



## HAAS SERVICE AND OPERATOR MANUAL ARCHIVE

### VF Maintenance Manual 97-7000 English July 1993

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

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

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

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



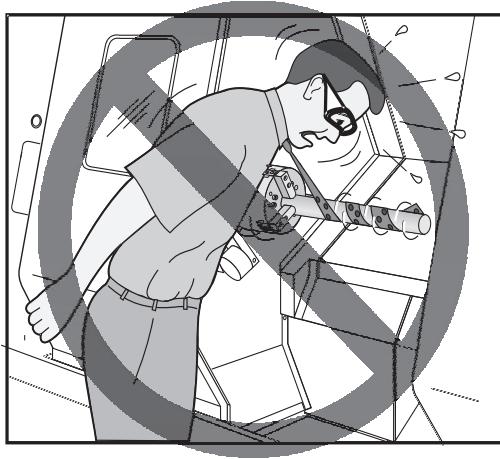
Haas Technical Publications

Manual\_Archive\_Safety\_Pages Rev A

June 6, 2013

# HAAS SAFETY PROCEDURES

# THINK SAFETY!



## DON'T GET CAUGHT UP IN YOUR WORK

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

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



## READ BEFORE OPERATING THIS MACHINE:

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



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

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

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

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

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

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

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

### **Unattended Operation**

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

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

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

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

## **MODIFICATIONS TO THE MACHINE**

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



## SAFETY DECALS

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

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

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

### NEVER OPERATE THIS MACHINE WITH THE DOORS OPEN





## MILL WARNING DECALS

### DANGER

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

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

### WARNING

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

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

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25-0769 Rev E

### NOTICE

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

### DANGER

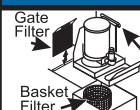


Safety windows may become brittle and lose effectiveness when exposed to machine coolants and oils over time. If signs of discoloration, crazing, or cracking are found, replace immediately. Safety windows should be replaced every two years.

### WARNING



### NOTICE



Clean the filter screen weekly.

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

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

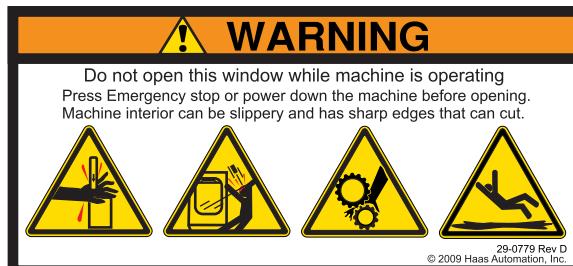
Do not use toxic or flammable liquids as a coolant.

29-0765 Rev F  
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## OTHER SAFETY DECALS

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





## INTRODUCTION

This document approaches maintenance from two viewpoints. The first is the regular maintenance of the machine to ensure problems do not occur; the second involves troubleshooting problems that do occur.

### 1. Regular Maintenance

#### CAUTION !!!!

NEVER SERVICE THIS MACHINE WITH THE POWER CONNECTED. Do not leave the control boxes open with power energized. There is DEADLY HIGH VOLTAGE present in all areas inside the cabinet.

WARN operators not to stick their hands or arms inside the vertical column through the rectangular holes in the side of the machine. The large counterweight inside the column can cause severe injury when it moves up and down.

#### CAUTION !!!!

#### 1.1 Daily Maintenance

Check the coolant level and way lube oiler. Clean chips from way covers and bottom pan. Avoid using air pressure to clean on underside of table guides. Clean chips from tool changer. Wipe spindle taper clean with cloth rag.

#### 1.2 Weekly Maintenance

Check the automatic dump air line's water trap for proper operation. Check the air gauge/regulator for 85 pounds air pressure. Check oil mist lubricator's oil level. Clean aluminum air filter on control heat exchanger. Clean exterior painted surfaces with mild cleaners. Do not use solvents.

#### 1.3 Monthly Maintenance

Place a few drops of lubricating oil on the outside edge of the Geneva wheel star and guide rails of the tool changer and run through all tools.

Inspect way covers for proper operation and lubricate with light oil if necessary.

Clean the upper screen on the coolant tank. Remove the middle plate on the tank and remove any sediment inside of the tank and clean the inlet filter to the rotary pump. Be careful to disconnect the coolant pump from the control or to POWER OFF the control before working on the coolant tank.

Drain oil and water from the trap/drain at rear of the machine.



## 1.4 Fluid Requirements Maintenance

Way Lube: Medium way lube Vactra #2 or equivalent.

Coolant: water soluble, synthetic, or cutting oil, 20 gallons (30 gallons on optional tank). Do not use additives, kerosene, MEK, or other solvents. Every six months, replace coolant and thoroughly clean tank.

Oil mist lubricator: Hydraulic oil, DTE Light, 24 weight oil or equivalent only. Set lubricator for one drop per 10 tool releases. On machines built after October 1, 1992, the oil mist lubricator supply comes from the way lube tank, and does not need to be refilled.

Gear Box: Mobil DTE 25 Non-Foaming Gear Oil.

## 1.5 Spindle Maintenance

The spindle is air-pressurized oil drip lubricated. The gear box uses an oil sump in the VF-1, VF-2, and VF-3. The VF-0 has no gearbox. The VF-1, VF-2, and VF-3 spindles are cooled by gear oil. The VF-0 spindle is air-cooled.

Contact your dealer for service on this item.



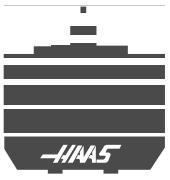
## 2. Troubleshooting

**CAUTION !!!!** Never attempt to troubleshoot the electronics unless you turn off the main breaker first and wait five minutes for the capacitors to discharge. Never work on the electronics without someone else present to render assistance. Lethal voltages are present in all areas inside the cabinet.

Troubleshooting involves interpreting alarms and other symptoms and relating them to the possible causes and subsequently correcting the problem. Troubleshooting will begin with alarms, proceed to circuit breakers, and then begin to isolate problems to their respective assemblies. The major assemblies in this VMC are:

- 1) Base and column iron castings including:  
Oiler pump and reservoir,  
Air pressure regulator and mist supply,  
Y-axis servo motor,  
Z-axis servo motor, and  
Y and Z home sense switches.
- 2) Saddle and table including:  
X-axis servo motor,  
X home sensor switch.
- 3) Rear control cabinet including:  
Power supply assembly,  
Microprocessor assembly,  
Servo drive assembly,  
Input/output assembly,  
Spindle drive, and  
Transformer assembly.
- 4) Front control panel including:  
Support arm from control cabinet,  
Front panel enclosure,  
CRT,  
Membrane keypad,  
POWER ON and POWER OFF buttons,  
Spindle Load Meter,  
EMERGENCY STOP button,  
JOG handle, and  
CYCLE START and FEED HOLD buttons.
- 5) Spindle head including:  
Counterweight and support chains,  
Spindle motor,  
Air solenoids,  
Low air pressure sensor,  
Tool unclamp mechanism,  
Optional spindle position encoder,  
Optional head mounted work light,  
Gear box, and  
Spindle orientation mechanism.

(Cont'd)



## 2. Troubleshooting (Cont'd)

- 6) Tool changer including:  
In/out shuttle mechanism,  
Shuttle in/out motor,  
Tool carousel turret,  
Turret motor,  
Shuttle position sensor switches,  
Turret in-position sense switch, and  
Tool #1 sense switch.
- 7) Plastic enclosure including:  
Sliding doors,  
Door open switches, and  
Enclosure-mounted work light.

### 2.1 Alarms

Any time an alarm is present, the lower right hand corner will have a blinking "Alarm". Push the ALARM MSGS display key to view the current alarms. All alarms are displayed with a reference number and a complete text 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. See Section 2.5 for the detailed alarm list and explanations.

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, then selecting AUTO ALL AXES.

### 2.2 Tool Changer Problems

Tool changer problems can be caused by several things; some are caused by the user's tools and some are caused by machine problems.

An oversize tool can interfere with the tool storage carousel or with the spindle. Make sure that any problem is not caused by an oversize tool.

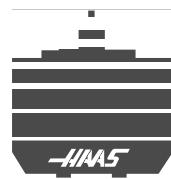
Taper problems on the tool holder can also cause problems with tools sticking in the spindle and not clamping correctly. Make sure that any problems are not caused by taper problems.

Problems with the pull stud can cause tool changer problems. Make sure that any problems are not caused by an incorrect or loose pull stud.

In addition to the above, make sure that you have the correct type of tools. This tool changer can be fitted to either BT40 or CAT40 tools. They are NOT compatible.

A problem with the air supply (too low pressure) or circuit breaker CB4 may also cause tool clamp or unclamp problems. You should check these.

If you cannot isolate the cause of a tool changer problem, see Section 5.7 for a detailed description of the tool change sequence and possible problem areas.



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 shuttle should become jammed, the control will automatically come to an alarm state. To correct this, push the EMERGENCY STOP button and remove the cause of the jam. 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.

## 2.3 Spindle 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. See Section 28 for adjustment.

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 decel rate (See Section 28) or reduce the frequency of spindle speed changes.

## 2.4 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 Section 2.5 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 light or not as described in Section 24.1.

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.

(Cont'd)



## 2.4 Diagnostic Data (Cont'd)

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:

### DISCRETE INPUTS

#	Name	Description	#	Name	Description
1	TC IN	Tool Changer In	17	SP LOK	Spindle Locked
2	TC OUT	Tool Changer Out	18	SP FLT	Spindle Drive Fault
3	T ONE	At Tool One	19	SP SP*	Spindle Not Stopped
4	LO CNT	Low Coolant	20	SP AT*	Spindle Not At Speed
5	TC MRK	T.C. Geneva Mark	21	LO OIL	Spindle/GB coolant low
6	SP HIG	Spindle In High	22	A161	Safety Interlock status
7	SP LOW	Spindle In Low	23	spare	
8	EM STP	Emergency Stop	24	spare	
9	DOOR S	Door Open Switch	25	UNCLA*	Remote tool unclamp
10	M-FIN*	Not M Func Finish	26	LO PH A	Low voltage in phase 1
11	OVERV*	Not Over Voltage	27	LO PH B	Low voltage in phase 2
12	LO AIR	Low Air Pressure	28	LO PH C	Low voltage in phase 3
13	LO LUB	Low Lube Oil	29	GR FLT	Ground fault
14	OVRHT*	Not Over Heat	30	SKIP	Skip Signal
15	DB OPN	Tool Unclamped	31	spare	
16	DB CLS	Tool Clamped	32	spare	

### DISCRETE OUTPUTS

#	Name	Description	#	Name	Description
1	SRV PO	Servo Power On	17	M21	Spare M Functions
2	SP FOR	Spindle Forward	18	M22	
3	SP REV	Spindle Reverse	19	K111	Spindle & T.C. Enable
4	SP RST	Spindle Reset	20	K210	E-Stop Enable
5	4TH BK	4th Axis Brk Rel	21	UNCLPR	Unclamp pre-charge
6	COOLNT	Coolant Pump	22	M26	
7	AUT OF	Auto Turn Off	23	5TH BK	5th Axis Brake
8	SP FAN	Spind Motor Fan	24	Y160	Door Lock
9	TC IN	Tool Changer In	25	spare	
10	TC OUT	Tool Changer Out	26	spare	
11	TC CW	Tool Changer CW	27	spare	
12	TC CCW	Tool Changer CCW	28	spare	
13	SP HIG	Spindle High Gear	29	spare	
14	SP LOW	Spindle Low Gear	30	spare	
15	T UNCL	Tool Unclamped	31	spare	
16	SP LOK	Spindle Lock Cmd	32	spare	

The 32 inputs are numbered the same as the 32 connections on the inputs printed circuit board. The last eight outputs are reserved for expansion by HAAS.



The second page of diagnostic data is displayed using the PAGE UP and PAGE DOWN keys. It contains:

## INPUTS2

Name	Description	Name	Description
X Z CH	X-axis Z Channel	X ZIRQ	X-axis Z channel interrupt
Y Z CHY	Axis Z Channel	Y ZIRQ	Y-axis Z channel interrupt
Z Z CH	Z-axis Z Channel	Z ZIRQ	Z-axis Z channel interrupt
A Z CH	A-axis Z Channel	A ZIRQ	A-axis Z channel interrupt
X HOME	X-axis Home/Lim Switch	1K IRQ	1 kHz Interrupt
Y HOME	Y-axis Home	Z IRQ	Z channel interrupt
Z HOME	Z-axis Home	SPZIRQ	Spindle encoder Z interrupt
A HOME	A-axis Home	SELF T	Self-Test Input
X OVRH	X Motor OverTemp	X CABL	Broken cable to X encoder
Y OVRH	Y Motor OverTemp	Y CABL	Broken cable to Y encoder
Z OVRH	Z Motor OverTemp	Z CABL	Broken cable to Z encoder
A OVRH	A Motor OverTemp	A CABL	Broken cable to A encoder
OVC X	X Drive Overcurrent	spare	
OVC Y	Y Drive Overcurrent	spare	
OVC Z	Z Drive Overcurrent	spare	
OVC A	A Drive Overcurrent	AD EOC	A-to-D End of Conversion

## ANALOG DATA

Name	Description
DC BUSS	DC Servo Buss Voltage
SP TEMP	Spindle temperature F
SP LOAD	Spindle load in %
AUX TMP	Not used
SP SPEED	Spindle RPM CW or CCW

## 2.5 Alarm List

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

Note that 102 (Servo Off) is not actually an alarm but is describing a condition of the control. At any time that the servos are off, this alarm will be displayed. This happens at initial power-on and as a result of several different motor or tool changer alarm conditions.

Alarm number and text:      Possible causes:

102 Servos Off

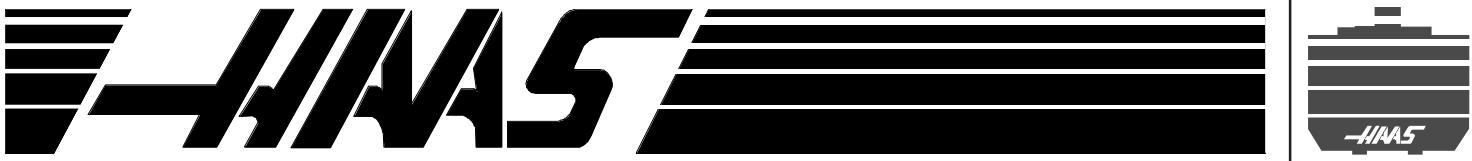
Indicates that the servo motors are off, the tool changer is disabled, the coolant pump is off, and the spindle motor is stopped. Caused by EMERGENCY STOP, motor faults, tool changer problems, or power fail.

(Cont'd)



## 2.5 Alarm List (Cont'd)

- 103 X Following Error 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 Following Error same as 103.  
105 Z Following Error same as 103.  
106 A Following Error same as 103.
- 107 Emergency Off EMERGENCY STOP button was pressed. Servos are also turned off. After the E-STOP is released, the RESET button must be pressed at least twice to correct this; once to clear the E-STOP alarm and once to clear the Servo Off alarm.
- 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 108.  
110 Z Servo Overload same as 108.  
111 A Servo Overload same as 108.
- 112 No Interrupt Electronics fault. Call your dealer.
- 113 Shuttle In Fault Tool changer 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, so check fuse FU5 and relays 1-8, 2-1, and 2-2.
- 114 Shuttle Out Fault Tool changer not completely to left. During a tool changer 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, so check fuse FU5 and relays 1-8, 2-1, and 2-2.
- 115 Turret Rotation Tool carousel motor not in position. During a tool changer operation the tool turret failed to start 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, so check fuse FU5 and relays 1-8, 2-3, and 2-4.



- 116 Spindle Orient Fault Spindle did not orient correctly. 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 the time-out times. 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 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, the solenoids circuit breaker CB4, and the spindle drive.
- 118 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 solenoids circuit breaker CB4, and the spindle drive.
- 119 Over Voltage Incoming line voltage is above maximum (about 255V when wired for 240 or 235 when wired for 208). The servos will be turned off and the spindle, tool changer, and coolant pump will stop. If this condition remains for 4.5 minutes, an automatic shutdown will begin.
- 120 Low Air Air pressure dropped below 80 PSI for a period defined by Parameter 76. Check your incoming air pressure for at least 100 PSI and ensure the regulator is set at 85 PSI.
- 121 Low Lub 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 P5 on the side of the control cabinet. Check that the lube lines are not blocked.
- 122 Overheat The control internal temperature is above 150° F. This can be caused by almost anything in the control overheating. But is usually caused by over heat of the two regen resistors for servos and spindle drive. This alarm will also turn off the servos, spindle drive, coolant pump, and tool changer. One common cause of this overheat condition is an input line voltage too high. If this condition remains for 4.5 minutes, an automatic shutdown will begin.
- 123 Spindle Drive Fault Overheat or failure of spindle drive or motor. The exact cause is indicated in the LED window of the spindle drive inside the control cabinet. This can be caused by a stalled motor, shorted motor, overvoltage, undervoltage, overcurrent, overheat of motor, or drive failure.
- 124 Low Battery Memory batteries need replacing within 30 days. This alarm is only generated at power on and indicates that the 3.3V Lithium battery is below 2.5V. 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.

**(Cont'd)**



## 2.5 Alarm List (Cont'd)

126	Gear Fault	Gearshifter is out of position when a command is given to 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 solenoids circuit breaker CB4, and the spindle drive.
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.
128	Tool In Turret	Pocket opposite spindle has tool in it. Future option not yet implemented.
129	M Fin Fault	M-FIN was active at power on. Check the wiring to your <b>M</b> code interfaces. This test is only performed at power-on.
130	Tool Unclamp	Tool release piston is energized at power up. This is a possible fault in the air solenoids, relays on the IO Assembly, the draw bar assembly, or wiring.
131	Tool Not Clamped	Tool Release Piston is not Home. This is a possible fault in the air solenoids, relays on the IO Assembly, the draw bar 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 2-8, the wiring to the sense switch, and the switch.
134	Tool Clamp Fault	Tool did not release from spindle when commanded. Check air pressure and solenoid circuit breaker CB4. Can also be caused by misadjustment of draw bar assembly.
135	X Motor Over Heat	Servo motor overheat. The temperature sensor in the motor indicates over 150°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 135.
137	Z Motor Over Heat	same as 135.
138	A Motor Over Heat	same as 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 connectors at P1-P4.
140	Y Motor Z Fault	same as 139.
141	Z Motor Z Fault	same as 139.
142	A Motor Z Fault	same as 139.



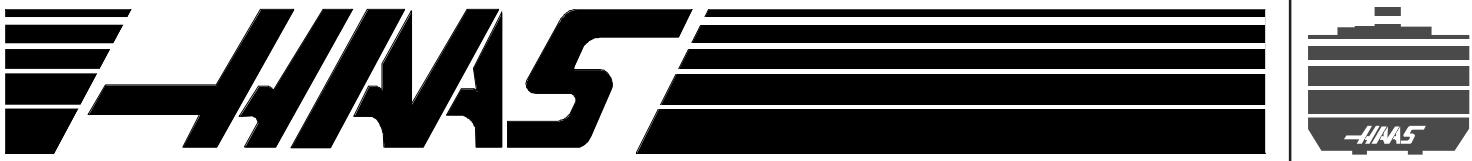
143	Spindle Not Locked	Shot pin not fully engaged when a tool change operation is being performed. Check air pressure and solenoid circuit breaker CB4. This can also be caused by a fault in the sense switch that detects the position of the lock pin.
144	Time-out - Call Your Dealer	Time allocated for 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 145
147	Z Limit Switch	same as 145
148	A Limit Switch	Normally disabled for rotary axis.
149	Spindle Turning	Spindle not at zero speed for tool change. A signal from the 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	Tool changer not at home and <b>Z</b> is not either at machine home or above tool. 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 Coolant	Coolant supply is below about five gallons or P7 is disconnected. To run without coolant, Setting 32 can be set to IGNORE.
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 Channel Missing	Broken wires or encoder contamination. All servos are turned off. This can also be caused by loose connectors at P1-P4.
154	Y-axis Z Channel Missing	same as 153.
155	Z-axis Z Channel Missing	same as 153.
156	A-axis Z Channel Missing	same as 153.
157	Motor Interface Failure	Internal circuit board problem. The MOTIF PCB in the processor stack is tested at power-on. Call your dealer.
158	Video/Keyboard 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.

**(Cont'd)**



## 2.5 Alarm List (Cont'd)

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 below 190 when wired for 230V or drops below 165 when wired for 208V.
161	X-axis Over Current	Current in <b>X</b> 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 lead to ground.
162	Y-axis Over Current	same as 161.
163	Z-axis Over Current	same as 161.
164	A-axis Over Current	same as 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 <b>Z</b> 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 165.
167	Z Zero Ret Margin Too Small	Same as 165.
168	A Zero Ret Margin Too Small	Not normally enabled for A-axis.
169	Spindle Direction Fault	Problem with rigid tapping hardware. The spindle started turning in the wrong direction.
170	Phase Loss L1-L2	Problem with incoming line voltage between legs L1 and L2. This usually indicates that there was a transient loss of input power to the machine.
171	Phase Loss L2-L3	Problem with incoming line voltage between legs L2 and L3.
172	Phase Loss L3-L1	Problem with incoming line voltage between legs L3 and L1.
173	Spindle Ref Signal Missing	The <b>Z</b> 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	Overheat Shutdown	An overheat condition persisted for 4.5 minutes and caused an automatic shutdown.
177	Overvoltage Shutdown	An overvoltage condition persisted for 4.5 minutes and caused an automatic shutdown.
178	Divide by Zero	Software Error; Call your dealer.
179	Low Pressure Spindle Coolant	Spindle coolant oil is low or low pressure condition in lines.
180	Tool Arm Rotation Fault	For Side Mount Tool Changer, the tool exchange operation did not sense the 180° rotation switch.
181	Tool Pot Position Fault	For Side Mount Tool Changer, the tool pot positioning mechanism is not working.
182	X Cable Fault	Cable from X-axis encoder does not have valid differential signals.
183	Y Cable Fault	Same as 182.
184	Z Cable Fault	Same as 182.
185	A Cable Fault	Same as 182.
186	Spindle Not Turning	Status from spindle drive indicates error.
201	Parameters CRC Error	Parameters lost maybe by low battery. Check for a low battery and low battery alarm.
202	Settings CRC Error	Settings lost maybe by low battery. Check for a low battery and low battery alarm.
203	Lead Screw Comp.	Lead screw compensation tables lost maybe by low battery. Check for CRC Error low battery and low battery alarm.
204	Offsets CRC Error	Offsets lost maybe by low battery. Check for a low battery and low battery alarm.
205	Programs CRC Error	Users program lost maybe by low battery. Check for a low battery and low battery alarm.
206	Internal Program Error	Software Error; Call your dealer.
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.

