE	X SERVO MOTOR	——
P	610	X DRIVE SIGNAL	MOCON PCB	P2
TB -HV +HV	——	320VDC	SPINDLE DRIVE	——
Y AXIS AMP				
P	580	LOW VOLTAGE	L. V. POWER SUPPLY	——
TB A, B, C	——	MOTOR DRIVE	X SERVO MOTOR	——
P	620	X DRIVE SIGNAL	MOCON PCB	P3
TB -HV +HV	——	320VDC	SPINDLE DRIVE	——
Z AXIS AMP				
P	590	LOW VOLTAGE	L. V. POWER SUPPLY	——
TB A, B, C	——	MOTOR DRIVE	X SERVO MOTOR	——
P	630	X DRIVE SIGNAL	MOCON PCB	P4
TB -HV +HV	——	320VDC	SPINDLE DRIVE	——
A AXIS AMP				
P	600	LOW VOLTAGE	L. V. POWER SUPPLY	——
TB A, B, C	——	MOTOR DRIVE	X SERVO MOTOR	——
P	640	X DRIVE SIGNAL	MOCON PCB	P5
TB -HV +HV	——	320VDC	SPINDLE DRIVE	——

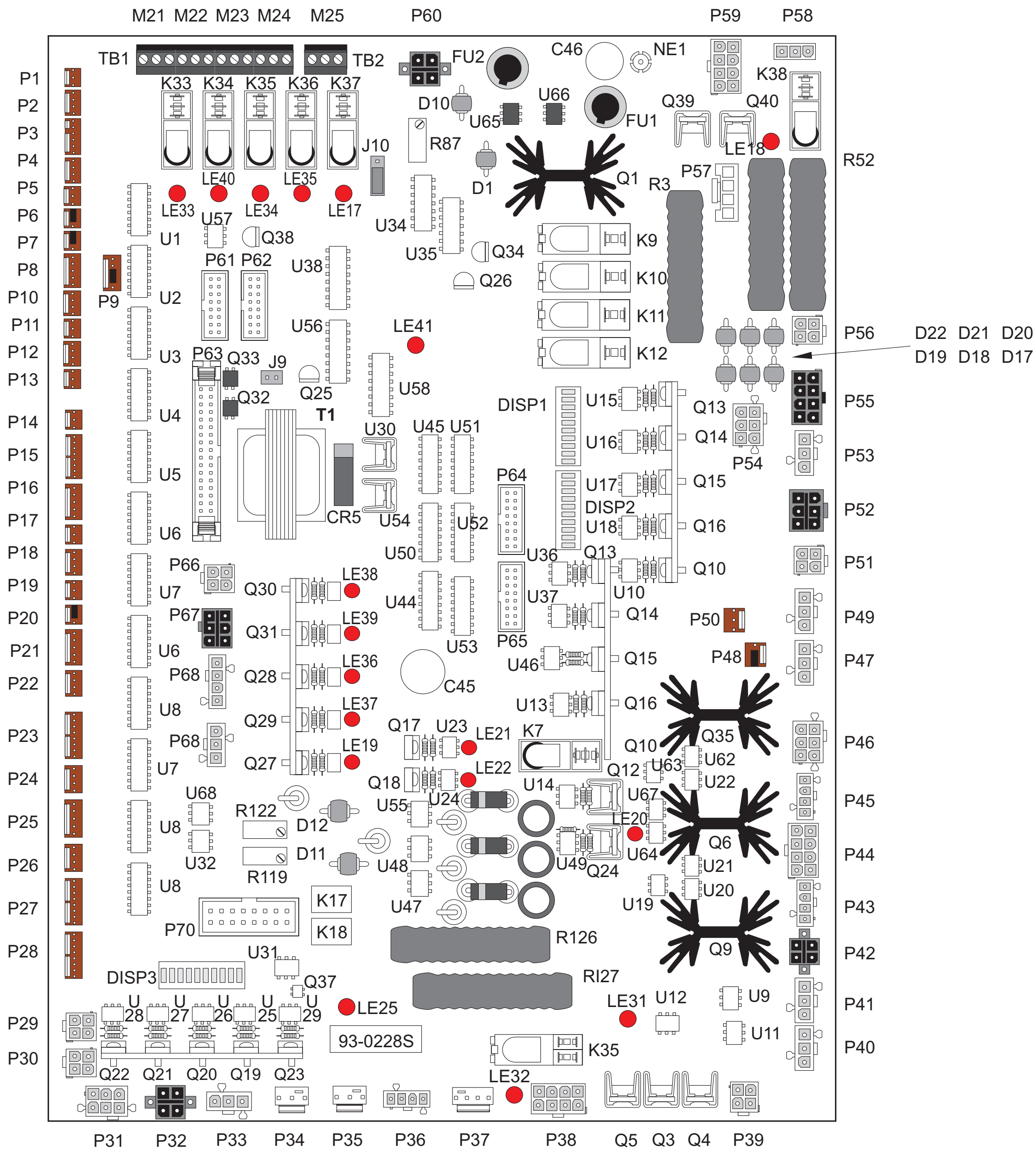
POWER PCB 93-0227



POWER PCB - P/N 93-0227
CABLE CONNECTIONS

I/O PLUG #	CABLE #	SIGNAL NAME ⇨ TO ⇨	LOCATION	PLUG#
P1		+12VDC	CNC Unit Fan	
P2	90B	115VAC	Low Voltage Power Supply	
P3	90B	115VAC	Probe PS	
P4	90B	115VAC	Work Light	
P5	90B	115VAC	Switch Door Fan	
P6	90B	115VAC	Servo Fan	
P7	90B	115VAC	Delta-Wye	
P8	860	+12/-12/+5 VDC In	From Low Voltage Power Supply	
P9	860	+12/-12/+5 VDC In	From Low Voltage Power Supply	
P10	90B	115VAC	Door Fan	
P11	90B	115VAC	Monitor	
P12	90C	115VAC	Regen Fan	
P13	90C	115VAC	SMTC PCB	P4
P14	90C	115VAC	spare	
P15	90C	115VAC	spare	
P16	90C	115VAC	spare	
P17	90C	115VAC	Trans PCB	P2
P19	90	3PH 115VAC	IO PCB	P56
P18	90C	115VAC	spare	
P20	930	230V CLNT/TSC	IO PCB	P44
P21	160	Chip Conv. 230V 3PH	IO PCB	P39
P23	170	Auto Off/Contactor	Contactor K1/IO PCB	P42
P22	740	On/Off	Front Panel	
P24		Prim/Sec	To T5	
P25	71, 72, 73	Overvolt Protection	From Contactor K1	
P26	860	+12VDC	SKBIF	
P27	860	+12/+5 VDC	IO PCB	P60
P28	860	+12/+5 VDC	Motif PCB	P15
P29	860	+12/+5 VDC	Processor PCB	J3
P30	860	+12/-12/+5 VDC	spare	
P31	860	+12/+5 VDC	Video PCB	P1
P32	860	+12/-12/+5 VDC	Mocon 1 PCB	P15
P33	860	+12/-12/+5 VDC	Mocon 2 PCB	P15
P34	860	+12 VDC	SMTC PCB	P2
P35	860	+12 VDC	MCD Relay PCB	P2
TB1	94, 95, 96	115VAC	From Transformer	
TB2	90A	115 VAC Out	Barfeeder / T/C PCBA	P8
TB3	77, 78, 79	3PH 230V In	From Transformer	

I/O PCB S - P/N 93-0228



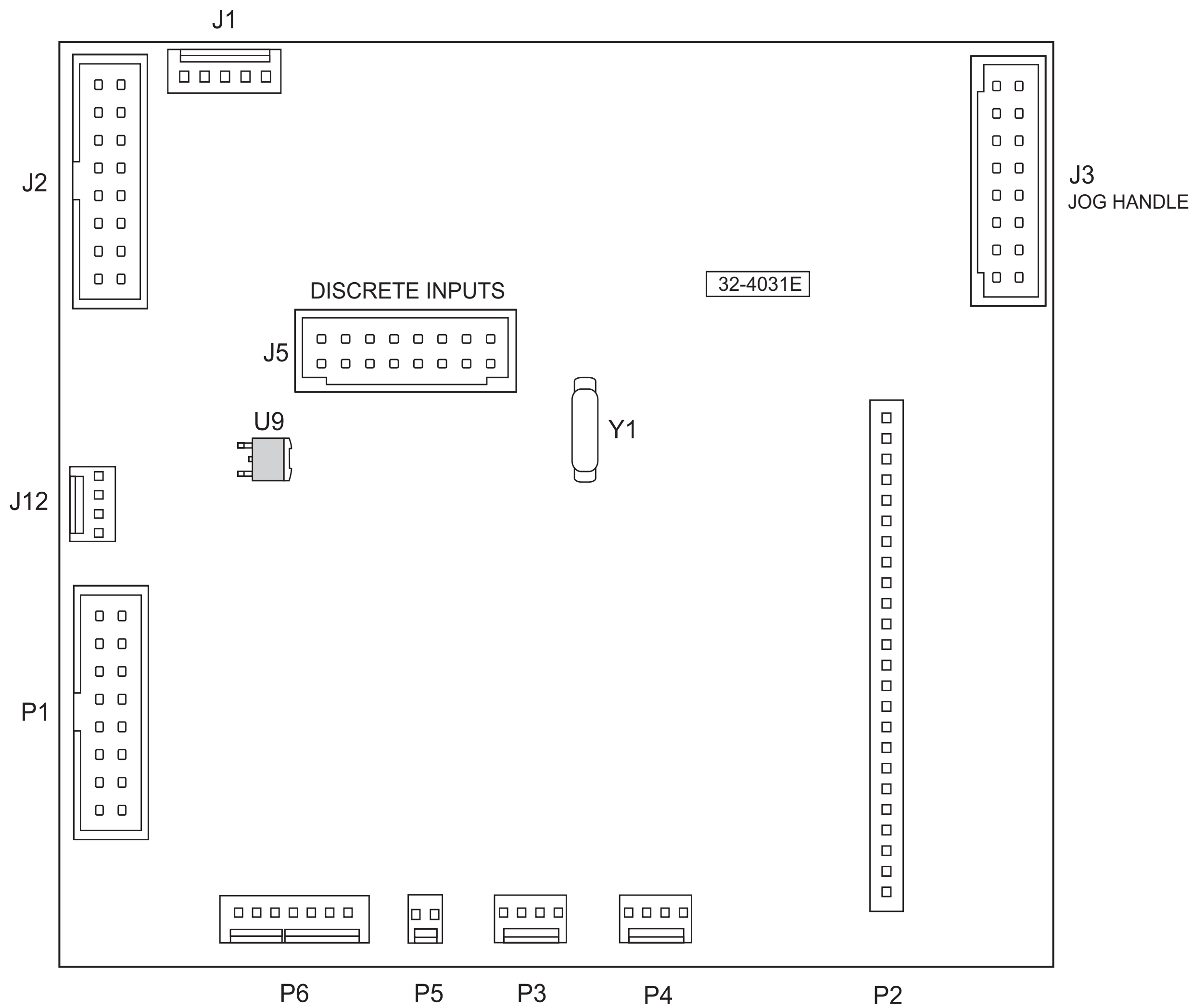
I/O PCB S - P/N 93-0228 CABLE CONNECTIONS

I/O PLUG #	CABLE #	⇨ TO ⇨	LOCATION	PLUG #
P1	140B		Not Used	
P2	820B		T/C In/Out	
P3	820		DB Up/Down	
P4	900		TSC Pump (Low TSC)	
P5	770		E-Stop Switch A Front Panel	
P6	770A		E-Stop Switch B	
P7	770B		E-Stop Switch C	
P8	1050		Side Door Open	
P9	1050A		Side Door Open (spare)	
P10	100		(External) M-Fin	
P11	970		Vector Drive Over Volt	VD J1
P12	950		Low Air/Oil	
P13	960		Low Air/Lube	
P14	830		Regen Overheat	

I/O PCB S - P/N 93-0228 CABLE CONNECTIONS

I/O PLUG #	CABLE #	⇨ TO ⇨	LOCATION	PLUG #
P15	890		Spin Head Status	
P16	780		Spare	
P17	410		T/C Air Door SW.	
P18	790		Pallet CW/CCW	
P19	190		Frnt Door sw.	
P20	190A		Op Station Locked/Frnt Door sw.	
P21	240		Pallet Up/Down	
P22	1070		Skip	
P23	420		SMTC status	
P24	440		SMTC status	
P25	450		SMTC status	
P26	460		SMTC status	
P27	470		SMTC status	
P28	480		Spare	
P29	1040A		Door Interlock B	
P30	1040		Door Interlock A	
P31	230		5th Axis Brake	
P32	250		HTC Shuttle	
P33	270		TSC Purge	
P34	260		Pal Ready	
P35	200		Spare	
P36	280		Beacons	
P37	140A		Side Chip Conv En/Rev	HOPT P5
P38	140		230V to Chip Conv Mtrs	
P39	160		230V to Chip Conv. Circuit	PSUP P21
P40	300		Panel Lube Oil Pump	
P41	300A		SP Fan/Oil Pump/Luber	
P42	170		Auto Off	PSUP P23
P43	940		Coolant Mtr	
P44	930		230V to TSC/Coolant Circuit	PSUP P20
P45	940A		TSC Mtr	
P46	390		4th Axis Brake	
P47	350		Axis Brake	TRANS P6
P48	120		Coolant O/T Sensor	
P49	350A		Hyd En	TRANS P4
P50	130		TSC O/T Sensor	
P51	430		Pallet Up	
P52	710		BF Collet	
P53	880C		Wye-Delta Switch	
P54	880A		High/Low Gear 50T	
P55	880B		Spindle Sol.	
P56	90		115V Power To IOPCB	PSUP P27
P57			Ext. Drawbar Mtr. Resitor	HOPT P3
P58	810A		N/A	
P59	810		Main DB Up - Down/Shuttle In - Out Mtrs.	
P60	860A		5V/12V Logic Pwr IOPCB	PSUP 27
P61	540		Outputs Cable 24-55	MOCON P14
P62	540A		Outputs Cable Mcd Relay	MCD Relay P1
P63	550		Inputs Cable	MOCON P10
P64	520		Outputs Cable 8-15	MOCON P12
P65	510		Outputs Cable 0-7	MOCON P11
P66	M27		Air Blast	
P67	M28		Beeper	
P68	310		Pallet CW/CCW	
P69	220		TC Air Door	
P70	530		Outputs Cable 16-23	MOCON P13
TB1	M21-24		Probe, M-Fin, User Spare	
TB2	M25		User Spare	

SERIAL KEYBOARD INTERFACE PCB WITH HANDLE JOG
P/N 93-1072B

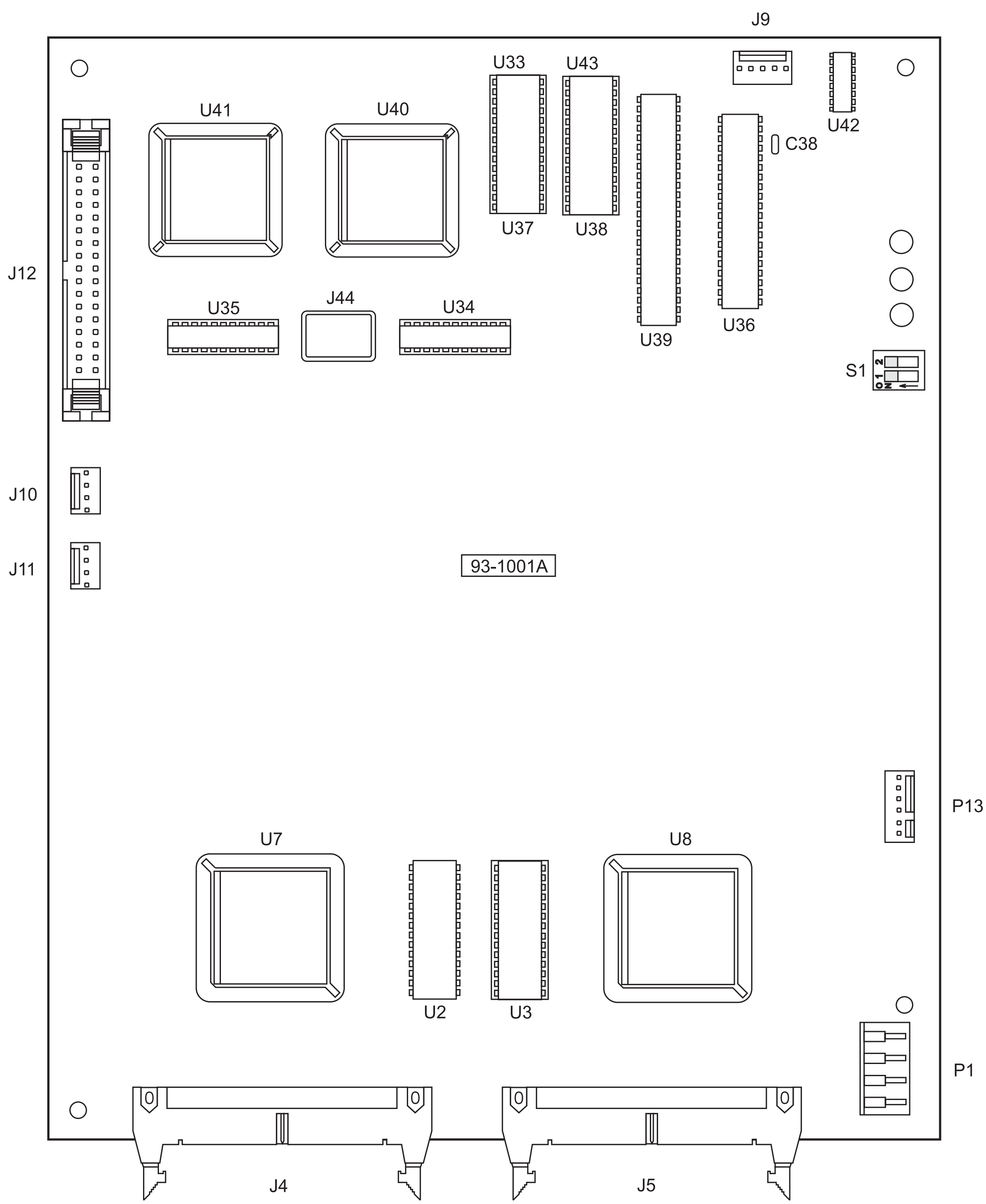


SERIAL KEYBOARD INTERFACE PCB WITH HANDLE JOG P/N 93-1072B CABLE CONNECTIONS

PLUG#	CABLE#	⇨ TO ⇨	LOCATION	PLUG#
P1	700B		PROCESSOR	850
P2	—		KEYPAD	—
P3	700A		CYCLE START/ HOLD SWITCHES	—
P4	730		SP LOAD METER	—
P5	—			—
P6	—		AUX FPANEL	—
J1	—			—
J2	—		REMOTE JOG HANDLE	—
J3	750		MOCON	P18
J5	—		(MIKRON ONLY)	—
J7	—		EXTERNAL KEYBOARD	—
J12	860C		FT. PANEL FAN	—

* See "Keyboard Diagnostic" section of this manual for Troubleshooting information.

VIDEO & KEYBOARD PCB W/ FLOPPY DRIVE
P/N 93-1001A



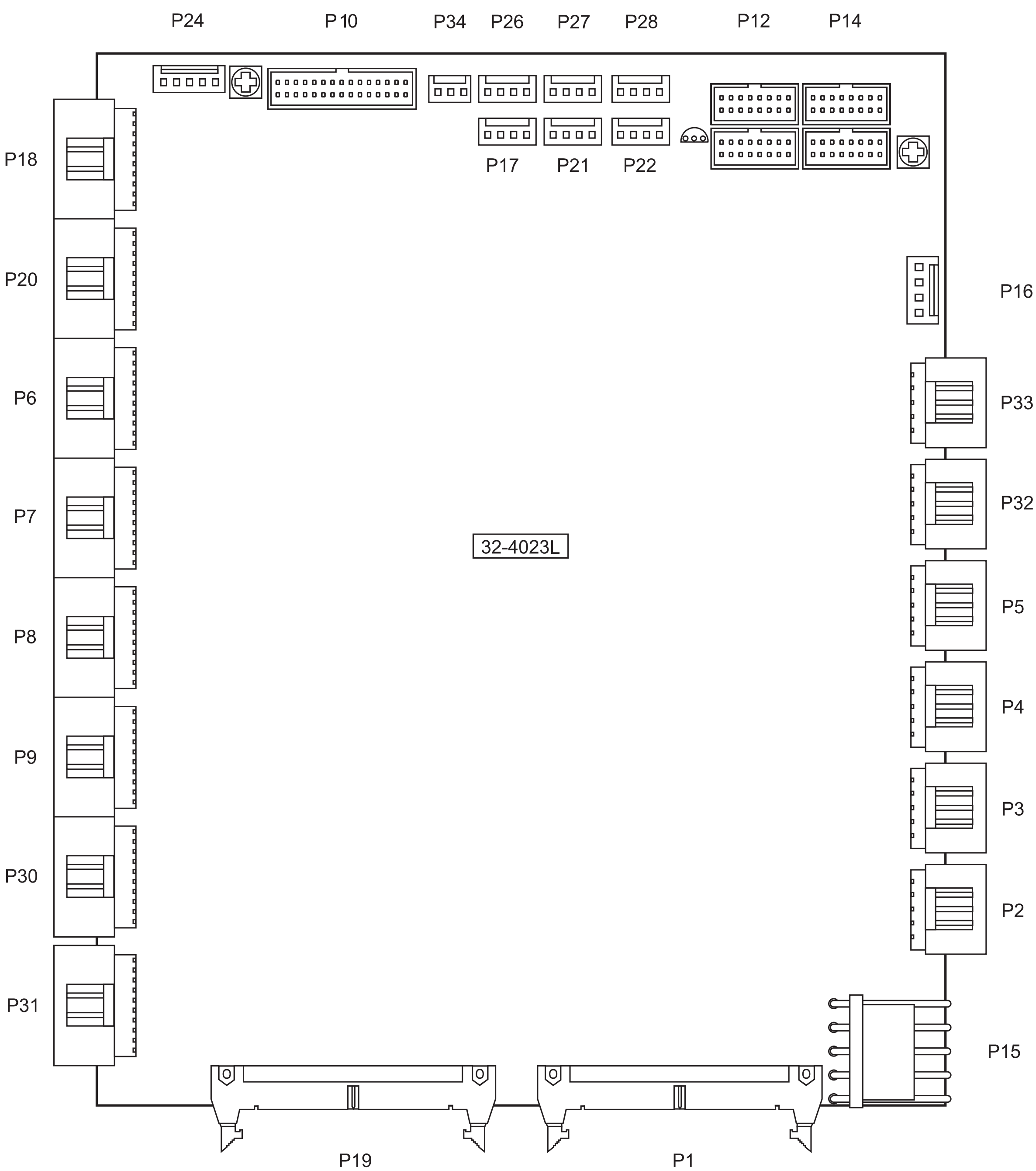
VIDEO & KEYBOARD PCB W/ FLOPPY DRIVE P/N 93-1001A CABLE CONNECTIONS

VIDEO

PLUG #	CABLE #	SIGNAL NAME	⇨ TO ⇨	LOCATION	PLUG #
P1	860	LOW VOLTAGE		POWER SUPPLY PCB	——
J3*	700	KEYBOARD INFO.		KEYBOARD INT.	——
J4	——	ADDRESS BUSS		MICRO PROC. PCB	——
J5	——	DATA BUSS		MOTIF PCB	——
J10	——	FLOPPY DR. POWER		FLOPPY DRIVE	——
J11	——	SPARE		N/A	N/A
J12	——	FLOPPY DR. SIGNAL		FLOPPY DRIVE	——
P13	760	VIDEO SIGNAL		CRT	——
J9	——	RS422 B		N/A	N/A
J13	850	SERIAL DATA		N/A	J1

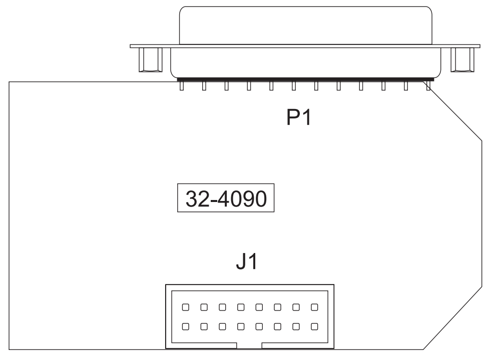
* Not used with Serial Keyboard Interface

MOCON PCB - P/N 32-4023L



MOCON PCB - P/N 32-4023L CABLE CONNECTIONS

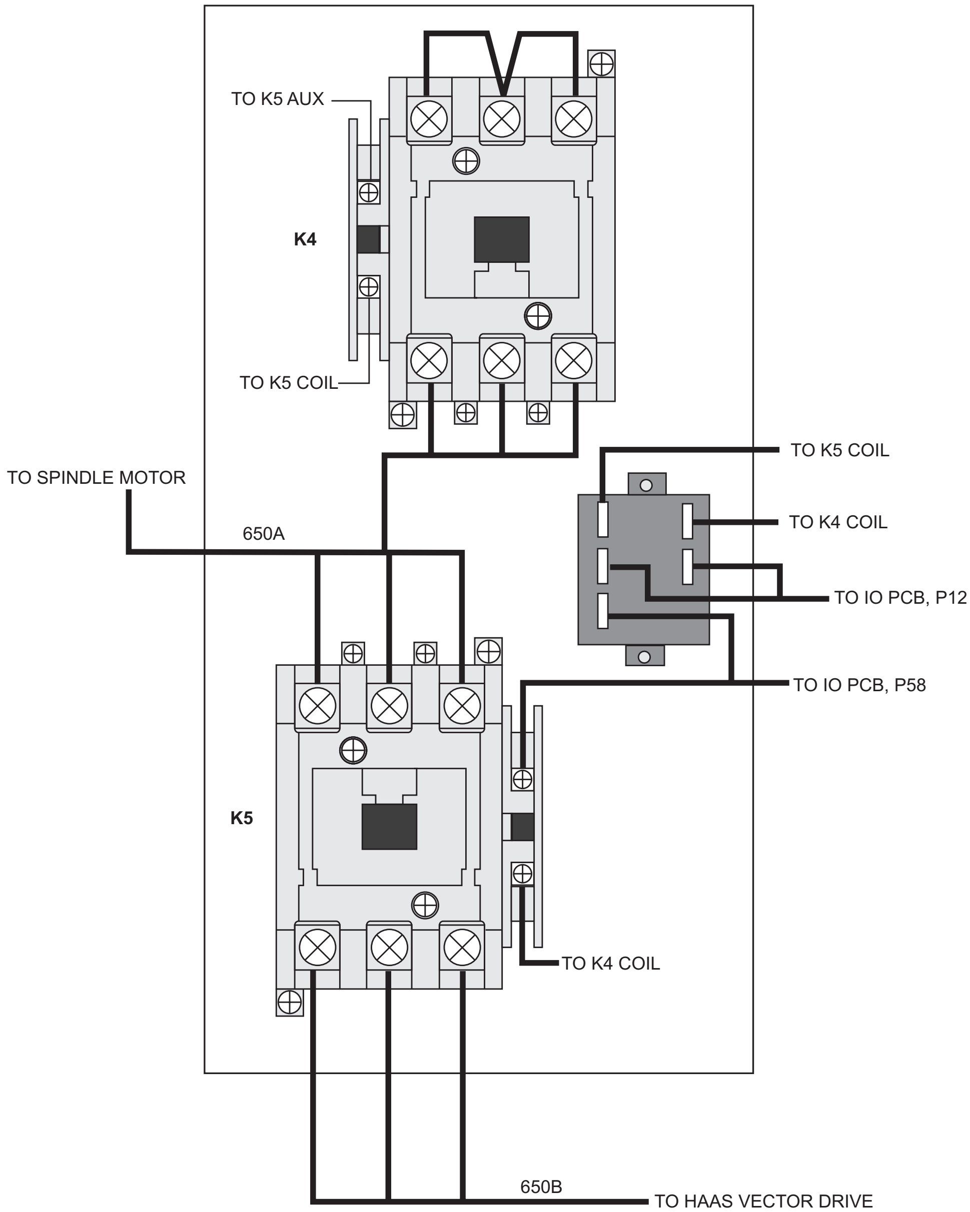
MOCON PLUG #	CABLE #	SIGNAL NAME	⇨ TO ⇨	LOCATION	PLUG #
P1	——	DATA BUSS		VIDEO PCB	——
				MICRO PROC. PCB	——
P2	610	X DRIVE SIGNAL		X SERVO DRIVE AMP.	P
P3	620	Y DRIVE SIGNAL		Y SERVO DRIVE AMP.	P
P4	630	Z DRIVE SIGNAL		Z SERVO DRIVE AMP.	P
P5	640	A DRIVE SIGNAL		A SERVO DRIVE AMP.	P
P32	640B	B DRIVE SIGNAL		B SERVO DRIVE AMP.	P
P6	660	X ENCODER INPUT		X ENCODER	——
P7	670	Y ENCODER INPUT		Y ENCODER	——
P8	680	Z ENCODER INPUT		Z ENCODER	——
P9	690	A ENCODER INPUT		A ENCODER	——
P30	690B	B ENCODER INPUT		B ENCODER	——
				(BRUSHLESS TOOL CHANGER)	
P10	550	MOTIF INPUTS/			
		I/O OUTPUTS		I/O PCB	P4
P11	510	I/O RELAYS 1-8I/O		PCB	P1
P12	520	I/O RELAYS 9-16		I/O PCB	P2
P13	530	I/O RELAYS 17-24		I/O PCB	P51
P14	540	I/O RELAYS 25-32		I/O PCB	P3
P15	860	LOW VOLTAGE		POWER SUPPLY PCB	——
P16	720	SP. LOAD METER		LOAD METER	——
P17	980	VOLTAGE MONITOR		N/A	N/A
P18	750	JOG ENCODER INPUT		JOG HANDLE	——
P19		ADDRESS BUSS		VIDEO PCB	——
				MICRO PROC. PCB	——
P20	1000	SP. ENCODER INPUT		SPINDLE ENCODER	——
P21		X-AXIS TEMP SENSOR			
P22	730B	SP. DRIVE LOAD		SPINDLE DRIVE	——
P24	990	HOME SENSORS		X, Y & Z LIMIT	——
P26		Y-AXIS TEMP SENSOR			
P27		Z-AXIS TEMP SENSOR			
P31	690C	C-AXIS ENCODER INPUT		SPINDLE MOTOR (lathe)	
P33	640C	VCTR DR CUR. CMD.		VECTOR DRIVE	J3

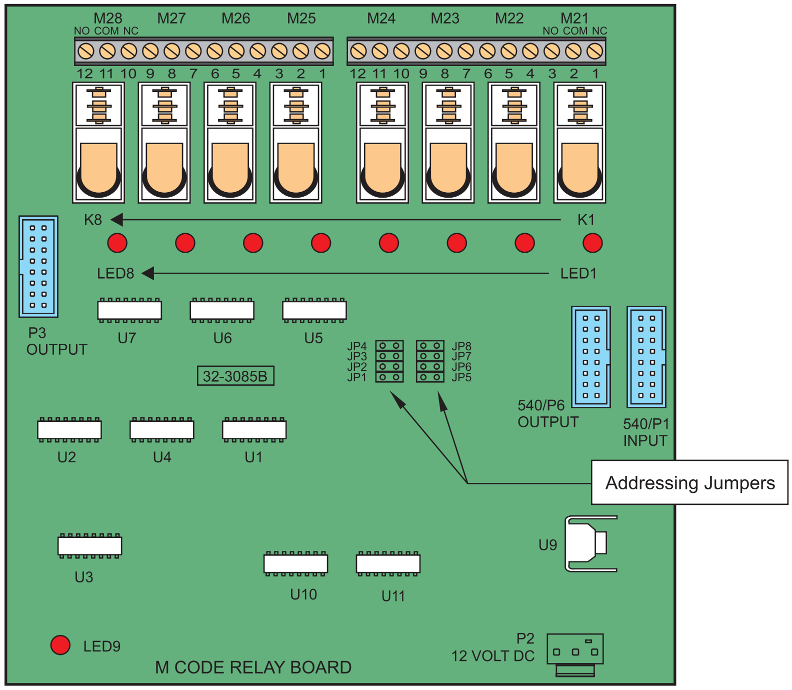


RS-232 PORT #1 PCB - P/N 32-4090
CABLE CONNECTIONS

PLUG #	CABLE #	⇨ TO ⇨	LOCATION	PLUG #
P1 INTERNAL	850		VIDEO & KEYBOARD	J13
J1 EXTERNAL	——		——	——

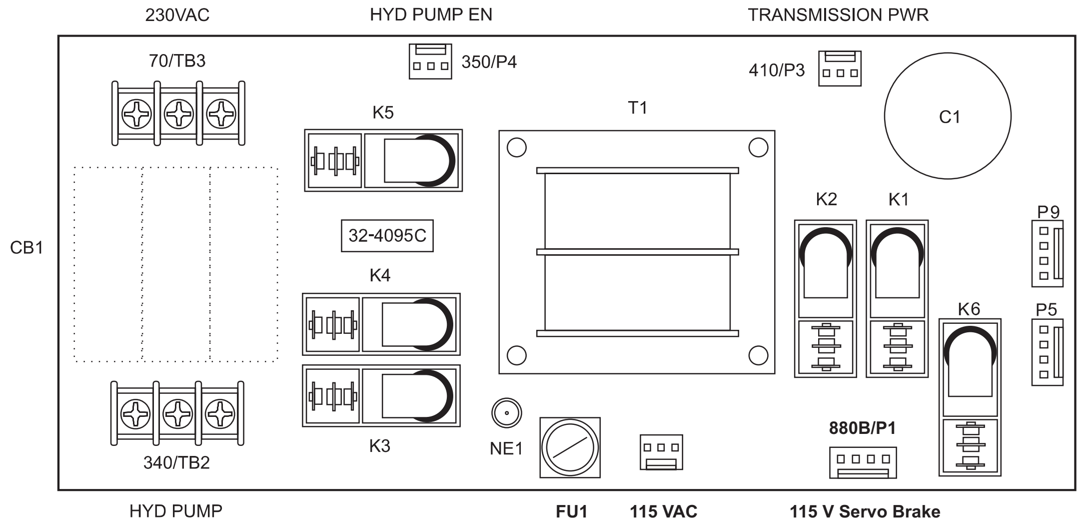
Y-DELTA SWITCH ASSEMBLY
P/N 32-5850A





M CODE RELAY BOARD
P/N 93-1057B CABLE CONNECTIONS

PLUG #	CABLE #	SIGNAL NAME ⇨ TO ⇨	LOCATION	PLUG #
P1	540	MOCON INPUT	IO PCB`	P62
P2	860A	12VD TO M-CODE PCBA	PSUP	P31
P3	540A	IOPCB OUTPUT		
P4	M21	M-FUNCTION		
	M22	PROBE OPTION		
	M24	spare		
P5	M25	spare		
	M26	spare		
	M27	spare		
P6	540B	M CODE OUTPUT	2nd MCD	P1