**(Cont'd)**



## 2.5 Alarm List (Cont'd)

210	Insufficient Memory	Not enough memory to store user's program. Check the space available in the LIST PROG mode and possibly delete some programs.
211	Odd Program Block	Software Error; Call your dealer.
212	Program Integrity Error	Software Error; Call your dealer.
213	EPROM CRC Error	Electronics fault; Call your dealer.
240	Empty Prog or No EOB	Software Error; Call your dealer.
241	Invalid Code	RS-232 load bad. Data was stored as comment. Check the program being received.
242	No End	Software Error; Call your dealer.
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.
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 Error Begin Odd	Software Error; Call your dealer.
250	Program Data Error	Same as 249.
251	Prog Data Structure Error	Same as 249.
252	Memory Overflow	Same as 249.
253	Program Data Error	Same as 249.
254	Program Data Error	Same as 249.
255	Program Data Error	Same as 249.
256	Program Data Error	Same as 249.
302	Invalid R In G02 or G03	Check your geometry with the Help page. <b>R</b> must be less 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 with the Help page.
304	Invalid I, J, or K In G02 or G03	Check your geometry with the Help page. Radius at start must match radius at end of arc within 0.0010 inches.



305	Invalid Q In Canned Cycle	<b>Q</b> in a canned cycle must be greater than zero.
306	Invalid I, J, or K In Canned Cycle	<b>I</b> , <b>J</b> , and <b>K</b> in a canned cycle must be greater than zero.
307	Subprogram Call Nesting Too Deep	Subprogram nesting is limited to nine levels. Simplify your program.
308	Canned Cycle Nesting Too Deep	Software Error; Call your dealer.
309	Max Feed Rate Exceeded	Use a lower feed rate.
310	Invalid G Code	<b>G</b> code not defined and is not a macro call.
311	Unknown Code	Possible corruption of memory by low battery. Call your dealer.
312	Program End	End of subroutine reached before M99. Need an M99 to return from subroutine.
313	No P Code In M98	Must put subprogram number in <b>P</b> code.
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 <b>P</b> code must be the name of a program stored in memory without a decimal point for M98 and must be a valid <b>N</b> number for M99.
316	X Over Travel Range	X-axis will exceed stored stroke 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.
317	Y Over Travel Range	same as 316.
318	Z Over Travel Range	same as 316.
319	A Over Travel Range	Not normally possible with A-axis.
320	No Feed Rate Specified	Must have a valid <b>F</b> code for interpolation functions.
321	Auto Off	A fault turned off the servos automatically; occurs in debug mode only.
324	Invalid P Code In G04	<b>P</b> code in G04 is over 1000.0 or over 9999.
325	Queue Full	Control problem; call your dealer.
326	G04 Without P Code	Put a <b>Pn.n</b> for seconds or a <b>Pn</b> for milliseconds.
327	No Looping For M Code Except M97, M98	<b>L</b> code not used here. Remove <b>L</b> Code.

(Cont'd)



## 2.5 Alarm List (Cont'd)

328	Invalid tool number	Tool number must be between 1 and 16.
329	Undefined M Code	That <b>M</b> code is not defined and is not a macro call.
330	Undefined Macro Call	Macro name <b>O90nn</b> 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 Codes Not Matched	This alarm is generated when Setting 15 is turned ON and an <b>H</b> code number in a running program does not match the tool number in the spindle. Correct the <b>Hn</b> codes, select the right tool, or turn off Setting 15.
333	X-axis Disabled	Parameters have disabled this axis. Not normally possible in VMC.
334	Y-axis Disabled	same as 333.
335	Z-axis Disabled	same as 333.
336	A-axis Disabled	Parameters have disabled this axis. Must enable A-axis to program it or remove programming of A-axis. The A-axis can be disabled permanently by Parameter 43 or temporarily by Setting 30.
338	Invalid IJK and XYZ in G02 or G03	There is a problem with circle definition; check your geometry.
339	Multiple Code	Only one <b>M</b> , <b>X</b> , <b>Y</b> , <b>Z</b> , <b>A</b> , <b>Q</b> , etc. allowed in any block or two <b>G</b> codes in the same group.
340	Cutter Comp Begins With G02 or G03	Select cutter comp earlier.
341	Cutter Comp Ends With G02 or G03	Disable cutter comp later.
342	Cutter Comp Path Too Small	Geometry not possible. Check your geometry with the Help page.
344	Cutter Comp With G18 or G19	Cutter comp only allowed in XY plane (G17).
345	Scaling Parameters Wont Allow G17 Plane	Parameters 5 and 19 must be same value.
346	Scaling Parameters Wont Allow G18 Plane	Parameters 5 and 33 must be same value.
347	Scaling Parameters Wont Allow G19 Plane	Parameters 19 and 33 must be same value.



348	Illegal Spiral Motion	Linear axis path is too long. For helical motions, the linear path must not be more than the length of the circular component.
349	Prog Stopped Without Cancel of Cutter Comp	Information message only. Fix or Ignore.
350	Cutter Comp Look Ahead Too Small	There are too many non-movement blocks between motions when cutter comp is being used. Remove some intervening blocks.
352	Aux Axis Power Off	Aux <b>B</b> , <b>C</b> , <b>U</b> , <b>V</b> , or <b>W</b> axis indicate servo off. Check auxiliary axes. Status from control was OFF.
353	Aux Axis No Home Yet	A ZERO RET has not been done yet on the aux axes. Check auxiliary axes. Status from control was LOSS.
354	Aux Axis Not Connected	Aux axes not responding. Check auxiliary axes and RS-232 connections.
355	Aux Axis Position Lost	Mismatch between VMC and aux axes position. Check aux axes and 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 Circ Pocket Milling	Check your geometry with the Help page.
360	Tool Changer Disabled By Parameters	Check Parameter 57. Not a normal condition for VMC.
361	Gear Change Disabled By Parameters	Check Parameter 57. Not a normal condition for VMC.
362	Tool Usage Alarm	Tool life limit was reached. To continue, reset the usage count in the Current Commands display and press RESET.
363	Coolant Locked	Override is off and program tried to turn on coolant.
364	No Circular Interp Allowed On Aux Axis	Only rapid or feed is allowed with aux axes.
365	Cutter Comp Interference	G02 or G03 cut cannot be done with tool size.
366	Cutter Comp Interference	Tool doesn't fit inside of cut.
367	Cutter Comp Interference	G01 cannot be done with tool size.

(Cont'd)



## 2.5 Alarm List (Cont'd)

- |     |                                    |   |
|-----|------------------------------------|---|
| 368 | Groove Too Small                   | Tool too big to enter cut.  |
| 369 | Tool Too Big For Cutter Comp       | 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 restrictions to DNC.  |
| 374 | Missing XYZA in G31 or G36         | G31 skip function requires an <b>X</b> , <b>Y</b> , <b>Z</b> , or <b>A</b> move.  |
| 375 | Missing Z or H in G37              | G37 auto offset skip function requires <b>H</b> code, <b>Z</b> value, and tool offset enabled. <b>X</b> , <b>Y</b> , and <b>A</b> 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      | Auto work offset probing must be done without tool offset.  |
| 382 | D code required in G35             | A <b>Dnn</b> code is required in G35 in order to store the measured tool diameter.  |
| 383 | Inches 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 Code In G10     | G10 was used to changes offsets but <b>L</b> , <b>P</b> , or <b>R</b> code is missing or invalid.   |
| 403 | RS-232 Directory Full              | Cannot have more than 100 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 Program Name	Check files being loaded. Program name must be <b>Onnnn</b> 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 File	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 Insufficient Memory	Program received doesn't 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 38400 bits per second.
415	RS-232 Overrun	Data sent too fast to CNC. This alarm is not normally possible as this control can keep up with as much as 38400 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.



## 2.6 Transmission Problems (VF-1, VF-2, VF-3)

Transmission problems are almost always indicated by an alarm. These alarms indicate either a failure to go into the gear selected or a between-gear indication when trying to start a program. Transmission problems can be caused by circuit breaker CB4 supplying the solenoids and controlling the air to the gear changer. They can also be caused by an air supply problem such as too low pressure, water in the lines, or too much oil in the lines.

In addition to these, if the gears get hung between high and low, such as by a RESET during a gear change, you will not be allowed to start a program. The only recovery to this is to manually turn the spindle until the gears drop into the commanded position. There is always air pressure pushing the gears into either high gear or low gear so the gears should easily drop into position. **CAUTION!** **NEVER TOUCH THE SPINDLE WHEN THERE IS ANY CHANCE OF IT BEING IN MOTION.** Unless you have an emergency, never press RESET or EMERGENCY STOP during a tool change as this may cause the transmission to hang between gears.

## 2.7 AC Line Supply Voltage

Many problems can be caused by AC supply line voltage problems. This control requires voltage between 198V AC and 250V AC, three-phase. The applied voltage must be stable within plus or minus 5%. This is called the normal operating range. If you have any alarms relating to voltage, you should check all three phases of the incoming power. It is important to check the supply voltage when a load is being placed on the supply. This could be done by measuring the line voltage while the spindle is accelerating to 5000 RPM. **Always have only qualified personnel taking such measurements as these are lethal voltages.** This machine will run from either 50 or 60 Hertz. There are four voltage ranges selected by taps on an internal transformer. They are:

208 to 210	OR LOW 208 RANGE
211 to 226	FOR HIGH 208 RANGE
227 to 243	FOR LOW 240 RANGE
244 to 260	FOR HIGH 240 RANGE

For other voltages, an external transformer is required. Power required is 30 amps, three-phase, using #10 gage wire. Phase orientation is required. Under no circumstances should this control be supplied with more than 260V at 60 Hz or 250V at 50 Hz.

If the power service is more than 120 feet from the machine, you should use #8 gage wire. Power entry to the control is at the top of the control near the main circuit breaker. An external earth ground must be connected to the ground connection adjacent to the main circuit breaker.

Use of single-phase power is not possible with this machine.

The supply voltage brought into the control is measured from leg-to-leg of the three wires. There is no neutral wire connection and voltages are not measured from earth to any of the power leads. There are three combinations of these three wires and all three voltages should be checked.

The control is designed to continue operation even if the voltage changes plus or minus 10% for short periods of time (less than one second) but longer periods may cause an alarm.

Another common problem with line voltage occurs if it exceeds 250V. If this occurs, the regen load resistors near the center of the control cabinet will start to heat and, if they exceed 100° C, an overheat alarm is generated.



### **3. Fuse Check/Replacement And Circuit Breakers**

Both circuit breakers and fuses are used in this control to protect the electronics and to prevent fire and personal injury. All circuits that might trip in normal operation contain circuit breakers that can be visually checked and manually reset. All other circuits are protected with fuses.

#### **3.1 Circuit Breakers**

All circuit breakers are located on the power supply assembly inside the main control cabinet in the top right corner.

There are up to four resettable circuit breakers in the control. The first, CB1, is the main breaker and the control will not run with it off. This breaker might be blown by a failure of the spindle drive, a lightning strike, or a major short circuit.

CB2 controls the power to the servo transformers and, if tripped, will turn off the CRT, low voltage supply, cooling fans, servo motors, and air solenoids. It might 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.

CB4 controls the 115V AC to the air solenoids, 4th axis brake, and the oiler. It is never expected to trip. If it does trip, it is likely caused by a short circuit in the wiring on the I/O assembly or the wiring to the solenoids on the spindle head. If you have a 4th axis rotary table, a short in its brake solenoid wiring will also blow CB4.

#### **3.2 Fuses**

There are three fuses on each of the servo drive cards. If these fuses are ever blown, the associated motor will stop. This will only happen if there is a failure of the drive card and the user should never attempt to replace these fuses.

The main breaker, CB1, has a printed circuit board next to it containing three ½-amp fuses. 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; type AGC ½A, 250V.

On the servo drive assembly, there is a printed circuit board (SDIST) containing three one-amp fuses. Two of these fuses protect the contactor and small transformers. They are never expected to blow. The third fuse protects the regen load circuit load from shorts.

FU5 (ABC, 250V, 5A) protects the tool changer and FU6 (AGC, 250V, ½A) protects the operator's lamp. These fuses are located on the POWER PCB in the power supply assembly.



## 4. Servo Motors

There is very little that a user might do to repair a servo motor. Problems with servo motors may include open-circuited motor, shorted winding of motor, motor shorted to case, water (coolant) in motor, or overheat damage to motor. None of these can be fixed by the user so the motor must be replaced. All of the above problems would generate alarms identifying one of the servo motors as having failed. These alarms are 103-106 (following error too large), 108-111 (servo overload), 135-138 (overheat), 139-142 (Z channel fault), 153-156 (Z channel missing), and 161-164 (overcurrent).

Note: repairs to the motor, ball screw, or home switch will affect the ZERO RETURN point and must be done only by a factory-trained technician. Serious damage to the ball screw, way covers, linear guides or tool changer may occur if the ZERO RETURN point is improperly set.

### 4.1 Check And Replacement Of DC Motor Brushes

The brushes on the three axes servo motors should be checked about once per year. Any dust inside the brush enclosure should be blown out with a dry air supply. If the brushes are shorter than 0.375 inches, they should be replaced. Failure to clean out the brush-produced dust may cause an arcing in the motor commutator that will destroy the motor. For operation of two or three shifts, a check should be made at least every six months.

### 4.2 Servo Motor Encoders

Attached to each DC servo motor, there is an incremental encoder that is either 2000 lines per revolution. These encoders also supply a Z channel pulse once per revolution. The encoders and Z channel are continuously monitored to ensure the number of pulses matches for each revolution of the motor. If the encoders become contaminated, these pulse counts will be wrong and an alarm will be generated. This ensures that the data from the encoders is reliable. There can never be a loss of servo position due to accumulated encoder errors. The alarms generated will indicate that either the Z pulse occurred and the encoder pulse was wrong or, after one and one half motor revolutions, the Z pulse did not occur.

Encoders' faults can be caused by contamination of the encoder or by a wiring problem. If the encoder is contaminated, it must be replaced. Wiring problems may be a broken wire, shorted wire, or missing shield. All wires to the encoder are enclosed in their own shielded cable. In addition, all power wires to the motor are enclosed in a separately shielded cable. Failure of either of these shields may cause noise in the encoder circuits and result in the encoder fault alarms.

Never connect or disconnect the servo motor cables with the control powered as this will cause an apparent encoder fault.

The servo motor encoders are differential line drivers. This means that the A, B, and Z signals are transmitted to the control as signal pairs. A cable test is performed on these signals to ensure the differential pair are always present.



## 4.3 Servo Drive Motors Overheat Sense Switches

Each servo motor contains a normally-open overtemperature sense thermostat. When the motor case temperature exceeds 150° F, an alarm will be generated and operation of the machine will stop. This alarm should not occur under any normal operating circumstances and usually indicates that there is serious problem with the motor or drive circuit. After September 1990, the overheat sensor was changed to normally closed. This change is specified in the parameters.

## 4.4 Servo Drive Overcurrent Sensor

Each servo motor drive circuit contains a current limit setting and an overcurrent sense circuit. When an overcurrent condition persists for more than 0.01 second, an alarm will be generated and operation of the machine will stop. This current limit is presently set at 20 amps.

## 4.5 Servo Characteristics

This machine is not capable of instantly changing speed. That is, it takes some non-zero time to accelerate and decelerate. Acceleration and deceleration in this machine have both a constant accel/decel mode and an exponential mode. Constant acceleration is used at the beginning of a rapid move and at the end of any move whose speed exceeds the exponential accel/decel time constant.

Constant acceleration is a type of motion when the amount of speed change over time is constant. This constant is set by Parameters 7, 21, 35, and 49. It has units of encoder increments per second per second.

Exponential acceleration and deceleration is a type of motion where the speed is proportional to the distance remaining in a programmed travel. The exponential accel/decel time constant is set by Parameters 113, 114, 115, and 116. It has units of 0.0001 seconds. The speed limit at which exponential accel/decel is not available is defined by the relationship between Parameters 7 and 113 (for the X-axis). Thus if Parameter 7 is 1200000 steps/sec/sec and Parameter 113 is 750 (0.075 seconds); the maximum velocity for accurate interpolation should be:

$$1200000 \times 0.075 = 90000 \text{ steps/second}$$

For a 2000 line encoder and 6 mm screw, this would be:

$$60 \times 90000 / 33867 = 159 \text{ inches/minute}$$

In the normal feed cutting mode, with G64 active, giving continuous cutter motion, deceleration of the axes in motion begins at some distance away from the end point. If look-ahead has provided another motion, the acceleration for that motion will begin at the same instant. This means that two motions, at right angles to each other, will not produce a perfectly square corner. The corner will be rounded. It also means that if the two motions are parallel or nearly parallel, there will be a smooth transition from one stroke to the next.

Rapid moves have a slightly different operation when continuous cutter mode is active. Acceleration for the next motion is started when the axes being moved all fall within the "In Position Limit" Parameters 101, 102, 103, and 104. These parameters have units of encoder steps. Rapid moves will also decelerate at the constant accel/decel limit until the speed drops below that for

(Cont'd)



## 4.5 Servo Characteristics (Cont'd)

exponential accel/decel (see example above giving 159 inches per minute). Parameter 57 can be used to override this.

To prevent the rounding of corners, you can specify exact stop either with G09 (non-modal) or with G61 (modal). When either of these is active in a motion, all of the axes are brought to an exact stop, at zero speed, before the next motion is started.

The tool path in a circular move (G02 or G03) is not changed by the exponential acceleration/deceleration so there is no error introduced in the radius of the cut unless the speed exceeds that for exponential accel/decel (see example above giving 159 inches per minute).

## 4.6 Ground Fault Detector

This control has a ground fault sense circuit added to the servo drive power supply. This circuit will detect a short to ground on any of the servo motor power leads or in the internal 115V AC power. A ground fault can be caused by arcing brushes in the servo motors and will shut off all servo power.



## 5. Tool Changer

The tool changer is an all electric fixed shuttle type. 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 P6 on the side of the control cabinet.

For a detailed sequential description of a tool change, see Section 5.7

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 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 to the shuttle occurs. When the TOOL RELEASE button 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.

If the shuttle should become jammed, the control will automatically come to an alarm state. To correct this, push the EMERGENCY STOP button and remove the cause of the jam. 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.

FU5 is a fuse for the tool changer motors. It might be blown by an overload or jam of the tool changer. 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.

### 5.1 Tool Change Lubrication

Place a few drops of lubricating oil on the outside edge of the Geneva wheel star and guide rails of the tool changer and run through all tools.

### 5.2 Shuttle In/Out Motor

A DC brush motor is used to move the tool changer assembly towards and away from the spindle. This is called the shuttle. The motor is geared down to a low RPM and then connected to an arm that rotates through 180° and pushes the shuttle in and out.

**NOTE:** This motor should never be disassembled.



## 5.3 Turret Rotation Motor

A DC brush motor is used to rotate the tool turret between tool changes. This motor is geared down to a low RPM and connected to a Geneva mechanism. One revolution of the Geneva mechanism moves the tool turret one tool position forward or backward. **NOTE:** This motor should never be disassembled.

## 5.4 Shuttle In/Out Switches

Two switches are used to sense the position of the tool changer shuttle and the arm that moves it. One switch is activated when the shuttle 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.

## 5.5 Geneva Wheel Position Mark

The turret rotation mechanism has a switch mounted so that it is activated for about 30° of travel of the Geneva mechanism. When activated, this switch indicates that the turret is centered on a tool position. This switch is normally closed. The diagnostic display will show this status of this input switch as "TC MRK". A "1" indicates the Geneva wheel is in position.

## 5.6 Tool #1 Sense Switch

The tool rotation turret has a switch that is activated when tool one is in position or facing towards the spindle. At POWER ON this switch can indicate that tool #1 is in the spindle. If this switch is not active at power-on, the first tool change will rotate the turret until the switch engages and then move to the selected tool. The diagnostic display will show this status of this input switch as "TOOL #1". A "1" indicates that tool #1 is in position.

## 5.7 Tool Change Sequence

When a tool change operation is performed, the following sequence of events occurs:

- 1) If coolant is **on**, turn it **off**,
- 2) A rapid Z motion to machine zero is started,
- 3) If the spindle is turning, it is commanded to stop,
- 4) Pause until spindle is stopped,
- 5) Spindle orientation speed is commanded forward,
- 6) Pause until spindle is at orientation speed,
- 7) Command spindle lock air solenoid active,
- 8) Pause until spindle locked status is active and stable,
- 9) Pause until Z rapid motion is complete,
- 10) Command tool shuttle IN,
- 11) Pause for max shuttle start time or NOT OUT status,
- 12) Alarm and stop if still OUT status,
- 13) Pause for max shuttle end time or IN status,



- 14) Alarm and stop if not IN status,
- 15) Command shuttle power off,
- 16) Command tool unclamp air solenoid active,
- 17) Start Z motion up by Parameter 71 amount and Parameter 72 speed,
- 18) Pause for draw bar open status or max delay time,
- 19) Alarm and stop if draw bar not open,
- 20) Command rapid Z up to ref position by Parameter 64,
- 21) Wait for Z motion to complete,
- 22) Start Geneva rotation in shortest direction to tool,
- 23) Pause for max start time or Geneva mark status off,
- 24) Alarm and stop if still Geneva status,
- 25) Pause for max end time or Geneva mark status on,
- 26) Alarm and stop if no Geneva status,
- 27) If at correct tool, command rotation off, else go 19,
- 28) Start rapid Z down to home plus Parameter 71,
- 29) Command tool unclamp air solenoid off,
- 30) Start Z down to zero at Parameter 72 speed,
- 31) Wait for tool clamped status or max delay,
- 32) Alarm and stop if draw bar open,
- 33) Command spindle lock air solenoid off,
- 34) Command tool shuttle OUT,
- 35) Pause for max shuttle start time or NOT IN status,
- 36) Alarm and stop if still IN status,
- 37) Pause for max shuttle end time or OUT status,
- 38) Alarm and stop if not OUT status,
- 39) Command shuttle power off,
- 40) If coolant was on at start, turn it back on.