50T TRANSMISSION P.S. / HYDRAULIC C.B. PCB P/N 32-4095C CABLE CONNECTIONS

PLUG #	CABLE #	⇨ TO ⇨	LOCATION	PLUG #
P1	880B		IO PCB	P12
P2	90		POWER PCB	P8
P3	410		GEAR BOX	
P4	350		IO PCB	P54
TB2	340		HYDRAULIC MTR	
TB3	70		MAIN TRANSFORMER (VECTOR DRIVE UNIT)	

9. CABLE LIST

WIRE/ TERMINAL NUMBER	FUNCTION NAME:
	INCOMING POWER 195-260 VAC (353-480 VAC OPTIONAL)
L1	INCOMING 195-260VAC PHASE 1, TO CB1-1
L2	INCOMING 195-260VAC PHASE 2, TO CB1-2
L3	INCOMING 195-260VAC PHASE 3, TO CB1-3
71	PROTECTED 195-260VAC CB1-4 TO K1-1
72	PROTECTED 195-260VAC CB1-5 TO K1-2
73	PROTECTED 195-260VAC CB1-6 TO K1-3
74	195-260VAC FROM K1-4 TO XFORMER T1
75	195-260VAC FROM K1-5 TO XFORMER T1
76	195-260VAC FROM K1-6 TO XFORMER T1
77	230VAC PHASE 1, FROM XFORMER T1 TO SPINDLE DRIVE/CHIP CONV
78	230VAC PHASE 2, FROM XFORMER T1 TO SPINDLE DRIVE/CHIP CONV
79	230VAC PHASE 3, FROM XFORMER T1 TO SPINDLE DRIVE/CHIP CONV
90	115 VAC FROM TB2 (CB2 OUTPUT) TO IOPCB P33 - SHIELD +3
91	115 VAC FROM TB2-1 TO IOPCB P33 PIN 1, #20
92	115 VAC FROM TB2-2 TO IOPCB P33 PIN 2, #20
93	115 VAC FROM TB2-3 TO IOPCB P33 PIN 3, #20
94	SHIELD DRAIN
-	115 VAC FROM XFORMER T1 TO TB1 (CB2 INPUT)
94	STEPPED-DOWN 115 VAC (FROM XFORMER T1) #14
95	STEPPED-DOWN 115 VAC (FROM XFORMER T1) #14
96	STEPPED-DOWN 115 VAC (FROM XFORMER T1) #14
90A	115 VAC TO CRT - SHIELD +2
91A	LEG 1 #16
92A	LEG 2 #16
93A	SHIELD DRAIN
90B	115 VAC CABINET DOOR FAN
91B	LEG 1 #16
92B	LEG 2 #16
93B	SHIELD DRAIN

90C	115 VAC TO CB4 - SHIELD +2
91C	LEG 1 #20
92C	LEG 2 #20
93C	SHIELD DRAIN
100	M-FUNCTION INPUT - SHIELD +2
101	SIGNAL #20
102	COMMON #20
103	SHIELD DRAIN
100A	M-FUNCTION OUTPUT M21 (MCD RELAY BOARD M21) -SHIELD +2
101A	UNSWITCHED LEG 1 #20
102A	SWITCHED LEG 2 #20
103A	SHIELD DRAIN
110	SPARE (115 VAC SERVO POWER)
140	230VAC 3PH POWER TO CHIP CONVEYOR MOTOR
141	PHASE A 230VAC
142	PHASE B 230VAC
143	PHASE C 230VAC
144	STARTING WINDING 230VAC
145	STARTING WINDING 230VAC
160	3PH 230VAC TO CHIP CONVEYOR CONTROLLER - SHIELD +3
161	PHASE A 230VAC #20
162	PHASE B 230VAC #20
163	PHASE C 230VAC #20
164	SHIELD DRAIN
170	AUTO OFF FUNCTION - SHIELD +2
171	UNSWITCHED LEG 1 #20
172	SWITCHED LEG 2 #20
173	SHIELD DRAIN

180 SPARE (COOLANT SPIGOT DETENT SWITCH)

190	LOAD STATION INPUT SWITCH - SHIELD +2
191	SIGNAL #20
192	RETURN #20
193	SHIELD DRAIN
200	SPARE (12 VDC COOLANT SPIGOT MOTOR)

210 DATA CABLE TO 3" FLOPPY DISK DRIVE (34 PINS)

230	5'th AXIS BRAKE (PALLETS UP HS-1RP) - SHIELD +2
231	115VAC COMMON
232	115VAC SWITCHED
233	SHIELD DRAIN
240	PALLETS UP AND DOWN INPUTS - SHIELD +3
241	PALLETS UP #20
242	PALLETS DOWN #20
243	COMMON #20
244	SHIELD DRAIN
250	115 VAC TO TOOL CHANGER SHUTTLE VALVE - SHIELD +2
251	LEG 1 #20
252	LEG 2 #20
253	SHIELD DRAIN
260	12 VDC RELAY OUTPUT TO PALLET READY LAMP - SHIELD +2
261	SWITCHED LEG 1 #20
262	UNSWITCHED LEG 2 #20
263	SHIELD DRAIN
270	115 VAC RELAY OUTPUT TO PURGE SOLENOID - SHIELD +2
271	UNSWITCHED LEG 1 #20
272	SWITCHED LEG 2 #20
273	SHIELD DRAIN
280	115 VAC RED/GREEN BEACON CABLE -SHIELD +3
281	RED LAMP 115VAC
282	GREEN LAMP 115VAC
283	COMMON 115VAC
284	SHIELD DRAIN
290	115VAC TO XFORMER T2 10VAC OUTPUT
291	LEG 1 PRIMARY
292	LEG 2 PRIMARY
293	CENTER TAPPED (GROUND)
294	LEG 1 SECONDARY
295	LEG 2 SECONDARY
300	115VAC TO SPINDLE MOTOR FAN/OILER PUMP - SHIELD +2
301	LEG 1 115VAC PROTECTED #20
302	LEG 2 115VAC PROTECTED #20
303	SHIELD DRAIN
350	SPARE (115 VAC SERVO BRAKE)

390	115VAC TO 4'TH AXIS BRAKE - SHIELD +2
391	LEG 1 #20
392	LEG 2 SWITCHED #20
393	SHIELD DRAIN
410	LIMIT SWITCH TOOL CHANGER DOOR
490	ALL BRUSHLESS AXIS SERVO MOTOR DRIVE POWER CABLE
491	A PHASE
492	B PHASE
493	C PHASE
494	GROUND
490A	325VDC FROM SPINDLE DRIVE TO THE AMPLIFIERS - SHIELD +2
491A	HIGH VOLT P1/+ RED #12
492A	HIGH VOLT N/- BLACK #12
493A	SHIELD DRAIN
490B	325VDC FROM AMPLIFIER TO SERVO POWER SUPPLY
491B	HIGH VOLT + RED #20
492B	HIGH VOLT - BLACK #20
510	RELAY CARD 1 DRIVE CABLE - 16 WIRE RIBBON #24
520	RELAY CARD 2 DRIVE CABLE - 16 WIRE RIBBON #24
530	RELAY CARD 3 DRIVE CABLE - 16 WIRE RIBBON #24
540	RELAY CARD 4 DRIVE CABLE - 16 WIRE RIBBON #24
550	INPUTS CARD CABLE (MoCon-P10) 34 WIRE RIBBON #24
570	LOW VOLTAGE BRUSHLESS AMPLIFIER POWER CABLE ASSEMBLY
571	+12 VDC #22
572	GROUND
573	-12 VDC #22
610	X AXIS HAAS AMPLIFIER CABLE TO MOTOR CONTROLLER BOARD (MOTOR CONTROLLER BOARD SIDE CONNECTION)
610-1	+A CHANNEL
610-2	ANALOG GROUND
610-3	+B CHANNEL
610-4	ANALOG GROUND
610-5	ENABLE
610-6	LOGIC GROUND
610-7	FAULT
610-8	LOGIC GROUND
610-9	NOT USED
610-10	SHIELD/ANALOG GROUND

620	Y AXIS HAAS AMPLIFIER CABLE TO MOTOR CONTROLLER BOARD (SAME AS 610-1 THRU 610-10)
630	Z AXIS HAAS AMPLIFIER CABLE TO MOTOR CONTROLLER BOARD (SAME AS 610-1 THRU 610-10)
640A	A AXIS HAAS AMPLIFIER CABLE TO MOTOR CONTROLLER BOARD (SAME AS 610-1 THRU 610-10)
640B	B AXIS HAAS AMPLIFIER CABLE TO MOTOR CONTROLLER BOARD (SAME AS 610-1 THRU 610-10)
640C	HAAS VECTOR DRIVE CURRENT COMMAND CABLE.(ALL#24)
640C-4	FAULT
640C-5	325 VDC VOLTAGE MONITOR
640C-6	A PHASE RETURN
640C-7	B PHASE RETURN
640C-8	DIGITAL GROUND
640C-9	FAULT RETURN
640C-10	ANALOG GROUND
650	230VAC, THREE PHASE POWER TO SPINDLE MOTOR-SHIELD+3
651	PHASE 1
652	PHASE 2
653	PHASE 3
654	SHIELD DRAIN
650A	230VAC, THREE PHASE POWER, CONTACTOR TO SPINDLE MOTOR (WYE-DELTA OPTION)
651A	PHASE 1
652A	PHASE 2
653A	PHASE 3
654A	SHIELD DRAIN
650B	230VAC, THREE PHASE POWER, CONTACTOR TO VECTOR DRIVE (WYE-DELTA OPTION)
651B	PHASE 1
651B	PHASE 2
651B	PHASE 3

660	X-AXIS ENCODER CABLE (ALL #24)
660-1	LOGIC RETURN (D GROUND)
660-2	ENCODER A CHANNEL
660-3	ENCODER B CHANNEL
660-4	+5 VDC
660-5	ENCODER Z CHANNEL (OR C)
660-6	HOME/LIMIT SWITCH
660-7	OVERHEAT SWITCH
660-8	ENCODER A*
660-9	ENCODER B*
660-10	ENCODER Z* (OR C*)
660-11	X HALL A (NOT USED)
660-12	X HALL B (NOT USED)
660-13	X HALL C (NOT USED)
660-14	X HALL D (NOT USED)
660-15	SHIELD DRAIN
660-16	NOT USED
670	Y-AXIS ENCODER CABLE (SAME AS 660-1 THRU 660-16)
680	Z-AXIS ENCODER CABLE (SAME AS 660-1 THRU 660-16)
690A	A-AXIS ENCODER CABLE (SAME AS 660-1 THRU 660-16)
690B	B-AXIS ENCODER CABLE (SAME AS 660-1 THRU 660-16)
690C	C-AXIS ENCODER CABLE (SAME AS 660-1 THRU 660-16)
700	KEYBOARD CABLE - 34 WIRE RIBBON WITH IDC (FROM VIDEO P4 TO KBIF P1)
710	SPARE
711	SPARE
712	SPARE
713	SPARE
714	SPARE
715	SPARE
720	ANALOG SIGNAL FROM MOCON TO SPINDLE DRIVE TO LOAD MONITOR
721	0 TO +10 VOLTS SPEED COMMAND
722	COMMON
723	SHIELD DRAIN

740	POWER ON/OFF CABLE TO FRONT PANEL - SHIELD +4
741	POWER ON SWITCH LEG 1 (24 VAC) #20
742	POWER ON SWITCH LEG 2 #20 N.O.
743	POWER OFF SWITCH LEG 1 (24 VAC) #20
744	POWER OFF SWITCH LEG 2 #20 N.C.
745	SHIELD DRAIN

750 JOG-CRANK DATA CABLE (REM JOG SIDE CONNECTION)(ALL #24)

750-1	LOGIC RETURN (D GROUND) 0 VDC
750-2	ENCODER A CHANNEL
750-3	ENCODER B CHANNEL
750-4	+5 VDC
750-5	JUMPER TO 750-1 (0 VDC)
750-6	X-AXIS
750-7	Y-AXIS
750-8	ENCODER A* CHANNEL
750-9	ENCODER B* CHANNEL
750-10	JUMPER TO 750-4 (+5 VDC)
750-11	Z-AXIS
750-12	A-AXIS
750-13	X 10
750-14	X 1
750-15	SHIELD DRAIN
750-16	NOT USED

750A	JOG HANDLE DATA CABLE - SHIELD +4 (ALL #24)
751A	0 VDC
752A	A
753A	B
754A	+5 VDC
755A	SHIELD DRAIN

750B JOG HANDJE DATA CABLE-SHIELD (ALL#24)

750B	JOG HANDLE DATA CABLE SHIELD +6 (ALL#24)
750B-1	+5 VDC JOG HANDLE
750B-2	0VDC
750B-3	JOG HANDLE A CHANNEL
750B-4	JOG HANDLE A* CHANNEL
750B-5	JOG HANDLE B CHANNEL
750B-6	JOG HANDLE B* CHANNEL

760	MONITOR VIDEO DATA CABLE - SHIELD +7 (ALL #24) (FROM VIDEO P13 TO CRT)
770	EMERGENCY STOP INPUT CABLE - SHIELD +2
771	SIGNAL #20
772	RETURN (D GROUND) #20
773	SHIELD DRAIN

770A	SECOND E-STOP/COUNTER BALANCE - SHIELD +2
771A	SIGNAL #20
772A	RETURN (D GROUND) #20
773A	SHIELD DRAIN
780	SPARE
781	SPARE
782	SPARE
783	SPARE
784	SPARE
790	PALLET CHANGER CW/CCW - SHIELD +3 (ALL #20)
791	PALLET CW
792	PALLET CCW
793	COMMON
794	SHIELD DRAIN
800	10VAC TO PALLET READY LAMP - SHIELD +2
801	UNSWITCHED LEG 1 #20
802	SWITCHED LEG 2 #20
803	SHIELD DRAIN
800A	LAMP SWITCH JUMPER
801A	JUMPER TO 802A
801A	JUMPER TO 801A
810	+/-160 VDC TO LOAD STATION DRAWBAR MOTOR - SHIELD +2
811	MOTOR + #20
812	MOTOR - #20
813	SHIELD DRAIN
810A	+/-160 VDC TO MAIN DRAWBAR MOTOR - SHIELD +2
811A	MOTOR + #20
812A	MOTOR - #20
813A	SHIELD DRAIN
820	TOOL CHANGER AND MAIN DRAWBAR INPUT STATUS (ALL #20)
821	TOOL CHANGER IN SIGNAL
822	TOOL CHANGER OUT SIGNAL
823	MAIN DRAWBAR UP SIGNAL
824	MAIN DRAWBAR DOWN SIGNAL
825	COMMON (RETURN DATA GROUND)
826	SHIELD DRAIN
830	VECTOR DRIVE OVERHEAT THERMOSTAT - SHIELD +2
831	OVERHEAT SIGNAL #20
832	OVERHEAT RETURN (D GROUND) #20
833	SHIELD DRAIN

850	SERIAL PORT #1 INTERFACE CABLE (16 WIRE RIBBON #24) 33-0510
850A	SERIAL PORT #2 INTERFACE CABLE (16 WIRE RIBBON #24) 33-0510
860	+5V/+12V/-12V/Gnd FROM MAIN POWER SUPPLY (ALL #18)
861	+5 VOLTS
862	LOGIC POWER RETURN
863	LOGIC POWER RETURN
864	+12 VOLTS
865	-12 VOLTS
860A	12 VDC POWER TO M CODE RELAY BOARD - SHIELD +2
861	+12 VOLTS #20
865	LOGIC POWER RETURN (D GROUND) #20
863	SHIELD DRAIN
860C	12 VDC POWER TO MONITOR FAN - SHIELD +2
861C	+12 VOLTS #20
862C	LOGIC POWER RETURN #20
863C	SHIELD DRAIN
880A	115 VAC TO SPINDLE HEAD SOLENOIDS - SHIELD +6 (ALL #24)
881	WYE -DELTA SWITCH COMMAND
882	TOOL UNCLAMP
883	LOW GEAR
884	HIGH GEAR
885	115 VAC COMMON
886	SHIELD DRAIN
887	PRECHARGE
890	SPINDLE HEAD INPUT STATUS SWITCHES - SHIELD +6 (ALL #24)
891	HIGH GEAR SIGNAL
892	LOW GEAR SIGNAL
893	TOOL UNCLAMPED SIGNAL
894	TOOL CLAMPED SIGNAL
895	SPARE
896	COMMON (DATA GROUND)
897	SHIELD DRAIN
900	LOW THROUGH SPINDLE COOLANT STATUS - SHIELD +2
901	LOW COOLANT SIGNAL #20
902	RETURN (DATA GROUND) #20
910	115 VAC CIRCUIT BREAKER (CB4) TO SOLENOIDS - SHIELD +2
911	LEG 1 #20
912	LEG 2 #20
913	SHIELD DRAIN

910A	115 VAC TO PALLET CHANGER CW/CCW/AIR SOLENOIDS - SHIELD +2
911A	UNSWITCHED LEG 1 #20
912A	SWITCHED LEG 2 (FROM MCD RELAY BOARD M25, M26, M27) #20
913A	SHIELD DRAIN
910B	115 VAC TO SERVO FAN - SHIELD +2
911B	LEG 1 #20
912B	LEG 2 #20
910C	115 VAC TO PURGE SOLENOID - SHIELD +2
911C	UNSWITCHED LEG 1 #20
912C	SWITCHED LEG 2 (FROM 270 IOPCB P48)
913C	SHIELD DRAIN
910D	115 VAC TO PALLET ALARM - SHIELD +2
911D	SWITCHED LEG 1 (FROM MCD RELAY BOARD M24) #20
912D	UNSWITCHED LEG 2 #20
913D	SHIELD DRAIN
930	230 VAC FOR COOLANT PUMP FROM CB3 - SHIELD +2
931	LEG 1 #20
932	LEG 2 #20
933	SHIELD DRAIN
940	230 VAC SINGLE PHASE POWER TO COOLANT PUMP
941	LEG 1 #20
942	LEG 2 #20
940A	230 VAC SINGLE PHASE POWER TO THROUGH SPINDLE COOLANT PUMP
941A	LEG 1 #20
942A	LEG 2 #20
950	LOW AIR PRESSURE/OIL LUBE SENSOR - SHIELD +3
951	LOW AIR SIGNAL #20
952	LOW OIL LUBE SIGNAL #20
953	COMMON (DATA GROUND) #20
954	SHIELD DRAIN
960	LOW TRANSMISSION OIL LUBE - SHIELD +2
961	LOW TRANSMISSION OIL LUBE SIGNAL #20
962	COMMON (RETURN DATA GROUND)#20
963	SHIELD DRAIN

970 VECTOR DRIVE OVER-VOLT SENSOR

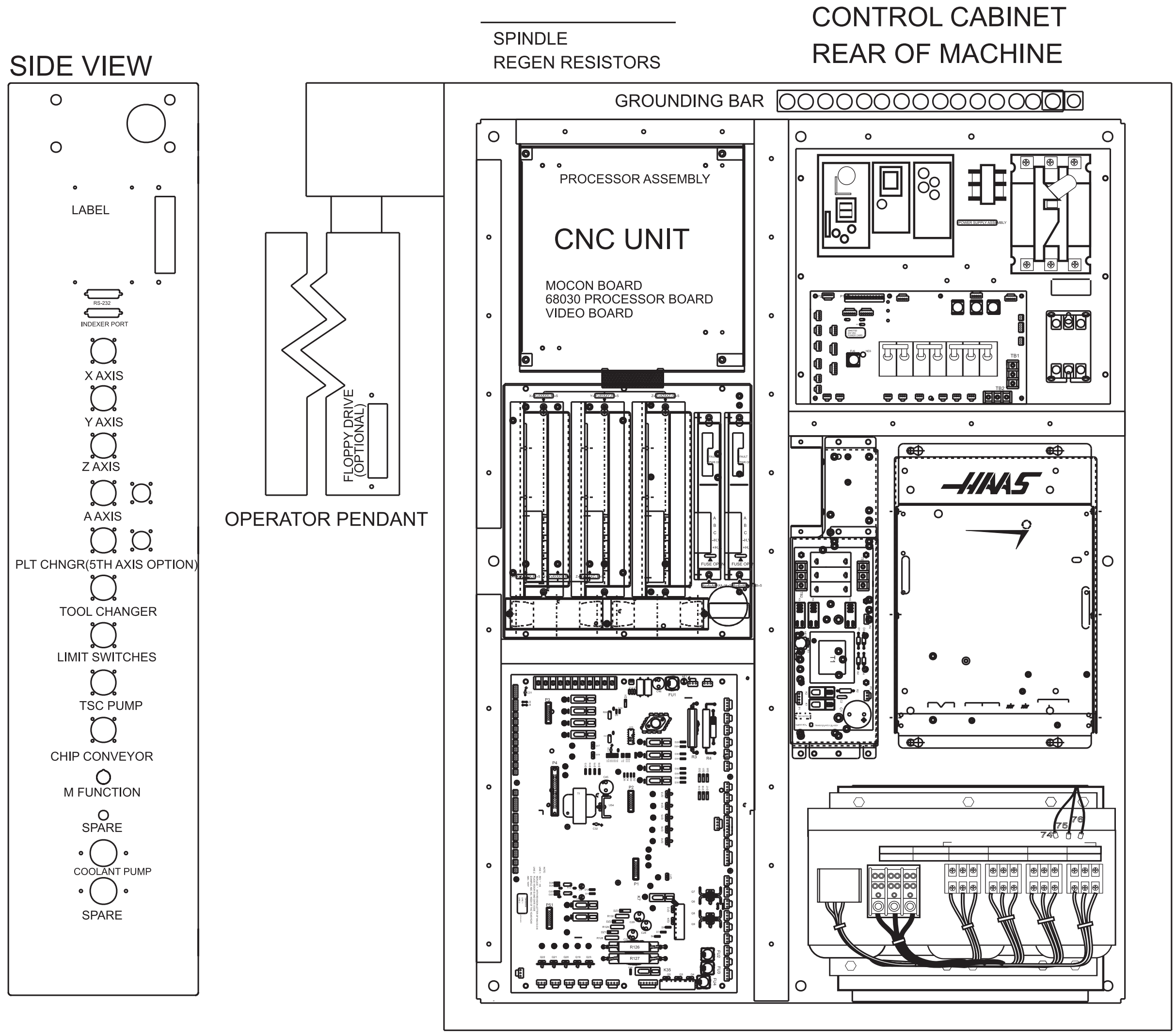
990	HOME SENSORS - SHIELD +4 (ALL #20)
991	COMMON (DATA GROUND)
992	X-AXIS HOME SWITCH
993	Y-AXIS HOME SWITCH
994	Z-AXIS HOME SWITCH
1000	SPINDLE ENCODER CABLE (MoCon SIDE CONNECTION) ALL #24
1000-1	LOGIC RETURN (D GROUND)
1000-2	ENCODER A CHANNEL
1000-3	ENCODER B CHANNEL
1000-4	+5 VDC
1000-5	ENCODER Z CHANNEL
1000-6	NOT USED
1000-7	SPINDLE MOTOR OVERHEAT SENSOR
1000-8	ENCODER A* CHANNEL
1000-9	ENCODER B* CHANNEL
1000-10	ENCODER Z* CHANNEL
1000-11	NOT USED
1000-12	NOT USED
1000-13	NOT USED
1000-14	NOT USED
1000-15	SHIELD DRAIN
1000-16	NOT USED
1010	AUX FRONT PANEL CABLE (HS-1R/RP) - SHIELD +6 (ALL #24)
1011	COMMON FOR CYCLE START AND FEED HOLD RETURN
1012	CYCLE START
1013	PART READY
1014	COMMON FOR PALLET ROTATE AND PART READY
1015	PALLET ROTATE
1016	FEED HOLD
1017	SHIELD DRAIN
1030	SPINDLE LOAD RESISTOR - SHIELD +2
1031	REGEN LOAD RESISTOR FOR SPINDLE DRIVE #18
1032	REGEN LOAD RESISTOR FOR SPINDLE DRIVE #18
1040	115 VAC TO MIKRON DOOR INTERLOCK SWITCH - SHIELD +2
1041	LEG 1 #20
1042	LEG 2 #20
1043	SHIELD DRAIN
1050	DOOR SWITCH INPUT - SHIELD +2
1051	DOOR SWITCH SIGNAL #20
1052	DOOR SWITCH RETURN (D GROUND) #20
1053	SHIELD DRAIN
1060	SPARE (GROUND FAULT DETECTION SENSE INPUT)

1070	PROBE INPUT (OPTION) - SHIELD +2
1071	PROBE SIGNAL #20
1072	LOGIC COMMON #20
1073	SHIELD DRAIN

1070A	PROBE OUTPUT (MCD RELAY BOARD M22) (OPTION) - SHIELD +2
1071A	UNSWITCHED LEG 1 #20
1072A	SWITCHED LEG 2 #20
1073A	SHIELD DRAIN

———————END———————-

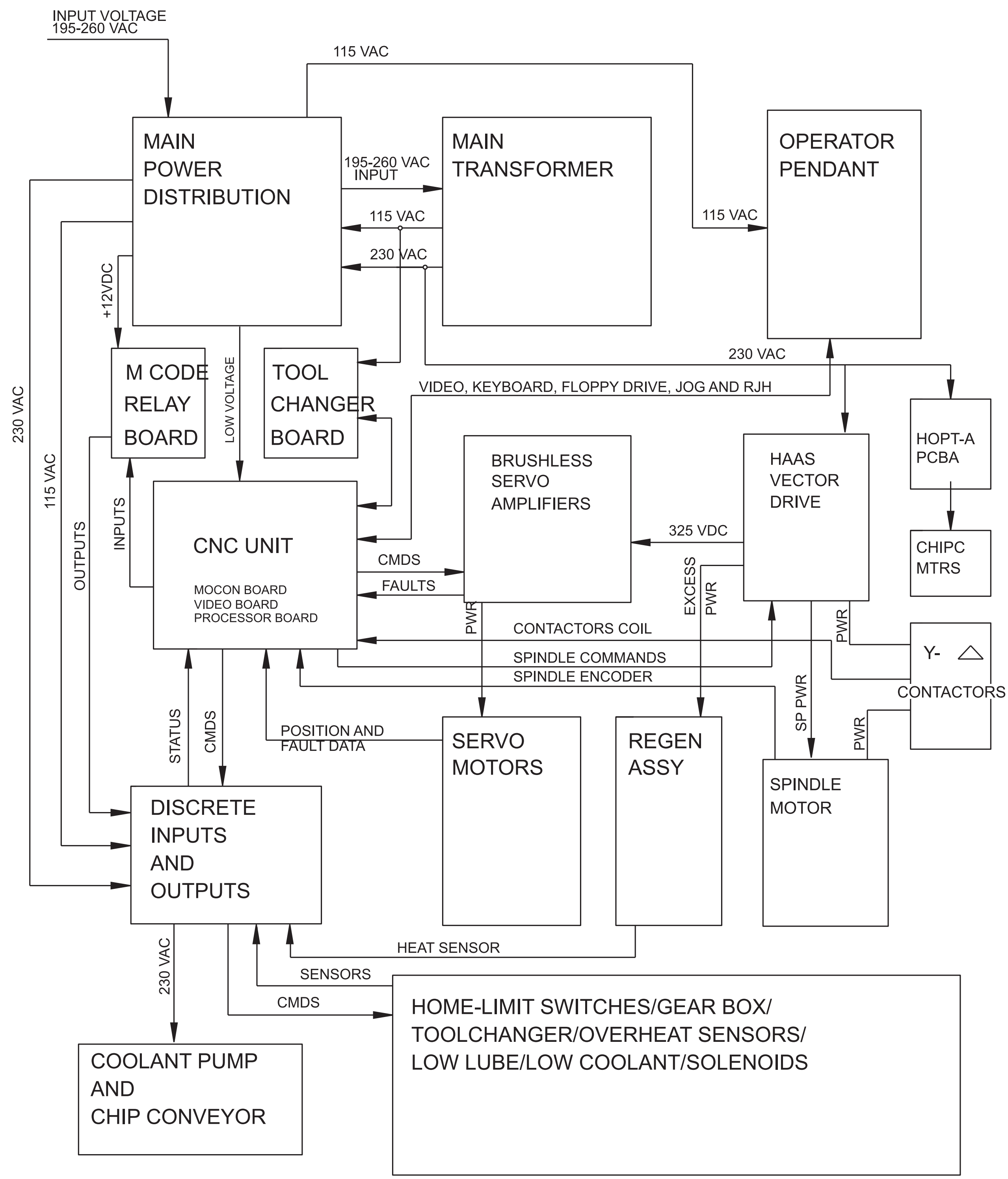
ELECTRICAL WIRING DIAGRAMS



ITEM DESCRIPTION	PAGE #	ITEM DESCRIPTION	PAGE #
CNC LAYOUT	A	RELAY COIL DRIVERS, IOPCB	8-11
SYSTEM BLOCK DIAGRAM	B,C	SPINDLE DRIVE UNIT	12
CABLE INTERCONNECT DIAGRAM	D,E	AXIS MOTOR & ENCODER	14,15
SERVO SYSTEM	1	CABINET CONNECTORS	16
MAIN TRANSFORMER	2,3	TOOL CHANGE MOTORS	17
CNC UNIT	4	CHIP CONVEYOR/SPIGOT MOTOR	18
115VAC CIRCUITS	5	OPERATOR PENDANT	19
INPUTS IOPCB	6,7	ELECTRICAL SYMBOLS	21

CONTROL LAYOUT DIAGRAM

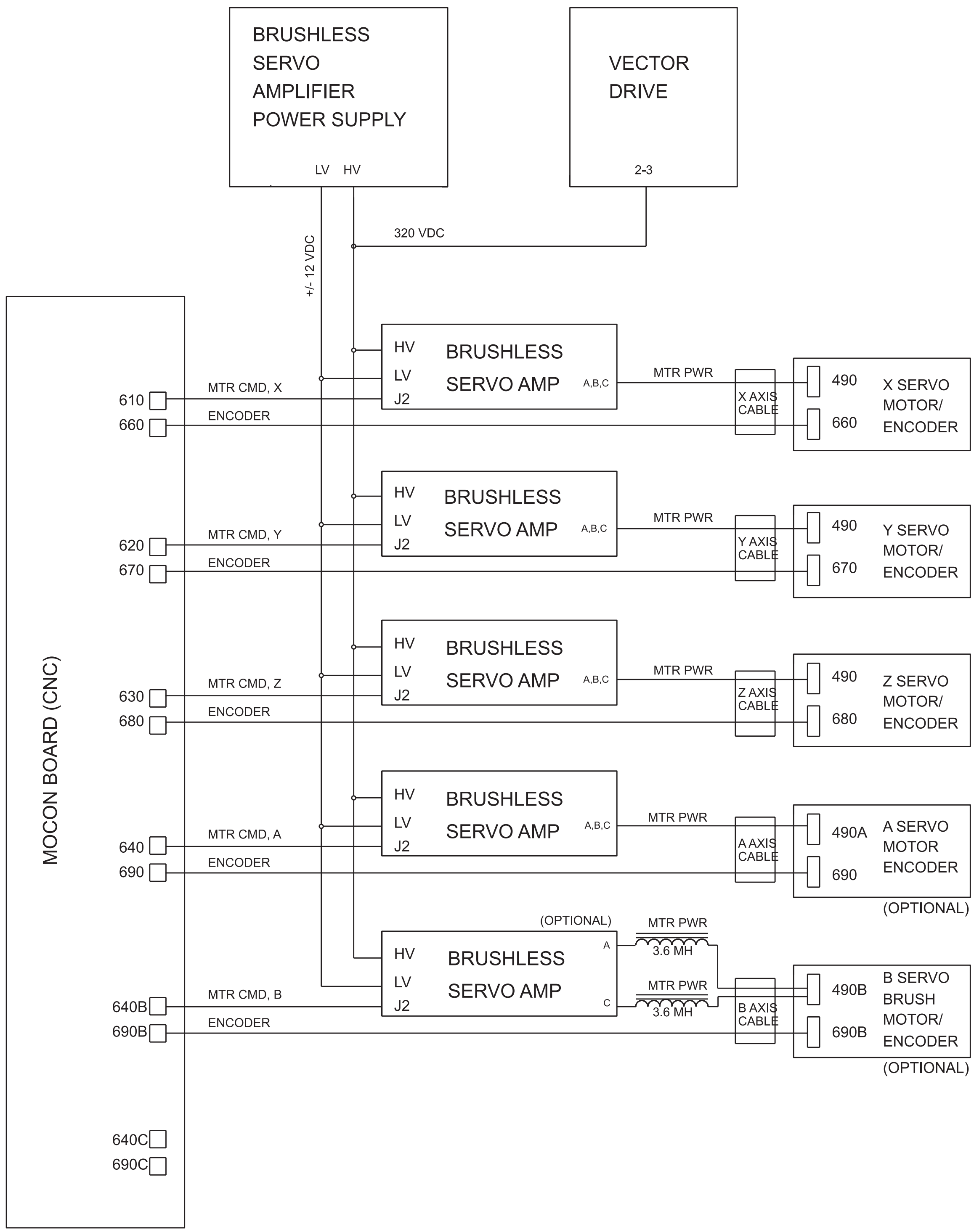
HAAS AUTOMATION HS SERIES PAGE A



NOTE FOR HIGH VOLTAGE IN, SEE PAGE C.