## 6. Air Supply

Connect a minimum 100 PSI at 4 CFM minimum air supply to the machine. The air gauge/regulator should indicate 85 +/- 2 pounds per square inch. The minimum I.D. supply hose size is 3/8" and minimum fittings are 1/4 NPT. Do not hook this machine up to small light duty house/garage type compressors as the tool changer will not function properly. A one H.P. compressor with a 20-gallon tank that turns on when pressure drops to 100 PSI is the minimum to use. When the machine is operating and the pressure gauge drops by more than 10 PSI during tool changes, you do not have sufficient capacity.

### 6.1 Air Regulator

At the rear of the mill, there is an air pressure regulator. This regulator should be set to 85 PSI. It supplies air to the tool unclamp piston, spindle orientation lock, and gear changer.

The air regulator contains a reservoir of light oil that is used to add an oil mist to the air lines. In addition, when the air pressure drops very low, the water trap will dump any water.

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.

### 6.2 Low Air Pressure Sense Switch

A low air pressure sensor and switch, located on the spindle head, monitors the pressure coming out of our regulator. If the pressure drops below 75 PSI for more than one second, an alarm will be generated. The diagnostic display will show the status of this input switch. A "1" indicates an open circuit or low air pressure. The normal one-second delay on the alarm is actually set by Parameter 76.



## 7. Spare User M Code Interface

The M code interface uses outputs 17 to 24 and one discrete input circuit. M codes M21 through M27 will activate relays 17 through 23. These relay contacts are isolated from all other circuits and may switch up to 120V AC at one amp. The relays are SPDT.

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 eight 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:

M21      A timing diagram showing a single pulse starting at time 0 and ending at time .05 sec. The signal is high during this period and low thereafter.

M-FIN      A timing diagram showing a single pulse starting at time 0 and ending at time .05 sec. The signal is high during this period and low thereafter.

CNC:      running | waiting | .05 sec | waiting | running

The Diagnostic Data display page may be used to observe the state of these signals.

### 7.1 M Function Relays

As of January 1991, there is no longer a requirement for a separate M function relay board. The IOPCB contains position for eight relays (M21-M28) and six of these are installed. In addition, 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.

### 7.2 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 millamps of current. M-FIN is discrete input #10 and is wired from input #10 on the Inputs PCB on the Input/Output Assembly. 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.

### 7.3 Turning M Functions On And Off

The eight optional M code relays can also be separately turned on and off using M codes M51-M58 and M61-M68. M51 to M58 will turn on one of the eight relays and M61 to M68 will turn the relays off. M51 and M61 correspond to M21, etc.



## 8. 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.

The wiring for the door switches is wired in either of two paths. The first one applies to machines built before March 1990; this uses connector P5 at the side of the cabinet and routes the wires past the oiler and through the base of the mill. The second wiring routes through the front panel support arm and down through the top of the plastic enclosure.

If the doors are open, you will not be able to start a program. Door hold will not stop a tool change operation, will not turn off the spindle, and will not turn off the coolant pump.

The door hold function can be temporarily disabled with Setting 51, but this setting will return to OFF when the control is turned off.

## 9. Way Covers

The way covers are very important in keeping the ball screws and guides clean and to keep coolant and chips out of the motors and encoders.

Do not use air pressure to clean way covers joints as this will only force the small chips inside the machine. Wipe off with a rag.



## 10. Coolant Tank And Pump

Connect the coolant tank power and pipe fittings to the machine. Fill the tank with 20 gallons of coolant (30 gallons for optional tank). The coolant pump is a gear type and needs coolant for lubrication. An alternate pump is a sump type. Running the pump for even a few minutes without coolant will damage the pump. The pump is interlocked against running with a low coolant alarm. Do not defeat its purpose. The pump can be disabled through the Setting page. The power connector is the bottom plug on the control side of the cabinet. All wiring to the coolant pump and sensor is through P7 on the side of the control cabinet.

**WARNING!!!** There is HIGH VOLTAGE at the coolant tank and pump any time the pump is connected and the control is powered on. Do not work on the pump with it connected to the control. Be careful to disconnect the coolant pump from the control or to power off the control before working on the coolant tank.

### 10.1 Coolant Tank

Coolant: Water Soluble, Synthetic, or Cutting Oil, 20 Gallons (30 gallons for optional tank). Do not use additives, kerosene, MEK, or other solvents. Every six months replace coolant and thoroughly clean tank. Be careful to disconnect the coolant pump from the control or to power off the control before working on the coolant tank.

### 10.2 Coolant Pump

1/4 H.P., 20 Gallons Per Minute, 230V AC, single-phase.

### 10.3 Low Coolant Sense Switch

When less than five gallons of coolant remain in the tank, an alarm will be generated. This alarm will not occur until the end of a program is reached. There is no low pressure sensor associated with the coolant. This alarm is not installed on machines manufactured after March 1992.

### 10.4 Coolant Pump Circuit Breaker

An overload of the coolant pump may blow circuit breaker CB3. This circuit breaker is located inside the rear cabinet at the upper right hand corner. CB3 controls only the 230V AC to the coolant pump.



## 11. Way and Screw Lubrication Pump

Way Lube: Medium Way Lube Vactra #2 or Equivalent. Add Oil through the large cap at the top.

### 11.1 Lubrication Tank

The lubrication tank has a capacity of one quart. That should be enough for 100 hours continuous running on time to the VMC. The mist lube comes from a different tank.

### 11.2 Lubrication Pump

The lubrication pump is powered whenever the spindle is on or any axes are in motion. It operates from 115V AC On a cyclic basis, it will pump oil to the screws and guides. It cycles at least once every 30 minutes.

### 11.3 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 90000. 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.

### 11.4 Oil Mist

The oil mist lubricator is located with the air pressure regulator at the lower rear of the mill.

The oil mist lubricator releases oil into the main air line whenever air is released from any of the air cylinders. These include the tool unclamp, spindle orientation, and gear changes. The most frequent is a tool release for a tool change.

The oil mist lubricator should be set to approximately one drop per 10 tool changes. The sight glass indicator is turned CW to decrease flow. Over oiling or use of solvent/penetrant type oils will shorten O-ring life. Add oil through the large screw at the top. Disconnect the air pressure first.

Oil mist lubricator: Mobil DTE 25 or equivalent only. Add oil through the large screw at the top. Disconnect the air pressure first. On machines built after October 1, 1992, the oil mist lubricator supply comes from the way lube tank, and does not need to be refilled.



## **12. Operator's Lamp**

A low voltage operator's lamp is mounted to the spindle head. Power to this lamp is supplied through a low voltage transformer and an overcurrent protection breaker. The operator's lamp is aimed at approximately the center of the work area and can be rotated slightly up and down for different setups.

### **12.1 Fuse For Lamp**

Fuse FU6 supplies power to transformer T2. It is rated at  $\frac{1}{2}$  amp at 230V AC.

### **12.2 Low Voltage Operator's Lamp**

The operator's lamp is a 12V, 50 watt, high intensity lamp. It is mounted inside the plastic enclosure, high, on the right side of the spindle. It is sealed against coolant and, since it is a low-voltage lamp, is safe in combination with water-based coolants.

### **12.3 Lamp On/Off Switch**

An on/off switch is supplied for the operator's lamp. It is located on the side of the control cabinet below all of the motor connectors.



## 13. Supply Voltage Sensor

A sensor circuit on the SDIST circuit board is used to monitor the voltage applied to the control. It actually monitors the DC buss voltage developed for the servo drives. When this voltage drops below a set point, an alarm is generated. The voltage being monitored is rectified from the 115V AC secondary of transformer T1. Cable 980 carries the analog voltage from the SDIST PCB to the MOTIF PCB.

### 13.1 Supply Voltage Display

The Diagnostic Data display page is used to display this voltage. It has a range of zero to 200V DC. If the machine is wired for 230V AC, a primary service voltage of 230V will provide a secondary voltage of about 120V; that will produce a servo buss voltage of about 168V DC.

Note that load variations on the servo motors and spindle drive will cause slight variations in this display. If the voltage varies by more than 10V under load, it indicates that the wiring to the control is dropping too much voltage and may need a larger gauge wire.

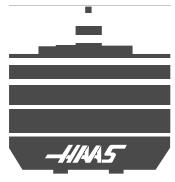
### 13.2 Low Voltage Trip Point

If this voltage drops below the following limits:

205V AC when wired for nominal 230V AC service  
190V AC when wired for nominal 208V AC service

an alarm will be generated. The sensor actually converts the servo DC buss analog voltage to digital and monitors the digital value. Both alarm trip points correspond to 140V DC on the servo buss.

If one leg of the three-phase incoming power is lost, there may not be an alarm. In this case, the machine may turn off completely, the electronics may shut down, or the servos and the video monitor may shut off.



## 14. Under/Over Voltage Sensors

An overvoltage sensor monitors the DC servo motor buss. When this voltage exceeds 185V DC, a load is applied to the servo buss. That load is called the regen load resistor. When this voltage exceeds 190V DC, an alarm is generated and machine operation stops. If the voltage remains between these two values for more than a few seconds, an overtemperature alarm may be generated. That alarm is caused by an overheat of the regen resistor.

The overvoltage alarm will be generated for different input service voltages depending on how the machine is configured. The following limits apply:

- 260V AC when wired for nominal 230V AC service
- 235V AC when wired for nominal 208V AC service

It is also possible that an overvoltage condition will be detected first by the spindle drive. This would initially show only a "spindle drive fault". A check of the status on the spindle drive LED's will show what the actual alarm is.

In controls built after April 1990, there is an undervoltage sensor that monitors the voltage of all three inputs' power phases. If this voltage drops below 180V AC for 208 input or drops below 200 for 230 input for any phase, an alarm will be generated. This phase sensor is built into the IOPCB circuit board in the lower left hand corner of the control.



## 15. X, Y, and Z Limit Switches

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 look-ahead 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 POWER UP or 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.

### 15.1 Auto Search For Zero

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.

Auto search for zero in the Z-axis is followed by a rapid move from the limit switch position down to the tool change position. This makes the Z-axis a little different from the other axes. The position found with the limit switch is not machine zero but is the position used to pull tools out of the spindle. Machine zero for Z is below this by Parameter 64. Be careful during the Z zero search and stay clear of that rapid move.

### 15.2 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.



## 16. Two-Speed Gear Transmission (VF-1, VF-2, VF-3)

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.

### 16.1 Gear Box Lubrication

Gear Box: Mobil DTE 25 oil.

The spindle is air-pressurized oil drip lubricated. The gear box uses an oil sump in the VF-1, VF-2, and VF-3. The VF-0 has no gearbox. The VF-1, VF-2, and VF-3 spindles are cooled by gear oil. The VF-0 spindle is air-cooled.

### 16.2 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.

### 16.3 Gear Box Sense Switches

On the VF-1, VF-2, and VF-3, 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".

### 16.4 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, go 8,
- 9) Turn off high and low gear solenoids.



## 17. Spindle Orientation

Orientation of the spindle is automatically performed for tool changes and can be programmed with **M19**. Orientation is performed by turning the spindle slowly until an air pressure driven pin drops into a detent and locks the spindle in place. This pin is located behind the spindle motor and above the gear box. If the spindle is oriented and locked, commanding spindle forward or reverse will release the lock.

### 17.1 Spindle Orientation Lubrication

The spindle orientation mechanism does not require regular lubrication.

### 17.2 Spindle Orientation Air Solenoid

A solenoid controls the air valve supplying pressure to the orientation lock pin. The diagnostic display can be used to display the status of the relay output and the switch inputs. Circuit breaker CB4 will interrupt power to this solenoid.

### 17.3 Spindle Orientation Sense Switch

A normally-closed switch is used to sense when the pin drops in to lock the spindle. When the pin drops, the switch opens indicating orientation is complete.

The normally-closed side of the same switch is wired to the spindle drive and commands it into the Coast Stop condition. This is done to make sure that the spindle motor is not powered when the pin is locking the spindle.

### 17.4 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) Command spindle lock air solenoid active,
- 6) Pause until spindle locked status is active and stable,
- 7) If not locked after time-out time, alarm and stop.



## 18. 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), from the keyboard, and from the button on the front of the spindle head. The two manual buttons only operate in MDI or JOG modes.

### 18.1 Tool Clamp/Unclamp Air Solenoids

A single solenoid controls the air pressure to release the tool clamp. This corresponds to relay 14. When the relay is activated, 115V AC is applied to the solenoid. This applies air pressure to release the tool. Relay 14 is on relay card #2, relay #6. Circuit breaker CB4 will interrupt power to this solenoid.

### 18.2 Tool Clamp/Unclamp Sense Switches

There are two switches 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 up 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.

### 18.3 Remote Tool Unclamp Switch

The Remote Tool Unclamp switch is mounted on the front of the cover to the spindle head. It operates the same as the button on the keyboard. It must be held for  $\frac{1}{2}$  second before the tool will be released and the tool will remain released for  $\frac{1}{2}$  second after the button is released.

While the tool is unclamped, air is forced down the spindle to clear chips, oil, or coolant away from the tool holder.



## 19. Control Panel Assembly

All normal operations of the mill are controlled from the control panel. It consists of a 12" video monitor, a plastic membrane keypad, a JOG handle, and several additional switches. All wiring to the control panel is routed through the support tube leading out to the control panel. Access to the inside of the control panel assembly requires removing all of the screws on the rear cover and removing the cover plate. DO NOT do this with power **on** or the main circuit breaker **on**. **CAUTION !!! THERE ARE DANGEROUS VOLTAGES PRESENT WHEN THE MAIN CIRCUIT BREAKER IS ON.**

### 19.1 Video Display Monitor

The video display monitor is a CRT that displays both text and graphics simultaneously. Text is either 40 or 80 columns wide and 25 lines high. Graphics is 640 pixels wide and 350 pixels high. The screen frame rate is 50 Hz. The microprocessor writes directly to the screen memory and there is no limit to the update rate. Most data displays are updated at least 10 times per second. The CRT may have a very high voltage present for several minutes even after turning the control off. **ONLY QUALIFIED PERSONNEL SHOULD WORK ON THE CONTROL PANEL.**

Brightness and hold adjustments to the CRT can be made by removing the rear cover of the front panel.

### 19.2 Printed Membrane Matrix Keypad

The keypad is a matrix of wires where a key press connects together a horizontal and a vertical wire. These keys are sequentially scanned at least 50 times per second. There is no key rollover so a key must be released before a second is pressed. The CYCLE START and FEED HOLD buttons are scanned in the same manner as the keypad.

Problems with the keypad can be caused by a broken wire that would disable an entire row or column of buttons, or by a shorted button that will cause an alarm at power-on and prevent any other keyboard keys from being processed. A shorted button will generate Alarm 158 at power-on.

### 19.3 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.

### 19.4 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 but this voltage is present any time the main circuit breaker is on.

## 19.5 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 (see Section 28) should also agree with the load meter within 5%.

There are four types of spindle drive that might be used in your control. They are all equivalent in performance but are adjusted differently. These drives are: Fuji, Mitsubishi Z200, Mitsubishi Z300, and Yaskawa.

With the Fuji drive, there are two adjustments to the spindle load meter. The coarse adjustment is inside the front control panel and is pot R1. It is set at the factory and should not need adjustment.

With the Mitsubishi drive, pot R1 in the front panel is used to adjust the load meter to match the screen display shown in diagnostics. The panel of the drive is used to adjust the screen load readout. The Mitsubishi drive is not normally shipped with the adjustment panel (called a parameter unit). The adjustments are permanently stored in the control. Your dealer will have this panel. The Mitsubishi Z300 drive comes with a control panel.

The Yaskawa drive is adjusted similarly to the Mitsubishi drive.

## 19.6 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 shuttle should become jammed, the control will automatically come to an alarm state. To correct this, push the EMERGENCY STOP button and remove the cause of the jam. 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.



## 19.7 Keyboard Interface PCB (KBIF)

The Keyboard Interface PCB provides interconnection among the front panel switches, connectors, and keypad and contains adjustment pots for load meter (R1) and beeper volume (R2). Access to these adjustment pots requires removing the rear cover of the Control Panel. The connectors used are:

- P1 34-pin cable to VIDEO (700)
- P2 24-pin flat ribbon to printed matrix keypad
- P3 START button and FEED HOLD button
- P4 Meter in and out (730)
- P5 Speaker

## 19.8 Keyboard Beeper

There is a speaker inside the control panel that is used as an audible response to pressing keyboard buttons and as a warning beeper. The beeper is a one 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-shutdown is about to occur and when the "BEEP AT M30" setting is selected. The volume of this beeper can be adjusted from pot R2 on the Keyboard Interface PCB inside the control panel. Controls built after January 1991 have this volume adjustment permanently set to **high**.

If the beeper is not audible when buttons are pressed, the problem could be in either the keypad or in the speaker. Check that the problem occurs with more than one button and check that the speaker volume is not turned down.



## 20. Auxiliary Axes Interface

Besides the four directly controlled axes in this control, up to five additional external positioning axes may be added. These axes may be commanded directly from the program using the B, C, U, V, and W axis codes. Commands to these axes are only allowed in a G00 or G01 block. Connection to these axes is done through the second RS-232 port to one or more HAAS single axis controls. The Setting page is used to select the number of auxiliary axes with Setting 38. The machine position display will show the present position of these axes.

Name in CNC:	axis select:	Servo Control Parameter 21:
B	5	Y
C	6	Z
U	1	U
V	2	2
W	3	3

There are no work offsets for these axes as all commands are in the machine coordinate system, but if a displaced zero position has been entered into the HAAS servo control, that position will be used as zero. On power-up of the CNC, the auxiliary axes controls will also be initialized.

Auxiliary axes communication is recommended at 4800 baud, seven data bits, even parity, two stop bits. Setting 50 in the CNC must be set to XON/XOFF. Setting 54 in the CNC should be 4800.

CNC  
Setting 38 value:      External Auxiliary axes:

0	none
1	B
2	B and C
3	B, C, and U
4	B, C, U, and V
5	B, C, U, V, and W

- Parameter 26 in the servo control must be set to 5 for 4800 baud.
- Parameter 33 in the servo control must be set to 1 for Xon/Xoff.
- Parameter 12 in the servo control must be set to 3 to prevent circular wraparound.

The cable connecting the CNC to the single-axis control must wire at least pins 1, 2, 3, and 7 directly from the second (lower) serial port of the CNC to the upper connector of the servo control.



## 21. Spindle

### 21.1 Spindle Maintenance

The spindle is air-pressurized oil drip lubricated. The gear box uses an oil sump in the VF-1, VF-2, and VF-3. The VF-0 has no gearbox. The VF-1, VF-2, and VF-3 spindles are cooled by gear oil. The VF-0 spindle is air-cooled. If the spindle is not run for more than seven days, break in at S300 for two hours before use. Contact dealer for service of these items.

The spindle accepts either CAT40 or BT40 type tools only. Changing between these two is a factory-required operation.

### 21.2 Spindle Operation

Speed speed is selectable from 1 to 7500 RPM. For the VF-1, VF-2, and VF-3, speeds at and below 1250 RPM automatically select low gear. Speeds at and above 1251 RPM automatically select high gear. 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.

### 21.3 Spindle Position Encoder

If the rigid tapping option is installed, a position encoder is connected to the spindle. It must be enabled with Parameter 57 and Parameter 79 must be set to the correct steps-per-revolution count.



## 22. RS-232 Interface

Programs are sent or received through the first RS-232 port located on the rear control box pendant side. All data sent or received is ASCII. In order to use this port, you will need to obtain a cable and connectors with the following wiring:

Pin #1	Shield Ground	Pin #2	TXD-Transmit Data
Pin #3	RXD-Receive Data	Pin #4	RTS (Optional)
Pin #5	CTS (Optional)	Pin #7	Signal Ground.

All other pins are optional and are not usually used. The RS-232 connector is A DB-25 and is wired as a DCE. This means that we send data on the RXD wire and receive data on the TXD wire. The simplest connection would be to an IBM PC that can be done with a standard cable made up of a DB-25 male on one end and a DB-25 female on the other. Pin 1 at one end is wired to Pin 1 at the other end, pin 2 to pin 2, etc.

In controls built after November 1989, the opposite wiring is true. Those controls are wired as DTE. This means that we send data on the TXD wire and receive data on the RXD wire. This wiring is more like that of other CNC controls.

All RS-232 data is ASCII but the number of bits, parity and speed can be changed from settings. Once the connection to your computer has been made and verified, go to the Setting page and set the baud rate, parity, number of data bits, number of stop bits, end of block (EOB) format, and leader parameters to match your requirements.

All programs sent to the control must begin with a line containing a single **%** and must end with a line containing a single **%**. All programs sent by the control will have the **%**.

To receive a program, push the LIST PROG key. Move the cursor to the word "ALL" and push the RECV RS-232 key and the control will receive all main and subprograms until it receives a **%** sign indicating end of input. Please note that all of your programs must have an address **Oxxxx** to be loaded this way. If you do not have a program number, type in the program number before you push RECV RS-232 and the program will be stored under that number. You can also select an existing program for input and it will be replaced. An ASCII EOF character will also terminate input.

When receiving RS-232 data, there is a status message at the bottom of the screen. It will update as follows:

WAITING	When you first press RECV RS232
LOADING	When first <b>%</b> is received
LOADING Onnnn	When program name is received
RS232 DONE	When complete and last <b>%</b> received
RS232 ABORT	When anything causes abnormal stop

To send a program, use the Cursor as above to select the program and push the SEND RS-232 key. You can select "ALL" to send all of the programs in memory. A setting can be turned on to add spaces to the RS-232 output and improve the readability of your programs.

The protocol used to send data to slower computers is selected from the Setting page. Transmission can be stopped with either the X-ON/X-OFF characters or the RTS/CTS wires.

(Cont'd)



## 22. RS-232 Interface (Cont'd)

Parameters, settings, and offsets may also be sent individually via RS-232 by selecting the LIST PROG mode, selecting the desired display screen, and pushing the SEND key. They can be received by pushing the RECEIVE key.

The settings that control RS-232 are:

- 11 BAUD RATE
- 12 PARITY
- 13 STOP BITS
- 14 SYNCHRONIZATION
- 24 LEADER TO PUNCH
- 25 EOB PATTERN
- 37 NUMBER DATA BITS

Port number 2 on the side cabinet is dedicated to auxiliary axes communication. See Section 20 for details.



## 23. Spindle Motor

The spindle motor for models VF-0, VF-1, and VF-2 is a five horsepower continuous, three-phase, induction motor. It can operate at 7.5 horsepower for up to 30 minutes. The spindle motor for the VF-3 is a 7.5 horsepower continuous, three-phase, induction motor. It can operate at 10 horsepower for up to 30 minutes. The spindle drive provides a variable frequency power source in order to vary the motor speed. At 60 Hertz, the motor will rotate at just below 1800 RPM.

### 23.1 Power To Spindle Motor

Power to the spindle motor is supplied by a variable frequency inverter. This motor driver can supply 150% load for 30 minutes. Speed commands are accurate down to about 100 RPM. Since there is a 4-to-1 transmission, this means that accurate spindle speeds are possible down to about 25 RPM.

### 23.2 Spindle Motor Overheat Sense Switch

There is a normally closed thermal switch in the spindle motor. This switch will cause an alarm when it reaches 210° F. This alarm reads as "Spindle Drive Fault".



## 24. Microprocessor Assembly

The microprocessor assembly is in the rear cabinet at the top left position. It contains three large boards. They are: 68020, VIDEO, and MOTIF. 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. They are 157 and 158. In addition, while the control is operating, it continually tests itself and a self test failure will generate Alarm 152.

### 24.1 Microprocessor PCB (68020)

The Microprocessor PCB contains the 68020 processor running at 16 MHz, between 128K and 512K bytes of EPROM, and between 128K and 384K bytes of CMOS 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 pots 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.<br>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.<br>If this light comes on, there is a serious problem with the processor PCB. Check that all of the EPROM's are plugged in. Test the card with the buss connectors off.  |
| POR  | Power-on-reset complete.<br>If this light does not come on, there is a serious problem with the processor PCB. Check that all of the EPROM's are plugged in. Test the card with the buss connectors off.   |
| SIO  | Serial I/O initialization complete.<br>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.<br>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.<br>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.<br>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 check that all of the EPROM's are plugged in. |



## RUN

Program running without fault exception.

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 is a two-position DIP switch on the processor PCB called S1. Position S1-1 must be ON to auto-start the CNC operational program. If S1-1 is OFF, the PGM light will remain off. Switch S1-2 is used to change the default data rate for power-up communications. If the switch is OFF, the rate is 9600; if S1-2 is ON, the rate is 38400.

The processor connectors are:

- P1 Address buss
- P2 Data buss
- P3 Serial port #1 (for upload/download/DNC) (850)
- P4 Serial port #2 (for auxiliary 5th axis) (850A)
- P5 Power connector
- P6 Battery
- P7 Battery
- P8 -12V DC / NMI\* / ext clk

## 24.2 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. Connectors P6 and P7 on the processor PCB can be used to connect an external battery.

## 24.3 Video and Keyboard PCB (VIDEO2)

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       | P4 | Keyboard (700)                        |
| P2 | Address buss          | P5 | EGA extended video connector (option) |
| P3 | Video connector (760) | P6 | Data buss                             |

## 24.4 Motor Interface PCB (MOTIF)

The Motor Interface PCB provides all of the interfaces to motors and discrete inputs and outputs. It contains a single pot R54 to adjust the output of the D-A converter. The MOTIF PCB connectors are:

- P1 Data buss
- P2 X drive control and overcurrent sense (610)
- P3 Y drive control and overcurrent sense (620)
- P4 Z drive control and overcurrent sense (630)

(Cont'd)



## 24.4 Motor Interface PCB (MOTIF) (Cont'd)

- P5 A drive control and overcurrent sense (640)
- P6 X-axis encoder, Z, home, and overheat (660)
- P7 Y-axis encoder, Z, home, and overheat (670)
- P8 Z-axis encoder, Z, home, and overheat (680)
- P9 A-axis encoder, Z, home, and overheat (690)
- P10 32 discrete inputs (550)
- P11 Relay drives 1 to 8 (510)
- P12 Relay drives 9 to 16 (520)
- P13 Relay drives 17 to 24 (530)
- P14 Relay drives 25 to 32 (540)
- P15 Power connector (+5,+12+)
- P16 D-to-A output and -12V DC (720)
- P17 A-to-D inputs for DC buss voltage (980)
- P18 Jog Crank input and aux 1,2 (750)
- P19 Address buss
- P20 Spindle encoder inputs (1000)
- P21 A-to-D input for spindle temperature (1020)
- P22 A-to-D input for spindle load monitor (730B)
- P23 A-to-D input spare
- P24 Home switch inputs X, Y, Z (990)
- P25 Spare inputs
- P26 A-to-D input spare
- P27 A-to-D inputs spare
- P28 A-to-D inputs spare
- P29 A-to-D inputs spare



## 25. Servo Drive Assembly

The servo drive assembly is on the left side of the main control cabinet and about halfway down. Never work on the servo drive assembly until the small red CHARGE light goes out. 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. This assembly contains four servo drive cards, a Servo Distribution card, and a fan.

### 25.1 160 Volt DC Power Supply

The Servo Distribution card contains a DC power supply that produces an unregulated voltage between 145 and 175 volts. This is derived from the three-phase 115V AC coming from transformer T1. The nominal 160V DC is supplied to the four servo drive cards for the X, Y, Z, and A axes and to the tool changer. This supply is filtered by two capacitors in parallel for a total of 4000 Mfd. A soft charge-up of these capacitors is provided by a small resistor that is bypassed by a relay when the servos are on.

The negative side of the 160V power supply is always connected to chassis ground. This means that when the relays on SDIST are released, all DC power is disconnected and the drives are safe. This also includes the tool changer that uses the 160V buss to drive the tool changer motors.

The minimum DC buss voltage is 145V and anything lower will result in an alarm. The maximum voltage is 185V and anything above this will cause heating of the servo regen load resistor. Anything above 190V will cause an alarm.

### 25.2 Servo Cooling Fan

There is a cooling fan on the servo drive assembly to help cool the servo drive cards. It blows air up past the servo drive cards in order to support convection cooling. The fan power is supplied from SDIST by P7.

### 25.3 Servo Distribution PCB (SDIST)

The Servo Distribution PCB is used to provide the 160V DC buss for the servo drives, the low voltage AC power for the drives, and to monitor the supply voltage for the servos.

There are three pots on this card. They are:

- R2     This pot adjusts the buss voltage at which the regen load resistor is applied as a load to the power supply. This will consume any excess power causes by the regenerative effects of decelerating the servo motors. This should be set to turn on the load between 183 and 187V DC.
- R11    This pot adjusts the fraction of the buss voltage that is sent to the Motor Interface PCB A-to-D converter. This is a full scale 5V input and the program will interpret full scale as 200V on the buss.
- R15    This pot adjusts the voltage at which an overvoltage alarm discrete is generated. This should be set to alarm between 188 and 192V DC (about 265 AC).

(Cont'd)



## 25.3 Servo Distribution PCB (SDIST) (Cont'd)

The red "CHARGE" LED is also mounted on the SDIST PCB. It indicates that the supply capacitors still contain a charge. The discharge resistors provide a load through this LED. It will dim and appear off when the voltage is below 20 volts.

The connectors on the SDIST PCB are:

- P1 Low voltage AC power to X drive card (570)
- P2 Low voltage AC power to Y drive card (580)
- P3 Low voltage AC power to Z drive card (590)
- P4 Low voltage AC power to A drive card (600)
- P5 12V DC from power supply (860)
- P7 115V AC to fan
- P8 160V DC supply to tool changer
- P9 Voltage monitor to A-D (980)
- P10 Regen load resistor (920)
- P11 Relay #1 contacts from IOPCB (110)
- P12 Overvoltage status to IOPCB (970)
- P13 Ground fault detect signal to IOPCB (1060)
- TB1 Three phase 115V AC to SDIST
- TB2 +160V DC and return to each servo drive card

There are three fuses mounted on the SDIST PCB; FU1 and FU2 protect the primaries of the fan and transformers T1, T2, T3 and T4. They are ½ amp, 240V AC, AGC type. FU3 protects the regenerative load circuit from a short circuit.

## 25.4 Servo Drive PCB's (DRIVER)

The servo drive PCB's are **H** drive with PWM control. There are eight states used in the **H** drive providing free-wheeling current during PWM and very low current ripple. The PWM frequency is 16 kHz. All drive cards are current limited at 20 to 22 amps. They operate from a nominal supply voltage of 160 volts. The peak power output is thus about 3000 watts, or 4 H.P. The continuous power output is, however, limited by a microprocessor based fuse setting, overcurrent shutdown, and motor thermal protection. Short circuit protection is provided by the drive card and, if sustained for over 0.01 second, the microprocessor will shut the servo drives off and generate an alarm.

The motor output circuit is fuse protected at 20 amps but this will only blow if there is a drive failure as the current limit circuit is much faster than the fuses.

The PWM signal is provided by the Motor Interface PCB along with direction and **H** drive state control. The processor also monitors the overcurrent status from the drive card.

The connectors on the servo drive cards are:

- P1 160V DC from SDIST PCB
- P2 low voltage AC power from SDIST PCB
- P3 PWM and H drive control signals from Motor Interface and overcurrent sense back
- P4 Power connection to servo motor



There are three fuses on each servo drive card. One is in series with each leg of the servo motor. These fuses are type ABC and are rated at 20 amps, 200V DC. A third fuse on each driver card limits the plus (+) side of the power supplied to each card; this fuse is an ABC, 250V, 10A.

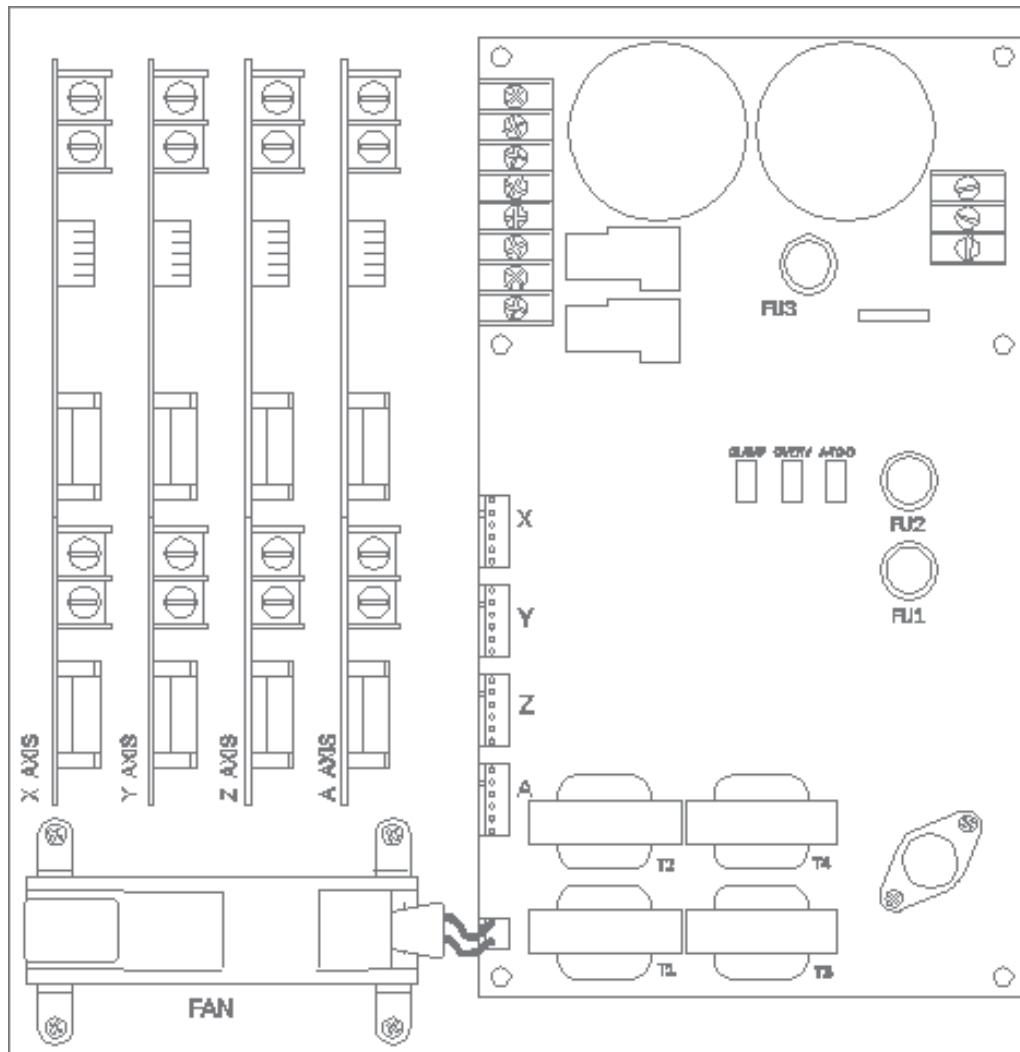


Fig. 27-1 Servo Drive Assembly.



## 26. Input/Output Assembly

The Input/Output Assembly consists of a single printer circuit board called the IOPCB. It contains the following connectors:

The IOPCB contains a circuit for electronically turning the tool changer power on and off. This prevents any arcing of the tool changer relays and increases their life tremendously. This includes an adjustable current limit to the tool changer. Potentiometer R45 adjusts the current limit to the tool changer motors. R45 should be set to limit current to between four and six amps.

The IOPCB also contains a circuit for sensing a ground fault condition of the servo power supply. If more than 0.5 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.

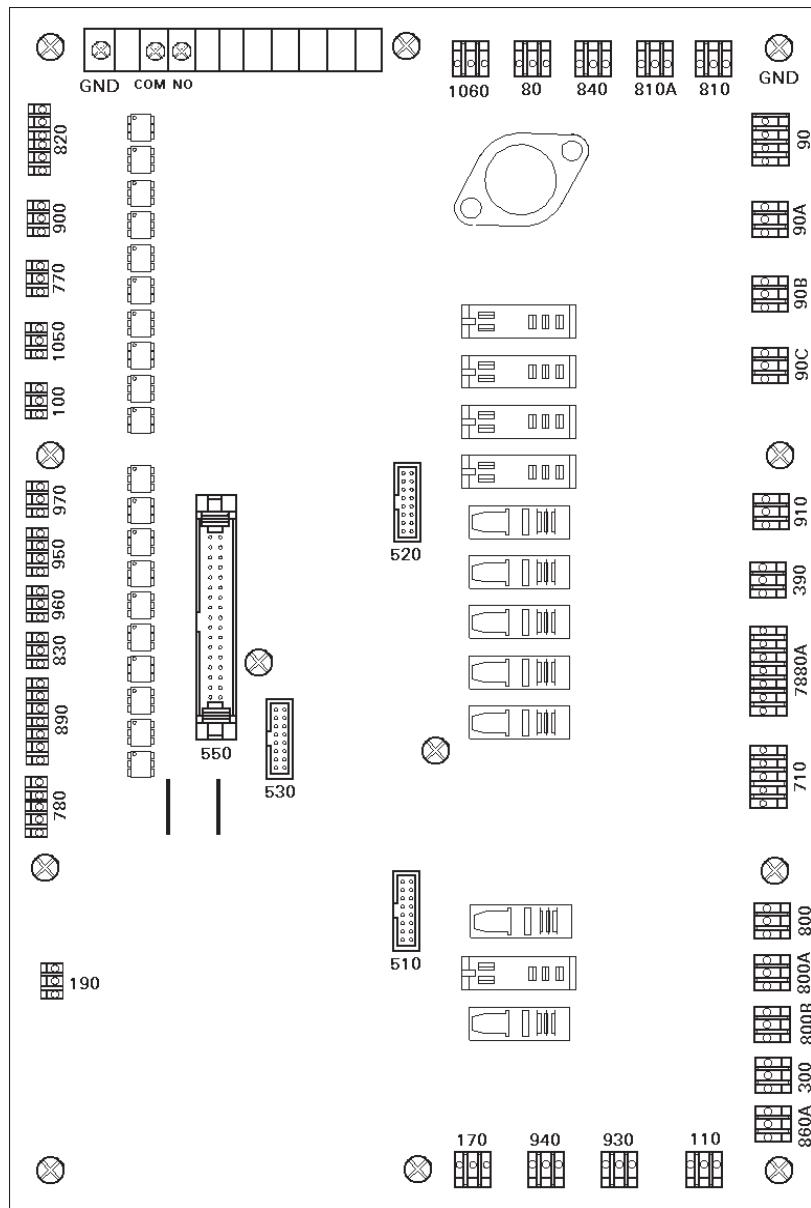
Relay K6 is for the coolant pump 230V AC. It is a plug-in type and is double-pole. Relays K9 through K12 are also plug in types for controlling the tool changer.

The connectors on the IOPCB are:

- P1 16-pin relay drivers from MOTIF 1 to 8 (510)
- P2 16-pin relay drivers from MOTIF 9 to 16 (520)
- P3 16-pin relay drivers from MOTIF 17 to 24 (M21-M28) (530)
- P4 34-pin inputs to MOTIF (550)
- P5 Servo power on relay 1-1 (110)
- P6 230V AC from CB3 (930)
- P7 230V AC to coolant pump (940)
- P8 Auto-off relay 1-7 (170)
- P9 Spindle drive commands (710)
- P10 Spindle fan and oil pump 115V AC (300)
- P11 +12V DC from power supply (860A)
- P12 115V AC to spindle head solenoids (880)
- P13 Tool changer status inputs (820)
- P14 Low coolant input (900)
- P15 Spindle head status inputs (890)
- P16 Emergency stop input (770)
- P17 Low Lube input (960)
- P18 Low Voltage Input (970)
- P19 Low Air Input (950)
- P20 Overheat input (830)
- P21 Spindle drive status inputs (780)
- P22 M-FIN input (100)
- P23 Remote Unclamp input (tool release) (190)
- P24 Spare inputs 21-24 (790)
- P25 Spare inputs 31-32 (200)
- P26 Spare terminals for M21 to M24
- P27 M28 output
- P28 115V AC from CB4 (910)
- P29 A-axis brake solenoid output (390)
- P30 Tool changer shuttle motor output (810A)
- P31 FU5 connection for tool changer (840)
- P32 160V DC for tool changer (80)
- P33 115V AC three-phase input from power supply assembly (90)



- P34 115V AC to CRT (90A)
- P35 115V AC to heat exchanger (90B)
- P36 115V AC to CB4 (90C)
- P37 115V AC to oiler (870)
- P38 Door open (1050)
- P39 Tool changer turret motor output (810)
- P40 12V AC from lamp transformer (800)
- P41 Operator lamp switch connection (800A)
- P42 12V AC to operator lamp (800B)
- P43 Ground fault sense signal input (1060)
- P44 M25 output
- P45 M26 output
- P46 M27 output
- P47 Skip input signal





## 27. Power Supply Assembly

All power to the control passes through the power supply assembly. Main incoming power is brought to this assembly and any fuses or circuit breakers that might trip in operation are located on this assembly. It is located on the upper right corner of the control cabinet.

### 27.1 Main Circuit Breaker CB1

Circuit breaker CB1 is rated at 30 amps 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. These 30 amps could correspond to as much as 15 horsepower.

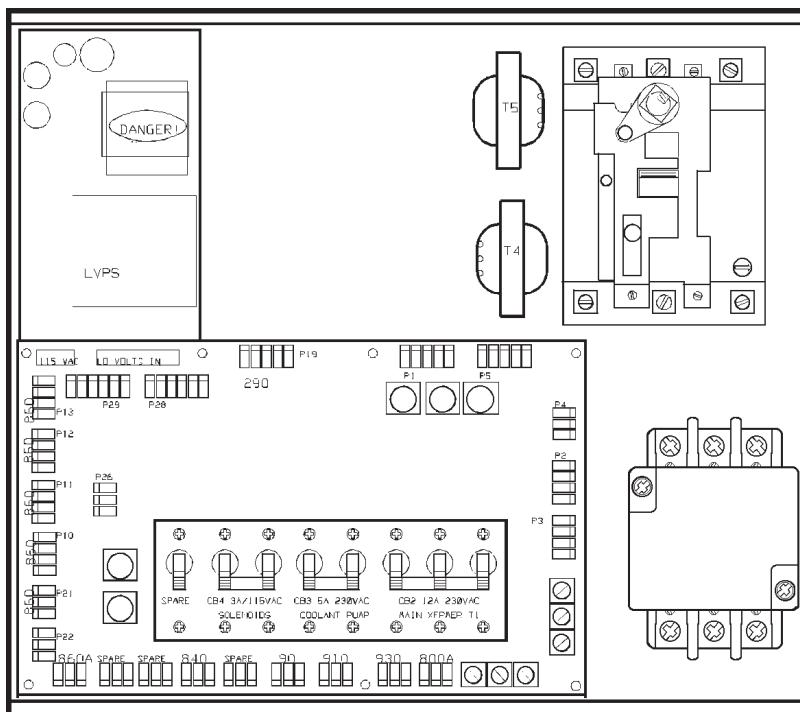


Fig. 27-1 Power Supply Assembly.