SYSTEM BLOCK DIAGRAM - LOW VOLTAGE

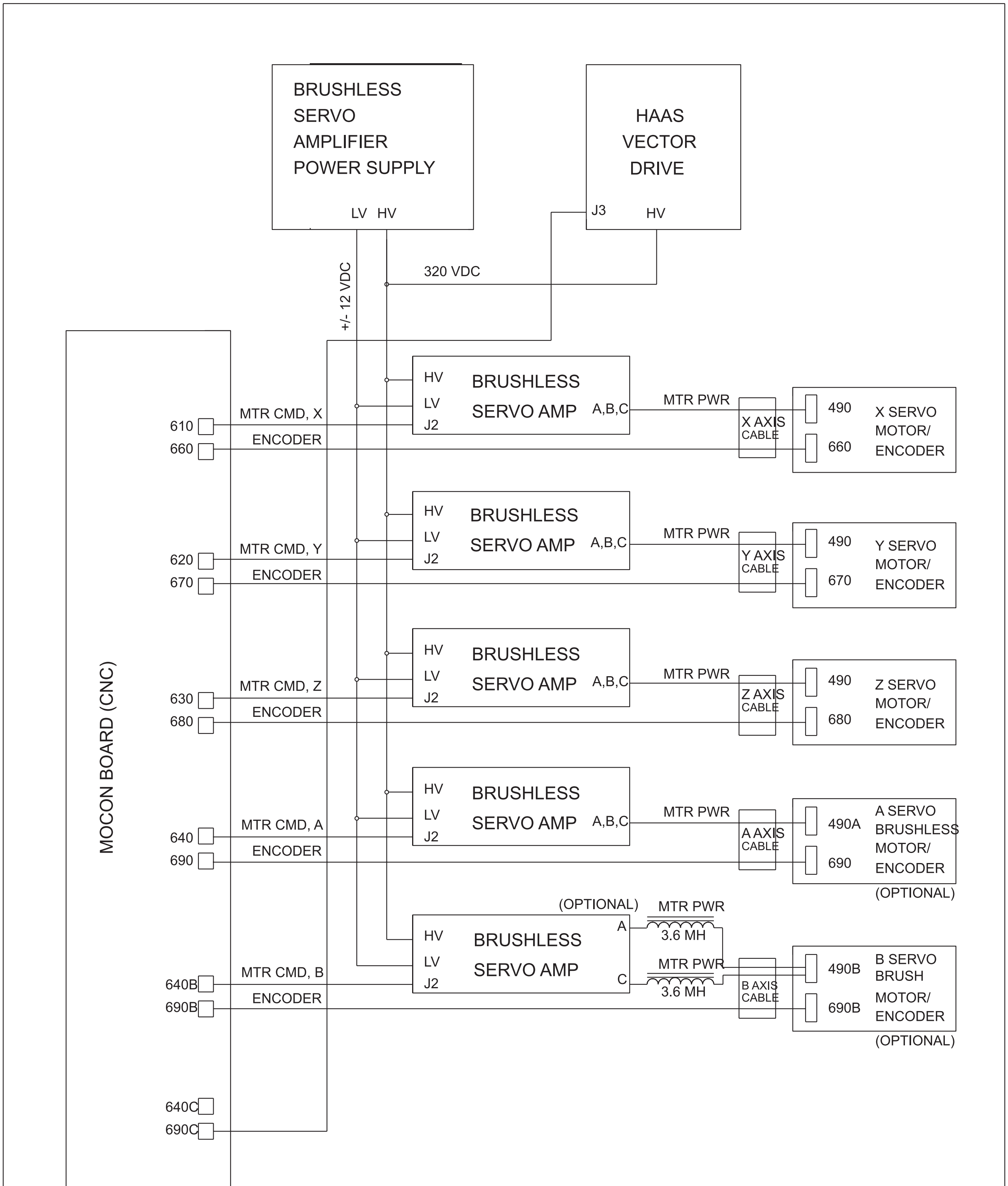
HAAS AUTOMATION HS SERIES PAGE B



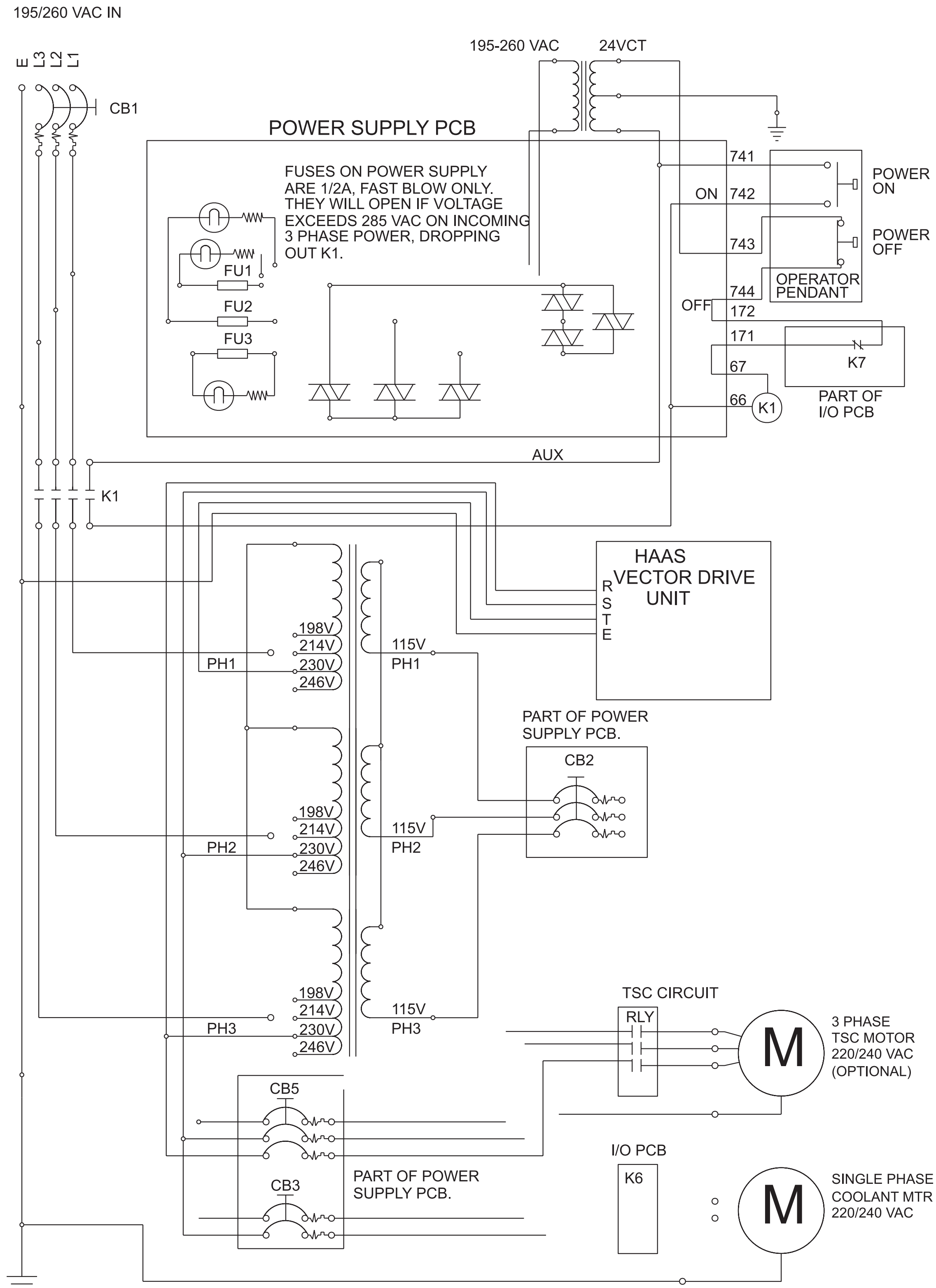
SERVO SYSTEM

HS-1 WITH BRUSH 5TH AXIS OPTION

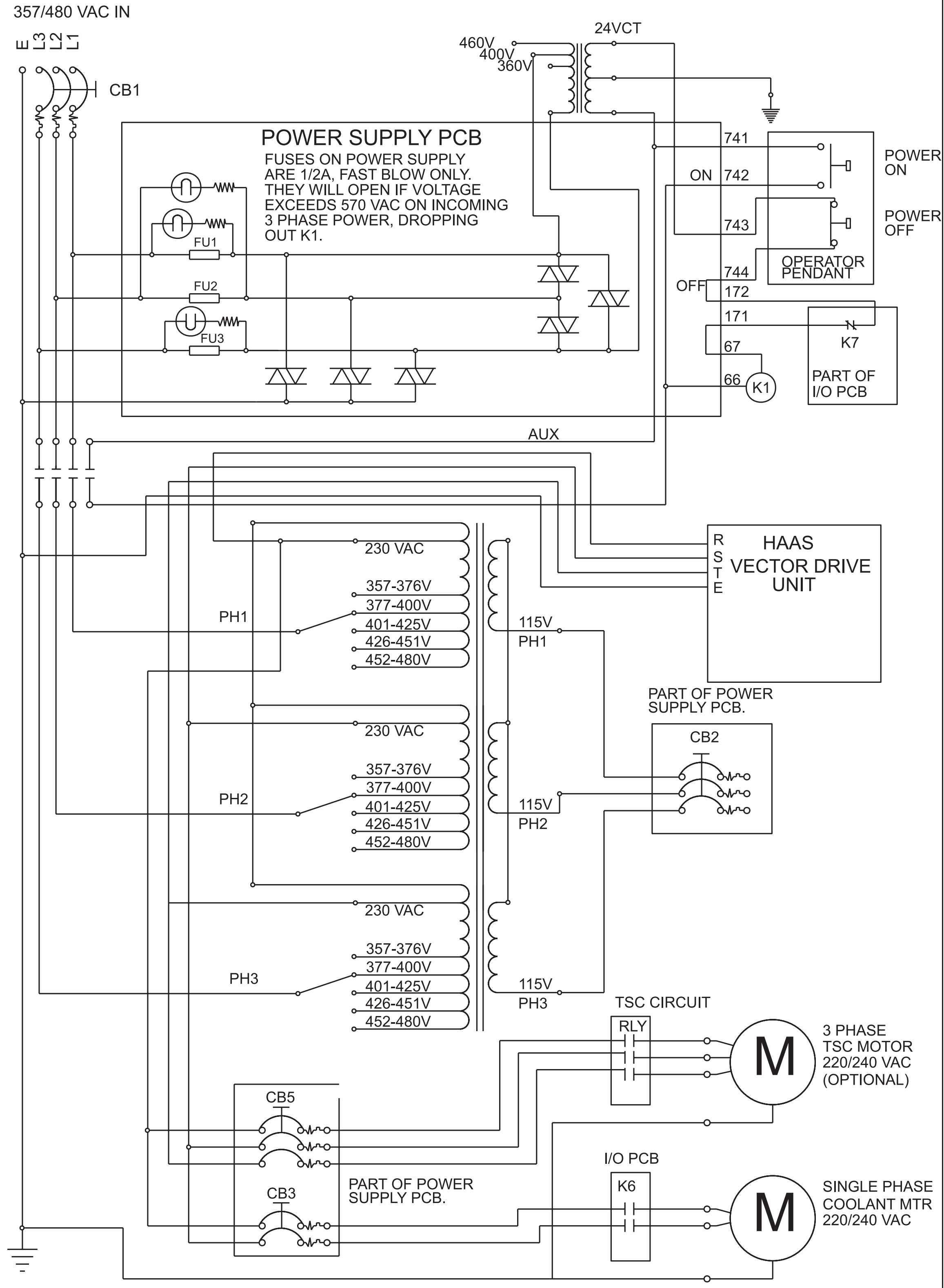
HAAS AUTOMATION PAGE 1



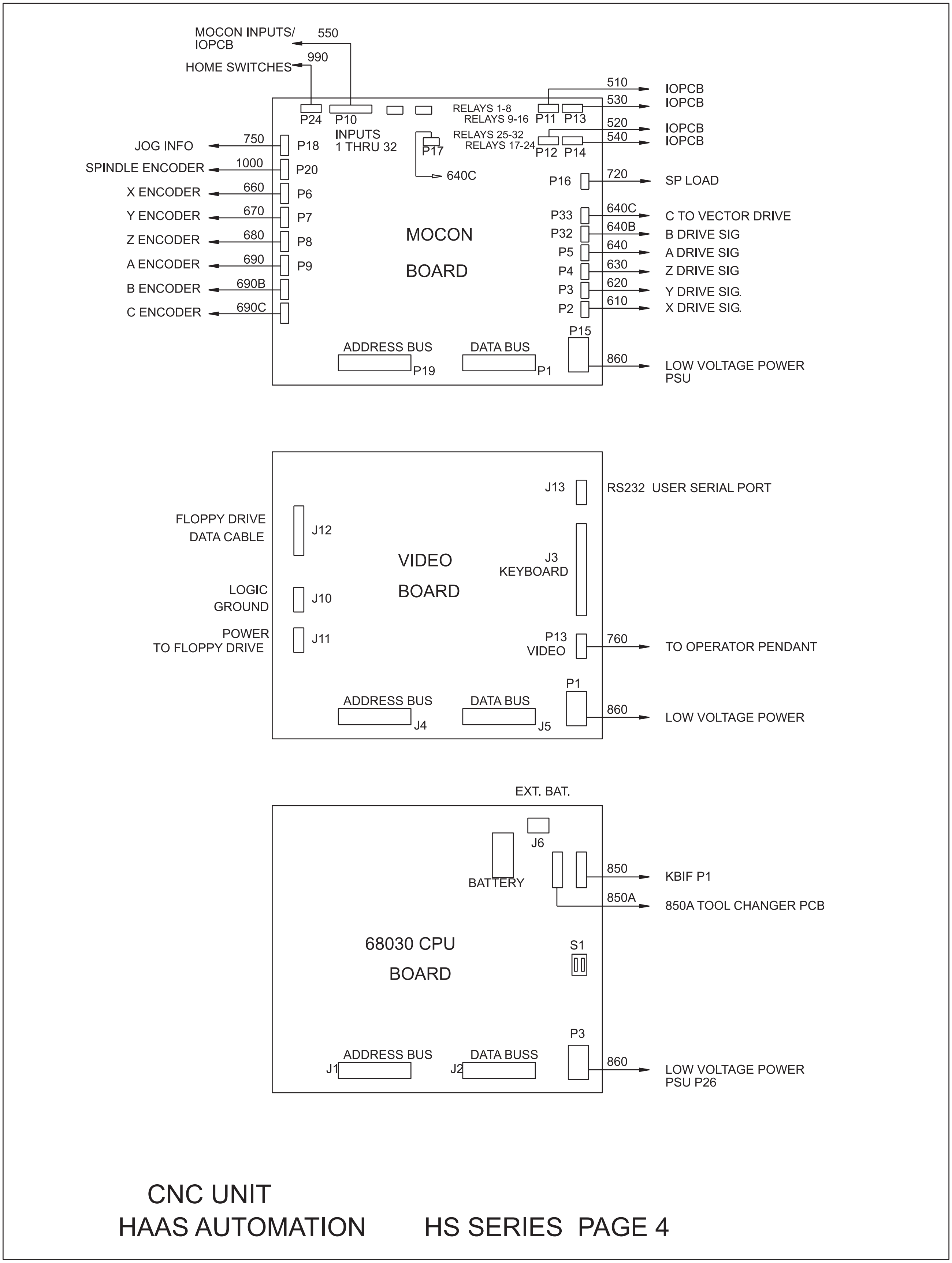
SERVO SYSTEM
HS-1 4TH AXIS BL AND 5TH AXIS OPTION (BRUSH)
HAAS AUTOMATION PAGE 1A

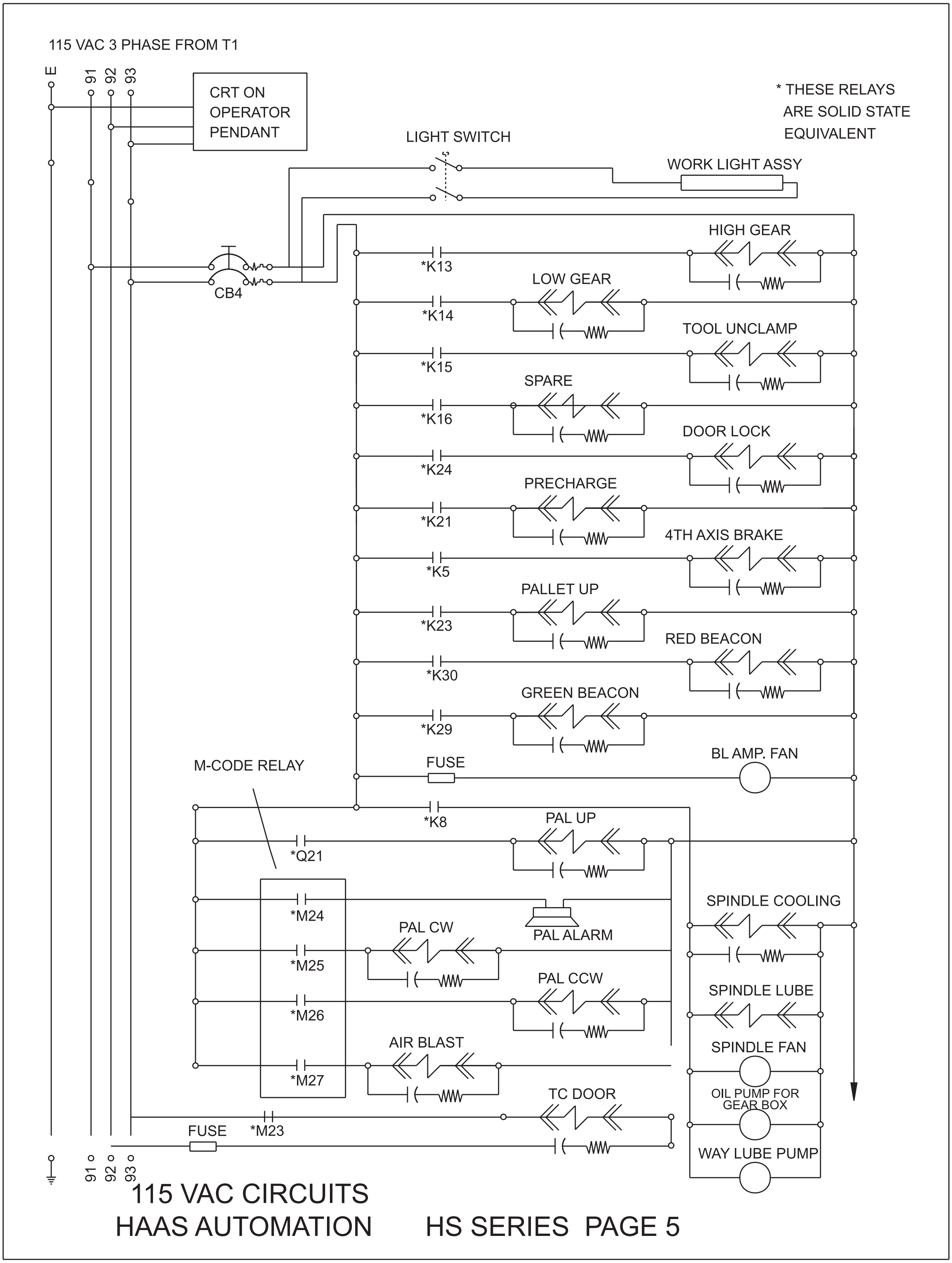


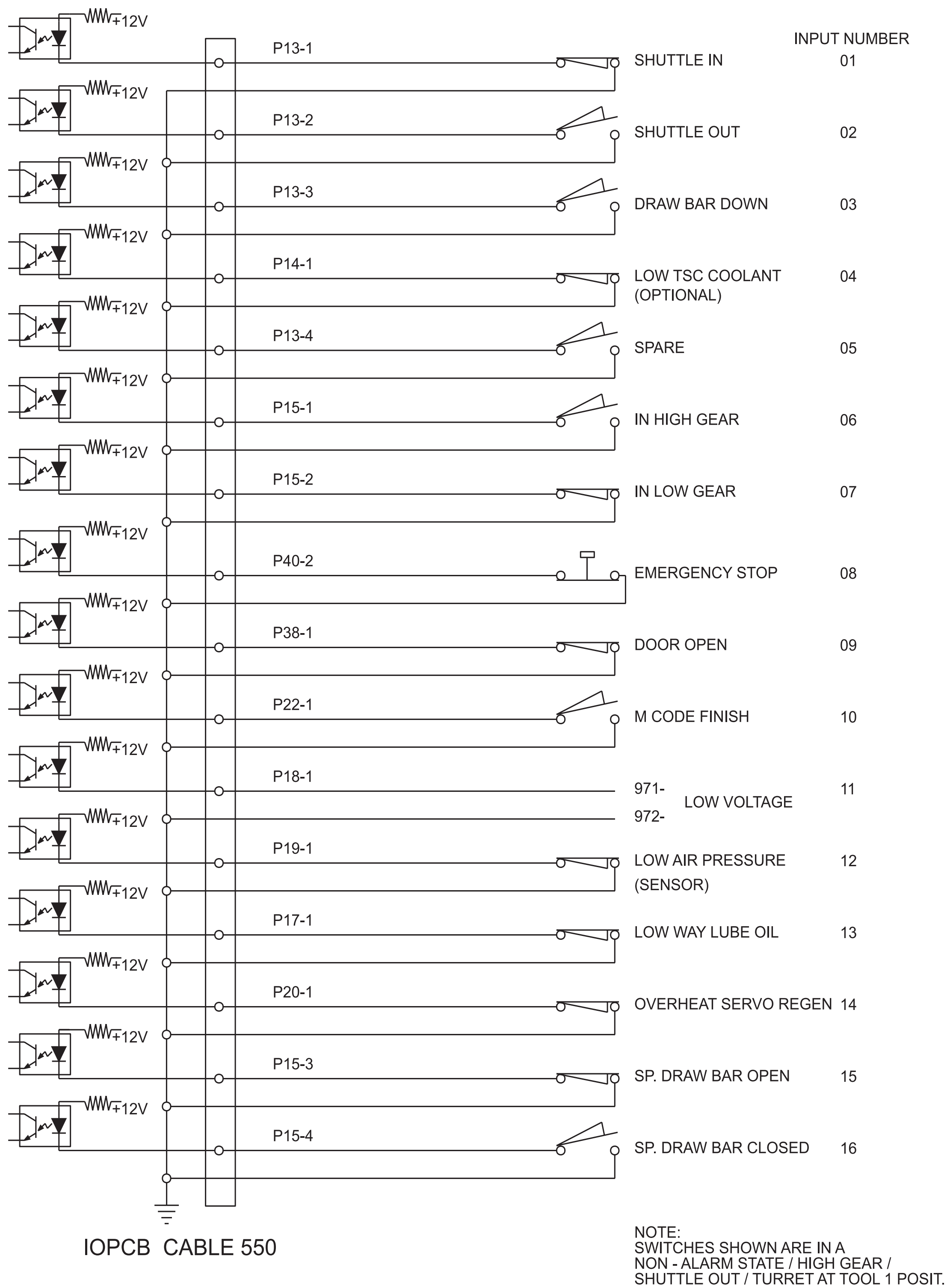
MAIN TRANSFORMER - LOW VOLTAGE
HAAS AUTOMATION HS SERIES PAGE 2



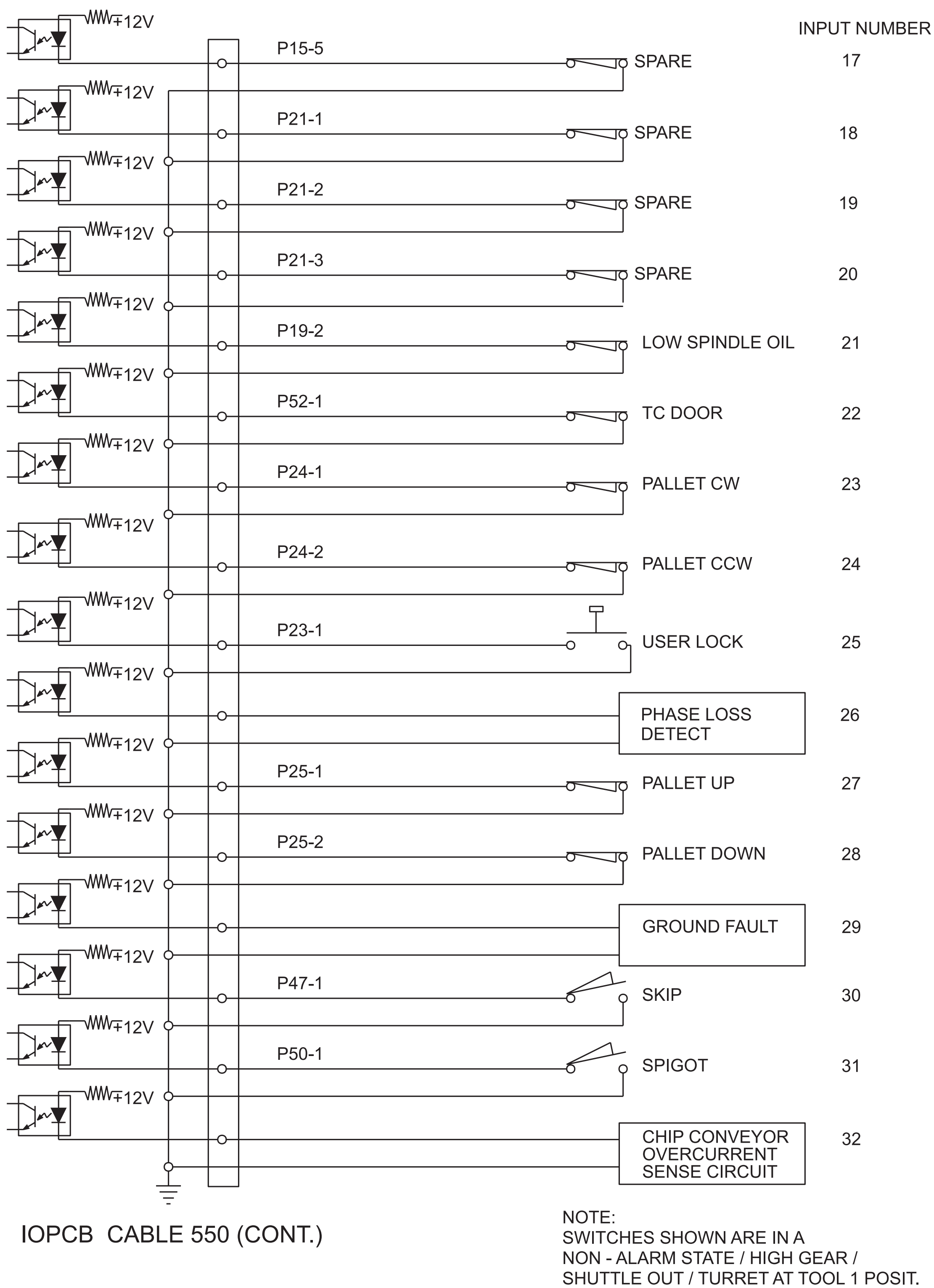
MAIN TRANSFORMER - HIGH VOLTAGE
HAAS AUTOMATION HS SERIES PAGE 3


MOCON INPUTS/
IOPCB
550
990
HOME SWITCHES
P24
P10
INPUTS
1 THRU 32
P17
640C
RELAYS 1-8
RELAYS 9-16
P11
P13
RELAYS 25-32
RELAYS 17-24
P12
P14
510
IOPCB
530
IOPCB
520
IOPCB
540
IOPCB
JOG INFO
750
P18
SPINDLE ENCODER
1000
P20
X ENCODER
660
P6
Y ENCODER
670
P7
Z ENCODER
680
P8
A ENCODER
690
P9
B ENCODER
690B
C ENCODER
690C
MOCON
BOARD
P16
720
SP LOAD
P33
640C
C TO VECTOR DRIVE
P32
640B
B DRIVE SIG
P5
640
A DRIVE SIG
P4
630
Z DRIVE SIG
P3
620
Y DRIVE SIG.
P2
610
X DRIVE SIG.
P15
ADDRESS BUS
DATA BUS
P19
P1
860
LOW VOLTAGE POWER
PSU
J13
RS232 USER SERIAL PORT
FLOPPY DRIVE
DATA CABLE
J12
VIDEO
BOARD
J3
KEYBOARD
LOGIC
GROUND
J10
POWER
TO FLOPPY DRIVE
J11
P13
VIDEO
760
TO OPERATOR PENDANT
P1
ADDRESS BUS
DATA BUS
J4
J5
860
LOW VOLTAGE POWER
EXT. BAT.
J6
BATTERY
850
KBIF P1
850A
850A TOOL CHANGER PCB
68030 CPU
BOARD
S1
P3
ADDRESS BUS
DATA BUSS
J1
J2
860
LOW VOLTAGE POWER
PSU P26
CNC UNIT
HAAS AUTOMATION
HS SERIES PAGE 4

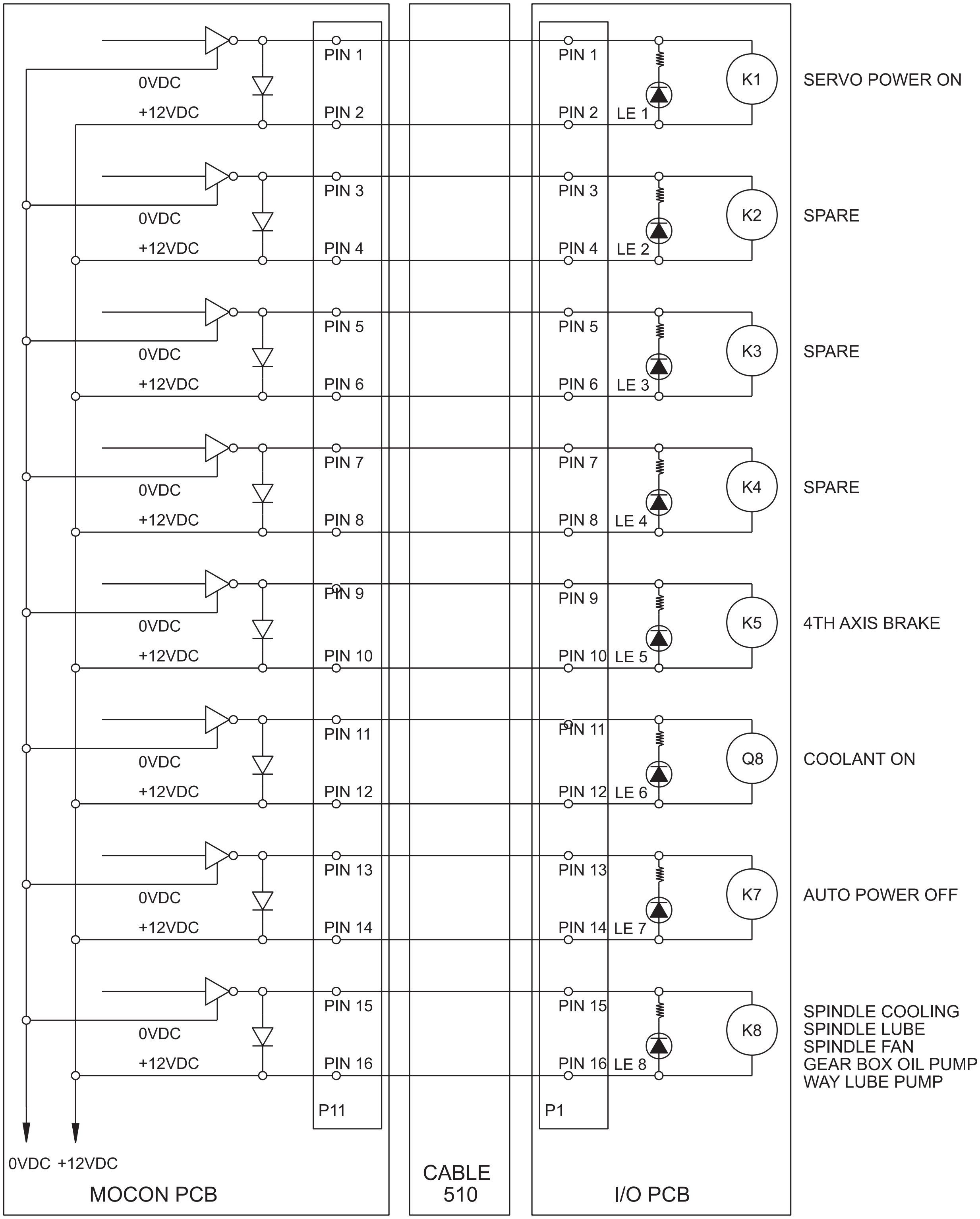

115 VAC 3 PHASE FROM T1
E
91
92
93
CRT ON
OPERATOR
PENDANT
* THESE RELAYS
ARE SOLID STATE
EQUIVALENT
LIGHT SWITCH
WORK LIGHT ASSY
CB4
HIGH GEAR
*K13
LOW GEAR
*K14
TOOL UNCLAMP
*K15
SPARE
*K16
DOOR LOCK
*K24
PRECHARGE
*K21
4TH AXIS BRAKE
*K5
PALLET UP
*K23
RED BEACON
*K30
GREEN BEACON
*K29
FUSE
BL AMP. FAN
M-CODE RELAY
*K8
PAL UP
*Q21
*M24
PAL ALARM
SPINDLE COOLING
PAL CW
*M25
PAL CCW
*M26
SPINDLE LUBE
AIR BLAST
SPINDLE FAN
*M27
TC DOOR
OIL PUMP FOR
GEAR BOX
FUSE
*M23
WAY LUBE PUMP
91
92
93
115 VAC CIRCUITS
HAAS AUTOMATION HS SERIES PAGE 5



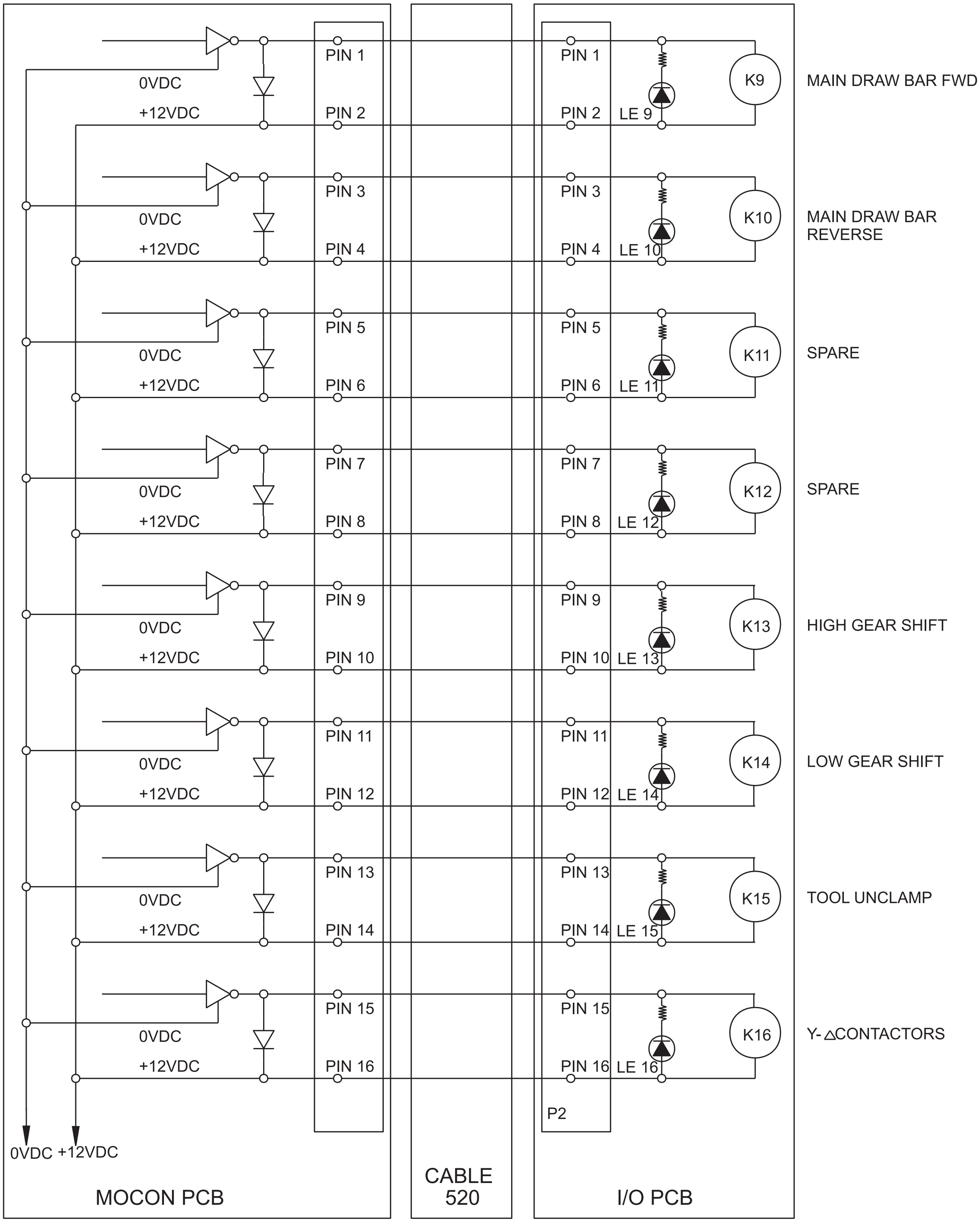
DISCRETE INPUTS 1 THROUGH 16
HAAS AUTOMATION HS SERIES PAGE 6



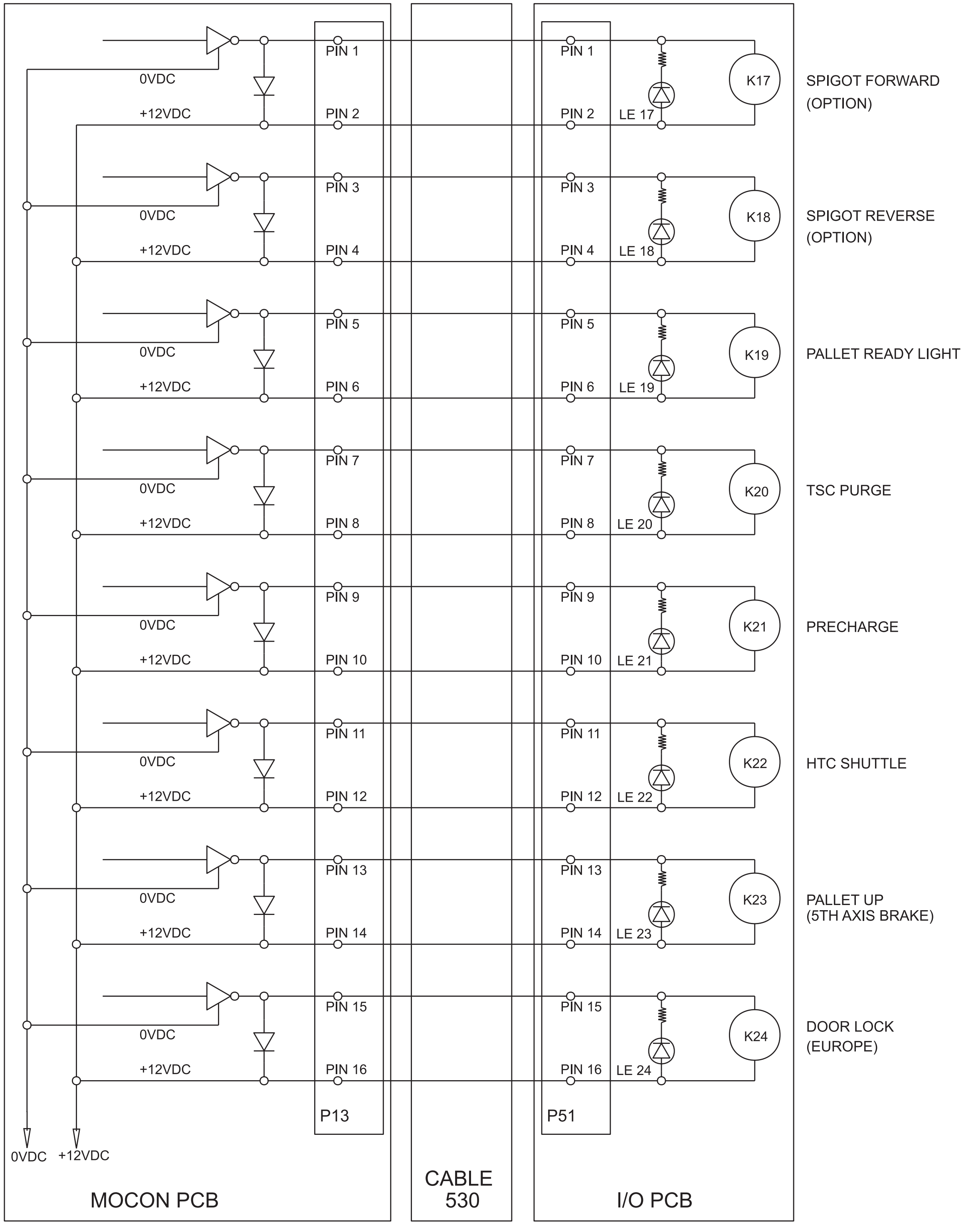
DISCRETE INPUTS 17 THROUGH 32
HAAS AUTOMATION HS SERIES PAGE 7



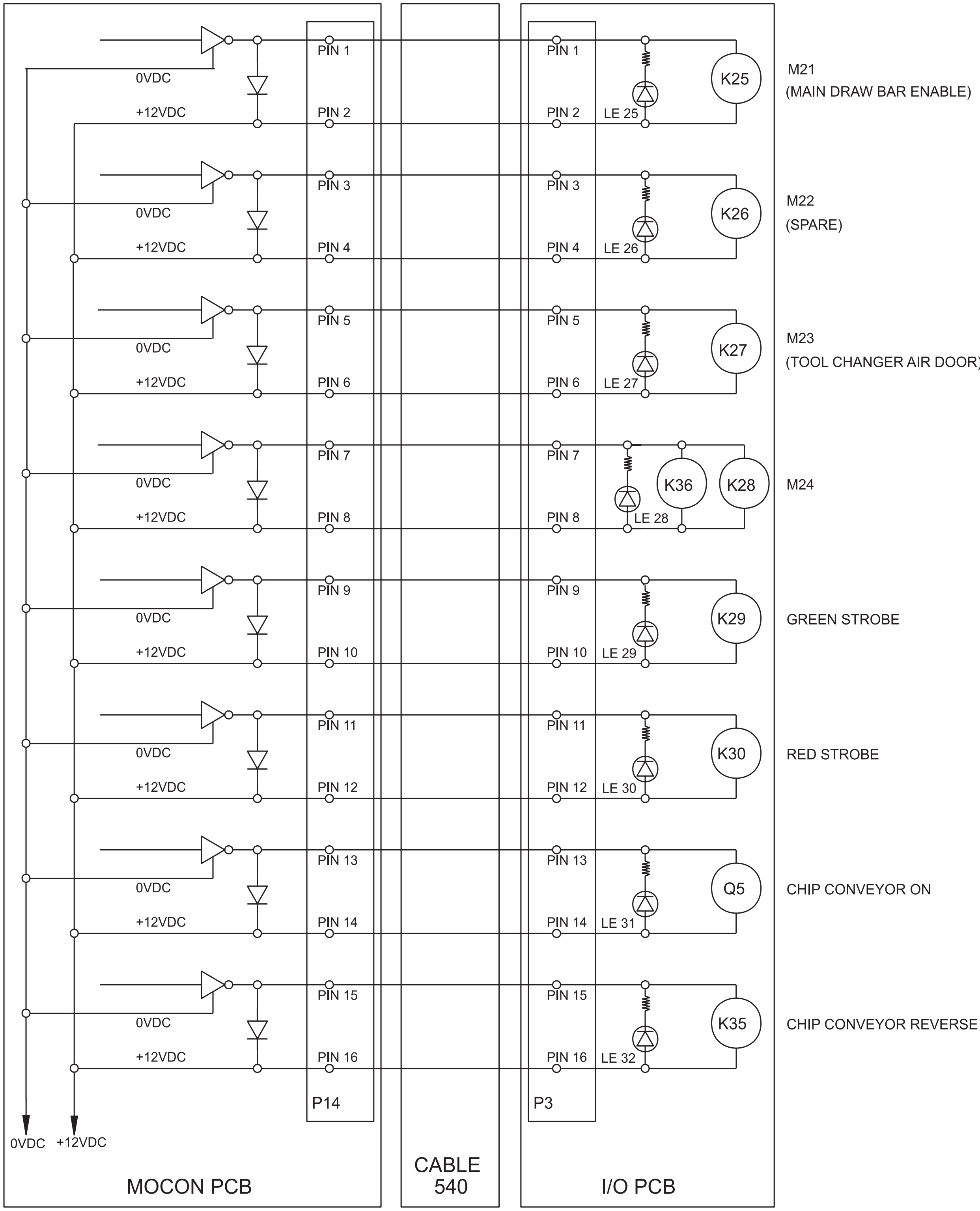
RELAY COIL DRIVERS, K1 THROUGH K8
HAAS AUTOMATION HS SERIES PAGE 8



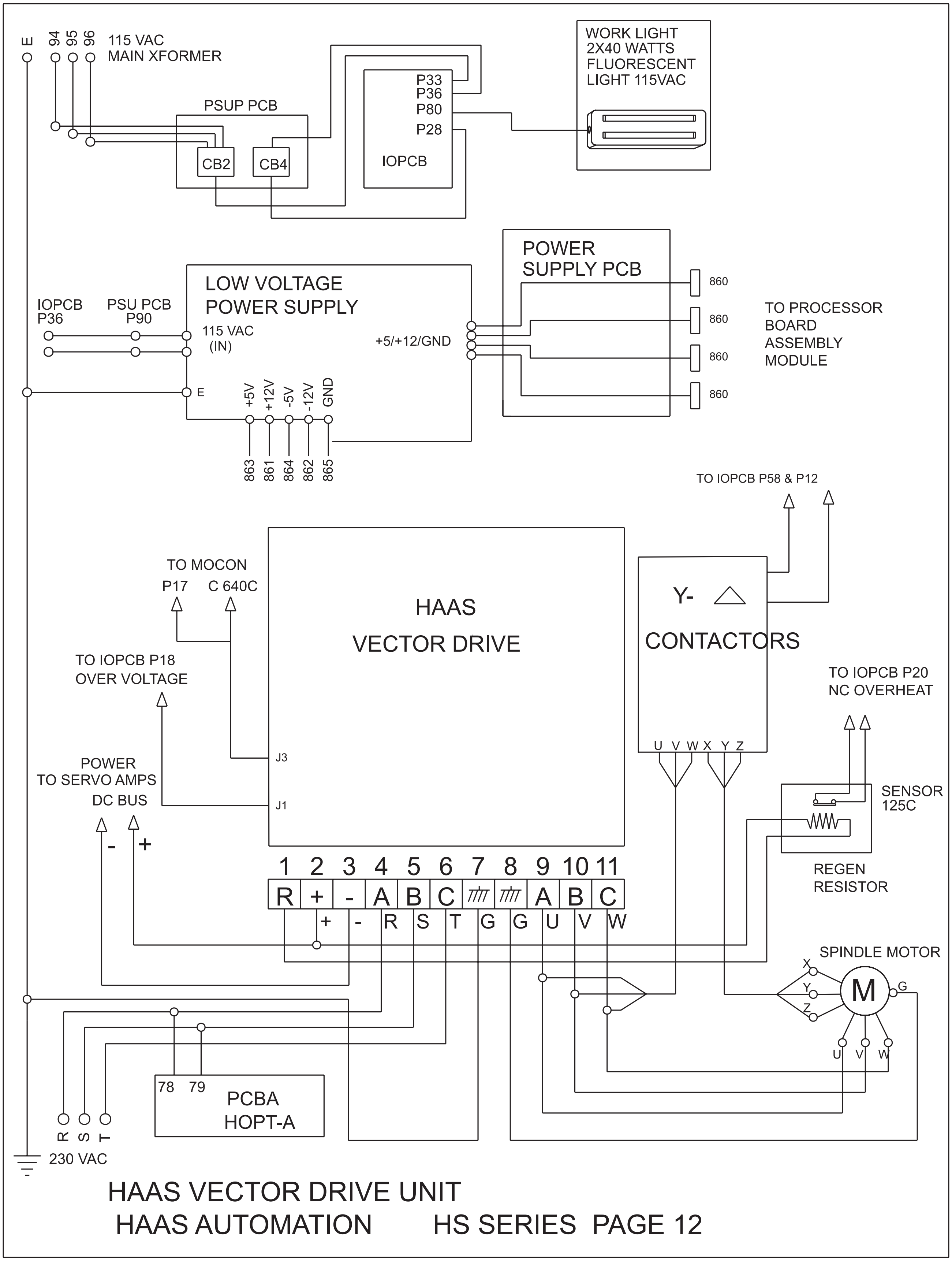
RELAY COIL DRIVERS, K9 THROUGH K16
HAAS AUTOMATION HS SERIES PAGE 9

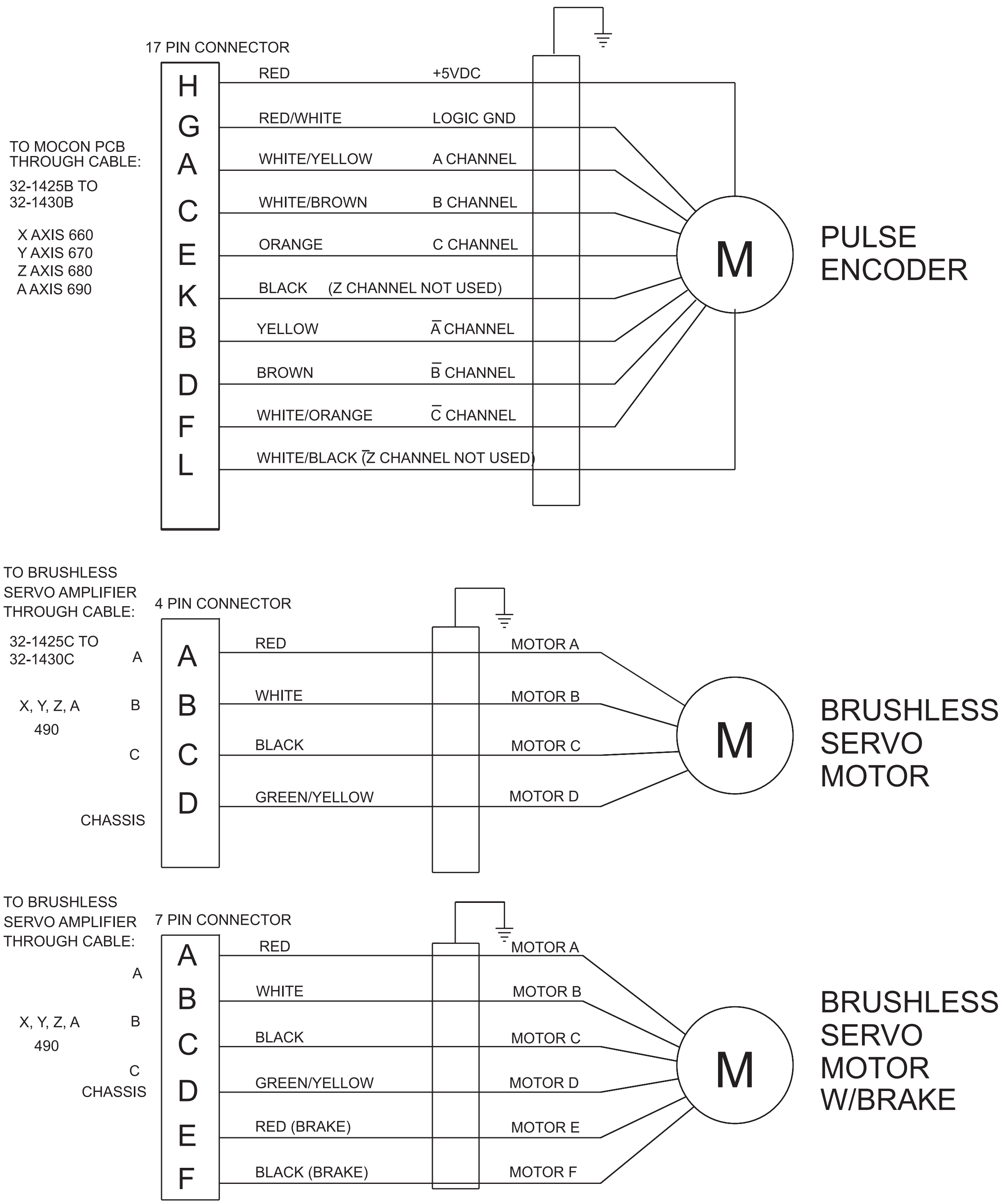


RELAY COIL DRIVERS, K17 THROUGH K24
HAAS AUTOMATION HS SERIES PAGE 10

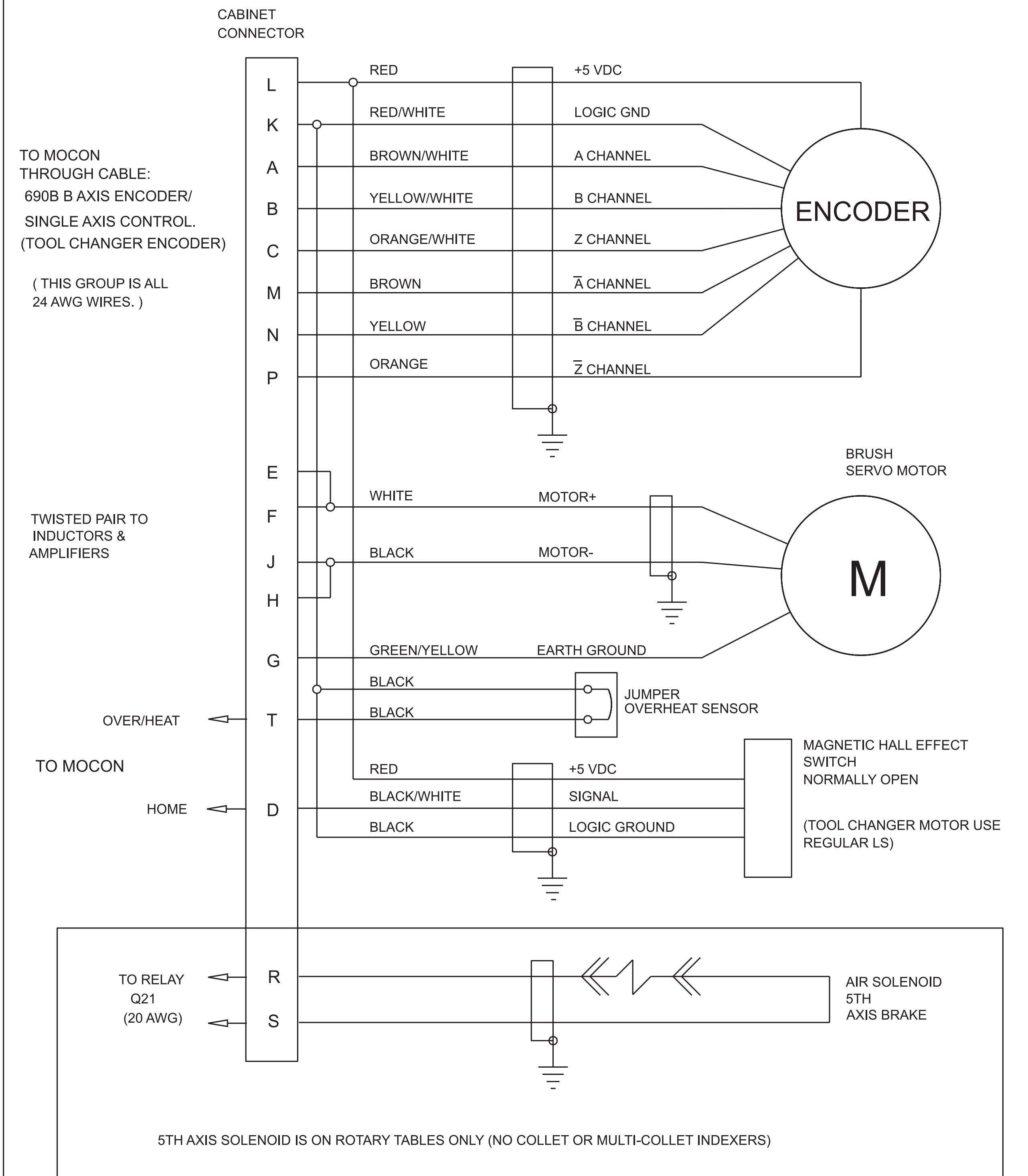


RELAY COIL DRIVERS, K25 THROUGH K32
HAAS AUTOMATION HS SERIES PAGE 11

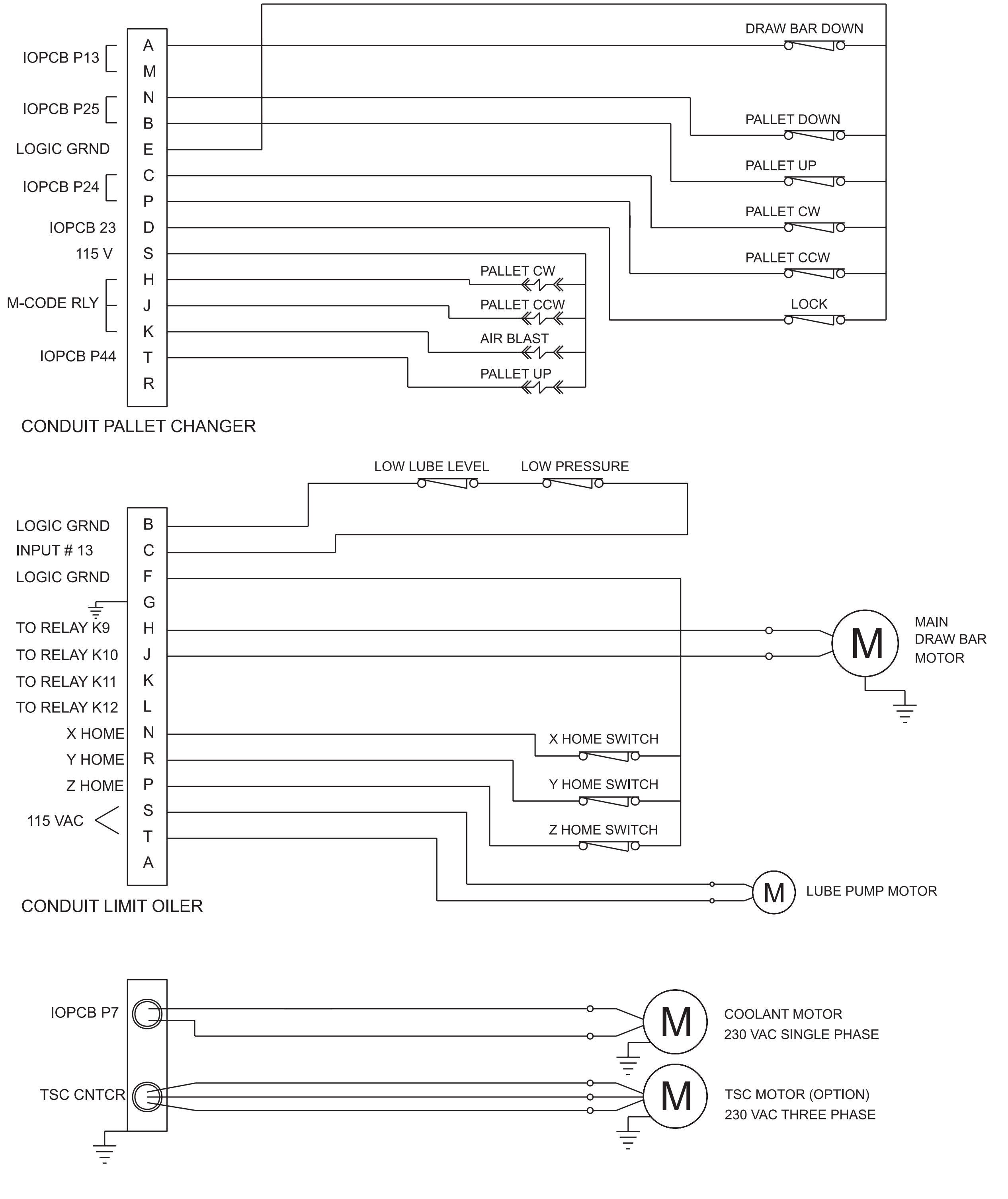

E
94
95
96
115 VAC
MAIN XFORMER
PSUP PCB
CB2
CB4
P33
P36
P80
P28
IOPCB
WORK LIGHT
2X40 WATTS
FLUORESCENT
LIGHT 115VAC
POWER
SUPPLY PCB
860
860
860
860
TO PROCESSOR
BOARD
ASSEMBLY
MODULE
LOW VOLTAGE
POWER SUPPLY
IOPCB
P36
PSU PCB
P90
115 VAC
(IN)
+5/+12/GND
E
+5V
+12V
-5V
-12V
GND
863
861
864
862
865
TO IOPCB P58 & P12
TO MOCON
P17
C 640C
HAAS
VECTOR DRIVE
Y-
CONTACTORS
TO IOPCB P18
OVER VOLTAGE
TO IOPCB P20
NC OVERHEAT
POWER
TO SERVO AMPS
DC BUS
J3
J1
U V W X Y Z
SENSOR
125C
REGEN
RESISTOR
1 2 3 4 5 6 7 8 9 10 11
R + - A B C A B C
+ - R S T G G U V W
SPINDLE MOTOR
M
X
Y
Z
G
U
V
W
78
79
PCBA
HOPT-A
R
S
T
230 VAC
HAAS VECTOR DRIVE UNIT
HAAS AUTOMATION HS SERIES PAGE 12



X, Y, Z, A AXIS MOTOR & ENCODER
HAAS AUTOMATION HS SERIES PAGE 13

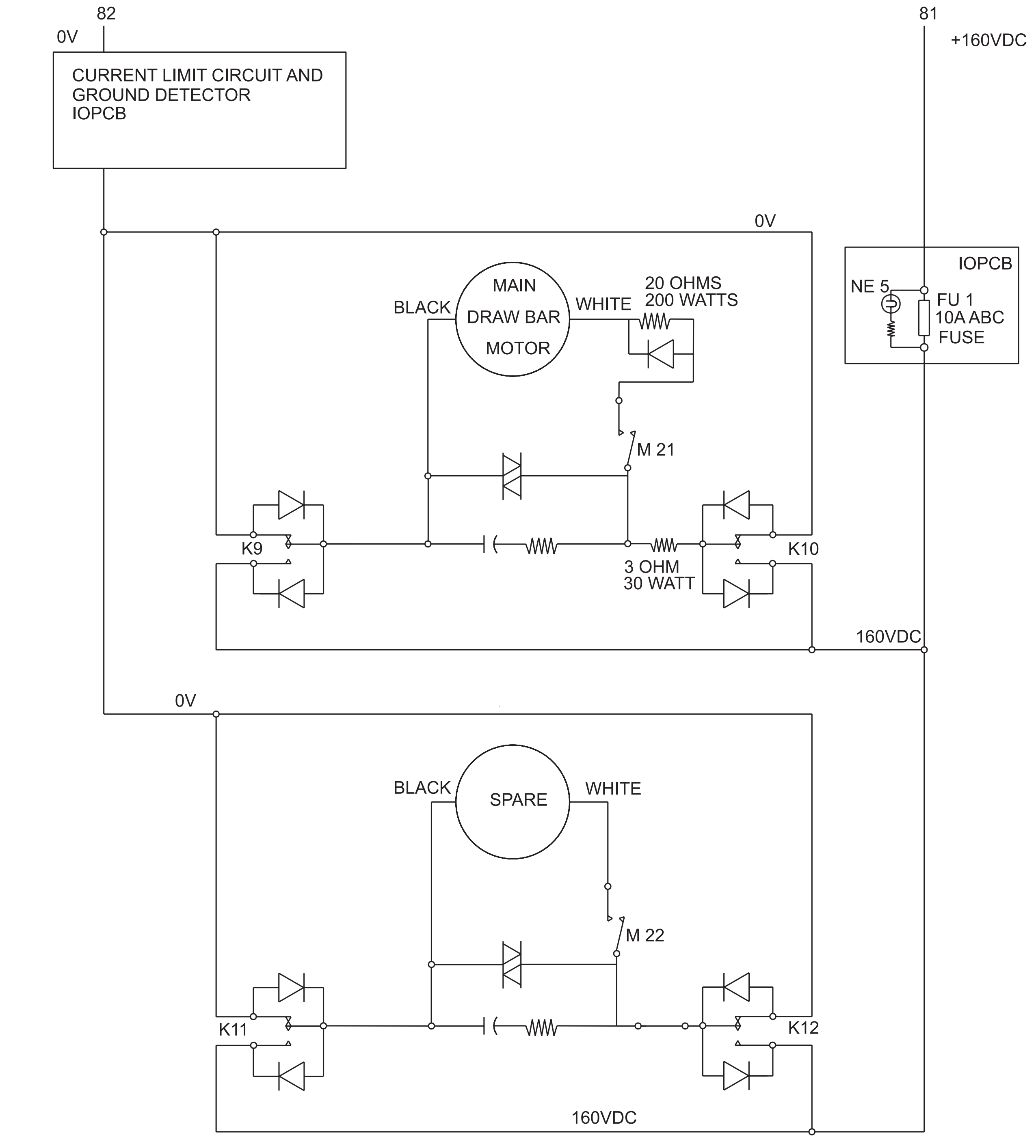


B AXIS, TOOL CHANGER MOTOR & ENCODER
HAAS AUTOMATION HS SERIES PAGE 14

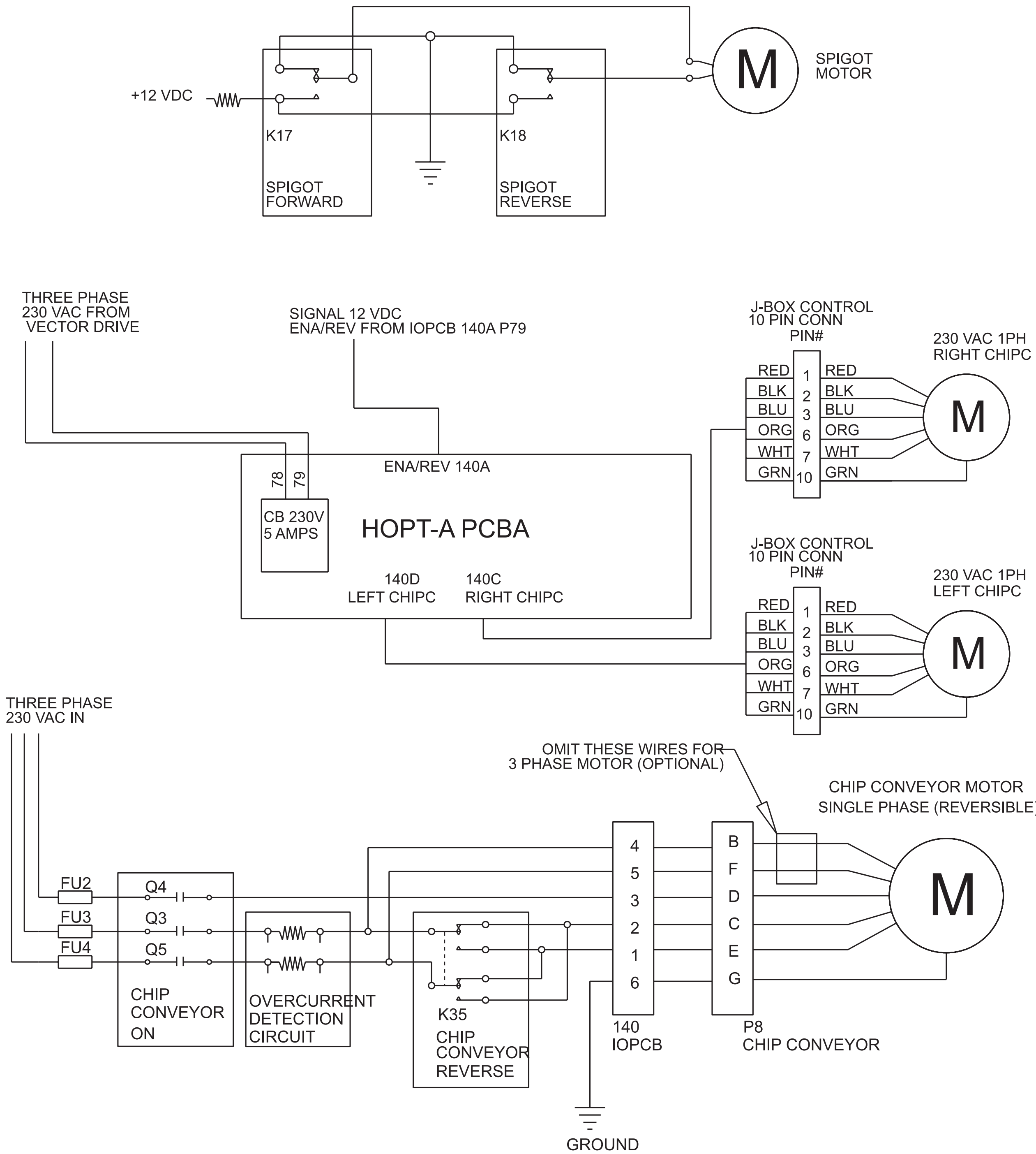


NOTE: CONNECTORS ARE LOCATED ON SIDE OF CONTROL CABINET.