### 27.2 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, an auxiliary switch 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 1/2 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 1/2 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.

## 27.3 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 is provided to the processor assembly through three carrying +12V/+5V/Gnd. The +5, +12, and -12V power is supplied to other circuits through TB2.

## 27.4 Power PCB (POWER)

The low voltage power distribution and high voltage fuses and circuit breakers are mounted on a circuit board called the POWER PCB (See Fig. 27-1). The following connectors are on it:

- P1 Five-pin brings 230V AC three ph from main breaker
- P2 On/Off connections to front panel (740)
- P3 Coil and aux connections to contactor K1
- P4 Auto-off connection to IOPCB (170)
- P5 Low voltage control transformer to power K1
- P6 230V AC from CB3 to coolant pump (930)
- P7 115V AC from CB4 to IOPCB for solenoids
- P8 115V AC from IOPCB for low voltage supply and solenoids (910)
- P9 Tool changer fuse circuit from FU5 to IOPCB (840)
- P10 +5/+12/Gnd form low volt supply to logic boards (860)
- P11 +5/+12/Gnd form low volt supply to logic boards (860)
- P12 +5/+12/Gnd form low volt supply to logic boards (860)
- P13 +5/+12/Gnd form low volt supply to logic boards (860)
- P14 12V AC to operator's lamp (800)
- P15 230V AC from contactor K1 for coolant pump (70)
- P16 Low voltage power from power supply
- P17 +12V DC to IOPCB (860A)
- P18 Not used
- P19 Connector to op. lamp transformer T4 (290)
- P20 115V AC to low voltage supply
- P21 -12V DC to processor PCB
- P22 -12V DC to MOTIF PCB
- P23 Spare circuit breaker CB5
- P24 Spare fuse FU7
- P25 Spare fuse FU8
- P26 +12V DC option connector
- P27 +5/+12/Gnd form low volt supply to logic boards (860)
- P28 Option connector for alternate supply
- P29 Option connector for alternate supply

For older internal transformer with 208/230 taps:

- TB1 230V AC from contactor K1
- TB2 230V AC to T1 primary

(Cont'd)



## 27.4 Power PCB (POWER) (Cont'd)

For newer internal transformer with 200/215/235/250 taps

TB1 115V AC from T1 secondary

TB2 115V AC to servo assembly and IOPCB

The POWER PCB contains three fuses that will blow if the voltage applied to the control exceeds about 280V. This may be caused by a line transient or a lightning strike. Power must be shut off this way in order to protect the rest of the machine. In the event that these fuses blow, you should check the line voltages (all three phases), replace the fuses, and continue operation. No other equipment in the control should be damaged by such an overvoltage condition.

## 27.5 Power-Up Low Voltage Control Transformer (T5)

In controls built after November 1989, the low voltage control transformer, T5, supplies power to the coil of the main contactor T1. 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.

## 27.6 Secondary Circuit Breakers

Five more circuit breakers are on the Power supply assembly.

In older controls, CB2 controls the power to the servo transformers and, if tripped, will turn off the CRT, cooling fans, servo motors, and air solenoids. It might be blown by a severe servo overload. In newer controls, CB2 controls the 115V AC from the T1 secondary.

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.

CB4 controls the 115V AC to the air solenoids, 4th axis brake, and the oiler. It is never expected to trip. If it does trip, it is likely caused by a short circuit in the wiring on the I/O assembly or the wiring to the solenoids on the spindle head.

## 27.7 Operator's Lamp Transformer

Transformer T2 supplies low voltage to the operator's lamp. The primary is 115V AC and the secondary is 10V AC. The primary is protected at ½ amp by F6. It is connected to the POWER PCB by connector P19.



## 28. Spindle Drive Assembly

The spindle drive is located in the main cabinet on the right side and halfway down. It has a blue cover on it. The spindle motor drive is a Fuji model Fmd 3AC-21A, a Mitsubishi Z200, a Mitsubishi Z300, or a Yaskawa G3. It operates from three-phase 200 to 240V AC. It has a 5 H.P. continuous rating, a 7.5 H.P. five-minute rating, and a 9 H.P. one-minute rating. The spindle drive is protected by CB1 at 30 amps. 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.

The three types of spindle drives that can be used in this control are all equivalent in performance but are adjusted differently.

For all other data on the spindle drives, refer to the supplied documentation for your drive.



## 29. Resistor Assembly

The Resistor Assembly is located near the center of the control cabinet. It contains the servo and spindle drive regen load resistors.

### 29.1 Spindle Drive Regen Resistor

A 20- or 30-ohm, 600-watt resistor 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° 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.

### 29.2 Servo Drive Regen Resistor

A 500-ohm, 100-watt resistor 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° 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.

### 29.3 Overheat Sense Switch

There is an overtemperature sense switch mounted near the above-mentioned regen resistors. This sensor is a normally-open switch that opens at about 100° C. It will generate an alarm and all motion will stop. After four minutes of an overheat condition, an automatic shutdown will occur in the control.



## 30. Power Transformer Assembly (T1)

The power transformer assembly is used to convert three-phase 230/208V to three-phase 115V. The 115V is used primarily by the servo drives. The video monitor, solenoids, fans, and oiler also use 115V AC. This transformer's maximum input voltage is 260V @ 60 Hertz, and 240V @ 50 Hertz. It is located in the main cabinet in the lower right corner. It is a polyphase bank transformer. It is rated at 3750 VA and its primary is protected at 12 amp.

In controls built after December 1991, this transformer is replaced by one that is much larger and can adjust the primary voltage applied to the spindle drive. The new transformer has four voltage connections that allow for a range of inputs from 195V to 260V (See Fig. 30-1).

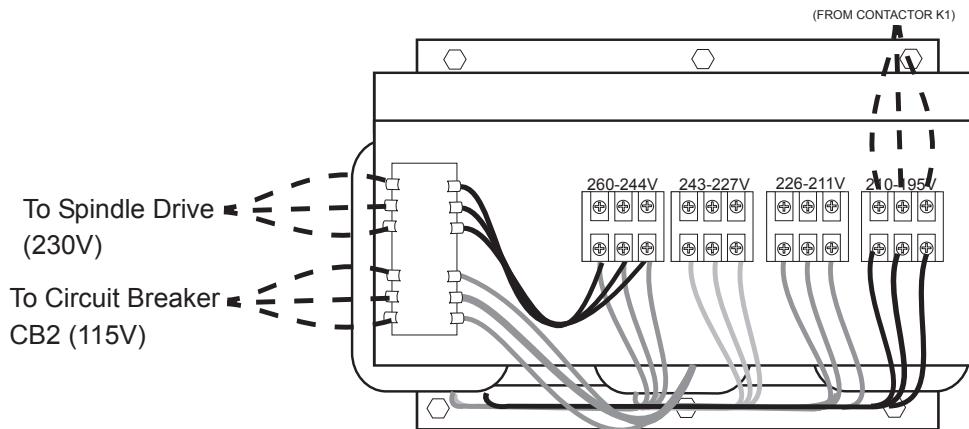


Fig. 30-1    Newer polyphase bank transformer assembly.

### 30.1 Primary Connection To T1

Input power to T1 is supplied from the power assembly through CB2; a 12 amp, three leg magnetic circuit breaker. Three-phase 230 to T1 is connected to the first three terminals of TB10. With the newer transformer, CB2 protects the secondary of transformer T1 and is rated at 25 amps.

The newer transformer acts as an auto-transformer and thus has an output connection on its primary side. This connection supplies 230V AC power to the spindle drive and coolant pump.

### 30.2 Voltage Selection Taps

With the older main transformer, terminal block TB11 is used to select the 208 or 230V taps of transformer T1. To select between 208 and 230, three terminals must be moved. The two positions for each of these terminals are marked 208 and 230.

With the newer transformer, 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.

### 30.3 Secondary Connection To T1

The secondary output from T1 is 115V AC three-phase. It is available on the last three terminals of TB10.



## 31. 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.

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. If you need to change parameters, contact your dealer. An explanation of each of the parameters is provided here.

### 31.1 Parameter List

There are 150 parameters in this control. The first 56 apply to the individual servo axes, 14 each. The first 14 of these will be described. The other axes' parameters (15 through 56) are identical in function.

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:

REV ENCODER Used to reverse the direction of encoder data.

REV POWER Used to reverse direction of power to motor.

DISABLED Used to disable any axis.

Z CH ONLY With **A** only, indicates that no home switch.

AIR BRAKE With **A** only, indicates that air brake is used.

DISABLE Z T Disables encoder **Z** test (for testing only).

SERVO HIST Graph of servo error (for diagnostics only).

INV HOME SW Inverted home switch (N.C. switch).

INV Z CH Inverted **Z** channel (normally high).

CIRC. WRAP. With **A** only, causes 360 wrap to return to 0.

NO I IN BRAK With **A** only, removes **I** feedback when brake is active.

LOW PASS +1X Adds 1 term to low pass filter.

LOW PASS +2X Adds two terms to low pass filter.

OVER TEMP NC Selects a normally closed overheat sensor in motor.

CABLE TEST Enables test of encoder signals and cabling.

Z TEST HIST History plot of **Z** channel test data.

SCALE FACT/3 Scale ratio is interpreted as divided by 3.

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/INCH)

The number of steps of the encoder per inch of travel. Encoder steps supply



four times their line count per revolution. Thus a 2000 line encoder and a 6mm pitch screw give:

$$2000 \times 4 \times 25.4 / 6 = 33867$$

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 and 2000 line encoder and 6 mm pitch screw give: <b>20.0 x 33867 = 677340</b>
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.
Parameter	10	X	FUSE LEVEL	Fuse level in % of max power to motor. Applies only when motor in motion.
Parameter	11	X	BACK EMF	Back EMF of motor in volts per 1000 RPM times 10. Thus a 63 volt/KRPM motor gives 630.
Parameter	12	X	STEPS/REVOLUTION	Encoder steps per revolution of motor. Thus a 2000 line encoder gives: <b>2000 x 4 = 8000.</b>
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/INCH)	See Parameter 5 for description.

(Cont'd)



### 31.1 Parameter List (Cont'd)

- |           |    |   |  |
|-----------|----|---|--|
| Parameter | 20 | Y | MAX TRAVEL (STEPS)<br>See Parameter 6 for description. |
| Parameter | 21 | Y | ACCELERATION<br>See Parameter 7 for description.       |
| Parameter | 22 | Y | MAX SPEED<br>See Parameter 8 for description.          |
| Parameter | 23 | Y | MAX ERROR<br>See Parameter 9 for description.          |
| Parameter | 24 | Y | FUSE LEVEL<br>See Parameter 10 for description.        |
| Parameter | 25 | Y | BACK EMF<br>See Parameter 11 for description.          |
| Parameter | 26 | Y | STEPS/REVOLUTION<br>See Parameter 12 for description.  |
| Parameter | 27 | Y | BACKLASH<br>See Parameter 13 for description.          |
| Parameter | 28 | Y | DEAD ZONE<br>See Parameter 14 for description.         |
| Parameter | 29 | Z | SWITCHES<br>See Parameter 1 for description.           |
| Parameter | 30 | Z | P GAIN<br>See Parameter 2 for description.             |
| Parameter | 31 | Z | D GAIN<br>See Parameter 3 for description.             |
| Parameter | 32 | Z | I GAIN<br>See Parameter 4 for description.             |
| Parameter | 33 | Z | RATIO (STEPS/INCH)<br>See Parameter 5 for description. |
| Parameter | 34 | Z | MAX TRAVEL (STEPS)<br>See Parameter 6 for description. |
| Parameter | 35 | Z | ACCELERATION<br>See Parameter 7 for description.       |
| Parameter | 36 | Z | MAX SPEED<br>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	BACK EMF 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 set 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/INCH) See Parameter 5 for description
Parameter	48	A	MAX TRAVEL (STEPS) See Parameter 6 for description
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

(Cont'd)



## 31.1 Parameter List (Cont'd)

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  
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:

REV CRANK Reverses direction of jog handle.  
DISABLE T.C. Disables tool changer operations.  
DISABLE G.B. Disables gear box functions.  
POF AT E-STOP Causes power off at EMERGENCY STOP.  
RIGID TAP Indicates hardware option for rigid tap.  
REV SPIN ENC Reverses sense direction of spindle encoder.  
REPT RIG TAP Selects repeatable rigid tapping.  
EX ST MD CHG Selects exact stop in moves when mode changes.  
SP DR LIN AC Enables display of Z channel test plot.  
OVER T IS NC Selects control over temp sensor as N.C.  
SKIP OVERSHT Causes Skip (G31) to act like Fanuc and overshoot sense point.  
NONINV SP ST Non-inverted spindle stopped status.  
SP LOAD MONI Spindle load monitor option is enabled.  
SP TEMP MONI Spindle temperature monitor option is enabled.  
ENA ROT & SC Enables rotation and scaling.  
ENABLE DNC Enables DNC selection from MDI.  
ENABLE BGEDT Enables BACKGROUND EDIT mode.  
ENA GRND FLT Enables ground fault detector.  
KEYBD SHIFT Enables use of keyboard with shift functions.  
ENABLE MACRO Enables macro functions.  
INVERT SKIP Invert sense of skip to active low=closed.  
HANDLE CURSR Enable use of jog handle to move cursor.  
NEG WORK OFS Selects use of work offsets in negative direction.  
SPIN COOLANT Enables spindle coolant pressure sense.  
SIDE MNT. TC Enables side mount T.C. logic.  
OILER ON/OFF Enables oiler power when servos or spindle is in motion.  
NC OVER VOLT Inverts sense of over voltage signal.  
ALT CHAR SET Enables alternate character set on CRT.  
DOOR STOP SP Enables functions to stop spindle and manual ops 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	MAX FEED RATE (UNIT) 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.
Parameter	61	TURRET STOP DELAY Maximum delay allowed in motion of tool turret. Units are milliseconds. After this time, an alarm is generated.
Parameter	62	SHUTTLE START DELAY Maximum delay allowed in start of tool shuttle. Units are milliseconds. After this time, an alarm is generated.
Parameter	63	SHUTTLE STOP DELAY Maximum delay allowed in motion of tool shuttle. Units are milliseconds. After this time, an alarm is generated.
Parameter	64	TOOL CHANGE OFFSET For Z-axis; displacement from home switch down to tool change position and machine zero. About 4.6 inches so for a 2000 line encoder this gives: <b>4.6 x 33867 = 155788</b>
Parameter	65	NUMBER OF TOOLS Number of tool positions in tool changer. This number must be 16 for the present VMC configuration.
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 DELAY Maximum delay allowed when clamping and unclamping tool. Units are milliseconds. After this, time an alarm is generated.
Parameter	69	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.

(Cont'd)



## 31.1 Parameter List (Cont'd)

Parameter 72

DRAW BAR Z VEL CLAMP

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 5000/256 RPM.

Parameter 74

SP LOW G/MIN SPEED

Command speed used to rotate spindle motor when orienting spindle in low gear. Units are 5000/256 RPM.

Parameter 75

GEAR CHANGE SPEED

Command speed used to rotate spindle motor when changing gears. Units are 5000/256RPM.

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

stable

Required time in milliseconds that the spindle lock must be in place and before spindle orientation is considered complete.

Parameter 78

GEAR CHANGE REVERSE 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 hard 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. After this time, operation will continue anyway.

Parameter 81

M MACRO CALL O9000

**M** code that will call O9000. Zero causes no call.

Parameter 82

M MACRO CALL O9001 same as 81

Parameter 83

M MACRO CALL O9002 same as 81

Parameter 84

M MACRO CALL O9003 same as 81

Parameter 85

M MACRO CALL O9004 same as 81

Parameter 86

M MACRO CALL O9005 same as 81

Parameter 87

M MACRO CALL O9006 same as 81

Parameter 88

M MACRO CALL O9007 same as 81

Parameter 89

M MACRO CALL O9008 same as 81

Parameter 90

M MACRO CALL O9009 same as 81



Parameter	91	G MACRO CALL O9010 <b>G</b> code that will call O9010. Zero causes no call.
Parameter	92	G MACRO CALL O9011 same as 91
Parameter	93	G MACRO CALL O9012 same as 91
Parameter	94	G MACRO CALL O9013 same as 91
Parameter	95	G MACRO CALL O9014 same as 91
Parameter	96	G MACRO CALL O9015 same as 91
Parameter	97	G MACRO CALL O9016 same as 91
Parameter	98	G MACRO CALL O9017 same as 91
Parameter	99	G MACRO CALL O9018 same as 91
Parameter	100	G MACRO CALL O9019 same as 91
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.
Parameter	102	IN POSITION LIMIT Y Same definition as Parameter 101.
Parameter	103	IN POSITION LIMIT Z Same definition as Parameter 101.
Parameter	104	IN POSITION LIMIT A Same definition as Parameter 101.
Parameter	105	HOLDING LIMIT X Fuse level in % of max power to motor. Applies only when motor is stopped.
Parameter	106	HOLDING LIMIT Y Same definition as Parameter 105.
Parameter	107	HOLDING LIMIT Z Same definition as Parameter 105.
Parameter	108	HOLDING LIMIT A Same definition as Parameter 105.
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.

(Cont'd)



## 31.1 Parameter List (Cont'd)

Parameter 113	X ACC/DEC T CONST Exponential acceleration time constant. Units are 1/10000 seconds. This parameter provides for a constant ratio between profiling lag and servo velocity. It is also the ratio between velocity and acceleration. In conjunction with Parameter 7, it defines the speed above which exponential accel/decel is not provided. Thus if Parameter 7 is 1200000 steps/sec/sec and this parameter is 750 (0.075 seconds); the maximum velocity for accurate interpolation should be: <b>1200000 x 0.075 = 90000 steps/second</b> For a 2000 line encoder and 6 mm screw, this would be 60 x 90000 / 33867 = 159 inches min
Parameter 114	Y ACC/DEC T CONST Same definition as Parameter 113
Parameter 115	Z ACC/DEC T CONST Same definition as Parameter 113
Parameter 116	A ACC/DEC T CONST Same definition as Parameter 113
Parameter 117	LUB CYCLE TIME If this is set non-zero, 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 steps/ms/ms for spindle motor.
Parameter 121	X BEMF BIAS Back EMF bias for <b>X</b> motor. This is arbitrary units.
Parameter 122	Y BEMF BIAS See Parameter 121 for description.
Parameter 123	Z BEMF BIAS See Parameter 121 for description.
Parameter 124	A BEMF BIAS See Parameter 121 for description.
Parameter 125	X GRID OFFSET This parameter shifts the effective position of the encoder <b>Z</b> 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	SPIN. Y TEMP. COEF. This parameter controls the amount of correction to the Y-axis in response to heating of the spindle head. It is 10 times the number of encoder steps per degree F.
Parameter 133	SPIN. Z TEMP. COEF. This parameter controls the amount of correction to the Z-axis in response to heating of the spindle head. It is 10 times the number of encoder steps per degree F.
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 $34/33867 = 0.001$ inch.
Parameter 138	X FRICTION FACTOR
Parameter 139	Y FRICTION FACTOR
Parameter 140	Z FRICTION FACTOR
Parameter 141	A FRICTION FACTOR 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.

(Cont'd)



## 31.1 Parameter List (Cont'd)

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.
Parameter 145	X ACCEL FEED FORWARD	This parameter sets the feed forward gain for the X-axis servo. It has no units.
Parameter 146	Y Same as Parameter 145.	
Parameter 147	Z Same as Parameter 145.	
Parameter 148	A Same as Parameter 145.	
Parameter 149	PRE-CHARGE DELAY	This parameter sets the delay time from pre-charge to tool release. Units are milliseconds.
Parameter 150	Max spindle RPM in	

## 31.2 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.

## 31.3 Settings

The setting page contains parameters that the user may need to change and that control machine operation. A complete list with descriptions is listed in the Programming and Operator's Manual. Most settings can be changed by the operator. The settings are preceded by a short description on the left and the value on the right. In general, settings allow the operator or setup person to lock out or turn on specific functions.

Use the vertical cursor keys to move to the desired setting. Depending on the setting, you may change it by entering a new number or, if the setting has specific values, press the horizontal cursor



The serial number is Setting 26 on this page and is protected from user change. If you need to change this setting, contact HAAS or your dealer.

One of the more commonly adjusted settings will be Setting 34, the "Rotary Axis Diameter". This setting is used to control the surface feed rate when the fourth axis is used in a cutting feed. Feeding with the **X**, **Y**, or **Z** and the **A** axes assumes that the linear motion is along the axis of the rotary motion. When this is true and the diameter setting is correct, the programmed surface feed rate will be correct for helical cuts. In addition, feeds of just the A-axis depend on this setting to determine the correct angular rate.

## 31.4 Setting Up a Fourth Axis

Installing a fourth axis in this machine requires that the servo control parameters be set for the type of fourth axis that you have. Any of the HAAS servo rotary products may be used but there are different parameter settings for each. If the fourth axis is purchased with the VMC, the parameters will be set correctly for that indexer. If the indexer is purchased at a later time, we will supply a list of parameter settings.

Once the parameters have been entered, be sure to turn parameter lock back on (Setting 7). The fourth axis can be disabled and re-enabled easily from the Setting 30. NEVER CONNECT OR DISCONNECT THE FOURTH AXIS CABLE WHILE THE CONTROLLER IS POWERED ON. When turning the control on after connecting the fourth axis, be sure to enable it from Setting 30 BEFORE doing an AUTO POWER UP or AUTO ALL AXES. When turning the control on after disconnecting the fourth axis, be sure to turn off Setting 30 BEFORE doing an AUTO POWER UP or AUTO ALL AXES.

The following parameters are to be used on the Haas VMC for fourth axis operation. The first Parameter (43) is a series of one-bit flags. These apply to 1000-line encoders only. Make sure that the rotary axis is also enabled from Setting 30 and the rotary axis diameter is set correctly with Setting 34. These apply to CNC software revision 3.5 and later.

Parameter:	S5C	7RT	9RT	MS5C
43:				
rev enc	1	1	1	1
rev pow	0	0	0	0
no l dec	0	0	0	0
disabled	0	0	0	0
Z ch only	1	0	0	1
air brake	0	1	1	0
dis Z tst	0	0	0	0
history	0	0	0	0
invert Ho	0	1	1	0
invert Z	0	0	0	0
circ wrap	0	0	0	0
no l brak	0	1	1	0
lo pass +1x	1	1	1	1
lo pass +2x	0	0	0	0
over temp NC	1	1	1	1

(Cont'd)



## 31.4 Setting Up a Fourth Axis (Cont'd)

encoder E	S5C	7RT	9RT	MS5C
Parameter:				
44	8	8	8	8
45	150	200	200	200
46	64	64	64	64
47	800	1600	2000	800
48	480000	480000	480000	480000
49	600000	240000	240000	320000
50	240000	128000	160000	160000
51	2000	2000	2000	2000
52	25	30	30	30
53	210	370	370	370
54	4000	4000	4000	4000
55	0	6	6	30
56	0	0	0	0
69	0	1000	1000	0
104	100	100	100	100
108	5	5	5	5
112	0	0	0	0
116	750	750	750	750
124	15	15	15	15

For a 4th and 5th axis arrangement, the single axis control must have Parameter 21 set to 5 and Parameter 26 set to 5. The mill control Setting 38 must also be set to 1.



## 32. Cable List

The following is a summary of the cables used in the wiring of this control:

WIRE/ TERMINAL NUMBER	FUNCTION NAME:
GND	INCOMING EARTH GROUND #8 -FROM INCOMING POWER GROUND -TO CHASSIS GROUND -TO 160V DC RETURN -TO SHIELD OF ALL BULK CABLES -TO LOGIC RETURN (D GROUND 65)
L1	INCOMING 230V AC, PHASE 1, TO CB1-1 #10
L2	INCOMING 230V AC, PHASE 2, TO CB1-2 #10
	L3 INCOMING 230V AC, PHASE 3, TO CB1-3 #10
L4	230V AC, PHASE 1, CB1 TO K1-1 #10
L5	230V AC, PHASE 2, CB1 TO K1-2 #10
L6	230V AC, PHASE 3, CB1 TO K1-3 #10
R/L7	230V AC FROM K1 TO SPINDLE DRIVE, PHASE 1 #10
S/L8	230V AC FROM K1 TO SPINDLE DRIVE, PHASE 2 #10
T/L9	230V AC FROM K1 TO SPINDLE DRIVE, PHASE 3 #10

(1 thru 32 are internally connected via #24 ribbon)

1	INPUT 1 ; SHUTTLE IN
2	INPUT 2 ; SHUTTLE OUT
3	INPUT 3 ; TOOL POSITION 1
4	INPUT 4 ; LOW COOLANT
5	INPUT 5 ; TURRET MARK
6	INPUT 6 ; SPINDLE IN HIGH
7	INPUT 7 ; SPINDLE IN LOW
8	INPUT 8 ; EMERGENCY STOP
9	INPUT 9 ; TOOL IN TURRET
10	INPUT 10 ; M-FIN *
11	INPUT 11 ; OVER VOLTAGE *
12	INPUT 12 ; LOW AIR
13	INPUT 13 ; LOW LUBRICATION
14	INPUT 14 ; OVERHEAT *
15	INPUT 15 ; DRAW BAR OPEN
16	INPUT 16 ; DRAW BAR CLOSED
17	INPUT 17 ; SPINDLE MARK/LOCK
18	INPUT 18 ; SPINDLE DRIVE FAULT +12
19	INPUT 19 ; SPINDLE STOPPED * ( FROM +12)
20	INPUT 20 ; SPINDLE AT SPEED * (FROM +12)
21	INPUT 21 ; Lo Oil
22	INPUT 22 ; Spare.
23	INPUT 23 ; Spare.

(Cont'd)



## 32. Cable List (Cont'd)

- 24 INPUT 24 ; Spare.  
25 INPUT 25 ; REMOTE TOOL UNCLAMP \*  
26 INPUT 26 ; AC LINE VOLTAGE LOSS PH1  
27 INPUT 27 ; AC LINE VOLTAGE LOSS PH2  
28 INPUT 28 ; AC LINE VOLTAGE LOSS PH3  
29 INPUT 29 ; SPARE  
30 INPUT 30 ; SPARE  
31 INPUT 31 ; SPARE  
32 INPUT 32 ; SPARE
- 65 INPUTS RETURN (LOGIC GROUND OR D GROUND)
- 66 MAIN CONTACTOR (K1) COIL A #20  
67 MAIN CONTACTOR (K1) COIL B #20
- 68 MAIN CONTACTOR (K1) AUX CONTACTS A #20  
69 MAIN CONTACTOR (K1) AUX CONTACTS B #20
- 71/L4 FUSED 230V AC (FROM MAIN CB1-4 TO K1-1) #10  
72/L5 FUSED 230V AC (FROM MAIN CB1-5 TO K1-2) #10  
73/L6 FUSED 230V AC (FROM MAIN CB1-6 TO K1-3) #10
- 74/R 230V AC (FROM MAIN CONTACTOR K1-4 TO T1) #12  
75/S 230V AC (FROM MAIN CONTACTOR K1-5 TO T1) #12  
76/T 230V AC (FROM MAIN CONTACTOR K1-6 TO T1) #12
- 77 230V AC FROM TRANSFORMER TO SPINDLE DRIVE #12  
78 230V AC FROM TRANSFORMER TO SPINDLE DRIVE #12  
79 230V AC FROM TRANSFORMER TO SPINDLE DRIVE #12
- 80 DISTRIBUTED 160V DC - SHIELD +2  
81 +160V DC HIGH VOLTAGE SUPPLY #16  
82 160V DC RETURN #16
- 90 115V AC FROM TRANSFORMER T1  
91/U STEPPED-DOWN 115V AC (FROM XFRMER T1) #12  
92/V STEPPED-DOWN 115V AC (FROM XFRMER T1) #12  
93/W STEPPED-DOWN 115V AC (FROM XFRMER T1) #12  
90A 115V AC TO CRT - SHIELD +2  
92 LEG 1 #16  
93 LEG 2 #16
- 94 STEPPED-DOWN TRANSFORMER TO PSUP BREAKER #12  
95 STEPPED-DOWN TRANSFORMER TO PSUP BREAKER #12  
96 STEPPED-DOWN TRANSFORMER TO PSUP BREAKER #12
- 90B 115V AC TO HEAT EXCHANGER - SHIELD +2  
91 LEG 1 #16  
93 LEG 2 #16



90C	115V AC TO CB4 - SHIELD +2
91	LEG 1 #16
92	LEG 2 #16
100	M-FIN (IOASM TO SIDE OF BOX)
101	LEG 1 #16
102	LEG 2 #16
110	SERVO POWER CONTROL - SHIELD +2
112	RELAY 1-1 COMMON (C1) ; SERVO POWER RELAY
113	RELAY 1-1 N.O.
170	AUTO OFF FUNCTION - SHIELD +2
172	RELAY 1-7 COMMON (C7) ; AUTO OFF
173	RELAY 1-7 N.O.
190	UNCLAMP FROM SPINDLE HEAD TO IOASM
191	INPUT 25
192	DIGITAL RETURN
200	SPARE ISOLATED INPUTS 31 thru 32
290	230V AC TO TRANSFORMER T2 (deleted 1-Aug-90)
300	115V AC TO SPINDLE MOTOR FAN
301	LEG 1 115V AC FUSED AT 3 A #18
302	LEG 2 115V AC FUSED AT 3 A #18
320	Not used
390	115V AC TO 4TH AXIS BRAKE - SHIELD +2
391	LEG 1 #18
392	LEG 2 SWITCHED #18
400	SPINDLE DRIVE COAST COMMAND - SHIELD +2
401	LOGIC COMMON #20
402	SPINDLE COAST COMMAND #20
490	ALL WIRES CARRYING SERVO MOTOR DRIVE POWER (all #14)
491	X-AXIS FUSED MOTOR POWER + (P1-E)
492	X-AXIS FUSED MOTOR POWER - (P1-F)
493	Y-AXIS FUSED MOTOR POWER + (P2-E)
494	Y-AXIS FUSED MOTOR POWER - (P2-F)
495	Z-AXIS FUSED MOTOR POWER + (P3-E)
496	Z-AXIS FUSED MOTOR POWER - (P3-F)
497	A-AXIS FUSED MOTOR POWER + (P4-E)
498	A-AXIS FUSED MOTOR POWER - (P4-F)
500	OVERTEMP SENSOR FROM SPINDLE MOTOR - SHIELD +2
501	OVERTEMP WIRE 1 #20 (N.C.)
502	OVERTEMP WIRE 2 #20
510	RELAY CARD 1 DRIVE CABLE - 16 WIRE RIBBON #24

(Cont'd)



## 32. Cable List (Cont'd)

- 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 (MOTIF-P10) 34 WIRE RIBBON #24
- 560 TO MICROPROCESSOR P8  
-12V FROM 862 AT SUPPLY TO P8-1 #24  
Gnd FROM 865 AT SUPPLY TO P8-4 #24
- 570 X AXIS DRIVER LOW VOLTAGE POWER - 6 WIRE RIBBON  
571 14V AC LEG 1 (DRIVER P2-1 #24)  
572 14V AC LEG 2 (DRIVER P2-2 #24)  
573 16V AC LEG 1 (DRIVER P2-3 #24)  
574 16V AC LEG 2 (DRIVER P2-4 #24)  
575 CHASSIS GROUND (DRIVER P2-5 #24)  
576 CHASSIS GROUND (DRIVER P2-6 #24)
- 580 Y AXIS DRIVER LOW VOLTAGE POWER  
(SAME AS 571 to 576)
- 590 Z AXIS DRIVER LOW VOLTAGE POWER  
(SAME AS 571 to 576)
- 600 A AXIS DRIVER LOW VOLTAGE POWER  
(SAME AS 571 to 576)
- 610 X AXIS DRIVER CONTROL CABLE - SHIELD +6  
611 LOW ENABLE\* (MOTIF P2-1) #24  
612 HIGH ENABLE\* (MOTIF P2-2) #24  
613 DRIVE DIRECTION (MOTIF P2-3) #24  
614 +5 VDC (MOTIF P2-4) #24  
615 OVERCURRENT SIGNAL (MOTIF P2-5) #24  
616 LOGIC RETURN (MOTIF P2-6) #24
- 620 Y AXIS DRIVER CONTROL CABLE - SHIELD +6  
(SAME AS 611-616)
- 630 Z AXIS DRIVER CONTROL CABLE - SHIELD +6  
(SAME AS 611-616)
- 640 A AXIS DRIVER CONTROL CABLE - SHIELD +6  
(SAME AS 611-616)
- 650 THREE PHASE POWER TO SPINDLE MOTOR - SHIELD +3  
651 LEG 1 OF 230V AC #14  
652 LEG 2 #14  
653 LEG 3 #14



660	X-ENCODER CABLE - SHIELD +7
661	LOGIC RETURN (D GROUND) #24
662	ENCODER A CHANNEL #24
663	ENCODER B CHANNEL #24
664	+5 VDC #24
665	ENCODER Z CHANNEL #24
666	HOME/LIMIT SW #24
667	OVERHEAT SWITCH #24
668	ENCODER A*
669	ENCODER B*
66T	ENCODER Z*
670	Y-ENCODER CABLE - SHIELD +7 (SAME AS 661-66T)
680	Z-ENCODER CABLE - SHIELD +7 (SAME AS 661-66T)
690	A-ENCODER CABLE - SHIELD +7 (SAME AS 661-66T)
700	KEYBOARD CABLE - 34 WIRE RIBBON WITH IDC (FROM VIDEO P4 TO KBIF P1)
710	FORWARD/REVERSE/RESET TO SPINDLE - SHIELD +4
711	FORWARD COMMAND (SP DR CN1-18 TO IO P9-4) #24
712	REVERSE COMMAND (CN1-19 TO IO P9-3) #24
713	RESET COMMAND (CN1-21 TO IO P9-2) #24
714	COMMON (CN1-14 TO IO P9-1) #24
720	ANALOG SPEED COMMAND TO SPINDLE - SHIELD +2
721	0 TO +10 VOLTS SPEED COMMAND (SPINDLE DRIVE CN1-1) #24
722	SPEED COMMAND REFERENCE (A GROUND) (CN1-17) #24
730	POWER METER FROM SPINDLE DRIVE TO KBIF - SHIELD +2
731	METER + (SPINDLE DRIVE CN1-5 TO KBIF) #24
732	METER - (CN1-6 TO KBIF) #24
730A	POWER METER FROM KBIF TO METER - SHIELD +2
733	METER + AFTER TRIM POT (KBIF TO METER) #24
734	METER - AFTER TRIM POT (KBIF TO METER) #24
730B	ANALOG SIGNAL FROM SPINDLE DRIVE LOAD MONITOR
731	SIGNAL 0..5V
732	GROUND
740	POWER ON/OFF CABLE TO FRONT PANEL - SHIELD +4
741	POWER ON SWITCH LEG 1 (24V AC) #24
742	POWER ON SWITCH LEG 2 #24 N.O.
743	POWER OFF SWITCH LEG 1 (24V AC) #24
744	POWER OFF SWITCH LEG 2 #24 N.C.

(Cont'd)



## 32. Cable List (Cont'd)

750	JOG-CRANK DATA CABLE - SHIELD +4
751	LOGIC RETURN (D GROUND) (65) #24
752	ENCODER A CHANNEL #24
753	ENCODER B CHANNEL #24
754	+5V DC #24
760	MONITOR VIDEO DATA CABLE - SHIELD +9 (all #24) (FROM VIDEO P3 TO CRT)
770	EMERGENCY STOP INPUT CABLE - SHIELD +2
771	SIGNAL (INPUT 8) #20
772	RETURN (D GROUND) (65) #20
780	STATUS CABLE FROM SPINDLE DRIVE - SHIELD +4
781	+12V DC (SPINDLE DRIVE CN1-25) #24
782	FAULT (INPUT 18 TO CN1-24) #24
783	AT SPEED (INPUT 20 TO CN1-23) #24
784	STOPPED (INPUT 19 TO CN1-22) #24
** 790 DELETED **	
790	AXIS ALARM INPUTS (OVERHEAT) - SHIELD +4
791	X-axis alarm (INPUT 21 from P1-L) #24
792	Y-axis alarm (INPUT 22 from P2-L) #24
793	Z-axis alarm (INPUT 23 from P3-L) #24
794	A-axis alarm (INPUT 24 from P4-L) #24
800	12V AC TO LAMP - SHIELD +2
801	UNSWITCHED LEG 1 #20
802	SWITCHED LEG 2 #20
800A	CABLE FOR LAMP SWITCH - SHIELD +2
800B	CABLE WITH 10V AC FROM TRANSFORMER T2 - SHIELD +2
810	TOOL CHANGER MOTORS - SHIELD +2 #20
811	TURRET MOTOR + (IO P30-2 TO P6-J) #14
812	TURRET MOTOR - (IO P30-1 TO P6-I) #14
810A	TOOL CHANGER MOTORS - SHIELD +2 #20
813	SHUTTLE MOTOR - (IO P30-4 TO P6-A) #14
814	SHUTTLE MOTOR + (IO P30-3 TO P6-B) #14
820	TOOL CHANGER STATUS - SHIELD +7
821	LOGIC RETURN (D GROUND) (P6-F/H/L/M) #24
822	GENEVA MARK (INPUT 5 TO P6-G) #24
823	TOOL #1 (INPUT 3 TO P6-E) #24
824	SHUTTLE IN (INPUT 1 TO P6-C) #24
825	SHUTTLE OUT (INPUT 2 TO P6-D) #24
830	OVERHEAT THERMOSTAT - SHIELD +2



831	OVERHEAT SIGNAL (INPUT 14) #20
832	OVERHEAT RETURN (D GROUND) (65) #20
840	CIRCUIT BREAKER FOR 160V DC - SHIELD +2
841	LEG 1 (TO 81) #14
842	LEG 2 #14
850	SERIAL PORT #1 INTERFACE CABLE (16 WIRE RIBBON #24)
850A	SERIAL PORT #2 INTERFACE CABLE (16 WIRE RIBBON #24)
860	+12V/+5V/Gnd POWER CABLES - 4 WIRE (all #18)
861	+12 VOLTS
862	-12 VOLTS FROM LOW V SUPPLY TO 68020 PCB
863	+5 VOLTS
864	-5 VOLTS
865	LOGIC POWER RETURN (D GROUND)
866	POWER GOOD SIGNAL FROM SUPPLY
860A	12 VOLT POWER TO IOPCB - SHIELD +2
861	+12 VOLTS
865	LOGIC POWER RETURN (D GROUND)
870	115V AC TO OILER - SHIELD +2
871	115V AC LEG 1 #18
872	115V AC LEG 2 #18
880	HIGH/LOW GEAR UNCLAMP/LOCK SOLENOID POWER - SHIELD +5
881	115V AC SOLENOID COMMON (IO P12-5) #18
882	HIGH GEAR SOLENOID (IO P12-4) #18
883	LOW GEAR SOLENOID (IO P12-3) #18
884	TOOL UNCLAMP SOLENOID (IO P12-2) #18
885	SPINDLE LOCK SOLENOID (IO P12-1) #18
886	PRE-CHARGE SOLENOID #18 (IO P12-7)
890	SPINDLE STATUS SWITCHES SHIELD +6
891	SIGNAL RETURN (D GROUND) (65) #24
892	HIGH GEAR (INPUT 6) #24
893	LOW GEAR (INPUT 7) #24
894	TOOL UNCLAMPED (INPUT 15) #24
895	TOOL CLAMPED (INPUT 16) #24
896	SPINDLE LOCKED (INPUT 17) #24
900	LOW COOLANT STATUS - SHIELD +2
901	LOW COOLANT SIGNAL (INPUT 4 TO P7-C) #20
902	LOW COOLANT RETURN (D GROUND) (65 TO P7-D) #20
910	115V AC CIRCUIT BREAKER TO SOLENOIDS - SHIELD +2
911	LEG 1 #18
912	LEG 2 #18

(Cont'd)



## 32. Cable List (Cont'd)

920	REGENERATIVE LOAD RESISTOR FOR SERVO - SHIELD +2
921	LEG 1 #18
922	LEG 2 #18
930	FUSED 230V AC FOR COOLANT PUMP - SHIELD +2
931	LEG 1 #14
932	LEG 2 #14
940	230V AC TO COOLANT PUMP - SHIELD +2
941	LEG 1 (P7-A) #14
942	LEG 2 (P7-F) #14
950	LOW AIR PRESSURE SENSOR - SHIELD +2
951	LOW AIR SIGNAL (INPUT 12) #20
952	LOW AIR RETURN (D GROUND) (65) #20
960	LOW LUB/DOOR OPEN SENSORS - SHIELD +4
961	LOW LUB SIGNAL (INPUT 13) #24
962	LOW LUB RETURN (D GROUND) (65) #24
963	DOOR OPEN SIGNAL (INPUT 9) #24
964	DOOR OPEN RETURN (D GROUND) (65) #24
970	LOW VOLTAGE SENSOR - SHIELD +2
971	LOW VOL SIGNAL (INPUT 11 FROM PMON P9-3) #24
972	LOW VOL RETURN (D GROUND) (PMON P9-4) #24
980	VOLTAGE MONITOR - SHIELD +2
981	VOLTAGE MONITOR 0 TO +5 (PMON P9-1 / MOTIF P17-1) #24
982	VOLTAGE MON RET (A GND) (PMON P9-2 / MOTIF P17-2) #24
990	HOME SENSORS - SHIELD +4
991	X HOME SWITCH (MOTIF P24-2 TO P5-B) #24
992	Y HOME SWITCH (MOTIF P24-3 TO P5-D) #24
993	Z HOME SWITCH (MOTIF P24-4 TO P5-L) #24
994	HOME SWITCH RETURN (MOTIF P24-1 TO P5-C) #24
1000	SPINDLE ENCODER CABLE - SHIELD +5
1001	LOGIC RETURN (D GROUND) (TO MOTIF P20-1) #24
1002	ENCODER A CHANNEL (TO MOTIF P20-2) #24
1003	ENCODER B CHANNEL (TO MOTIF P20-3) #24
1004	+5 VDC (TO MOTIF P20-4) #24
1005	ENCODER Z CHANNEL (TO MOTIF P20-5) #24
1020	SPINDLE TEMPERATURE SENSOR CABLE - SHIELD +3
1021	SIGNAL
1022	ANALOG RETURN
1023	+5 VOLTS TO SENSOR
1024	SHIELD GROUND
1030	SPINDLE LOAD RESISTOR - SHIELD +2
1031	REGEN LOAD RESISTOR FOR SPINDLE DRIVE (B1) #18
1032	REGEN LOAD RESISTOR FOR SPINDLE DRIVE (B2) #18



- |      |   |
|------|---|
| 1050 | DOOR SWITCH WIRING THRU SUPPORT ARM - SHIELD +2 |
| 1051 | DOOR OPEN SIGNAL (INPUT 9) #24                  |
| 1052 | DOOR OPEN RETURN (D GROUND) (65) #24            |
| 1060 | GROUND FAULT DETECTION SENSE INPUT              |
| 1061 | + INPUT FROM SENSE RESISTOR                     |
| 1062 | - INPUT FROM SENSE RESISTOR                     |
| 1070 | SKIP INPUT FROM SENSOR                          |
| 1071 |   |
| 1072 |   |



## 33. External Control Cabinet Connectors

The following is a list of the connectors on the side of the control cabinet:

Name	pins/type:	Function:
P1	14 Cannon	To X-axis servo motor
P2	14 Cannon	To Y-axis servo motor
P3	14 Cannon	To Z-axis servo motor
P4	17 Cannon	To A-axis servo motor
P5	11 Cannon	Home sensors and oiler
P6	14 Cannon	Tool changer
P7	7 Cannon	Coolant pump
P8	6 Molex	(switches from spindle head)
P9	6 Molex	(solenoids to spindle head)
P10	DB-25	First RS-232 port for up/download/dnc
P11	DB-25	Second RS-232 port for aux axes
P12	4-pin DIN	M21 and M-FIN

## 34. Spindle Load Monitor Function

In controls built with the Mitsubishi or Yaskawa spindle drives, there is an option to monitor the spindle drive load and provide a display on the CRT. This is done with the third A-to-D analog input channel. Cable 730B (or 1040) carries the analog voltage for spindle drive load from the drive to the MOTIF PCB. This function is not available with the Fuji drive.