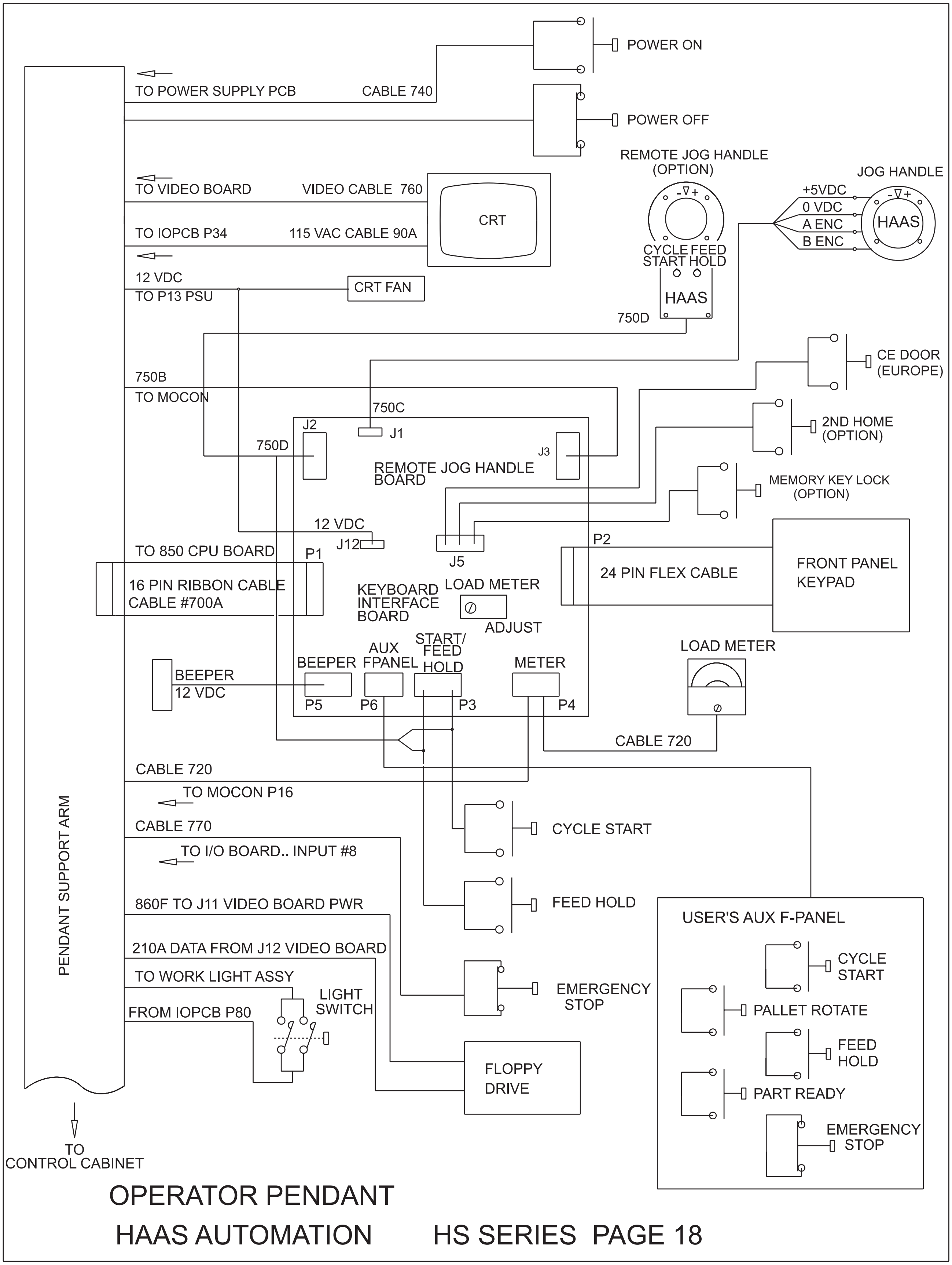
CABINET CONNECTORS
HAAS AUTOMATION HS SERIES PAGE 15

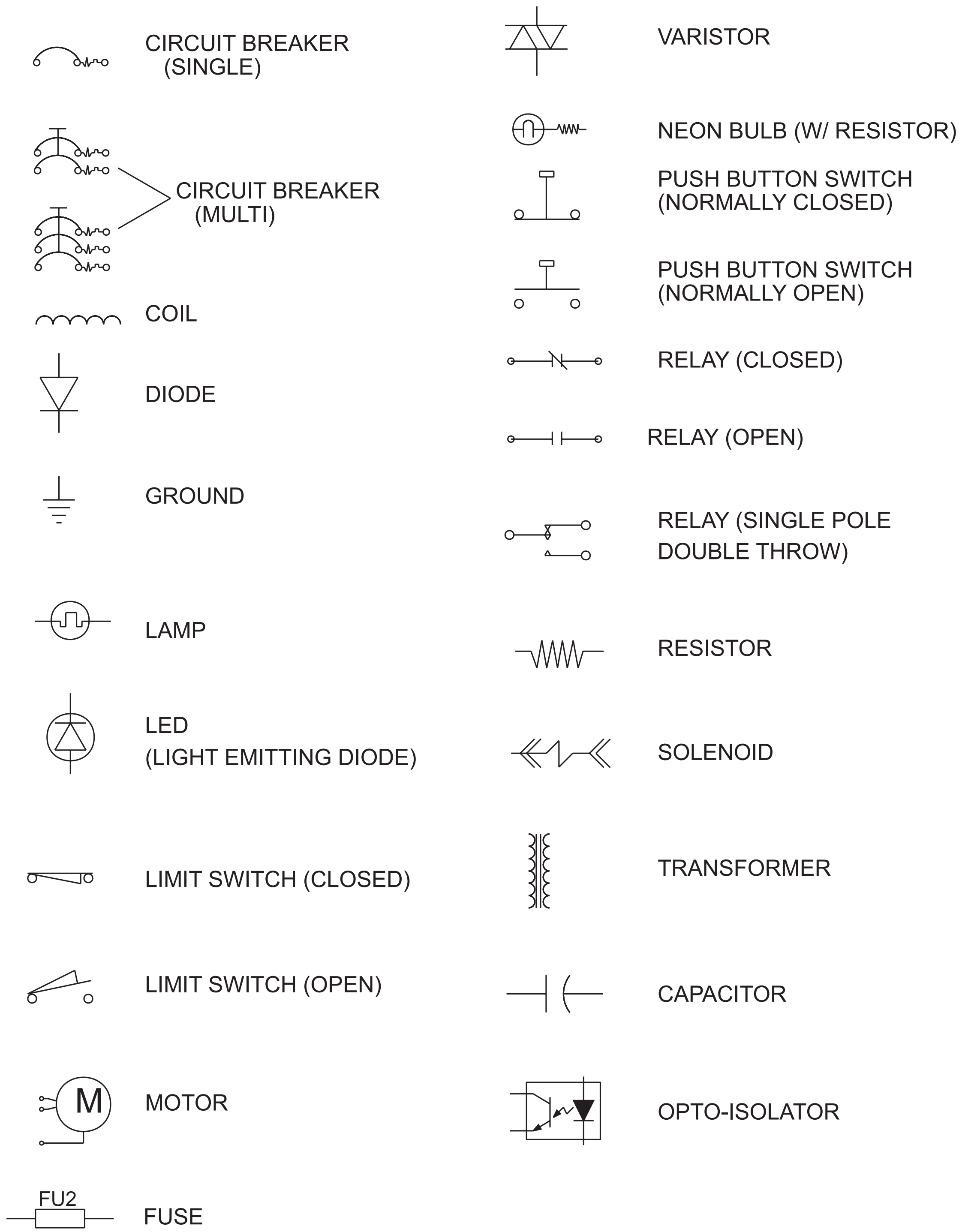


DRAW BARS MOTORS
HAAS AUTOMATION HS SERIES PAGE 16

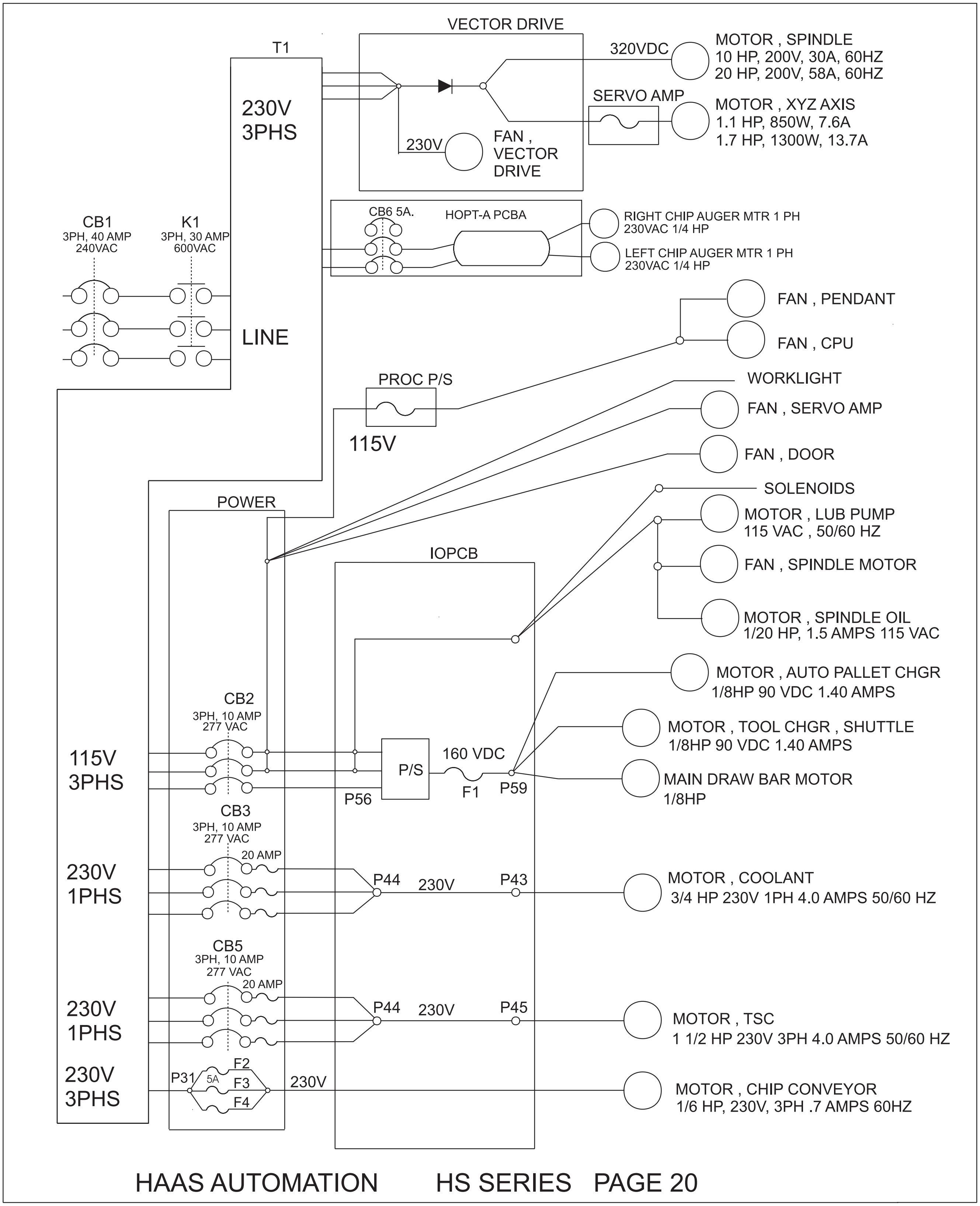


CHIP CONVEYOR AND SPIGOT MOTORS
HAAS AUTOMATION HS SERIES PAGE 17

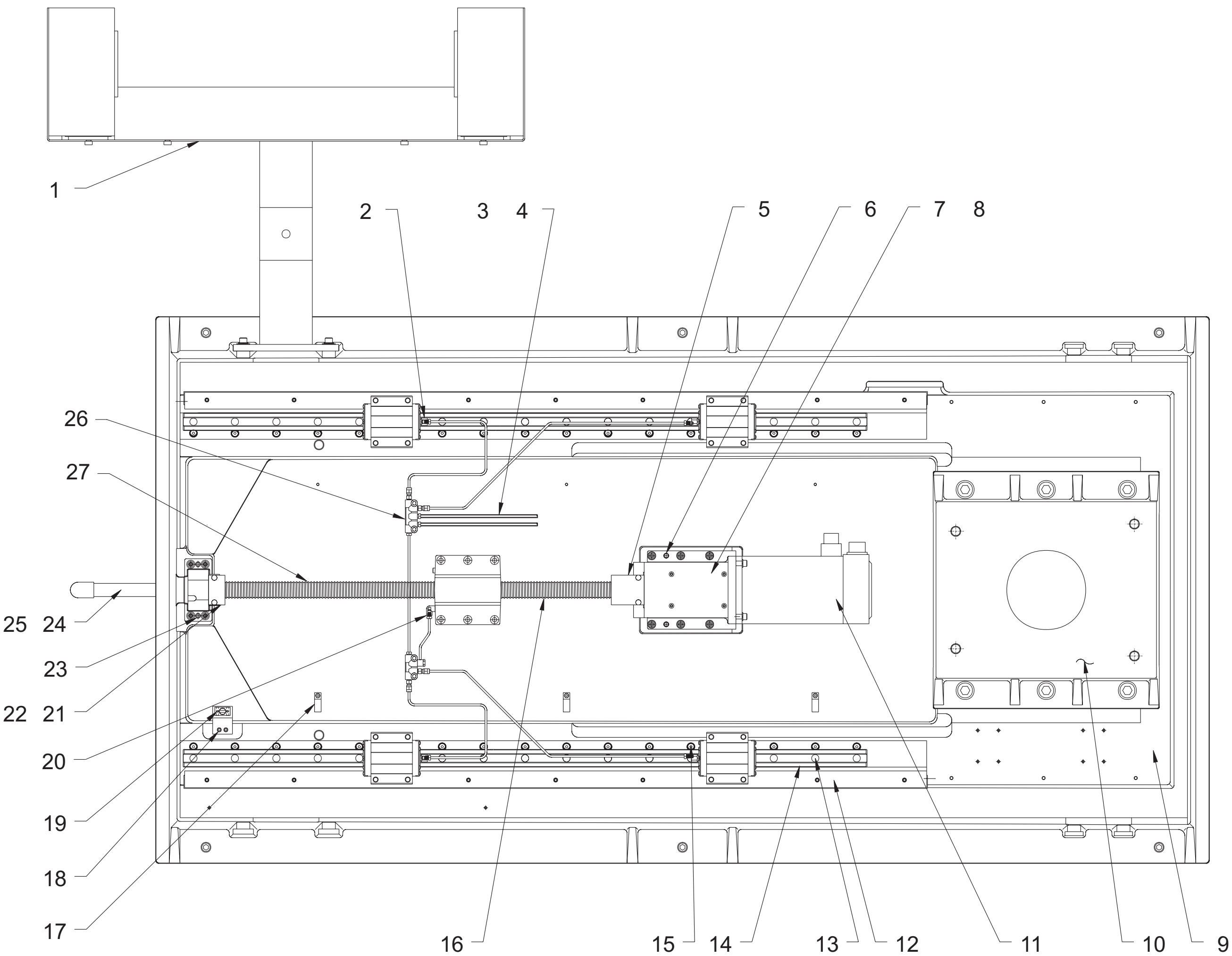

POWER ON
TO POWER SUPPLY PCB
CABLE 740
POWER OFF
REMOTE JOG HANDLE
(OPTION)
JOG HANDLE
TO VIDEO BOARD
VIDEO CABLE 760
CRT
+5VDC
0 VDC
A ENC
B ENC
HAAS
TO IOPCB P34
115 VAC CABLE 90A
CYCLE START
FEED HOLD
12 VDC
TO P13 PSU
CRT FAN
HAAS
750D
CE DOOR
(EUROPE)
750B
TO MOCON
750C
2ND HOME
(OPTION)
J2
J1
750D
J3
REMOTE JOG HANDLE
BOARD
MEMORY KEY LOCK
(OPTION)
12 VDC
J12
TO 850 CPU BOARD
P1
J5
P2
24 PIN FLEX CABLE
FRONT PANEL
KEYPAD
16 PIN RIBBON CABLE
CABLE #700A
KEYBOARD
INTERFACE
BOARD
LOAD METER
ADJUST
LOAD METER
BEEPER
12 VDC
BEEPER
AUX
FPANEL
START/
FEED
HOLD
METER
P5
P6
P3
P4
CABLE 720
CABLE 720
TO MOCON P16
CYCLE START
CABLE 770
TO I/O BOARD.. INPUT #8
FEED HOLD
860F TO J11 VIDEO BOARD PWR
USER'S AUX F-PANEL
210A DATA FROM J12 VIDEO BOARD
CYCLE
START
TO WORK LIGHT ASSY
LIGHT
SWITCH
EMERGENCY
STOP
FROM IOPCB P80
PALLET ROTATE
FEED
HOLD
PENDANT SUPPORT ARM
FLOPPY
DRIVE
PART READY
EMERGENCY
STOP
TO
CONTROL CABINET
OPERATOR PENDANT
HAAS AUTOMATION HS SERIES PAGE 18



ELECTRICAL SYMBOLS
HAAS AUTOMATION HS SERIES PAGE 19


VECTOR DRIVE
T1
230V
3PHS
320VDC
MOTOR , SPINDLE
10 HP, 200V, 30A, 60HZ
20 HP, 200V, 58A, 60HZ
SERVO AMP
MOTOR , XYZ AXIS
1.1 HP, 850W, 7.6A
1.7 HP, 1300W, 13.7A
230V
FAN , VECTOR DRIVE
CB6 5A.
HOPT-A PCBA
RIGHT CHIP AUGER MTR 1 PH
230VAC 1/4 HP
LEFT CHIP AUGER MTR 1 PH
230VAC 1/4 HP
CB1
3PH, 40 AMP
240VAC
K1
3PH, 30 AMP
600VAC
LINE
FAN , PENDANT
FAN , CPU
PROC P/S
115V
WORKLIGHT
FAN , SERVO AMP
FAN , DOOR
SOLENOIDS
POWER
MOTOR , LUB PUMP
115 VAC , 50/60 HZ
IOPCB
FAN , SPINDLE MOTOR
MOTOR , SPINDLE OIL
1/20 HP, 1.5 AMPS 115 VAC
MOTOR , AUTO PALLET CHGR
1/8HP 90 VDC 1.40 AMPS
CB2
3PH, 10 AMP
277 VAC
MOTOR , TOOL CHGR , SHUTTLE
1/8HP 90 VDC 1.40 AMPS
115V
3PHS
P/S
160 VDC
F1
P56
P59
MAIN DRAW BAR MOTOR
1/8HP
CB3
3PH, 10 AMP
277 VAC
20 AMP
230V
1PHS
P44
230V
P43
MOTOR , COOLANT
3/4 HP 230V 1PH 4.0 AMPS 50/60 HZ
CB5
3PH, 10 AMP
277 VAC
20 AMP
230V
1PHS
P44
230V
P45
MOTOR , TSC
1 1/2 HP 230V 3PH 4.0 AMPS 50/60 HZ
230V
3PHS
P31
5A
F2
F3
F4
230V
MOTOR , CHIP CONVEYOR
1/6 HP, 230V, 3PH .7 AMPS 60HZ
HAAS AUTOMATION HS SERIES PAGE 20

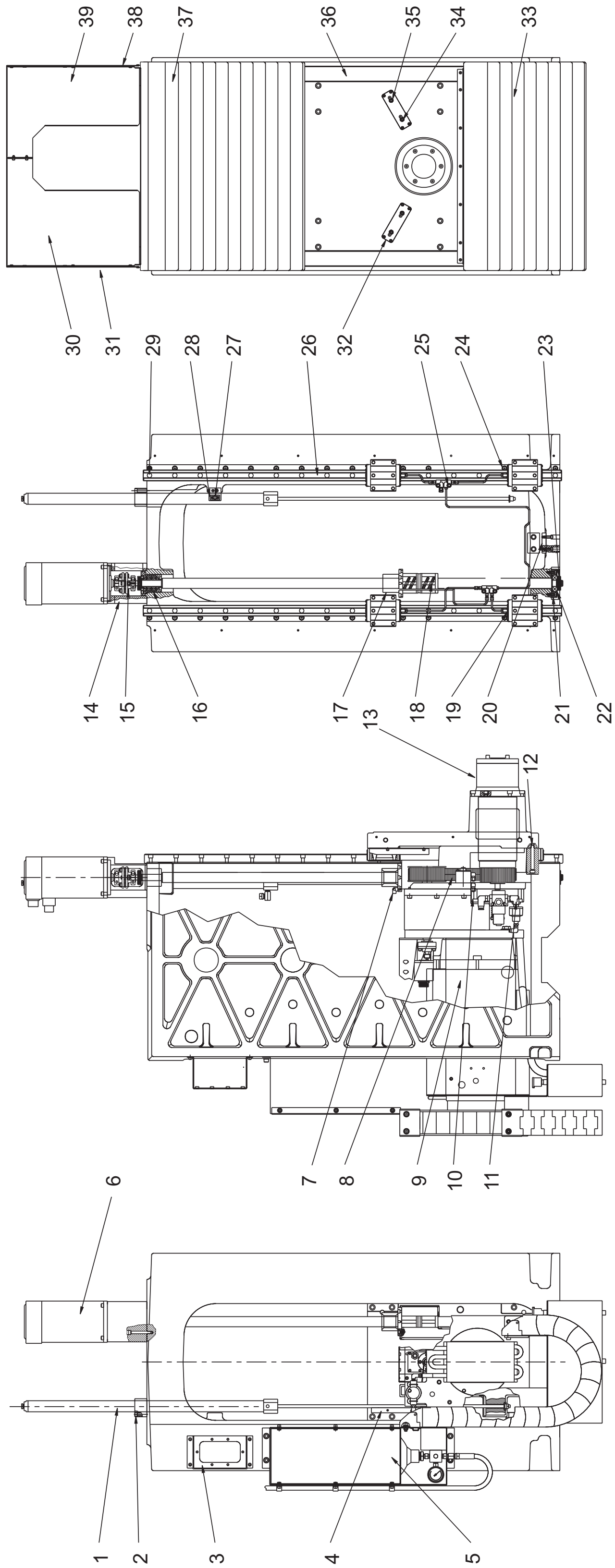
ASSEMBLY DRAWINGS AND PARTS LISTS



HS-1 Base

HS-1 Base

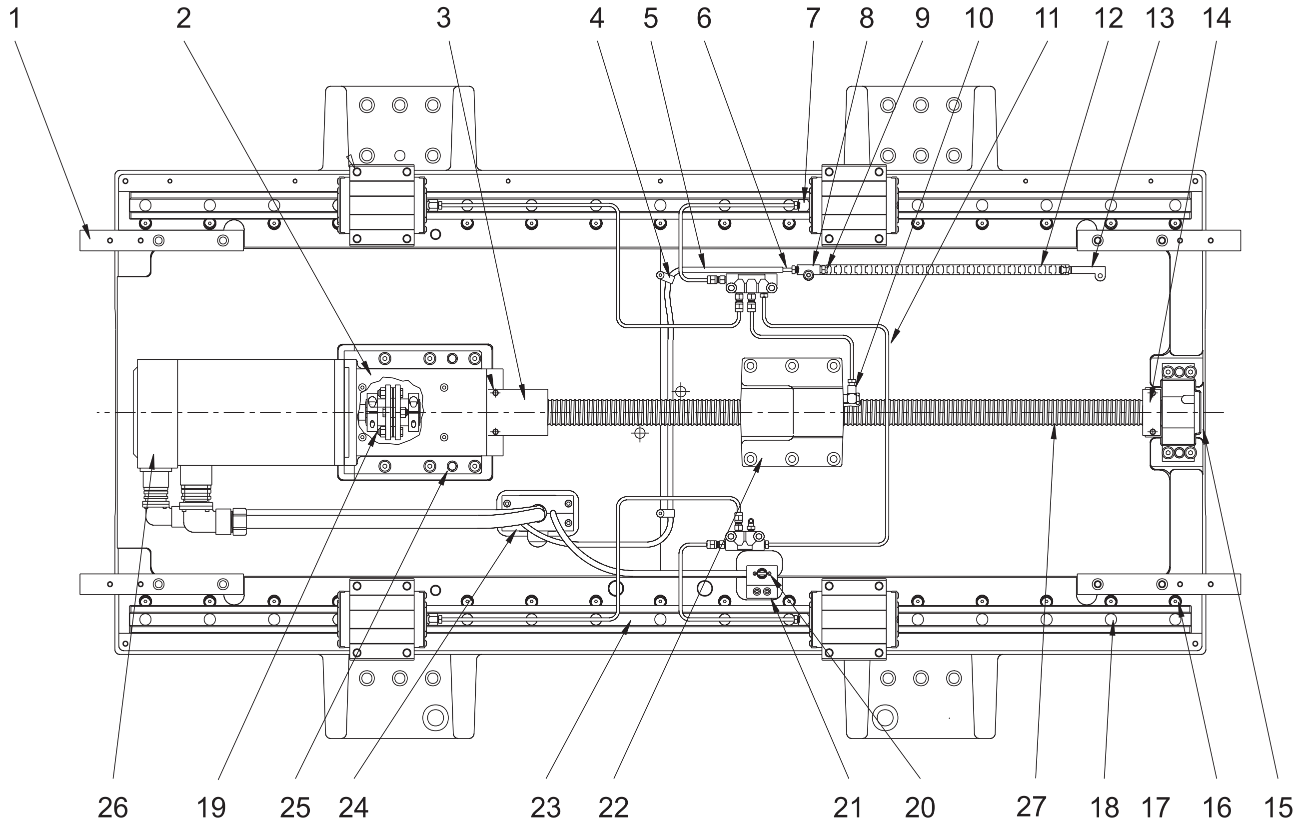
1.25-9645A Control box support
2. 24-7358 STR fit metric linear guide
3. 58-2000 Nylon tubing 1/4"
4. 58-2010 Nylon tubing 5/32
5. 20-7186 Bumper Y-axis (motor end)
6. 48-0045 Dowel pin 3/8 x 1 1/2
7. 25-7042 Cover plate motor mount
8. 40-1750 BHCS 10-32 x 3/8
9. Not sold
10. Not sold
11. 62-0014 Servo motor Yaskawa
12. 25-9620C Chip guard Z-axis
13. 59-6600 Plug guide rail
14. 50-3400 X-axis guide
15. 22-7458 Cam, linear guide
16. See Ball Screw Assemblies page
17. 63-1032 Cable clamp
18. 25-7267 Bracket, mounting Y-axis
19. 32-5060 Z-axis Limit switch
20. 58-3031 Banjo elbow 5/16 F x M6 M
21. 20-7187 Bumper Y-axis Bearing end
22. 25-7080 Bracket bumper
23. 48-0045 Dowel pin 3/8 x 1 1/2 pull
24. 58-3051 90 deg 1/8 union elbow
25. 58-3505 Nipple 1/2-14 NPTx10
26. 30-1165 Base oil line assembly
27. See Ballscrew page



HS-1RPA Column

HS-1RPA Column

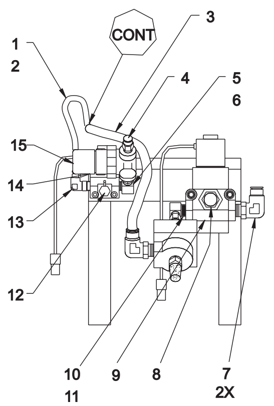
1. 30-3971 Hydraulic cylinder assembly
2. 49-1004 Shoulder bolt 5/16 x 1 1/4 1/4 x 20 thread
3. 25-9665A Bracket, cable carrier
4. 25-9614A Bracket, trip SP HD
5. 30-3972 FI tank assembly
6. 62-0014 Yaskawa Sigma 09 motor
7. 58-3031 Banjo elbow 5/16 F x M6 M
8. 54-2660 Belt drive GT spindle
9. 30-5600B Transmission 20 HP VD XHC
10. 43-7150 HHB 3/8-16 x 2 3/8 / 20-9364 TRP bolt spacer
11. 30-3296 TRP assembly rec.
12. 20-9391 Hardstop, spindle head
13. 30-0452A Spindle HS 7.5K air/oil
14. 20-9435A Y-axis motor mount
15. 30-1220A Coupling assembly
16. 30-1221 Ball screw SPT. BRG assembly
17. 20-9669A Bumper stop Y-axis
18. 24-9514B See Ball Screw Assemblies page
19. 24-7325 STR fit metric linear guide
20. 20-9390 Bumper column
21. 20-9393 Bearing plate column
22. 51-2025 Bearing radial 304PP
23. 51-0012 Bearing locknut BH-06
24. 22-7458 Cam, linear guide
25. 30-1166 Column oil line
26. 50-3400 Linear guide
27. 32-5050 Y-axis limit switch
28. 25-7267 25-7267 Bracket, mounting Y-axis
29. 59-6600 Plug guide rail
30. 25-9371 Intermediate shield X-axis LT
31. 25-9610B Guide left Y-axis waycover
32. 20-9392 Coolant manifold
33. 59-9608A Bellows lower Y-axis
34. 22-8730 Nozzel coolant T/H
35. 22-8739 Nozzle coolant .5 45 degree
36. 25-9563B Chip guard Y-axis
37. 59-9607A Bellow upper Y-axis
38. 25-9609B Guide right Y-axis waycover
39. 25-9387A Intermediate shield X-axis RT