## 35. Spindle Temperature Compensation Function

This control monitors the temperature of the spindle head and compensate for thermal expansion by shifting the Y- and Z-axis. A thermal sensor is added to the spindle head assembly and a display is provided in the diagnostics. This signal is input with the second A-to-D channel. Cable 1020 carries the supply voltage out to the sensor and returns the analog voltage to the MOTIF PCB.

The thermal sensor is mounted in the spindle head iron casting approximately halfway between the mounting rails and the spindle cartridge. It thus measures the average temperature of the spindle head. This provides a good estimate of the thermal expansion of the spindle in the Y-axis and an approximate measure of the expansion in the Z-axis.

Parameter 132 controls the coefficient of expansion for the Y-axis and Parameter 133 controls the coefficient of expansion for the Z-axis. These are signed numbers and are:

10 \* encoders counts per degree F (over 70°)

Thus a value of 40 will provide:

$$40 / 10 / 33867 \text{ inches per degree F} = 0.000118 \text{ inches per degree F}$$



# APPENDIX

## ASSEMBLY DRAWINGS & PARTS LISTS

ALL DRAWINGS APPLY TO VF-0, VF-1, AND VF-2 UNLESS SPECIFIED OTHERWISE.  
[TOOL CHANGER ASSEMBLIES APPLY TO ALL MACHINES.]

BASIC MACHINE ASSEMBLY .....	86
CASTING ASSEMBLIES .....	90
BASE ASSEMBLY .....	92
VERTICAL COLUMN ASSEMBLY .....	94
SADDLE ASSEMBLY .....	96
LEAD SCREW ASSEMBLY .....	98
SPINDLE ASSEMBLY .....	100
GEAR BOX ASSEMBLY (VF-1, VF-2) .....	102
DRY SUMP GEAR BOX ASSEMBLY (VF-1, VF-2) .....	106
PISTON SUB-ASSEMBLY .....	110
SHOT PIN SUB-ASSEMBLY .....	112
HARD TAPPING SUB-ASSEMBLY .....	114
TOOL RELEASE PISTON ASSEMBLY .....	116
VF-3 BASE ASSEMBLY .....	118
VF-3 COLUMN ASSEMBLY .....	120
VF-3 SADDLE ASSEMBLY .....	122
VF-3 LEAD SCREW ASSEMBLY .....	124
VF-3 SPINDLE ASSEMBLY .....	126
VF-3 GEAR BOX ASSEMBLY .....	128
16-POCKET TOOL CHANGER ASSEMBLY .....	132
20-POCKET TOOL CHANGER ASSEMBLY .....	140





## BASIC MACHINE ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SHEET #
1	2	20-7082	GUIDE BAR, FRONT WAY COVER	1
3	1	20-7197	SUPPORT BRACKET, SUPPORT ARM	1
6	2	25-4080	WAY COVER, FRONT FIX, "X" AXIS	1
7	2	25-7083	SADDLE COVER	1
9	2	25-7088	END SHIELD, SADDLE COVER	1
11	1	25-7093	FRONT COVER, SPINDLE HEAD	1
12	1	25-7094	COVER, LEFT HAND, SPINDLE HEAD	1
15	2	25-7103	TABLE COVER (TELEFLEX)	1
16	2	25-7142	CHIP GUARD, LINEAR GDE.	1
18	4	25-7152	DRESS PLATE, TABLE COVER	1
20	1	25-7154	STABILIZER BRACKET, FRONT WAY	1
21	1	25-7189	TABLE GUTTER	1
22	1	25-7261	SPRAY SHIELD	1
23	1	25-7262	SUPPORT, SPRAY SHIELD	1
24	1	25-7283	TOP COVER, SPINDLE HEAD	1
27	1	25-7327	J-BOX, MOTOR	1
30	1	30-3100	GEAR BOX ASSEMBLY	1
31	1	30-3200	TOOL RELEASE PISTON ASSEMBLY	1
32	1	30-3300	COOLANT NOZZLE ASSEMBLY	1
33	1	30-3400	SPINDLE ASSEMBLY	1
34	1	32-0000	CNC CONTROL FINAL ASSEMBLY	1
35	1	36-3035	SPINDLE MOTOR FAN ASSEMBLY	1
36	3	40-1603	HHB, 1/2-13 x 1 1/2"	1
37	7	40-16095	SHCS, 10-32 x 1/4"	1
38	2	40-1610	SHCS, 1/4-20 x 1"	1
39	3	40-1632	SHCS, 1/4-20 x 1/2"	1
41	16	40-16385	SHCS, 5/16-18 x 3/4"	1
42	18	40-1640	SHCS, 10-32 x 1/2"	1
47	6	40-1715	SHCS, 5/16-18 x 1 1/2"	1
48	13	40-1750	BHCS, 10-32 x 3/8"	1
49	97	40-1850	SHCS, 10-32 x 3/8"	1
50	6	40-1950	SHCS, 10-32 x 3/4"	1
51	6	40-2030	SHCS, 3/8-16 x 3/4"	1
52	2	44-1710	SSS, CUP PT 1/4-20 x 3/8"	1
53	104	45-1620	WASHER, SPLIT LOCK #10 MED	1
54	6	45-1730	WASHER, BLACK HARD 3/8"	1
55	3	45-1740	WASHER, BLACK HARD 1/2"	1
70	1	59-6110	GORTUBE, 42" L	1
72	1	59-7220	GROMMET, KEYSTONE #744	1
73	1	59-7291	SOUNDFOAM, FRONT SPINDLE COVER	1
77	1	61-0012	RED PUSH BUTTON TOP	1
78	1	61-0020	PUSH BUTTON CONTACT, N/OPEN	1





## BASIC MACHINE ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SHEET #
2	4	20-7084	EXTEND BAR SUPPORT, WAY SIDE	2
4	1	25-4060	WAY COVER, REAR "Y" AXIS	2
5	1	25-4070	WAY COVER, REAR FIX, FRONT "Y" AXIS	2
8	1	25-7087	WIPER RETAINING PLATE	2
10	2	25-7089	SUPPORT BRACKET, GUIDE ROLLER A	2
13	1	25-7095	COVER RIGHT HAND, SPINDLE HEAD	2
14	1	25-7096	COVER, BOTTOM, SPINDLE HEAD	2
17	1	25-7151	WIPER MOUNTING PLATE	2
19	2	25-7153	STABILIZE BRACKET, SIDE WAY	2
25	1	25-7284	INSPECTION COVER	2
26	1	25-7285	REAR SOUND SHIELD	2
28	1	26-7086	WIPER BLADE, NYLON	2
29	1	30-1000	MACHINE CASTING ASSEMBLY	2
40	4	40-1636	SHCS, 3/8-16 x 1 1/4"	2
43	4	40-1697	SHCS, 1/4-20 x 3/4"	2
44	36	40-1703	FHCS, 10-32 x 1/2"	2
45	8	40-1704	FHCS, 10-32 x 1/4"	2
46	6	40-1705	FHCS, 10-32 x 1"	2
56	10	45-2000	WASHER, SHIM 1/4", 0.010 THK	2
57	2	46-1625	NUT, HEX, BLACK OXIDE 1/4-20	2
58	2	49-2020	PTHS, 1/4-20 x 1 3/4" BLACK OXIDE	2
59	1	54-2650	GT SPINDLE DRIVE BELT	2
60	2	57-0100	"O" RING, 2-318	2
61	1	57-7337	GASKET, "Y" AXIS, FRONT COVER	2
62	1	57-7338	GASKET, "Y" AXIS, REAR COVER	2
63	15	58-2050	RUBBER HOSE, 1/2 x 7/8	2
64	8	58-2100	SLEEVE, LUBE ASSEMBLY	2
65	8	58-2110	SLEEVE, LUBE ASSEMBLY	2
66	1	58-3620	FEMALE ADAPTOR, 3/8-1/2	2
67	2	59-1490	VENT PLUG, MICROPLASTICS	2
68	1	59-2741	3/4 STRAIN RELIEF L/T FOR	2
69	2	59-4010	HOSE CLAMP, 7/8 HOSE	2
71	2	59-6400	GUIDE WHEEL	2
74	2	59-7292	SOUNDFOAM, SIDE SPINDLE COVER	2
75	1	59-7401	DAMPING SHEETBOTTOM SPINDLE COVER	2
76	1	59-7406	DAMPING SHEETREAR SOUND SHIELD	2





## MACHINE CASTINGS PARTS LIST

ITEM	QTY	DWG NUMBER	TITLE
1	1	30-1010	BASE SUB-ASSEMBLY
2	1	30-1020	COLUMN SUB-ASSEMBLY
3	1	30-1030	SADDLE SUB-ASSEMBLY
4	1	30-7000A	TOOL CHANGER SUB-ASSEMBLY
5	1	30-3400	SPINDLE SUB-ASSEMBLY
6	1	30-3100	GEAR BOX SUB-ASSEMBLY
7	1	30-3200	TOOL RELEASE PISTON SUB-ASSEMBLY





## BASE ASSEMBLY

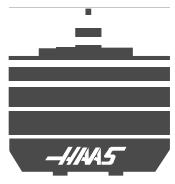
ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7002	BASE, MACHINED
2	8	20-7085	ALIGNMENT WEDGE, LINEAR GUIDE
3	1	20-2629	KEY, SQUARE 3/16"
4	4	24-7325	STR FIT-METRIC LINEAR GUIDE
5	1	25-7267	Y-AXIS MOUNT BRACKET
6	1	30-1100	LEAD SCREW ASSEMBLY
7	1	32-1600	Y MOTOR ASSEMBLY
8	1	32-2030	TELEMECHANIQUE 51" CABLE ASSEMBLY
9	26	40-16385	SHCS, 5/16-18 x 3/4"
10	2	40-16413	SHCS, M3 x 5
11	24	40-1703	FHCS, 10-32 x 1/2"
12	6	40-1705	FHCS, 10-32 x 1"
13	14	40-1715	SHCS, 5/16-18 x 1 1/2"
14	2	40-1850	SHCS, 10-32 x 3/8"
15	4	40-2026	SHCS, 10-32 x 1"
16	6	44-1700	SSS, CUP PT 3/4-10 x 4"
17	14	45-1600	WASHER, SPLIT LOCK 5/16 MED.
18	6	45-1620	WASHER, SPLIT LOCK #10 MED.
19	4	48-0045	PULL PIN, 3/8 x 1 1/2"
20	1	50-3300	LINEAR GUIDE
21	5.83	58-2000	NYLON TUBING, 1/4" CL, 5.83 FT
22	7.71	58-2010	NYLON TUBING, 5/32" C, 7.71 FT
23	12	58-2100	SLEEVE, LUBE ASSEMBLY
24	9	58-2110	SLEEVE NUTS, LUBE ASSEMBLY
25	5	58-2111	COMPRESSION NUT B-1095
26	6	58-2130	SLEEVE, COMP. NYLON TUBING
27	1	58-2763	3-WAY JUNCTION
28	1	58-3000	MANIFOLD, 4-WAY
29	1	58-3005	FITTING MANIFOLD, 5-WAY
30	1	58-3030	M-6 TO 5/32-24 ELBOW
31	1	58-3054	90° 1/2 NPT ELBOW
32	1	58-3505	NIPPLE, 1/2-14 NPT
33	5	58-4000	FLOWMETER, FJB-000
34	2	58-7301	COPPER TUBING - YA
35	2	58-7303	COPPER TUBING - YC
36	1	58-7305	COPPER TUBING - YE
37	1	58-7306	COPPER TUBING - YF
38	26	59-6600	PLUG, GUIDE RAIL
39	3	63-1027	STANDOFF, LYNITRON
40	3	63-1032	CABLE CLMP, KEYSTONE #8110





## COLUMN ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	7001-SH2	COLUMN, MACHINED-FROM CASTING 7001-SH1
2	1	7005-SH2	SPINDLE HEAD, MACHINING FROM CASTING 7005-SH1
3	2	20-7072	ATTACHMENT BAR, Z WAY COVER
4	8	20-7085	ALIGNMENT WEDGE, LINEAR GUIDE
5	1	20-7221	STRINGER, WIPER MOUNT
6	1	20-2629	KEY, SQUARE 3/16
7	4	24-7325	STR. FIT-METRIC, LINEAR GUIDE
8	1	25-4050	WAY COVER, UP FIX Z-AXIS
9	1	25-7159	TRIP BRACKET, Z-AXIS
10	1	25-7226	X- & Z-AXIS MOUNTING BRACKET
11	1	25-7485	BRACKET, OIL LINE CARRIER (L)
12	1	25-7485	BRACKET, OIL LINE CARRIER (R)
13	1	30-1100	LEAD SCREW ASSEMBLY
14	1	32-2040	TELEMECHANIQUE 85" CABLE ASSEMBLY
15	12	40-1500	SHCS, 5/16-18 x 1"
16	6	40-1610	SHCS, 1/4-20 x 1"
17	8	40-1632	SHCS, 1/4-20 x 1/2"
18	26	40-1667	SHCS, 5/16-18 x 1 1/4"
19	16	40-1697	SHCS, 1/4-20 x 3/4"
20	24	40-1703	FHCS, 10-32 x 1/2"
21	4	40-1705	FHCS, 10-32 x 1"
22	8	40-1750	BHCS, 10-32 x 3/8"
23	2	40-1850	SHCS, 10-32 x 3/8"
24	4	40-2010	FHCS, 1/4-20 x 1 3/4"
25	14	40-2020	FHCS, 1/4-20 x 2"
26	12	46-1600	WASHER, SPLIT LOCK 5/16 MED
27	2	45-1620	WASHER, SPLIT LOCK #10 MED
28	42	45-1800	WASHER, SPLIT LOCK 1/4" MED
29	4	48-0040	PIN-DOWEL 3/8 x 1"
30	16	49-4000	MC, 12 PT BOLT 5/16-18 x 1"
31	1	50-3300	LINEAR GUIDE, MODEL #HSR 35TB, HSR 35 HTB-PAIR
32	6.42FT	58-2000	NYLON TUBING, 1/4" CL
33	6.42FT	58-2010	NYLON TUBING, 5/32" CL
34	14	58-2100	SLEEVE, LUBE ASSEMBLY
35	11	58-2110	SLEEVE NUTS, LUBE ASSEMBLY
36	5	58-2111	COMPRESSION NUT B-1095
37	2	58-2130	SLEEVE, COMP. NYLON TUBING
38	1	58-2760	FITTING MANIFOLD, 2-WAY
39	1	58-3000	MANIFOLD, 4-WAY
40	1	58-3012	MANIFOLD, 6-WAY, B-3109
41	2	58-3015	CLOSURE PLUG, B-3784
42	1	58-3030	M6-1 TO 5/32-24 ELBOW
43	2	58-3045	P/N LE90585 ELBOW
44	5	58-4000	FLOWMETER, FJB-000
45	2	58-7315	COPPER TUBING - ZA
46	1	58-7316	COPPER TUBING - ZB
47	2	58-7317	COPPER TUBING - ZC
48	1	58-7319	COPPER TUBING - ZE
49	1	58-7320	COPPER TUBING - ZF
50	1.46FT	59-6150	PLASTIC CARRIER 0130.06
51	26	59-6600	PLUG, GUIDE RAIL





## SADDLE ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7003	SADDLE, MACHINED
2	1	20-7004	MILL TABLE, MACHINED
3	1	20-7255A	TOOL #1 STANDOFF
4	4	20-7456	COND. STRAIN RELIEF, SADDLE
5	1	20-2629	KEY, .1875/.1870 SQUARE
6	26	22-7458	CAM, LINEAR GUIDE
7	1	22-7459	SPACER SWITCH MOUNT
8	4	24-7325	STR FIT METRIC, LINEAR GUIDE
9	1	25-7157	TRIP BRACKET, SADDLE
10	1	25-7158	TRIP BRACKET, TABLE
11	1	25-7266	X-AXIS SWITCH MOUNT BRACKET
12	2	25-7485	BRACKET, OIL LINE CARRIER (L)
13	1	30-1100	LEAD SCREW ASSEMBLY
14	1	32-1400	X-AXIS MOTOR ASSEMBLY
15	1	32-2050	TELEMECHANIQUE 120" CABLE ASSEMBLY
16	2	40-1609	BHCS, 10-32 x 1/2"
17	6	40-1610	SHCS, 1/4-20 x 1"
18	4	40-1640	SHCS, 10-32 x 1/2"
19	2	40-16413	SHCS, M3 x 5
20	26	40-1667	SHCS, 5/16-18 x 1 1/4"
21	4	40-1705	FHCS, 10-32 x 1"
22	14	40-1715	SHCS, 5/16-18 x 1 1/2"
23	4	40-1850	SHCS, 10-32 x 3/8"
24	14	45-1600	WASHER, SPLIT LOCK 5/16" MED.
25	2	45-1620	WASHER, SPLIT LOCK #10 MED.
26	6	45-1800	WASHER, SPLIT LOCK 1/4" MED.
27	4	48-0045	PULL PIN, 3/8 x 1 1/2"
28	16	49-4000	MC, 12 PT BOLT 5/16-18 x 1"
29	1	50-3300	LINEAR GUIDE
30	1	58-2000	NYLON TUBING, 1/4" CL., 1.54 FT.
31	1	58-2010	NYLON TUBING, 5/32" C., 1.67 FT.
32	14	58-2100	SLEEVE, LUBE ASSEMBLY
33	11	58-2110	SLEEVE NUTS, LUBE ASSEMBLY
34	5	58-2111	COMPRESSION NUT B-1095
35	2	58-2130	SLEEVE, COMP. NYLON TUBING
36	1	58-2760	FITTING MANIFOLD, 2 WAY
37	2	58-3000	MANIFOLD, 4 WAY
38	1	58-3030	M6-1 TO 5/32-24 ELBOW
39	1	58-3045	P/N LE 90585 ELBOW
40	5	58-4000	FLOWMETER, FJB-000
41	1	58-7308	COPPER TUBING - XA
42	1	58-7309	COPPER TUBING - XB
43	1	58-7310	COPPER TUBING - XC
44	1	58-7311	COPPER TUBING - XD
45	1	58-7312	COPPER TUBING - XE
46	1	58-7313	COPPER TUBING - VF1/VF2XF
47	1.46FT	59-6150	PLASTIC CARRIER, 0130.06
48	26	59-6600	PLUG, GUIDE RAIL





## LEAD SCREW ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-2629	KEY
2	1	20-7008	NUT HOUSING, LEAD SCREW ASSEMBLY
3	1	20-7009	BEARING HOUSING, LEAD SCREW ASSEMBLY
4	1	20-7010	MOTOR MOUNT, LEAD SCREW ASSEMBLY
5	1	20-7041	BEARING SLEEVE, LEAD SCREW ASSEMBLY
6	1	20-7042	COVER PLATE, MOTOR MOUNT
7	1	20-7185	BUMPER BALL SCREW
8	2	20-7253	BEARING SPACER
9	1	24-7146	LEAD SCREW, MODIFIED
10	4	40-1750	BHCS, 10-32 X 3/8"
11	2	40-1632	SHCS, 1/4-20 X 1/2"
12	6	40-1697	SHCS, 1/4-20 X 3/4"
13	6	40-1610	SHCS, 1/4-20 X 1"
14	4	40-1667	SHCS, 5/16-18 X 1 1/4"
15	14	40-1715	SHCS, 5/16-18 X 1 1/2"
16	1	44-1619	M6 X 10 MM SHSS
17	2	45-1800	1/4" SPLIT LOCK WASHER
18	18	45-1600	5/16" SPLIT LOCK WASHER
19	4	48-0045	3/8" X 1 1/2" DOWEL PIN
20	2	51-0025	THRUST NEEDLE ROLLER CAGE
21	2	51-2010	RADIAL BEARING, 204PP
22	2	51-2012	BEARING LOCKNUT, BH-4
23	1	51-2025	RADIAL BEARING, FAFNIR 304PP
24	1	52-3305	COUPLING, AXIS MOTOR
25	4	55-0026	THRUST WASHER/1NA#AAS2035
26	1	62-0010	AXIS MOTOR





## SPINDLE CARTRIDGE ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7015	SPINDLE LOCKNUT MODIFIED
2	1	20-7016	SPINDLE HOUSING
3	1	20-7018	SPINDLE SHAFT
4	1	20-7019	TOP SPACER RING, SPINDLE
5	1	20-7020	CTR SPACER RING, SPINDLE
6	1	20-7021	INNER RING, SPINDLE
7	1	20-7022	SPINDLE LOCK
8	1	20-7024	TOOL DRAW BAR
9	1	20-7025	DIST. TUBE, TOOL HOLDER
10	1	20-7293	SPINDLE SLEEVE
11	1	20-7408	CLAMP RING
12	1	20-74091	7/8 DIA. PULLEY MODIFICATION
13	6	40-16385	SHCS, 5/16-18 x 3/4"
14	8	40-1697	SHCS, 1/4-20 x 3/4"
15	2	46-1010	5/8 -11 HEX. NUT
16	1	51-0020	BEARING, DEEP GRV. 6010
17	1	51-1000	ANGULAR CONTACT BEARING, (MATCHED)
18	2	51-1020	BEARING LOCK NUT #12
19	1	51-1030	BEARING LOCK NUT #10
20	1	55-0020	WAVE WASHER 3118
21	77	55-0030	SPRING WASHER, DRAW BAR
22	1	56-0010	SNAP RING, N-5000-125 TRU
23	1	57-0065	2-214 "O" RING
24	3	57-2984	"O" RING, BRAKE HUB 11 & 13"
25	1	57-2985	"O" RING (2-041)
26	4	59-2058	1/4" STEEL BALLS
27	1	59-2080	1 7/8 LOCKING RINGS