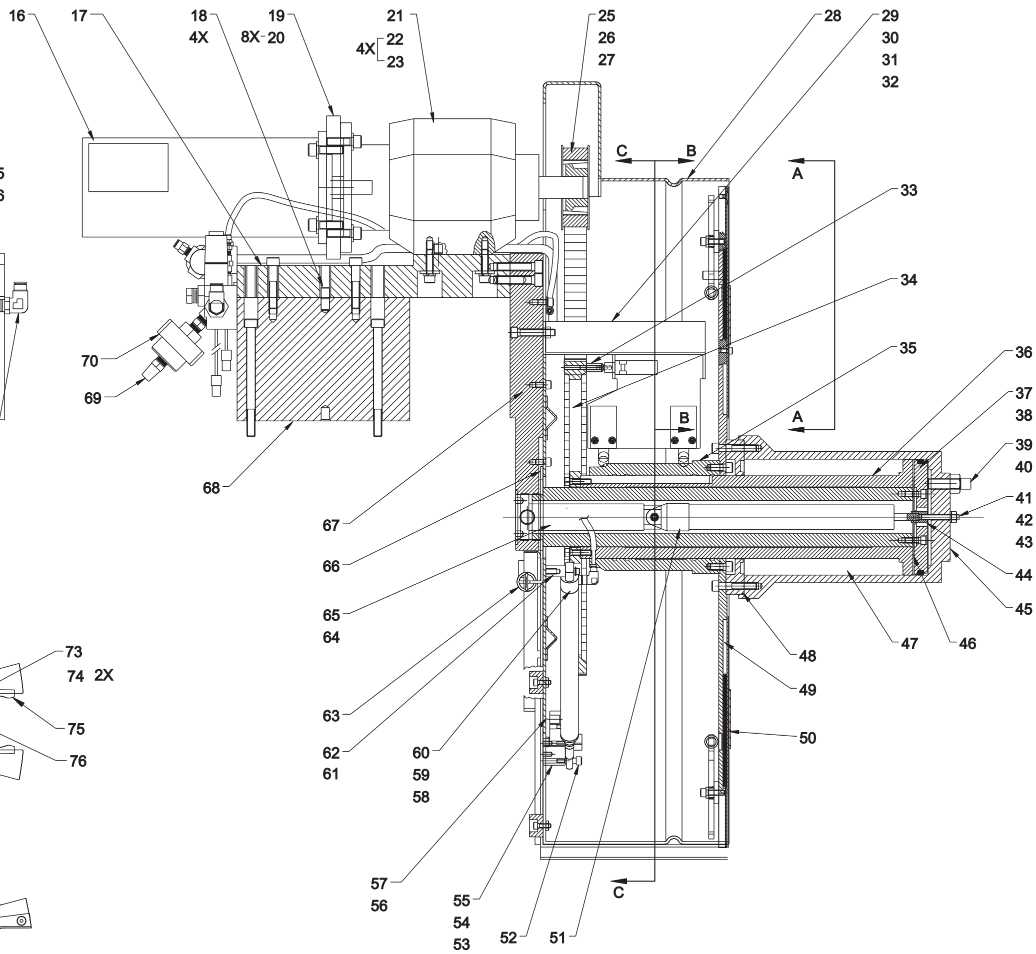


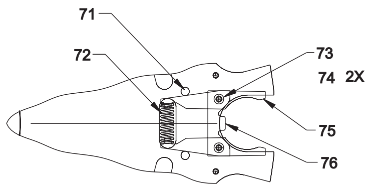
HS-1RPA HS Saddle Assembly

HS-1RPA HS Saddle Assembly

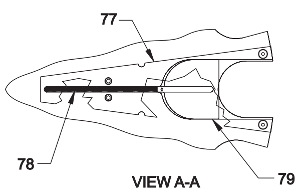
1.20-9557B Extender bar
2. 25-7042 Cover plate motor mount
3. 20-7186 Bumper Y-axis bearing /motor
4. 63-1031 Cable clamp
5. 58-2000 Nylon tubing 1/4
6. 58-2010 Nylon tubing 5/32
7. 24-7325 STR fit metric linear guide
8. 58-2760 Fitting manifold 2 way
9. 58-2130 Sleeve comp nylon tubing
10. 58-3031 Banjo elbow 5/16 F x M6 M
11. 30-1167 Oil line assembly
12. 59-6150 Plastic carrier
13. 58-2130 Bracket oil line carrier
14. 20-9057 Bumper Ballscrew
15. 25-7080 Bracket bumper
16. 22-7458 Cam linear guide
17. 59-6600 Plug, guide rail
18. 40-1667 SHCS 5/16 x 18 x 1/1/4
19. 30-1220A Coupling
20. 32-5040 Limit switch X-axis
21. 25-7267 Bracket mounting Y-axis
22. 2-9007 Nut housing machined
23. 50-3400 Linear guide
24. 20-7456 Conduit strain releif
25. 48-0045 Dowel pin 3/8 x 1 1/2
26. 62-0014 Yaskawa Sigma 09 motor
27. See Ball Screw Assemblies page



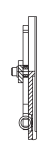


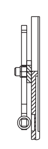


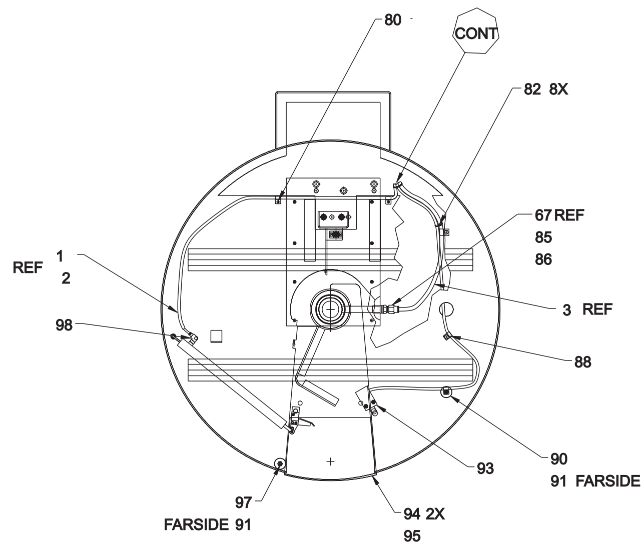
VIEW B-B
24 PLACES



VIEW A-A
24 PLACES


BT CONFIGURATION


CT CONFIGURATION

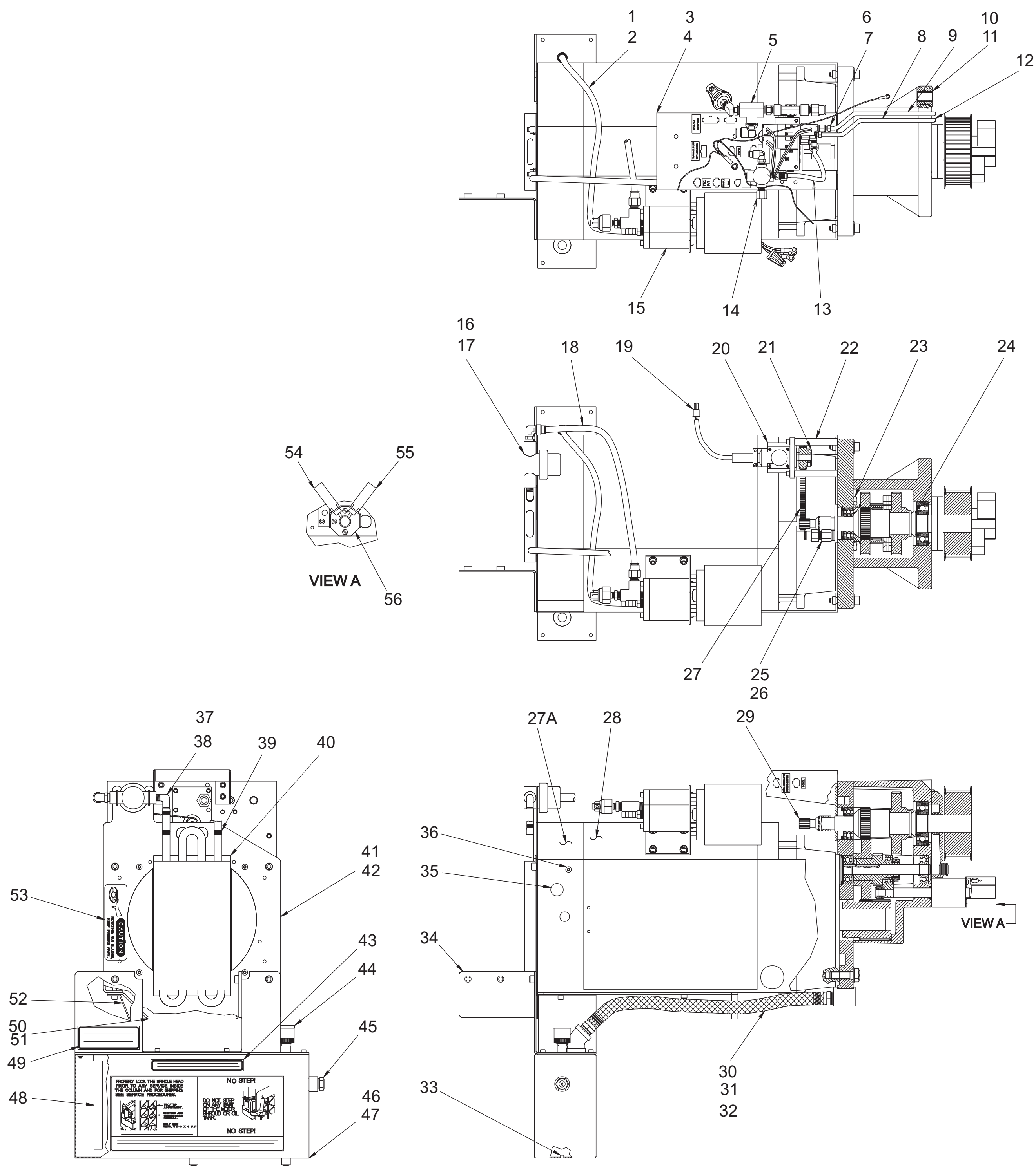


SECTION C-C
SOME ITEMS REMOVED FOR CLARITY

HS-1 24 Tool, Tool Changer Assembly

HS-1 24 Tool, Tool Changer Assembly

1. 58-2000 nylon tubing 1/4"
2. 58-2010 nylon tubing 5/32"
3. 58-2020 3/8 OD natural tubing
4. 58-3070 Fitting 1/8 NPT 1/4
5. 58-16700 Street elbow 1/8"
6. 58-16732 1/8 x 1/8 male hex joint
7. 58-36851/4 NPT M 3/8 tube swivel elbow
8. 58-2265 Air muffler 3/8 flat
9. 32-5620 TRP solenoid valve assembly
10. 58-3618 1/4 street elbow 90 deg
11. 58-3690 1/4 NPT male hex joint 1 1/8 AL 1 1/8
12. 58-2069 Orifice 1/8 NPT x .063
13. 58-3659 Air fitting 1/8 pipe 5/32
14. 36-30672 Solenoid assembly
15. 58-3065 Air regulator
16. 32-1820 Tool changer motor/cable assembly
17. 20-9657A Tool changer top plate
18. 48-0040 Dowel pin 3/8 x 1
19. 20-9789 Brush axis motor adaptor plate
20. 3/8-16 x 1 1/4 SHCS and washers
21. 59-4151 Gearbox flexolin
22. 5/16-18 x 1 1/2 SHCS and washers
23. 3/8 Lockwashers
24. N/A
25. 54-9505 Drive belt 3/8 pitch
26. 54-9510Timing pulley TL-30-L-100
27. 54-9520 Taper bushing 1610 x 1
28. 25-9583 Cover, tool changer
29. 25-9605A Shuttle switch bracket
30. 32-5030 Limit SW T/C motor
31. 32-5031 Limit SW T/C in
32. 32-5032 Limit SW T/C out
33. 22-7255A Tool #1 standoff
34. 20-9601 Large pulley modified
35. 20-9547A Reciprocating sleeve
36. 20-9585A Rotating sleeve
37. 20-9599 Locking cap
38. 57-0005 O-ring 124 ID x 5mm buna
39. 46-1721 Jam nut hex 1/2-13
40. 40-7080 SSS Oval pt 1/2-13 X 2
41. 44-1717 SSS cup pt 1/4-20 x 1 3/4
42. 46-1625 Nut hex blk ox 1/2-20
43. 45-16390 Washer 1/4 ID x 5/8 OD SAE
44. 20-9687 Shock mount front
45. 20-9602 Cylinder machined
46. 22-9637 Washer spacer
47. 59-9438 Spring tool changer
48. 22-9586A Spring seat
49. 20-9545B 24 tool carousel
50. 25-4676 Number ring, tool changer
51. 59-9545 Shock absorber
52. 49-1015 Shoulder bolt 1/4 x 1/2
53. 45-1741 #10 Hardened flat washer
54. 25-6461 Bracket trip T/C door
55. 20-9415 Front mount cylinder
56. 59-3023 Compression spring
57. 22-9417 Slider door stop
58. 8-32 x 3/8 SHCS and #8 washers
59. 59-9562 Ball joint rod end
60. 59-2738 Air cylinder T/C door
61. N/A
62. 20-9416 Rear pivot cylinder
63. 59-2761 Door spring tool changer
64. 49-1003 Shoulder bolt 1/4 x 3/4
65. 20-9682 Rear shock mount
66. 22-9742A Door washer
67. 20-9747A Shaft assembly, tool changer
68. 20-9654A Tool changer spacer
69. 58-3065 Air regulator 1/4 NPT
70. 59-2832 Quick exhaust tool changer
71. 48-0004 Sprin pin 3/8 x 1
72. 24-2040A Compression spring
73. 22-9256 Bushing, extractor
74. 1/4-20 x 7/8 SHCS and washers
75. 22-9574A CT extractor spring
76. 22-7067F Key, extractor spring
77. 25-9535 24 tool sliding panel cover
78. 24-9674 Spring, extractor
79. 25-7249 Sliding panel
80. 63-1031 Cable clamp
81. N/A
82. 70-0020 PLT 1.5M cable ties
83. N/A
84. N/A
85. 58-3665 1/4 NPT female 3/8 male
86. 1/4 NPT M 3/8 street tube
87. N/A
88. 63-1031 Cable clamp 1/4
89. N/A
90. 63-1031 Cable clamp 1/4
91. 59-1056 Bumper support arm 5/8
92. N/A
93. 32-5035 Limit SW T/C door
94. 22-7163 Rider trap door
95. 25-9723B Trap door T/C
96. N/A
97. 59-1056 Bumper, support arm 5/8L
98. 58-3659 Air fitting, 1/8 pipe, 5/32 tube



HS Transmission Assembly 15 HP VD

HS Transmission Assembly 15 HP VD

30-5600B Transmission Assembly

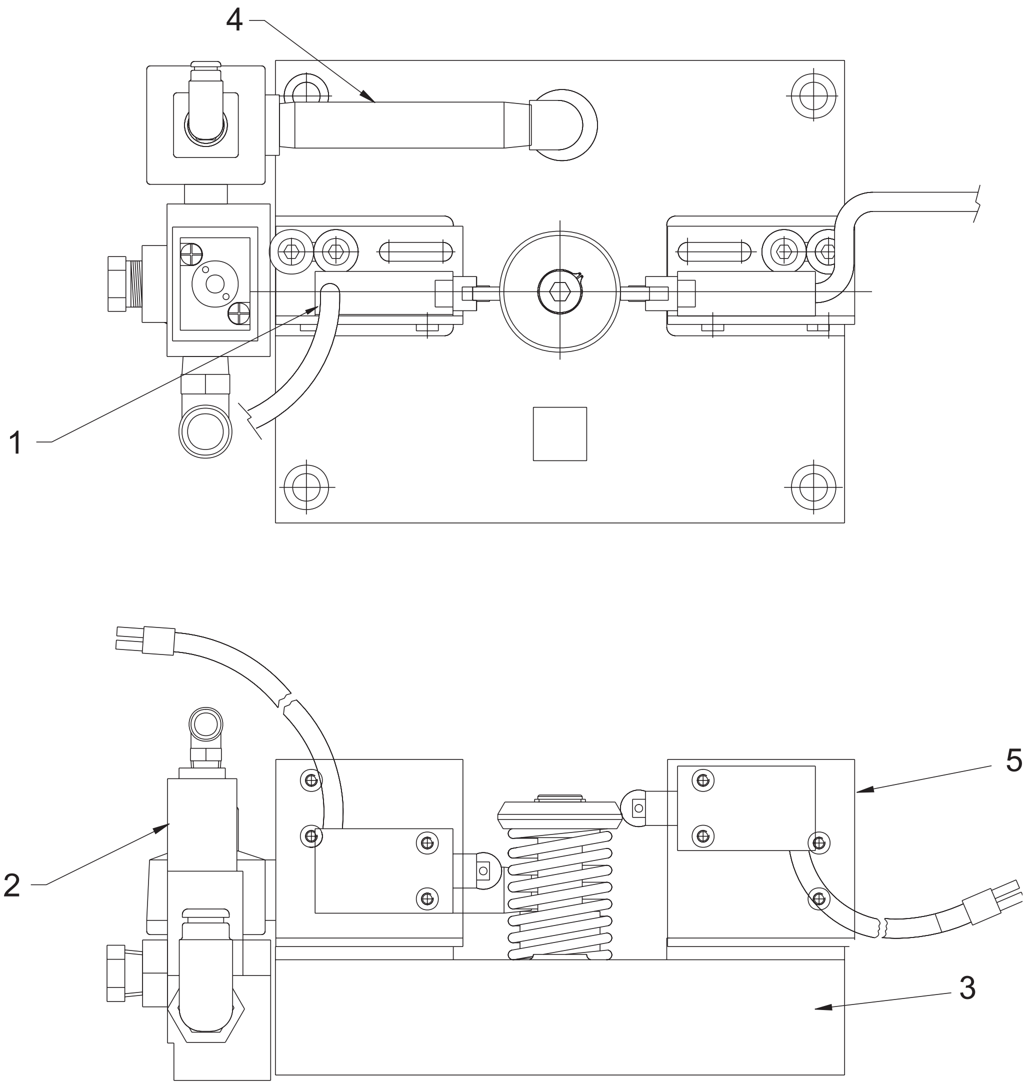
1. 58-2020 3/8 OD natural tubing
2. 59-0027 Hose clamp 1/2 hose
3. 25-7336A Mounting bracket solenoid
4. 33-3200 CBL890 SP status SW
5. 30-3146 Air solenoid assembly
6. 58-2100 Sleeve lube assembly
7. 58-2110 Sleeve nuts lube assembly
8. 58-7635 Low gear tube
9. 58-7636 High gear tube
10. 22-7520A Isolater transmission
11. 22-7521B Spacer transmission
12. 63-0001 Nylon cable clamp 1/2"
13. 58-7377 Air reg/solenoid tube
14. 30-3271 Precharge regulator XHC
15. 30-3260B Oil gear pump assembly
16. 53-1005 Oil filter
17. Magnetic oil filter
18. 58-2001 Polu hose 1/2D x 3/8ID 1A-111-10
19. 32-1457 Rigid tapping encoder with cable
20. N/A
21. 54-7127 Drive sprocket 3/8 Rtap
22. 22-7260 Encoder standoff
23. 58-16755 Male air fitting 1/8

23A. 58-7387 Top plate tube

24. N/A
25. 58-3657 1/4 Female 1/8 male adaptor
26. 58-3685 1/4 NPT m-3/8 tube-svl elbow
27. 54-2125 Belt drive HTD 300-3M-09

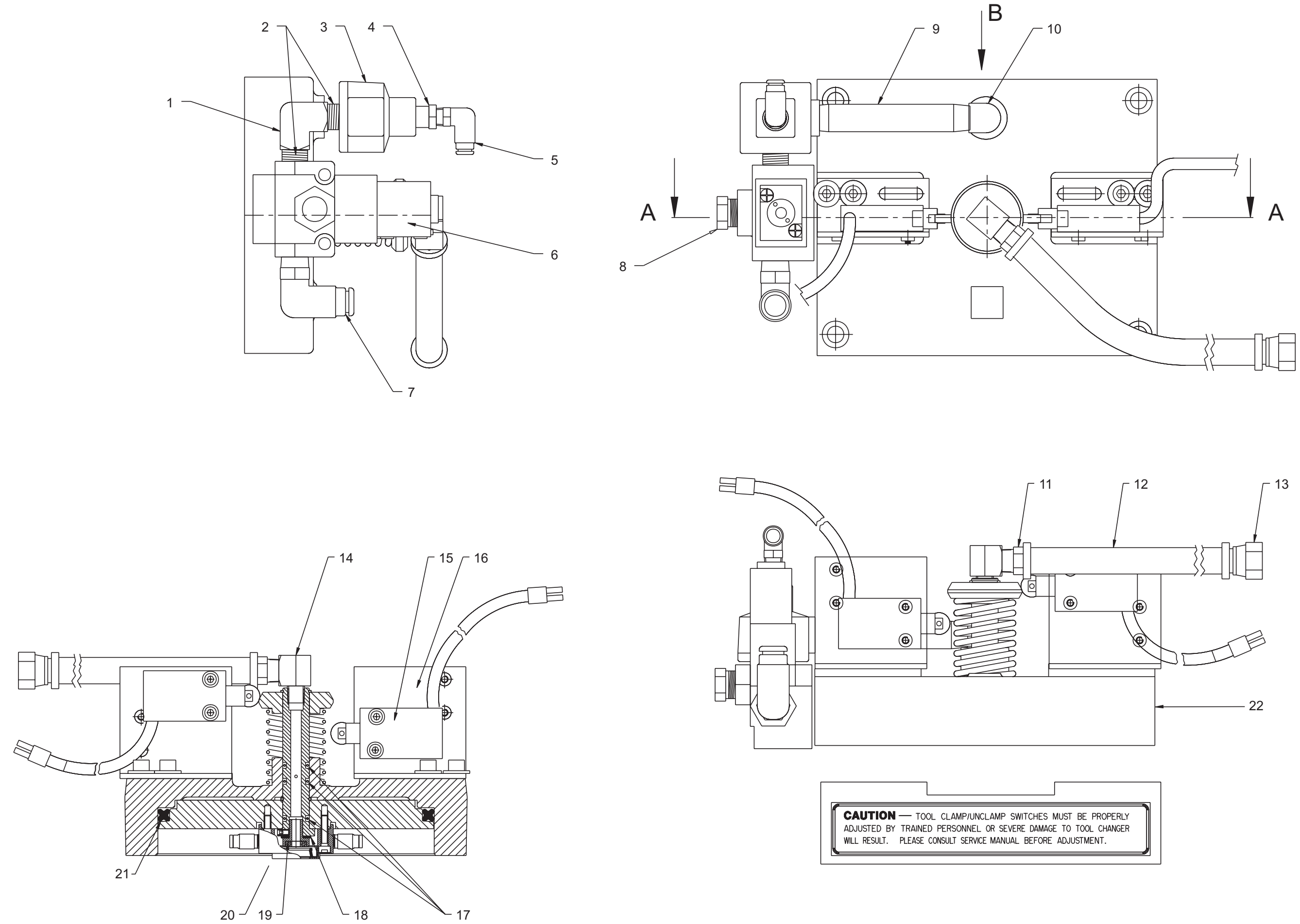
27A. 25-9130B HS motor shroud

28. 59-0046 Soundcoat shroud RT/LT
29. 20-0125 Drive sprocket encoder
30. 58-2049 PVC braided hose 3/4 x 1/2 NPT
31. 58-2066 Hose barb 3/4 x 1/2 NPT STR
32. 59-4009 Hose clamp 61/64-1 5/64
33. 58-2745 Magnetic oil filter
34. 25-9400A Oil reservoir mount
35. 59-1482 Nylon finish plug
36. 40-1750 BHCS 10-32 x 3/8
37. 58-3616 3/8 90 degree elbow 1/4 NPT
38. 59-4006 Hose crimp 35/64
39. 59-0027 Hose clamp 1/2 hose
40. 59-2910 Oil cooler
41. 25-9129A Fan bracket gear box
42. 36-3035 Spindle fan assembly
43. 29-9128 Label transmission
44. 22-7487 Oil fill cap
45. 58-1640 3/8 NPT sight glass
46. 25-9457B Oil reservoir gearbox
47. 29-9396B Decal HS trans service
48. N/A
49. 29-7399 Transmission motor lable
50. 25-9175 Motor shroud cover
51. 59-9179 Soundcoat front shroud cover
52. 25-9383 Brace reservoir
53. 29-0022 Shroud caution decal
54. 32-2011 Cable assembly 30" limit switch
55. 32-2010 Limit switch shuttle in/out 24"
56. 25-7264 Switch mounting bracket



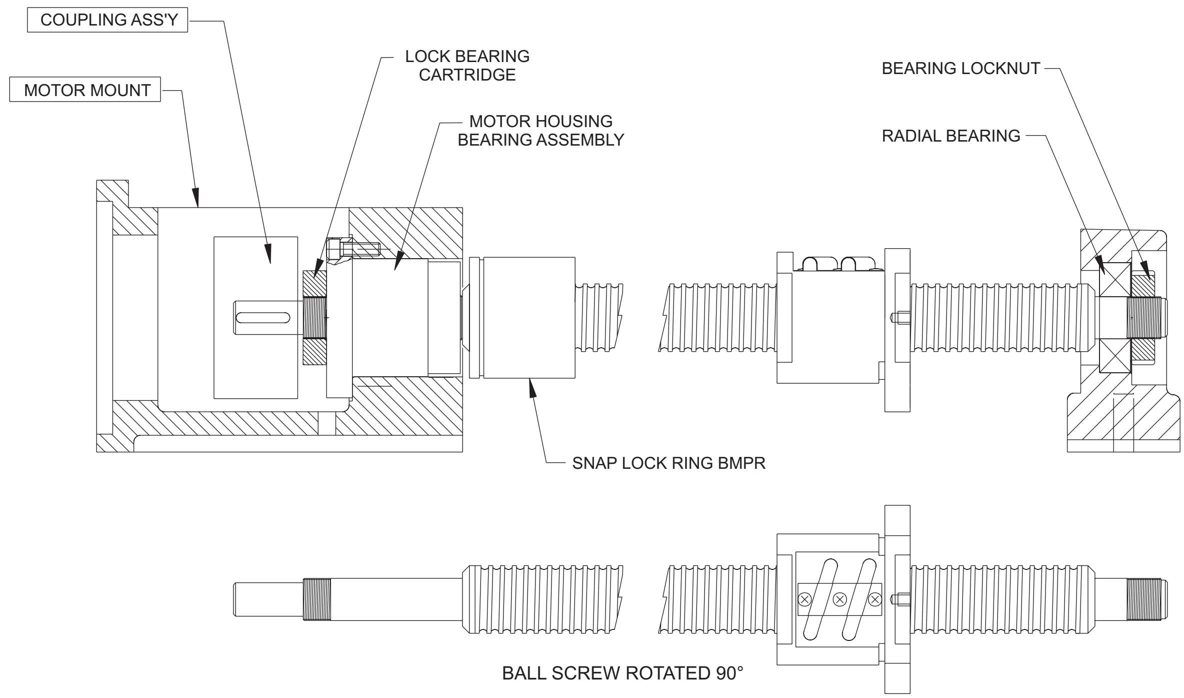
1. 32-2010 Limit Switch Shuttle In/out 24"
2. 32-5620 TRP solenoid valve assembly
3. 30-3205 TSC TRP base
4. 58-3729 Nipple BR 1/4 NPT x 4 1/2
5. 25-7050B Switch mount tool release

HS-1, R, RP, Tool Release Piston Assembly



1. 58-3056 90 deg 1/4 NPT elbow
2. 58-2162 Fitting close nipple 1/4 112 A-B
3. 59-2832B Quick exhaust 1/4
4. 58-3670 1/4 NPT M-18F reducer
5. 58-3685 1/4 NPT M-3/8 tube swivel elbow
6. 32-5620 TRP solenoid valve assembly
7. 58-3685 1/4 NPT M-3/8 tube-svl elbow
8. 58-2265 Air muffler 3/8 flat
9. 58-3729 Nipple BR 1/4 NPT x 4 1/2
10. 58-3618 1/4 street elbow 90 deg
11. 58-0028 Hose barb 3/8 PL-1/4 MP
12. 58-2046 Hose 3/8 ID pushloc 300psi
13. 55-0032 Hose barb 3/8 PL-3/8SAE-F
14. 58-3618 1/4 street elbow, 90deg
15. 32-2010 Limit Switch shuttle in/out 24"
16. 25-7050B Switch mount tool release
17. 57-0040 O-ring 2-111 buna
18. 45-0063 Washer, shim 3/8, .010 thick
19. 20-7627B Coolant tip carb. threaded
20. 30-3298 Seal housing assembly. TSC-HA
21. 57-2156 Quad-ring Q4-440 buna
22. Base

HS-1RP Tool Release Piston Assembly, TSCHP



BALL SCREW

HS-1, R, RP Base	24-9013
HS-1, R, RP Saddle	24-9013
HS-1, R, RP Column	24-9514C
HS-2RP Base	24-9960C
HS-2RP Saddle	24-9960C
HS-2RP Column	24-0005

LOCK BEARING CARTRIDGE

20-7418 HS-1 X, Y, Z, axes
20-9212 HS-2 X, Z axes
51-0008 HS-2 Y axis

MOTOR HOUSING BEARING

30-0154 HS-1 X, Y, Z, axes
30-1222 HS-2 X, Y, Z axis

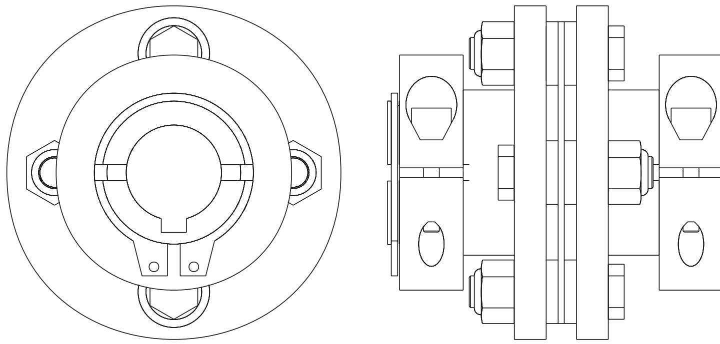
BEARING LOCKNUT

51-2012 HS-1 X, Y, Z, axes
20-9211 HS-2 X, Y, Z axis

RADIAL BEARING

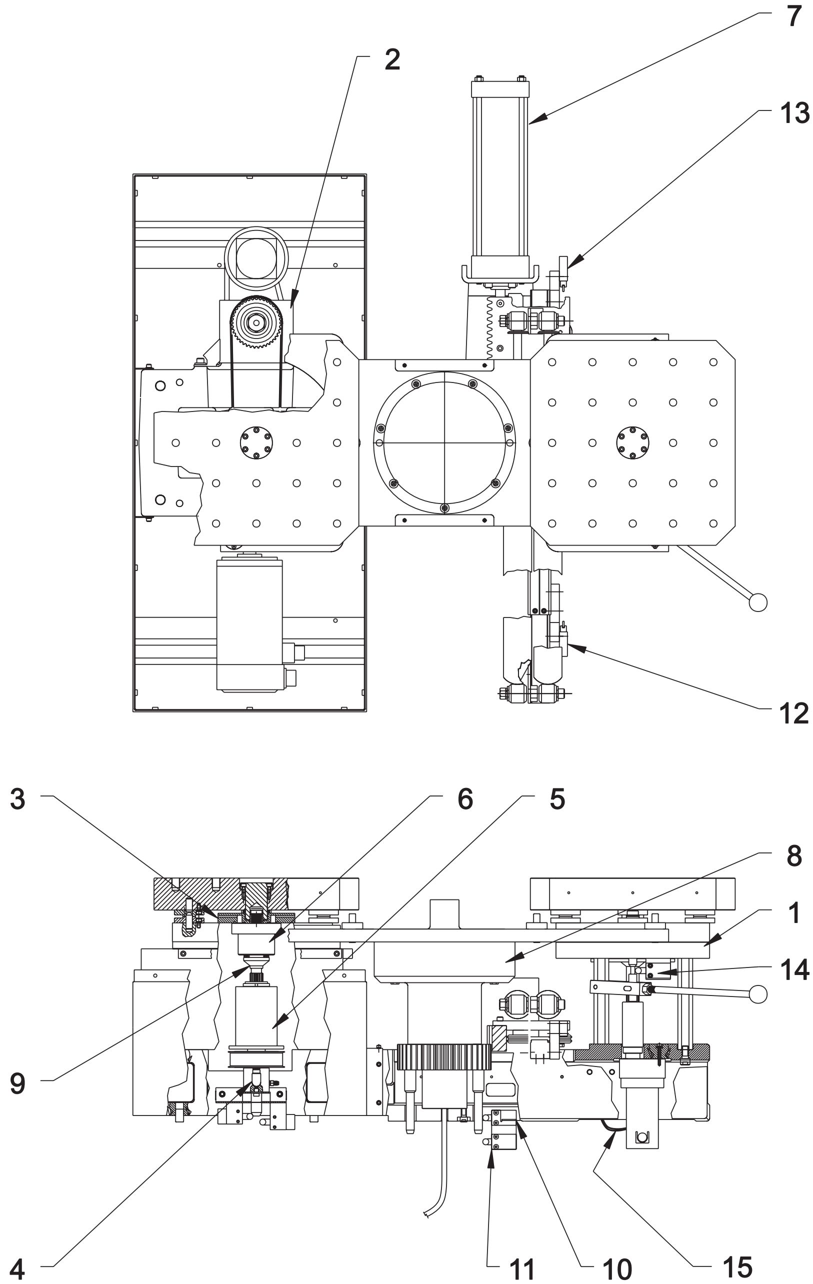
51-2025 HS-1 X, Y, Z, axes
51-1021 HS-2 X, Y, Z axes

BALL SCREW ASSEMBLIES



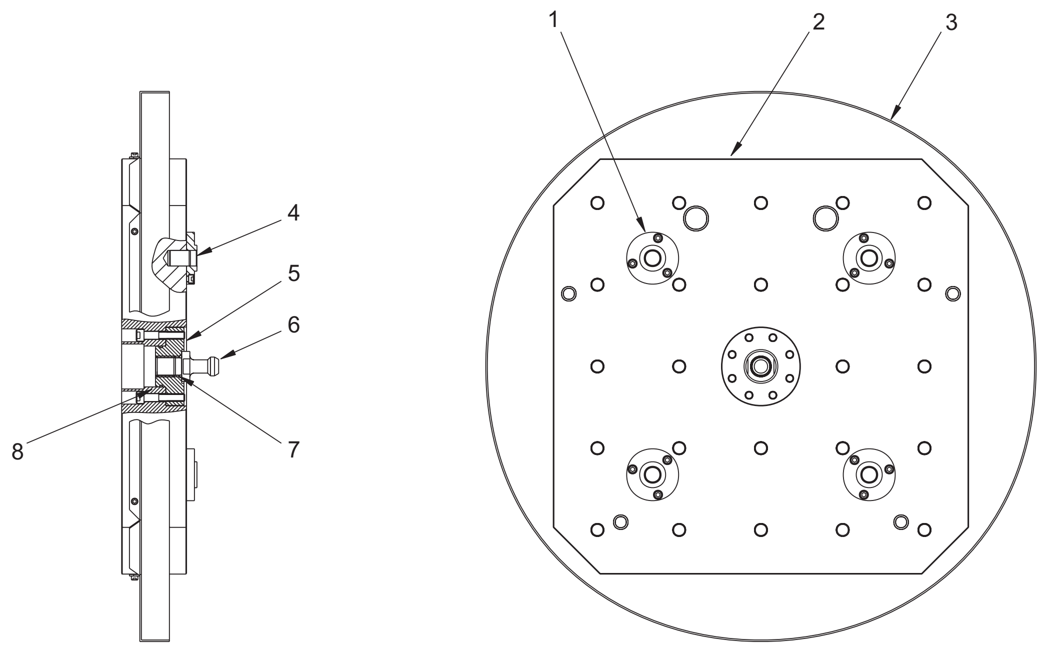
30-1517	Coupler assembly HS-2 Y axis
30-1219	Coupler assembly HS-2 X, Z axes
30-1220A	Coupler assembly HS-1 X, Y, Z axes

Coupler Assembly



1. 30-9411B Load station assembly
2. Motor assembly HS-1RP
3. 30-9414B Air blast manifold
4. 30-9415B Lube tube adaptor
5. 30-9416A Bearing sleeve assembly
6. 30-9417 Nut housing assembly
7. 30-9418 Rotating cylinder assembly
8. 30-9419 Lift cylinder assembly
9. 30-9420 Main drawbar assembly
10. 33-8010 Pallet up limit switch
11. 33-8011 Pallet down limit switch
12. 33-8012 Pallet clockwise limit switch
13. 33-8013 Pallet counter clock wise limit switch
14. 33-8015 Load station locked limit switch
15. 33-8023 Load station motor extension cable

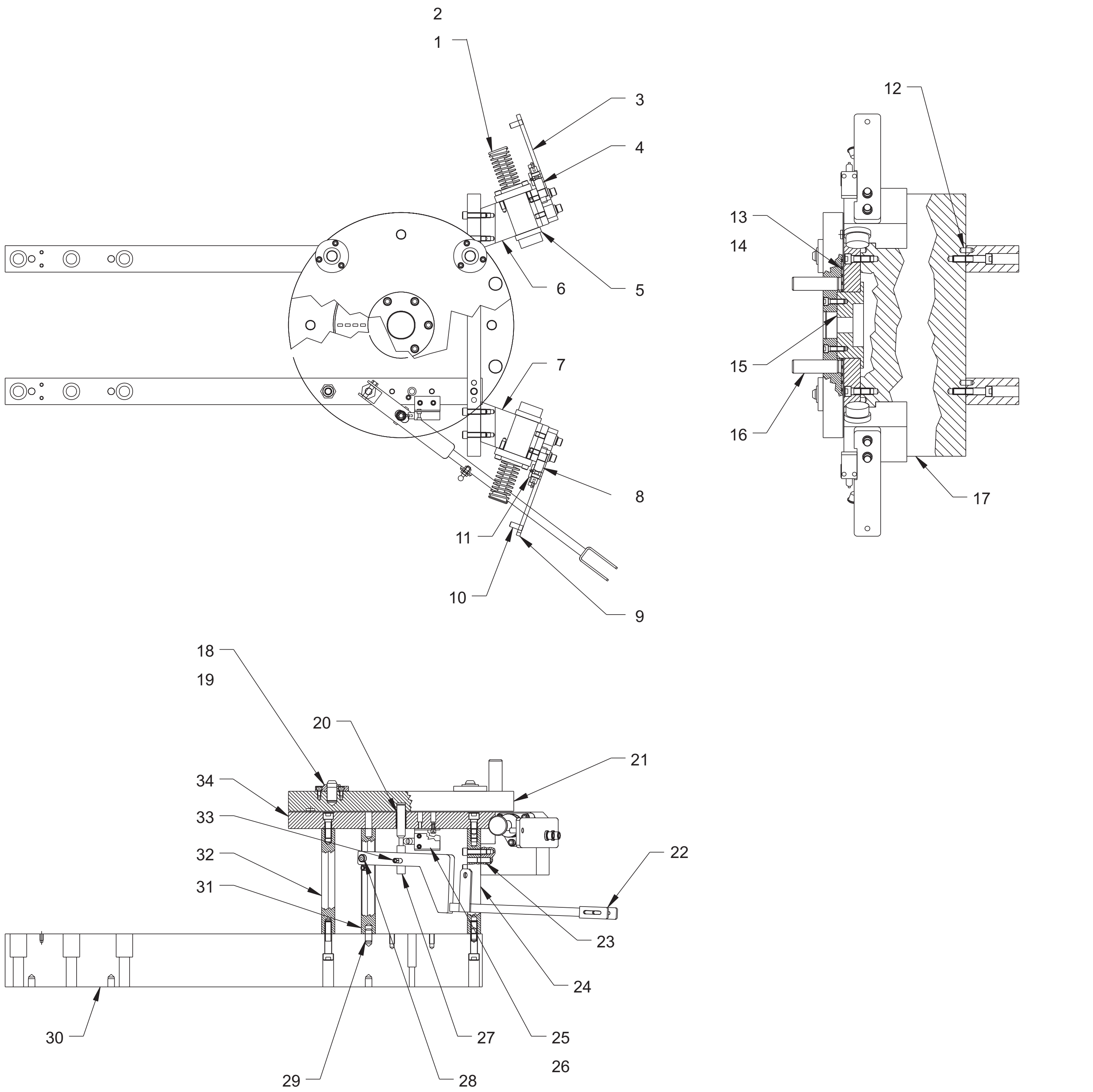
HS-1RP Pallet Changer (Threaded Drawbar Style)



30-0112 Pallet assembly

1. 20-6303 Bushing pallet index
2. 20-6301 Pallet 3 1/8 thick
3. 25-6302 Shroud pallet 500MM
4. 20-6303 Bushing, pallet index
5. 20-6455 Insert pallet pullstud
6. 20-6440 Pull stud drawbar
7. 57-0060 O-ring 2-211 Buna
8. 57-0096 O-ring 2-133 Viton
9. 57-4130 O-ring 2-138 Viton

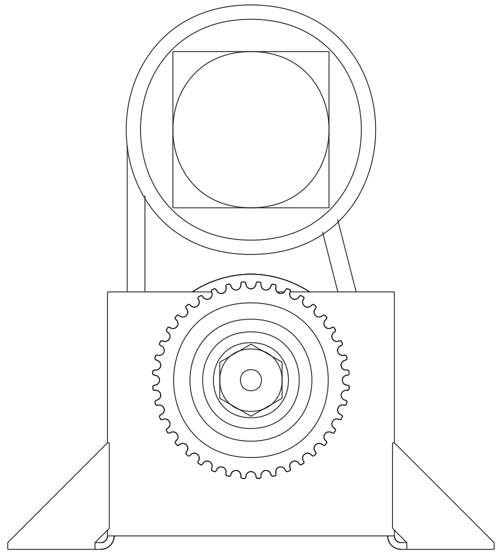
HS-2RP Pallet Assembly

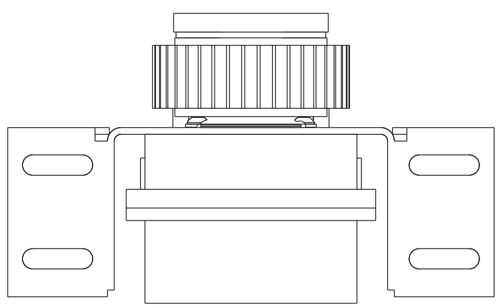


HS-2RP Load Station Assembly

1. 59-0045 Mount damper
2. 59-0055 2in stroke absorber
3. 20-6256 Adjustable stop right
4. 33-8076 Pallet clockwise limit switch
5. 59-0056 Lock ring
6. 20-6476 Shock mounting block, right
7. 20-6477 Shock mounting block, left
8. 33-8077 Pallet counterclockwise limit switch
9. 20-6255 Adjustable stop left
10. 48-0040 Dowel pin 3/8 x 1
11. 20-6197 Switch mounting bracket
12. 48-0035 Dowel pin 3/8 x 3/4
13. 25-6313 Roller bearing guide
14. 51-0018 Roller bearing 4mm x 7 1/2
15. 20-9781A Turntable spindle
16. 48-0011 Dowel pin 1 x 3 1/2
17. 20-6418 Mounting plate shock
18. 20-6303 Bushing pallet index
19. 20-6304 Load station pallet locating pin
20. 51-2133 Bearing bronze SS-2024-20
21. 20-6312 Pallet turntable
22. 22-6368 Lever load station index
23. 48-1660 Dowel pin 1/4 x 7/8
24. 50-6418 Mounting plate, shock
25. 25-9440 Switch bracket index
26. 33-8075 Load station limit switch
27. 22-9790 Turntable index pin
28. 49-0002 Shoulder bolt 3/8 x 1 1/4
29. 48-1662 Dowel pin 1/4 x 7/8
30. 20-6310 Support bar load station
31. 20-6342 Locating spacer
32. 20-6309 Load station spacer
33. 49-0010 Roll pin 5/16 x 1 1/2
34. 20-6311 Fixed table load station

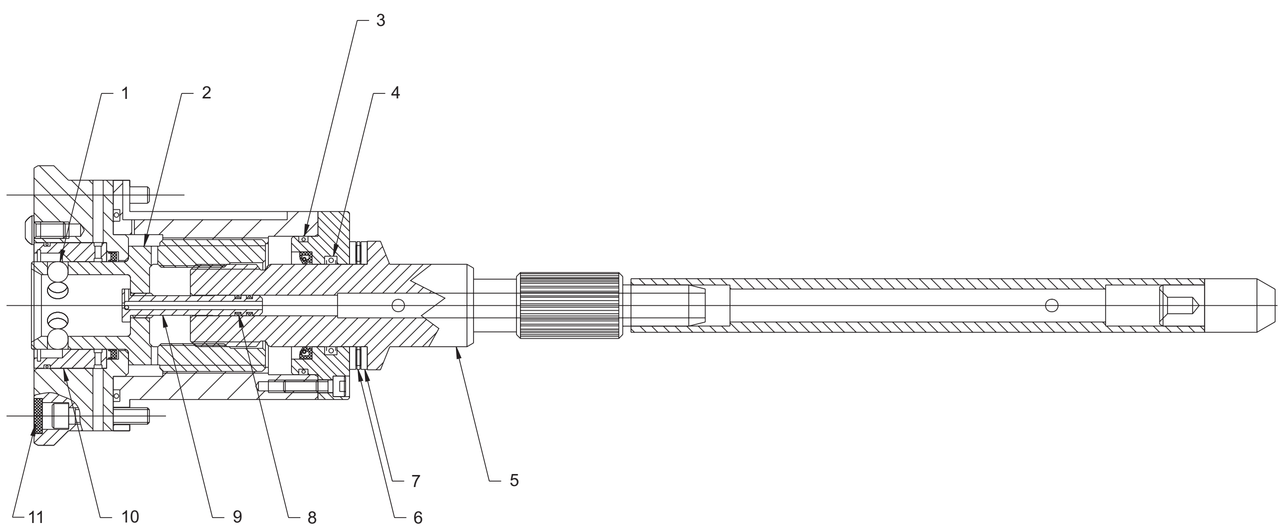
HS-2RP Load Station Assembly





Clutchless motor assembly part number 30-0301A

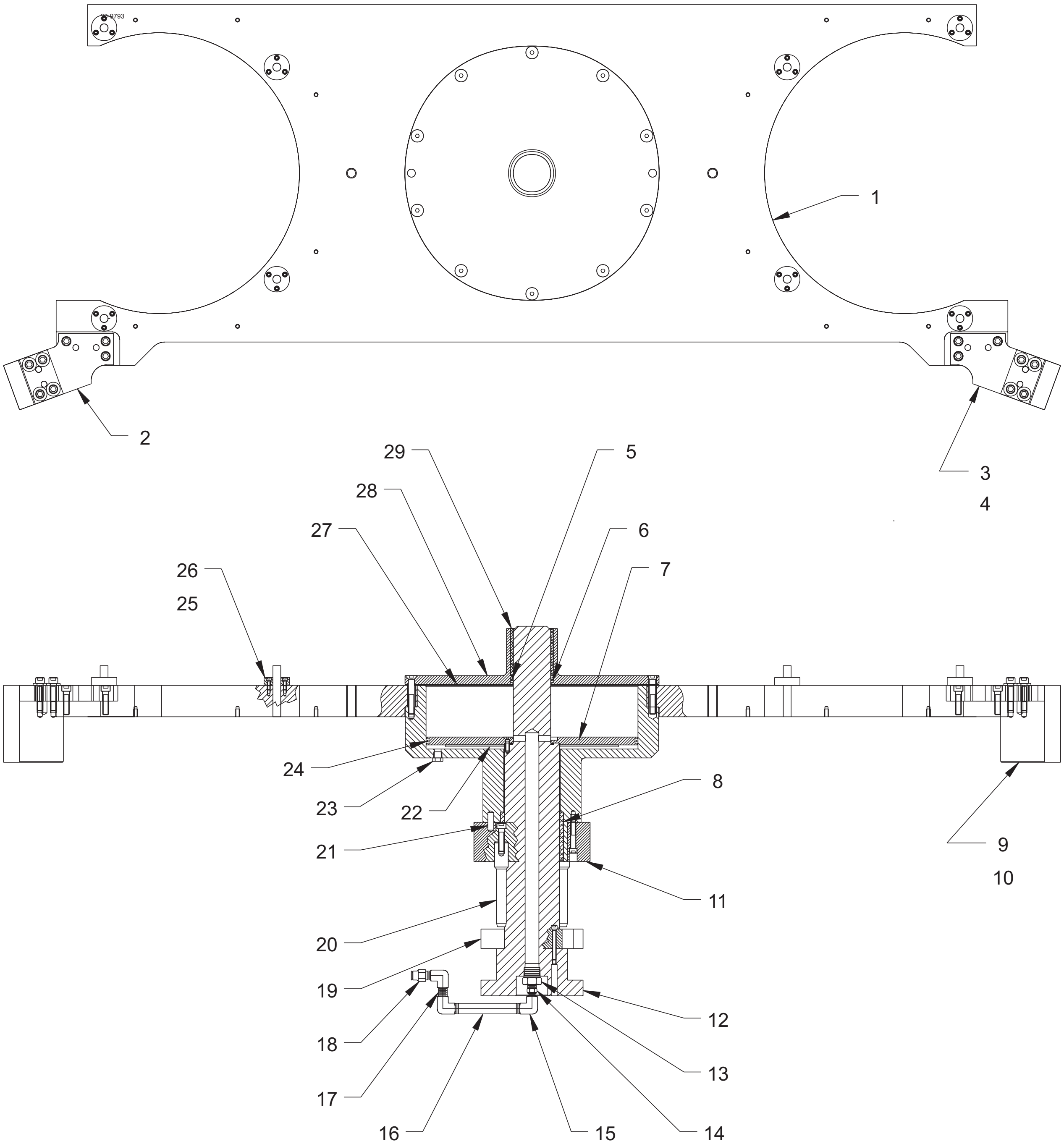
HS-1RP Clutchless Motor Assembly



Main drawbar assembly 30-0104

1. 59-2057 5/16 steel balls
2. 20-6251 Ball pull collet
3. 57-0041 O-ring 2-135 Viton
4. 57-2834 O-ring 2-218 Viton
5. 20-6445 Drawbar rotary table
6. 51-0040 Thrust bearing
7. 55-0027 Thrust washer TRC-2031
8. 57-0037 O-ring 2-009 Viton
9. 20-6453 Airpop ball collet
10. 20-6412A Insert ball guide
11. 59-6600 Plug, guide rails

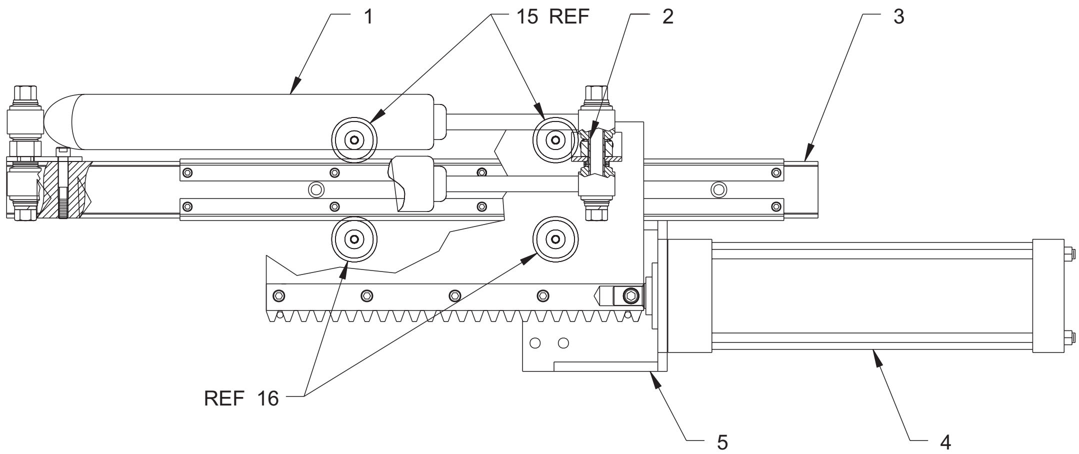
HS-2RP Main Drawbar Assembly

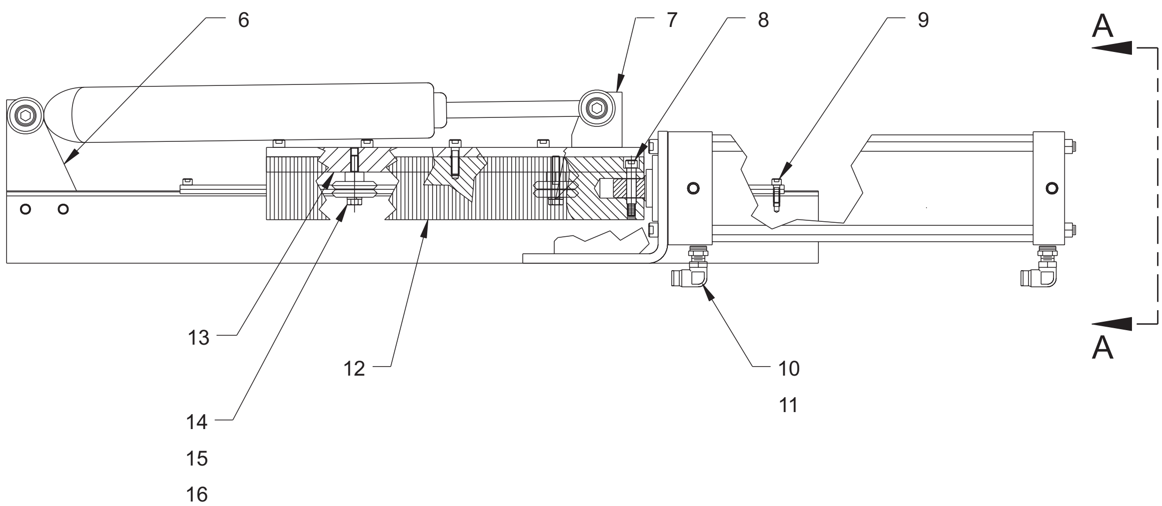


HS-2RP Lift Cylinder Assembly

1. 20-6316 H-frame
2. 20-6415A Strike mounting plate right
3. 20-6414A Strike mounting plate left
4. 20-6416A Strike plate shock
5. 57-0023 O-ring 2-232 Viton
6. 57-0044 O-ring 2-230 Buna
7. 20-6320 Cylinder piston
8. 51-0014 Sleeve bearing cylinder body
9. 20-6416A Strike plate shock
10. 48-0044 Dowel pin 3/8 x 1 1/2
11. 20-6341 Pinion modification
12. 20-6318A Cylinder rod
13. 58-3633 Reducer bush 3/4M-1/4F
14. 58-3690 1/4 NPT male hex joint 1 1/8 OAL
15. 58-3056 90 deg 1/4 NPT elbow
16. 58-3729 Nipple BR 1/4 NPT x 4 1/2
17. 58-3601 Close nipple 3/8 NPT
18. 58-3680 1/4 NPT M 3/8 straight tube
19. 20-6198 Downstop lift cylinder
20. 20-6321 Shaft safty stop
21. 48-0040 Dowel pin 3/8 x 1
22. 20-6337 Thrust washer lift cylinder
23. 58-0002 1/4 breather vent
24. 57-0043 O-ring 2-382 Viton
25. 48-0009 Dowel pin 1/2 x 3 1/4
26. 20-9793 Spacer H-frame pallet
27. 57-6323 Cylinder gasket
28. 20-6317 Cylinder cap
29. 51-0013 Sleeve bearing cylinder cap

HS-2RP Lift Cylinder Assembly

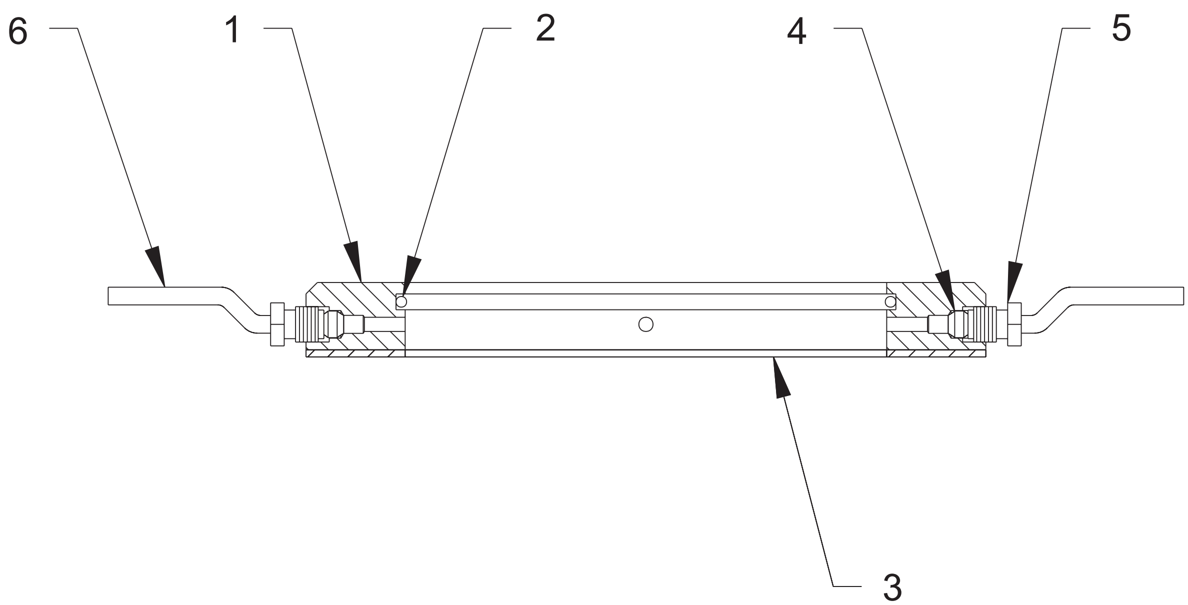




1. 59-9560 Stabilizer
2. 22-9428A Sleeve stabilizer
3. 20-6299 V guide mounting rail
4. 59-2750 Rotate cylinder
5. 22-6334 Cylinder mounting brackets
6. 25-9594 Shock mount fixed end
7. 25-9573 Shock mount rack end
8. 49-1010 Shoulder bolt 3/8 x 1 1/2
9. 22-7106 V-track tool changer
10. 58-3665 1/4 NPT female 3/8 male
11. 58-3685 1/4 NPT m-3/8 tube swivel elbow
12. 20-6298 Rack modification
13. 20-6347 Roller plate
14. 54-0030 Guide wheel
15. 54-0020 Bushing guide wheel
16. 54-0040 Standard bushing guide wheel

Complete assembly 30-0109

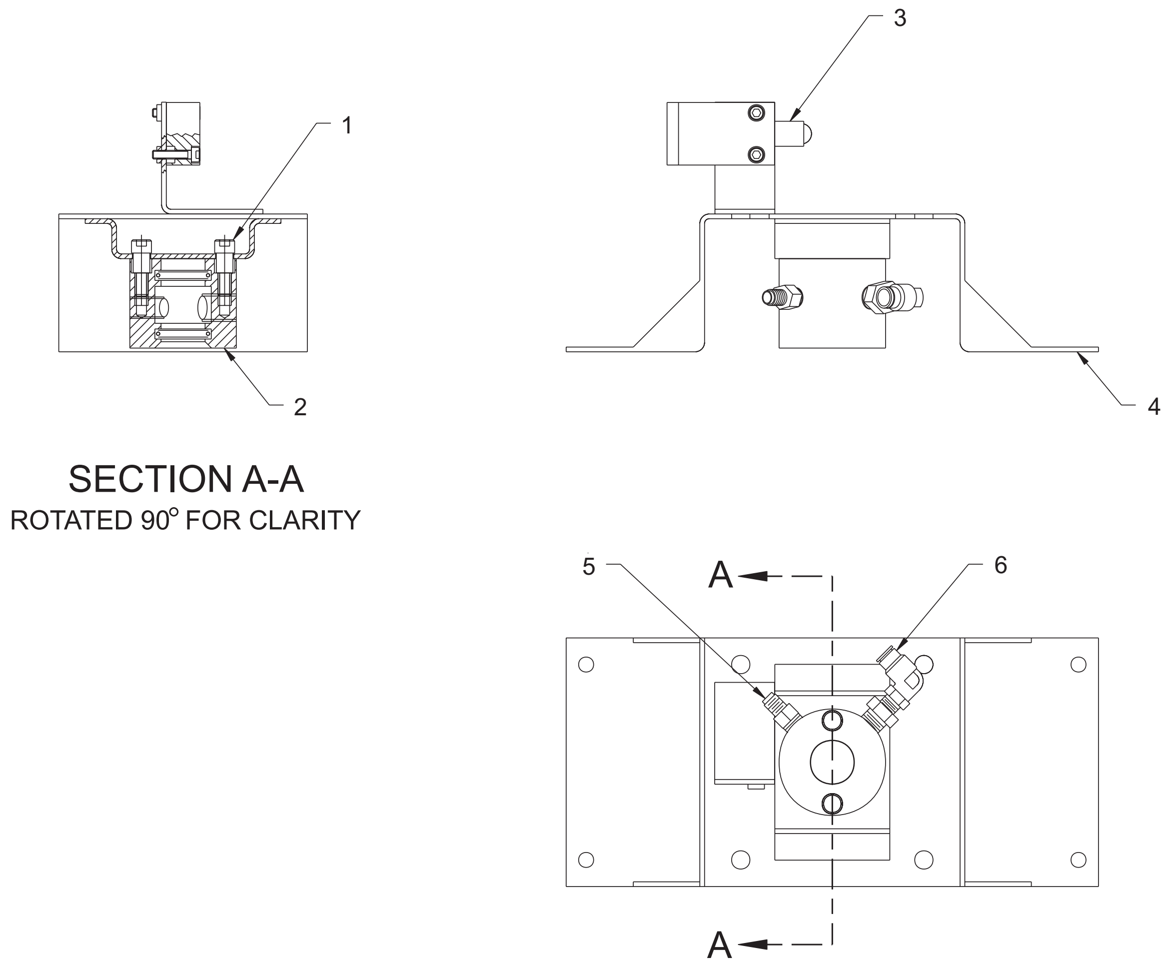
HS-2RP Rotating Cylinder Assembly



1. 20-6449 Airblast manifold assembly
2. 57-2250 O-ring 2-156 Viton
3. 57-6452 Gasket, manifold
4. 58-2100 Sleeve lube assembly
5. 58-2110 Sleeve nuts lube assesmbly
6. 58-6422 Tubing, air blast

30-0099 Complete assembly

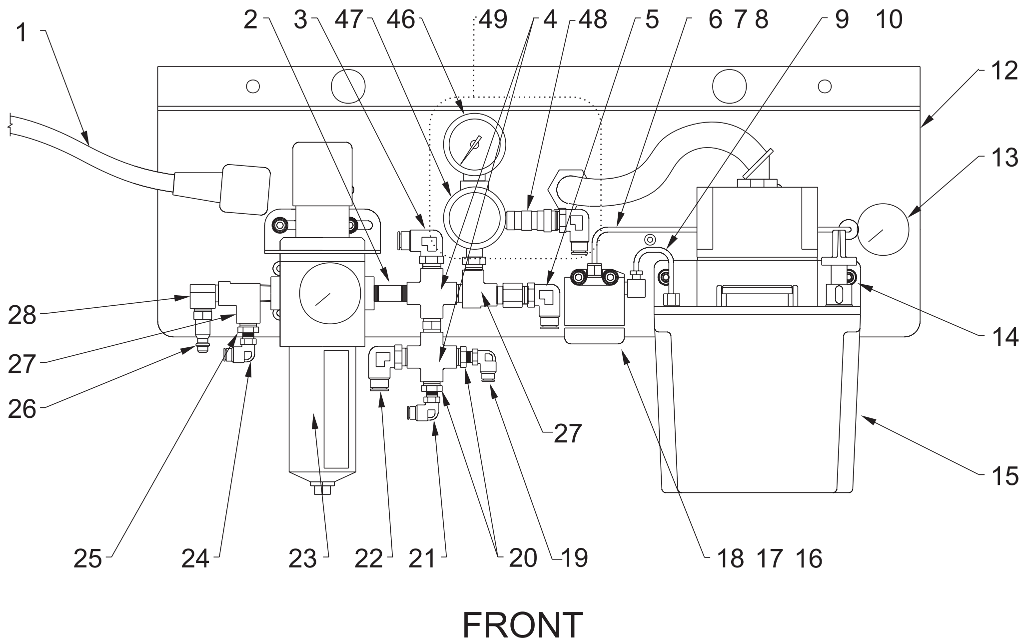
HS-2RP Air Blast Manifold Assembly

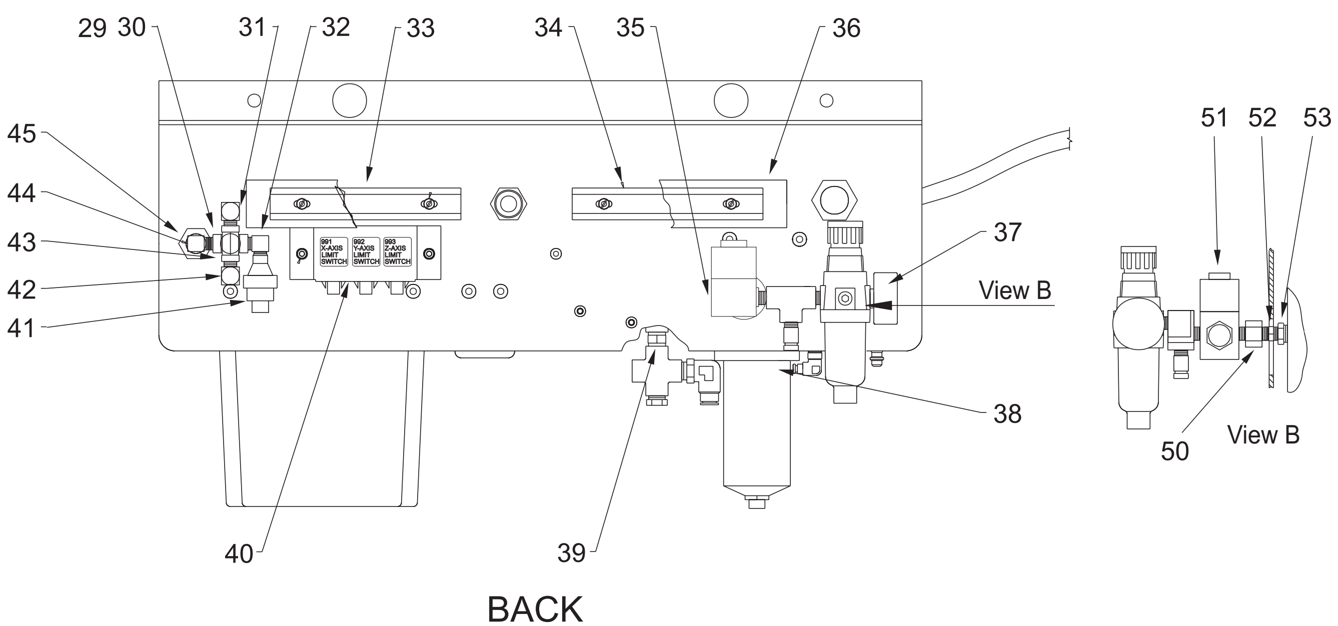


30-0098 Lube tube adaptor assembly

1. 49-1004Shoulder bolt 5/16 x 1 1/4 1/4-20 thread
2. 20-6456 Lube tube adaptor
3. 33-8069 Limit switch main drawbar down
4. 25-6339 Switch mounting plate
5. 58-4020 Flowmeter FSA -3/0
6. 58-3685 1/4 NPT M-3/8 tube swivel elbow

HS-2RP Lube Tube Adaptor Assembly



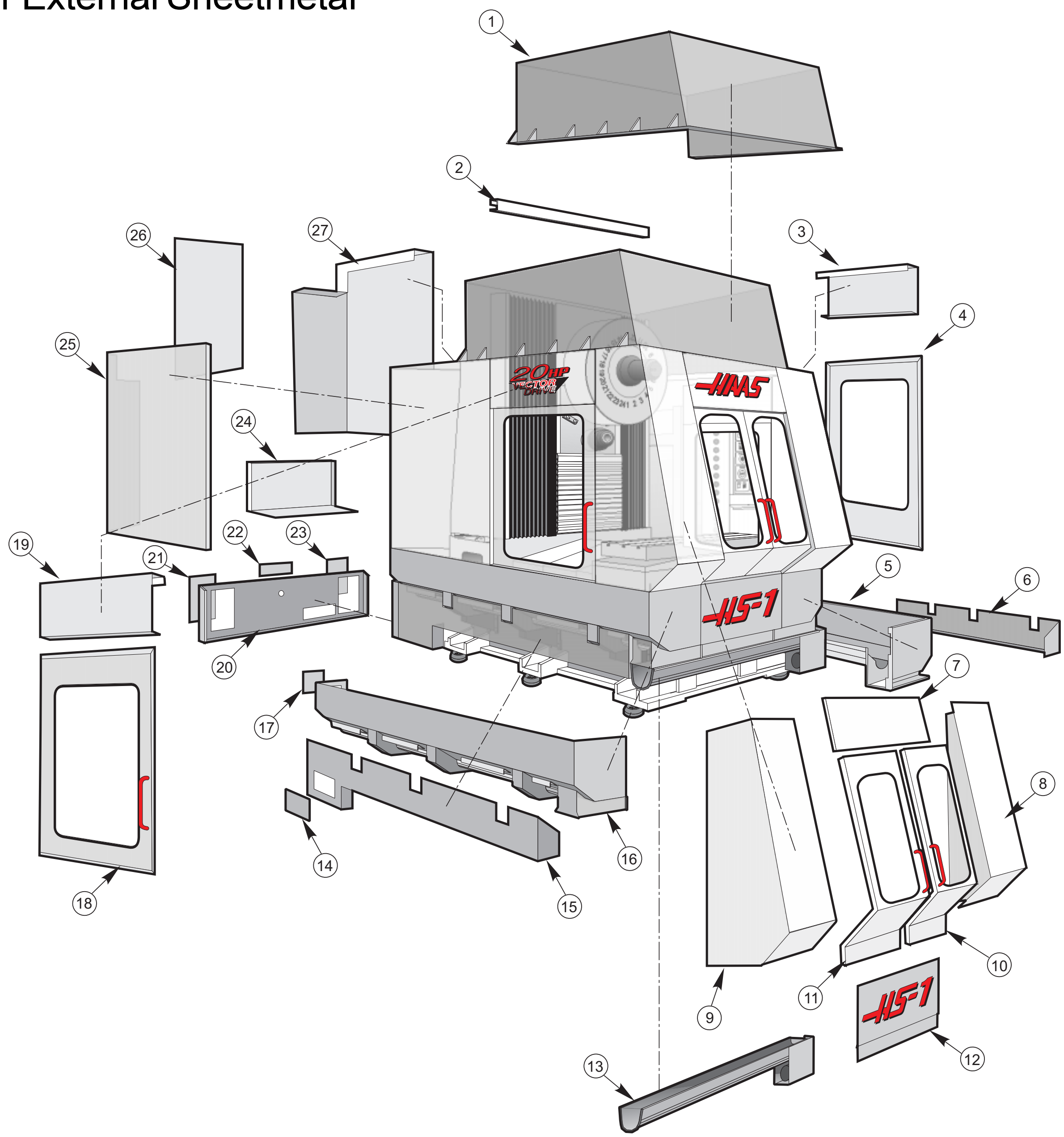


HS-2RP Air Regulator / Lube Assembly

HS-2RP Air Regulator / Lube Assembly

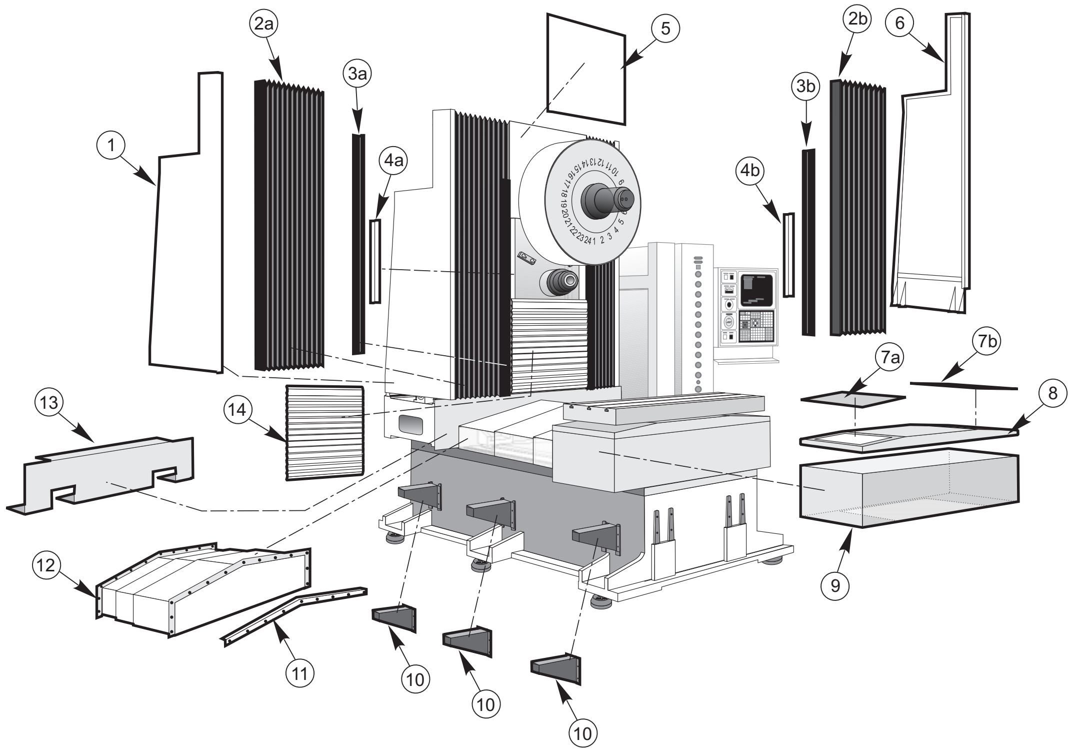
1.32-8030A Lube home DB mold
2. 58-0004 1/4 NPTx2 brass nipple
3. 58-3685 1/4 NPT M-3/8 tube swivel elbow
4. 58-3740 1/4 NPT female cross
5.58-1691 Elbow 3/8 Npt x 1/2 OD tube
6. 58-2100 Sleeve lube assembly
7. 58-2110 Sleeve nuts assembly
8. 58-7323B Copper tubing
9. 58-7322C Tube oil pump discharge
10. N/A
11.Removed
12. 25-7195K Mounting bracket
13. 58-27395 Air pressure gauge K-10
14. 40-1681 FBHCS 1/4-20 x 1/2
15. 36-3090D Lube pump large tank
16. 58-1550 1/8 NPT conn B-3488
17. 58-3058 5/32 tube elbow
18. 52-3059 Pressure filter
19. 58-3050 Elbow 1/4 nylon tubing
20. 58-3670 1/4 NPT M-1/8 F reducer 110A-BA
21. 58-3050 Elbow 1/4 nylon tubing
22. 58-3685 1/4 NPT M-3/8 tube swivel elbow
23. 53-2110A Filter regulator
24. 58-3050 nylon tubing
25. 58-3670 1/4 NPTM 1/8 F reducer
26. 58-3710 Quick release FTG-male
27. 58-3001 1/4 street tee
28. 1/4 Street elbow 90 deg
29. 58-1676 1/8 NPT cross fitting
30. N/A
31. 58-1550 1/8 NPT conn B-3488
32. 58-16700 Street elbow 1.8 inch
33. 79-1000 Wire channel 1" x 2"
34. 79-1000 Wire channel 1" x 2"
35. 58-3070 Fittting 1/8 NPT 1/4
36. 79-1001 Cover wire channel 1"
37. 58-2730 Air pressure gauge 0-15 psi
38. 52-0007 1/8 NPT air filter/regulator
39. 58-3691 1/4 NPT female hex joint 1-3/8 OAL 1-3/8
40. 25-4161 Switch connector bracket
41. 53-3002 Pressure switch PS-126
42. 58-3058 5/32 tube elbow
43. 58-2743 Branch T male W/1 Male
44. 58-16705 Male Elbow 1/8 male
45. 58-16760 Fluid connector
46. 58-2730 Air pressure guage 0-15 psi.
47. 58-2736 Air regulator 0-10 psi
48. 58-2751 Check valve 1/8 NPT male and 58-2746 1/8 x 1/8 Female coupler
49. 30-1033 Positive air regulator assembly
50. 58-2746 1/8 x 1/8 Female coupler
51. 36-30672 Solenoid
52. 58-1671 Long nipple 1/8-27NPT x2
53. 58-3670 1/4 NPTM-1/8 F reducer

HS-1 External Sheetmetal



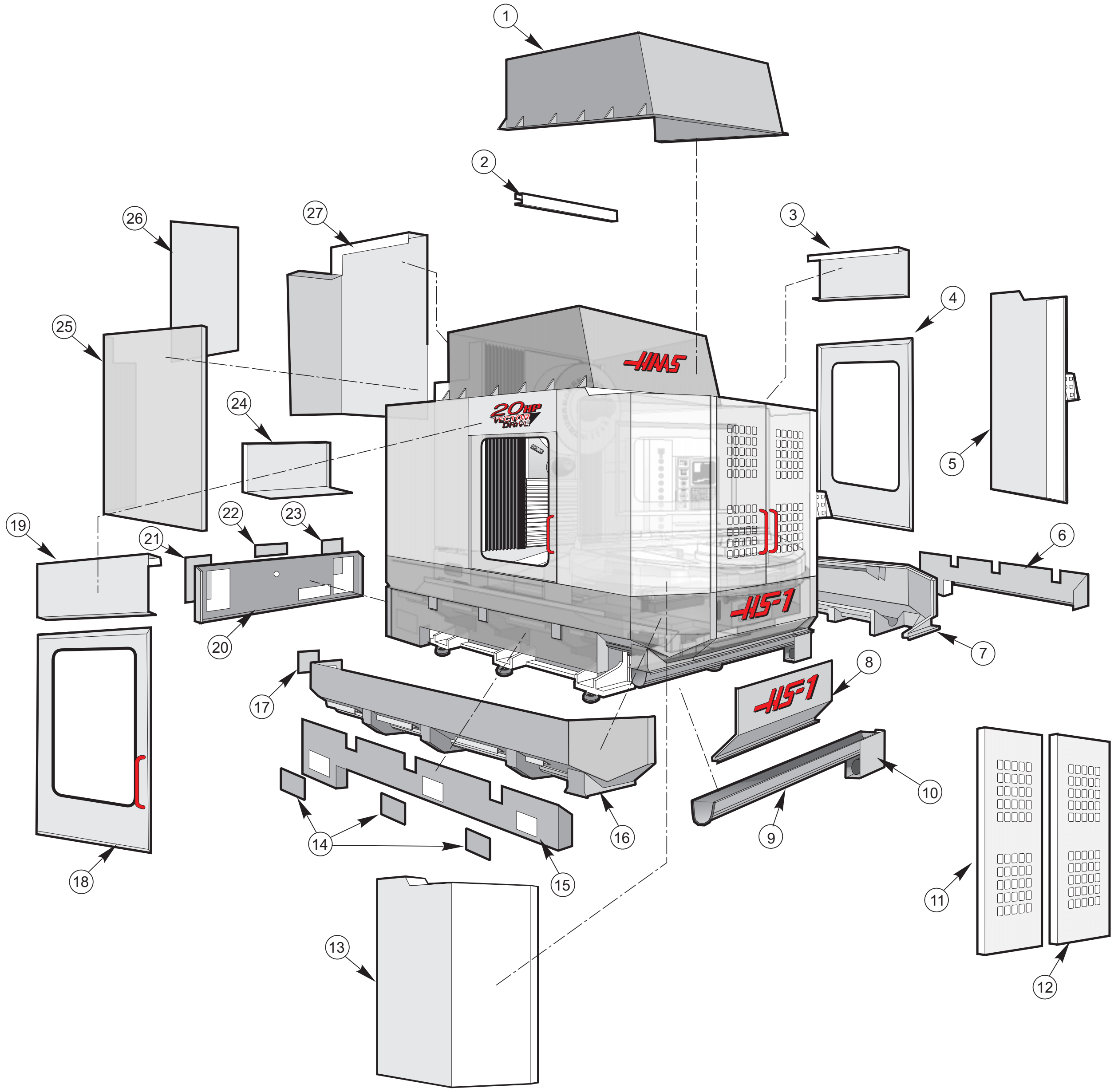
1.	Top Cover	25-9598C	15.	Right Apron	25-6488B
2.	Upper Bellow Guide	25-9372	16.	Left Side Pan	25-6462A
3.	Header Panel, Side	25-9651A	17.	Access Panel	25-9258
4.	Door	25-0909	18.	Side Door	25-0909
5.	Right Side Pan	25-6463A	19.	Header Panel, Side	25-9651A
6.	Left Apron	25-6487B	20.	Rear Apron	25-6489B
7.	Header Panel, Front	25-9652	21.	Access Panel	25-6465
8.	Right Front Panel	25-9661A	22.	Access Panel	25-6465
9.	Left Front Panel	25-9660	23.	Access Panel	25-6465
10.	Right Front Door	25-9534B	24.	Rear Pan	25-6481
11.	Left Front Door	25-9533B	25.	Left Side Panel	25-9529A
12.	Front Pan	25-9646B	26.	Rear Panel	25-9528A
13.	Front Coolant Trough	25-9424A	27.	Right Side Panel	25-9530B
14.	Aprons Access Cover	25-6490			

HS-1 Internal Sheetmetal



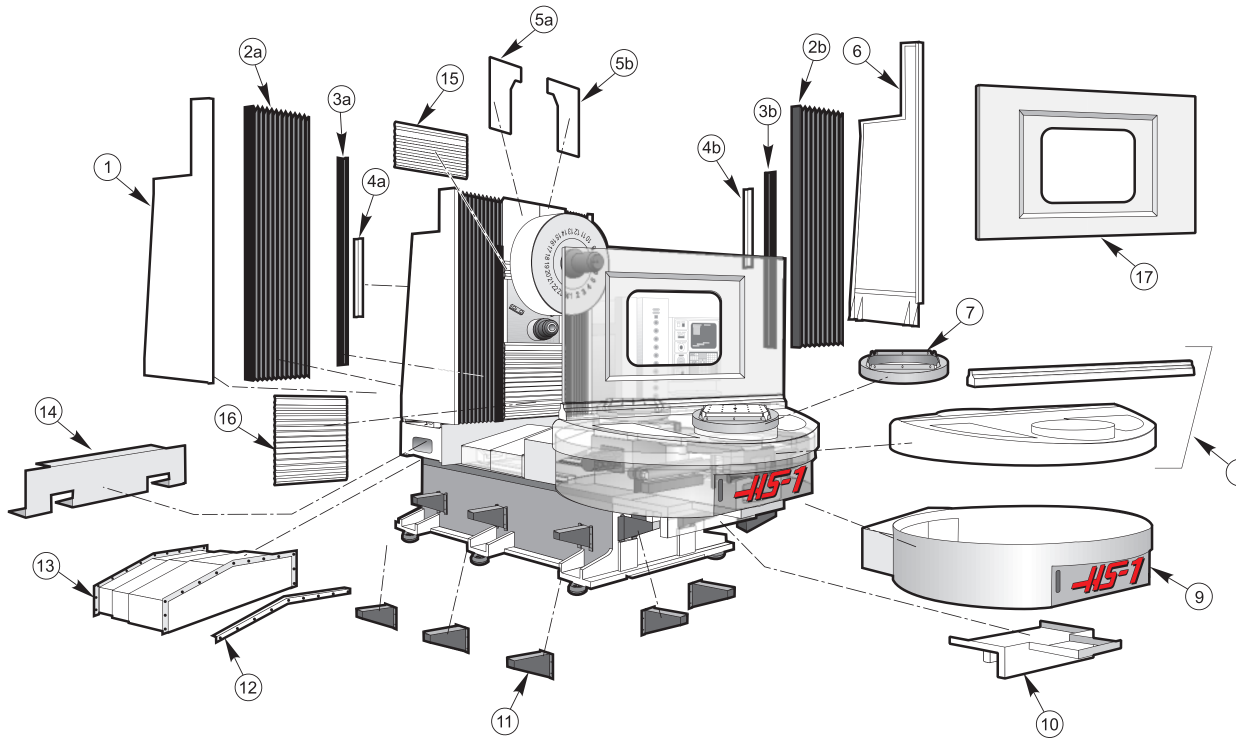
1.	Left X-Way Bellows Support	25-9641B	7a.	Top Access Cover	25-9492A
2a.	X-Waycover Bellows	59-9639A	7b.	Top Access Cover	25-9492A
2b.	X-Waycover Bellows	59-9639A	8.	Rotary Table Top Cover	25-9695B
3a.	Left Y-axis Waycover Guide	25-9610B	9.	Rotary Table Bottom Cover	25-9653B
3b.	Right Y-axis Waycover Guide	25-9609B	10.	Front Brace Pan	25-9659
4a.	Y-axis Chip Guard	25-9563B	11.	Z-axis Gasket Guide	25-6204
4b.	Y-axis Chip Guard	25-9563B	12.	Z-axis Waycover	25-9567C
5.	Upper Y-Axis Bellows	59-9607A	13.	Saddle Cover	25-9616A
6.	Right X-Way Bellows Support	25-9642B	14.	Lower Y-axis Bellows	59-9608A

HS-1RP External Sheetmetal



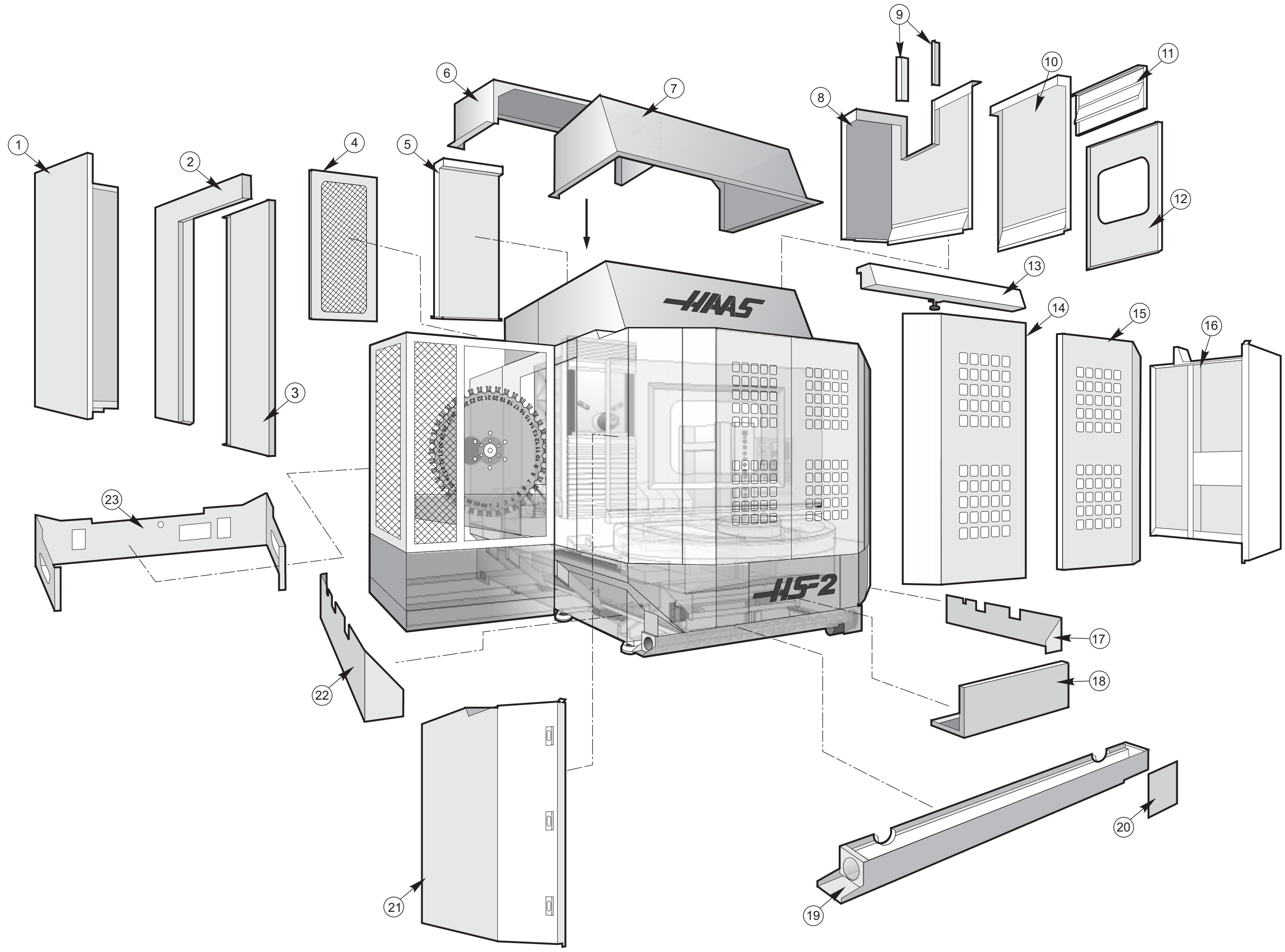
1.	Top Cover	25-9598C	15.	Left Apron	25-6487B
2.	Upper Bellow Guide	25-9372	16.	Left Side Pan	25-6478A
3.	Header Panel Side	25-9651A	17.	Access Panel	25-9258
4.	Side Door	25-0909	18.	Side Door	25-0909
5.	Right Panel	25-9530B	19.	Header Panel Side	25-9651A
6.	Right Apron	25-6488	20.	Rear Apron	25-6489B
7.	Right Side Pan	25-6479A	21.	Access Panel	25-6465
8.	Front Pan	25-6480A	22.	Access Panel	25-6465
9.	Front Coolant Trough	25-9424A	23.	Access Panel	25-6465
10.	Motor Cover	25-9411A	24.	Rear Pan	25-6481
11.	Left Front Door	25-9354	25.	Left Side Panel	25-9529A
12.	Right Front Door	25-9353	26.	Rear Panel	25-9528A
13.	Left Panel	25-9529A	27.	Right Side Panel	25-9530B
14.	Aprons Access Cover	25-6465			

HS-1RP Internal Sheetmetal



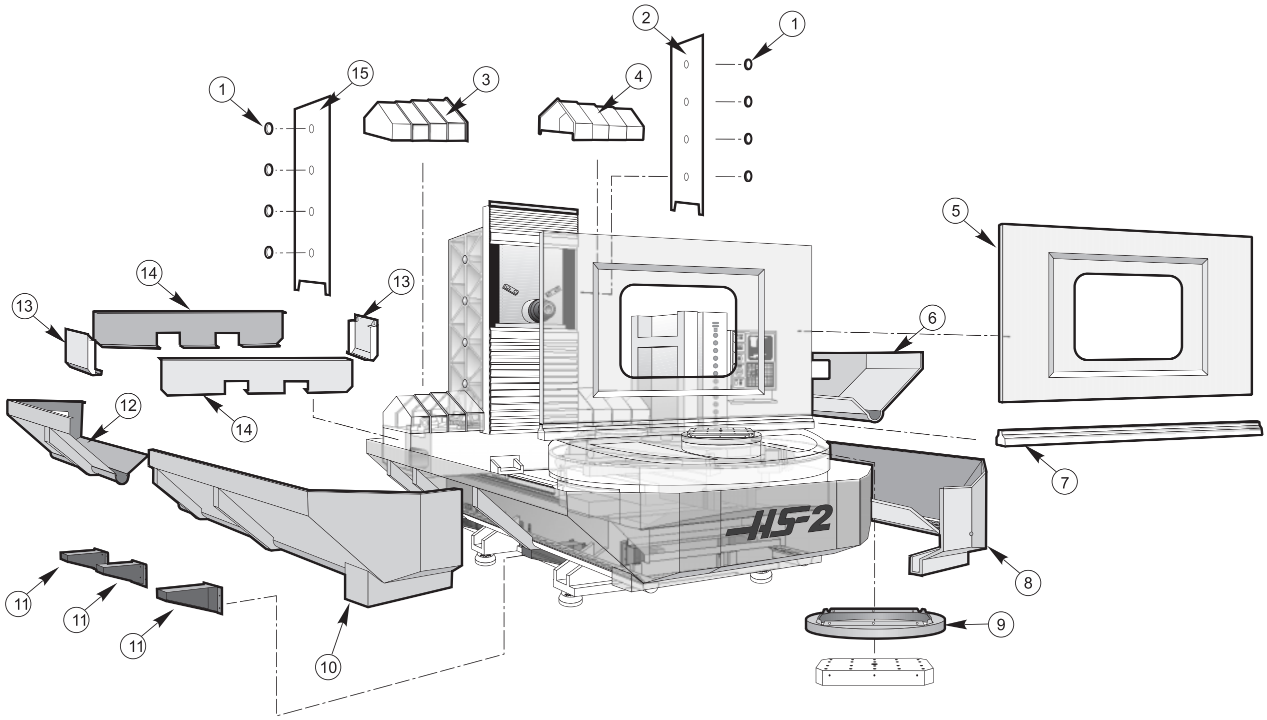
1.	X-Way Bellows Support	25-9641B	7.	Shroud Pallet	25-9406
2a.	X-Waycover Bellows (left)	59-9639A	8.	Rotary Top Cover	25-6485
2b.	X-Waycover Bellows (right)	59-9639A	9.	Rotary Cover	25-6484
3a.	Left Y-axis Waycover Guide	25-9610B	10.	Intermediate Pan	25-6482A
3b.	Right Y-axis Waycover Guide	25-9609B	11.	Front Brace Pan	25-9659
4a.	Left Y-axis Waycover Guide	25-9563B	12.	Z-axis Gasket Guard	25-6204
4b.	Right Y-axis Waycover Guide	25-9563B	13.	Z-axis Waycover	25-9667C
5.	Upper X-axis Bellows	25-9643A	14.	Saddle Cover	25-9616A
6.	Lower X-Way Bellows Guide	25-9644A	15.	Upper Y-axis Bellows	59-9607A
			16.	Lower Y-axis Bellows	59-9608A
			17.	Rotating Door	25-9475

HS-2RP External Sheetmetal



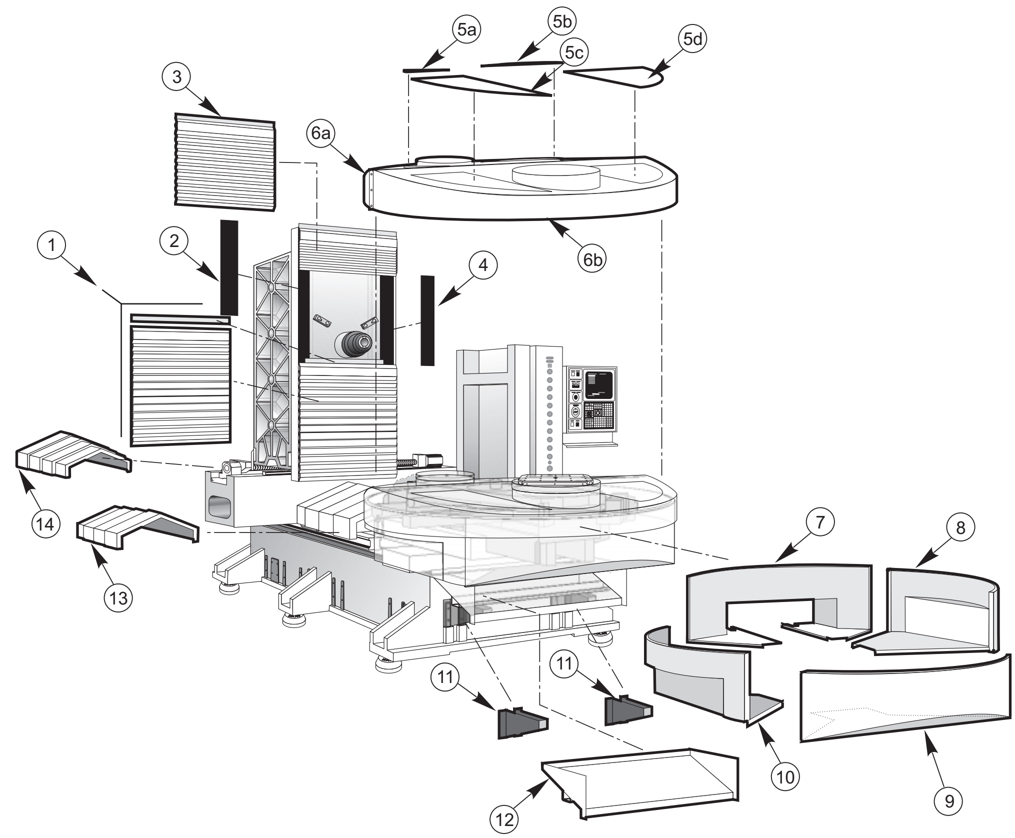
1.	Left Rear Panel	25-6232A
2.	Tool Changer Panel	25-6399A
3.	Left Intermediate Panel	25-6390
4.	Tool Changer Cage Panel	25-0167
5.	Rear Panel	25-6239A
6.	Rear Top Cover	25-6348
7.	Front Top Cover	25-6240A
8.	Right Rear Panel	25-6233A
9.	Carrier Guide	25-6210
10.	Intermediate Panel	25-6267
11.	Right Side Header	25-6235A
12.	Side Door	25-0909
13.	Front Header	25-6329
14.	Left Front Door	25-6230B
15.	Right Front Door	25-6231B
16.	Right Front Panel	25-6330C
17.	Right Side Apron	25-6225A
18.	Front Pan	25-6222
19.	Coolant Trough	25-6275
20.	Motor Cover	25-9411
21.	Left Front Panel	25-6331B
22.	Left Side Apron	25-0897
23.	Rear Apron	25-6227B

HS-2RP Internal Sheetmetal



1.	Finish Plug, 2 Inch	59-0074
2.	Y-axis Bellows Guide, Right	25-6281
3.	X-axis Waycover	25-6410
4.	X-axis Waycover	25-6410
5.	Rotating Door	25-6328A
6.	Right Side Pan, Rear	25-6215A
7.	Rotating Door Guide	25-6327A
8.	Right Side Pan, Front	25-6221
9.	Pallet Shroud	25-6302
10.	Left Side Pan, Front	25-6220
11.	Side Pan Support Brace	25-6228
12.	Left Side Pan, Rear	25-6214A
13.	End panel Saddle Cover	25-6407
14.	Saddle Cover	25-6258
15.	Y-axis Bellows Guide, Left	25-6280

HS-2RP Base Sheetmetal



1.	Y-axis Lower Bellows	59-6246	6b.	Top Cover, Pallet Changer	25-6326
2.	Y-axis Chip Guard	25-6243	7.	Bottom Cover, PC Section	25-6322
3.	Y-axis Upper Bellows	59-6245	8.	Bottom Cover, PC Section	25-6325
4.	Y-axis Chip Guard	25-6243	9.	Bottom Cover, PC Section	25-6324
5a.	Access Cover	25-6332	10.	Bottom Cover, PC Section	25-6325
5b.	Access Cover	25-6332	11.	Front Brace Pan	25-9659
5c.	Access Cover	25-6332	12.	Intermediate Pan	25-6224
5d.	Access Cover	25-6332	13.	Front Z-axis Waycover	25-6242
6a.	Top Cover, Pallet Changer	25-6326	14.	Rear Z-axis Waycover	25-6410