## GEAR BOX ASSEMBLY (OLD STYLE)

ITEM	QTY	DWG NUMBER	TITLE	SHEET #
2	1	20-7014	KEY, MOTOR SHAFT GEAR	1
4	1	20-7058	SPUR GEAR, MOTOR SHAFT	1
5	1	20-7062	BEARING FORK, GEAR CLUSTER	1
6	1	20-7063	TOP PLATE, GEAR BOX	1
7	1	20-7064	SHAFT, GEAR CLUSTER	1
8	1	20-7065	TRANSFER GEAR CLUSTER	1
9	2	20-7081	COUNTERWEIGHT, GEAR	1
10	1	20-7170	DRIVE SHAFT, COMPLETE	1
11	1	20-7226	CLAMP RING, SHOT PIN ASSEMBLY	1
12	1	20-7245	1/4 SQUARE KEY	1
13	1	20-7410	CLAMPING RING	1
15	1	30-3130	PISTON ASSEMBLY	1
16	1	30-3140	SHOT PIN ASSEMBLY	1
17	1	30-3150	AIR MANIFOLD ASSEMBLY	1
18	1	RTAP	HARD TAPPING ASSEMBLY	1
20	2	40-1602	FHCS, 1/4-28 x 5/8"	1
21	3	40-1603	HHB, 1/2-13 x 1 1/2"	1
22	4	40-1632	SHCS, 1/4-20 x 1/2"	1
23	8	40-16385	SHCS, 5/16-18 x 3/4"	1
25	10	40-1697	SHCS, 1/4-20 x 3/4"	1
27	1	40-1850	SHCS, 10-32 x 3/8"	1
28	3	41-1500	PPHS 8-32 x 3/8"	1
29	4	43-1001	HHB, 1/4-20 x 1 1/4"	1
30	1	44-1622	SSS, K CUP PT 1/4-20 x 1/4"	1
31	2	44-1710	SSS, CUP PT 1/4-20 x 3/8"	1
32	1	45-1682	WASHER, SPLIT LOCK 7/16 MED	1
33	3	45-1700	WASHER, INTERNAL LOCK #8	1
34	3	45-1740	WASHER, BLACK HARD 1/2"	1
36	1	46-1654	NUT, HEX 7/16-20	1
37	2	48-0020	PIN, DOWEL 1/4 x 1"	1
38	1	48-0050	PIN, DOWEL 1/8 x 7/16"	1
39	1	51-2010	RADIAL BEARING 204PP	1
40	2	51-2020	RADIAL BEARING, FAFNIR 303PP	1
41	1	51-2030	RADIAL BEARING 306PP	1
42	1	51-2040	RADIAL BEARING (9105PP)	1
43	1	51-2041	BEARING LOCKNUT, BH-05	1
44	1	54-3000	1 1/8 SPROCKET, 8M-44-S-17	1
45	2	55-0021	WAVE WASHER 2816	1
48	3	56-0060	SNAP RING, (5100-66)	1
50	1	57-0080	"O" RING, 2-023	1
52	1	57-1010	GREASE SEAL, CR#6680	1
54	1	58-1627	1/8-27 PIPE PLUG	1
55	1	58-3105	1/4 NPT PIPE PLUG	1
56	1	59-2075	1 1/8 LOCKING RINGS	1
57	1	62-1010	SPINDLE MOTOR LINCOLN	1
58	1	63-1029	WIRE CLAMP, 3/8"	1
59	4	77-8001	WIRE NUT, IDEAL #30-076	1
60	1	79-3001	LOCK NUT FOR PLAS CORD GR	1





## GEAR BOX ASSEMBLY (OLD STYLE)

ITEM	QTY	DWG NUMBER	TITLE	SHEET #
1	1	20-7011	HOUSING GEARBOX, MACHINING (14-7011 CASTING)	2
3	1	20-7049	SHOT PIN POSITIONING RING	2
14	1	25-7264	SWITCH MOUNTING BRACKET	2
19	2	32-2010	TELEMECHANIQUE 24" CABLE ASSEMBLY	2
24	4	40-16413	MSHCS, M3 x 5	2
26	4	40-1700	SHCS, 10-32 x 2"	2
35	7	45-1800	WASHER, SPLIT LOCK 1/4" MED	2
46	5	55-0022	WAVE WASHER	2
47	2	56-0055	SNAP RING, 5100-212	2
49	2	56-0070	SNAP RING, TRU ARC N5000	2
51	2	57-0095	"O" RING, 2-327	2
53	1	57-1030	GREASE SEAL, CR 14082	2





## DRY SUMP GEAR BOX ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SHEET #
2	1	20-7058	SPUR GEAR, MOTOR SHAFT	1
3	1	20-7062	BEARING FORK, GEAR CLUSTER	1
4	1	20-7063	TOP PLATE, GEAR BOX	1
5	1	20-7064	SHAFT, GEAR CLUSTER	1
6	1	20-7065	TRANSFER GEAR CLUSTER	1
7	2	20-7081	COUNTERWEIGHT, GEAR	1
8	1	20-7170	DRIVE SHAFT, COMPLETE	1
9	1	20-7411	1 1/8" PULLEY MODIFICATION	1
10	1	20-7415	OVERFLOW DRAIN, DRY SUMP	1
11	1	20-7427	CLAMPING RING, SHOT PIN	1
12	1	20-7428	POSITIONING RING	1
13	1	20-7432	OIL SLINGER	1
18	1	25-7434	SUMP TANK	1
22	1	25-7447	FAN BRACKET, DRY SUMP TRANSM.	1
23	1	30-3130B	PISTON ASS'Y, 7500 RPM	1
24	1	30-3140A	SHOT PIN ASS'Y	1
25	1	30-3150B	AIR MANIFOLD ASS'Y	1
27	2	40-1602	FHCS, 1/4-28 x 5/8"	1
28	3	40-1603	HHB, 1/2-13 x 1 1/2"	1
29	16	40-1632	SHCS, 1/4-20 x 1/2"	1
30	12	40-16385	SHCS, 5/16-18 x 3/4"	1
32	4	40-1669	BHCS, 8-32 x 3/8"	1
33	4	40-1697	SHCS, 1/4-20 x 3/4"	1
36	5	40-1850	SHCS, 10-32 x 3/8"	1
38	3	41-1500	PPHS, 8-32 x 3/8"	1
39	1	45-1682	WASHER, SPLIT LOCK 7/16 MED.	1
40	8	45-1700	WASHER, INTERNAL LOCK #8	1
41	3	45-1740	WASHER, BLACK HARD 1/2"	1
42	4	45-1800	WASHER, SPLIT LOCK 1/4" MED.	1
43	8	46-1617	NUT, HEX 8-32	1
44	1	46-1654	NUT, HEX 7/16-20	1
45	2	48-0020	PIN, DOWEL 1/4 x 1"	1
46	1	48-0050	PIN, DOWEL 1/8 x 7/16"	1
47	2	51-2020	RADIAL BEARING, #303PP	1
48	1	51-2022	RADIAL BEARING, #205PP	1
49	1	51-2030	RADIAL BEARING, #306PP	1
50	1	51-2040	RADIAL BEARING, #9105PP	1
51	1	51-2041	BRG. LOCK NUT, BH-05	1
53	1	54-3040	LOCKING ASS'Y, RINGFEEDER	1
54	2	55-0035	SPRING WASHER, #BS-204	1
55	2	55-0036	SPRING WASHER, #BS-205	1
57	3	56-0060	SNAP-RING, #5100-66	1
59	1	56-2087	SNAP RING, #5000-206	1
61	1	58-1627	1/8-27 PIPE PLUG	1
68	1	58-2745	OIL PLUG	1
78	1	59-7271	SOUNDCOAT, RIGHT SIDE	1
79	1	59-7272	SOUNDCOAT, LEFT SIDE	1
81	1	59-7441	RETAINING RING, OIL SLINGER	1
83	1	63-1029	WIRE CLAMP, 3/8	1





## DRY SUMP GEAR BOX ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SHEET #
1	1	20-7011B	HOUSING GEARBOX, MACHINING (14-7011CAST)	2
14	1	20-7435	OILER PLATE	2
15	1	25-7264	SWITCH MOUNTING BRACKET	2
16	1	25-7414	MOTOR SHROUD	2
17	1	25-7433	SUMP BRACKET	2
19	1	25-7444	OIL FILL TUBE	2
20	1	25-7445	OIL DRAIN TUBE	2
21	1	25-7446	OIL PICK UP TUBE	2
26	2	32-2010	TELEMECHANIQUE 24" CABLE ASS'Y	2
31	4	40-16413	MSHCS, M3 x 5	2
34	4	40-1700	SHCS, 10-32 x 2"	2
35	4	40-1715	SHCS, 5/16-18 x 1 1/2"	2
37	5	40-2026	SHCS, 10-32 x 1"	2
52	1	53-3002	PRESSURE SWITCH PS-126	2
56	2	56-0055	SNAP-RING, #5100-212	2
58	1	56-0070	SNAP RING, #5000-187	2
60	2	57-0095	"O" RING, 2-327	2
62	1	58-16700	STREET ELBOW, 1/8"	2
63	1	58-16732	1/8 x 1/8 MALE HEX JOINT	2
64	1	58-1674	ADAPTER MALE 1/4 NPT	2
65	3	58-2022	1/2" OD NATURAL TUBING	2
66	2	58-2065	COUPLING, 1/4 NPT	2
67	1	58-2259	BARB. FIT. 1/4-18 NPT	2
69	1	58-2746	1/8 x 1/8 FEMALE COUPLER	2
70	1	58-3618	1/4 STREET ELBOW	2
71	1	58-3635	COUPLING, 1/8 MALE 3/8 C/F	2
72	2	58-3655	COUPLING, 1/8 TO 1/4 BRASS	2
73	1	58-3657	1/4 FEMALE 1/8 MALE ADPT.	2
74	2	58-3680	MALE 1/4 NPT - 3/8 TUBE	2
75	1	58-3695	1/4 NPT FEMALE 'T'	2
76	1	58-3735	1/8 NPT x 4" PIPE NIPPLE	2
77	1	59-2910	OIL COOLER	2
80	1	59-7273	SOUNDCOAT, BACK SIDE	2
82	1	62-1010A	SPINDLE MOTOR, LINCOLN	2
84	1	32-1850	AGEAR PUMP MOTOR ASS'Y	2
85	1	36-3035	SPINDLE MOTOR FAN ASS'Y	2
86	2	58-2070	1/4 NPT TO 3/8 COMPRESSION	2
87	1	20-7487	OIL FILL CAP	2





## PISTON SUB-ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7059	PISTON SHAFT, GEAR BOX
2	1	20-7060	BODY, PISTON ASSEMBLY
3	1	20-7097	SHAFT PISTON, GEAR BOX
4	1	20-7243	SPACER, PISTON BODY
5	1	20-7244	PISTON DASH POT
6	4	56-0040	SNAP RING, TRU ARC #N-510
7	1	57-0020	"O" RING, #2-210, END CAP
8	1	57-0040	"O" RING, #2-111, SHAFT
9	2	57-0070	"O" RING, #2-114, BODY AND SPACER
10	2	57-0080	"O" RING, #2-023, BODY AND SPACER
11	2	58-16752	90° COMPRESSION FITTING

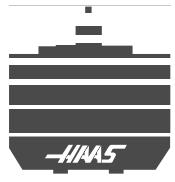




## SHOT PIN SUB-ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7046	SHOT PIN HOUSING
2	1	20-7047	SHOT PIN END CAP
3	1	20-7408	SHOT PIN PISTON
4	1	20-7145	SWITCH BRACKET, SHOT PIN ASSEMBLY
5	4	40-1693	SHCS 1/4-20 x 2
6	2	40-1850	SHCS 10-32 x 3/8
7	1	56-0100	RETAINING RING, N-5000-100
8	2	57-0020	"O" RING, #2-210, END CAP
9	2	57-0040	"O" RING, #2-111, SHAFT
10	2	58-16700	STREET ELBOW, 1/8 NPT
11	2	58-16755	MALE AIR FITTING, 1/8 NPT
12	1	32-2010	TELEMECHANIQUE MICROSWITCH





## RTAP HARD TAPPING SUB-ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	4	20-7260	ENCODER STANDOFF
2	4	40-1640	SHCS 10-32 x 1/2"
3	4	48-0041	DRIVE-LOCK 3/8 x 1 1/2"
4	1	54-1014	SPROCKET, P 28-3M-09-AL
5	1	60-1801	ENCODER, RENCO





## TOOL RELEASE PISTON ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7007E	CYLINDER HOUSING, TOOL RELEASE MECHANISM
2	1	20-7043	PISTON, TOOL RELEASE
3	1	20-7044C	SHAFT, TOOL RELEASE
4	1	20-7045	SPRING RETAINER, TOOL RELEASE
5	1	20-7246E	TOOL RELEASE BOLT
6	2	25-7050B	SWITCH MOUNTING BRACKET
7	2	32-2020	TELEMECHANIQUE LIMIT SWITCH, 20"
8	1	32-5620	TRIP SOLENOID VALVE ASS'Y
9	4	40-1632	SHCS, 1/4-20 x 1/2"
10	4	40-1800	SHCS, 8-32 x 3/4"
11	4	45-0040	1/4" HARD WASHER
12	4	45-2000	1/4 SHIM WASHER, 0.010 THK.
13	1	56-0030	SNAP RING, TRU ARC #N-5000-600
14	2	56-0040	SNAP RING, TRU ARC #N-5100
15	2	57-0040	"O" RING, #2-111, SHAFT
16	1	57-0090	"O" RING, #2-433, TOOL RELEASE
17	1	58-1674	ADAPTER, MALE 1/4 NPT TO 1/8 NPT
18	1	58-2265	AIR MUFFLER, 3/8 FLAT
19	1	58-3065	AIR MUFFLER, 1/4 NPT
20	1	58-3070	FITTING, 1/8 NPT
21	1	58-3685	MALE 1/4 NPT - 3/8 TUBE-SWVL
22	1	58-3690	1/4 NPT MALE HX JNT 1 1/8
23	1	58-3727	1/4 NPT x 5 1/2" NIPPLE
24	1	59-2230	SHUTTLE VALVE, NVR 1220N02
25	1	59-2232	QUICK EXHAUST VALVE
26	1	59-2760	COMPRESS. SPRING/LARGE WIRE





## VF-3 BASE ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-9002	BASE, MACHINED
2	1	20-9007	NUT HOUSING
3	1	22-2629	KEY, 0.1875/0.1870 SQUARE
4	24	22-7458	CAM SCREW, LINEAR GUIDE
5	1	25-7267	Y AXIS MOUNT BRACKET
6	1	30-1210	LEAD SCREW ASSEMBLY (Y,Z)
7	1	32-1600	Y AXIS MOTOR ASSEMBLY
8	1	32-2031	TELEMECHANIQUE SWITCH 62", Y-AXIS
9	2	40-16413	MSHCS, M3 x 5
10	24	40-1660	SHCS, 1/2-13 x 1 1/2"
11	4	40-1667	SHCS, 5/16-18 x 1 1/4"
12	5	40-1697	SHCS, 1/4-20 x 3/4"
13	5	40-1705	FHCS, 10-32 x 1"
14	14	40-1715	SHCS, 5/16-18 x 1 1/2"
15	2	40-1850	SHCS, 10-32 x 3/8"
16	3	40-2026	SHCS, 10-32 x 3/8"
17	6	44-1700	SSS, CUP PT 3/4-10 x 4"
18	14	45-1600	WASHER, SPLIT LOCK 5/16" MED.
19	5	45-1620	WASHER, SPLIT LOCK #10 MED.
20	4	48-0045	PIN, PULL 3/8" x 1 1/2"
21	1	50-9011	Y, Z AXIS LINEAR GUIDE
22	4	58-1550	1/8 NPT CONN. (BIJUR B3488)
23	1	58-2000	NYLON TUBING, 1/4" CL, 5.83 FT
24	1	58-2010	NYLON TUBING, 5/32" CL, 7.71 FT
25	12	58-2100	SLEEVE, LUBE ASS'Y
26	9	58-2110	SLEEVE NUTS, LUBE ASS'Y
27	5	58-2111	COMPRESSION NUT B-1095
28	6	58-2130	SLEEVE, COMP. NYLON TUBING
29	1	58-2763	3-WAY JUNCTION
30	1	58-3000	MANIFOLD, 4 WAY
31	1	58-3005	FITTING MANIFOLD, 5 WAY
32	1	58-3030	M6-1 TO 5/16-24 ELBOW
33	1	58-3054	90° 1/2 NPT ELBOW
34	1	58-3505	NIPPLE, 1/2-14 NPT x 10"
35	5	58-4000	FLOWMETER, FJB-000
36	2	58-9105	COPPER TUBING - YA
37	2	58-9106	COPPER TUBING - YC
38	1	58-9107	COPPER TUBING - YE
39	1	58-9108	COPPER TUBING - YF
40	24	59-6650	PLUG, GUIDE RAIL, THK C-12
41	3	63-1032	CABLE CLAMP, KEYSTONE #8110





## VF-3 COLUMN ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-9001	COLUMN, MACHINED-FROM CASTING 14-9001
2	1	20-9005	SPINDLE HEAD, MACHINED
3	1	20-9007	NUT HOUSING, VF-3
4	1	22-2629	KEY, 0.1875/0.1870 SQUARE
5	24	22-7458	CAM SCREW, LINEAR GUIDE
6	1	25-7267	Y AXIS MOUNTING BRACKET
7	1	25-7459	TRIP BRACKET, TABLE
8	1	25-7485	BRACKET, OIL LINE CARRIER (L)
9	1	25-7486	BRACKET, OIL LINE CARRIER (R)
10	1	25-9040	WAY COVER, Z AXIS VF-3
11	1	30-1210	LEAD SCREW ASS'Y VF-3 (Y, Z)
12	1	32-2041	TELEMECHANIQUE 90" CABLE, Z-AXIS, VF-3
13	1	40-16204	SHCS, 10-32 X 1 5/8"
14	2	40-16413	MSHCS, M3 x 5
15	16	40-1655	MSHCS, M12 x 65
16	24	40-1660	SHCS, 1/2-13 x 1 1/2"
17	5	40-1697	SHCS, 1/4-20 x 3/4"
18	4	40-1705	FHCS, 10-32 x 1"
19	14	40-1715	SHCS, 5/16-18 x 1 1/2"
20	8	40-1750	BHCS, 10-32 x 3/8"
21	2	40-1850	SHCS, 10-32 x 3/8"
22	18	40-2021	FHCS, 1/4-20 x 3"
23	18	45-1600	WASHER, SPLIT LOCK, 5/16" MED.
24	2	45-1620	WASHER, SPLIT #10 MED
25	4	45-1800	WASHER, SPLIT LOCK, 1/4" MED.
26	4	48-0045	PIN, PULL 3/8 x 1 1/2"
27	1	50-9011	Y,Z AXIS LINEAR GUIDE VF-3
28	4	58-1550	1/8 NPT CONN.(BIJUR B3488)
29	6.42FT	58-2000	NYLON TUBING, 1/4" CL
30	8.5 FT	58-2010	NYLON TUBING, 5/32" C
31	14	58-2100	SLEEVE, LUBE ASS'Y
32	11	58-2110	SLEEVE NUTS, LUBE ASS'Y
33	5	58-2111	COMPRESSION NUT B-1095
34	2	58-2760	SLEEVE, COMP. NYLON TUBING
35	1	58-2760	FITTING MANIFOLD, 2 WAY
36	1	58-3000	MANIFOLD, 4-WAY
37	1	58-3012	MANIFOLD, 6-WAY, B-3109
38	2	58-3015	CLOSURE PLUG, B-3784
39	1	58-3030	M6-1 TO 5/16-24 ELBOW
40	1	58-3045	P/N LE90585 ELBOW
41	5	58-4000	FLOWMETER, FJB-000
42	1	58-9109	COPPER TUBING - ZA VF-3
43	1	58-9110	COPPER TUBING - ZB VF-3
44	2	58-9111	COPPER TUBING - ZC VF-3
45	1	58-9112	COPPER TUBING - ZE VF-3
46	1	58-9113	COPPER TUBING - ZF VF-3
47	1.46FT	59-6150	PLASTIC CARRIER 0130.06
48	24	59-6650	PLUG, GUIDE RAIL, THK C-12
49	8	63-1031	CABLE CLAMP, 1/4"





## VF-3 SADDLE ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	2	20-7456	COND. STRAIN RELIEF, SADDLE
2	1	20-9003	SADDLE, MACHINED
3	1	20-9004	TABLE, MACHINED
4	1	20-9007	NUT HOUSING
5	1	22-2629	KEY, 0.1875/0.1870 SQUARE
6	30	22-7458	CAM SCREW, LINEAR GUIDE
7	1	25-7267	Y AXIS MOUNT BRACKET
8	2	25-7459	TRIP BRACKET
9	2	25-7485	BRACKET, OIL LINE CARRIER
10	1	30-1200	LEAD SCREW ASS'Y, VF-3 (X)
11	1	32-1401	X AXIS MOTOR ASS'Y (VF-3)
12	1	32-2050	TELEMECHANIQUE 120" CABLE, X-AXIS 2-3
13	4	40-1640	SHCS, 10-32 x 1/2"
14	2	40-16413	MSHCS, M3 x 5
15	16	40-1656	MSHCS, M12 x 130
16	34	40-1660	SHCS, 1/2-13 x 1 1/2"
17	4	40-1667	SHCS, 5/16-18 x 1 1/4"
18	5	40-1697	SHCS, 1/4-20 x 3/4"
19	5	40-1705	FHCS, 10-32 x 1"
20	14	40-1715	SHCS, 5/16-18 x 1 1/2"
21	1	40-1750	BHCS, 10-32 x 3/8"
22	8	40-1850	SHCS, 10-32 x 3/8"
23	18	45-1600	5/16" SPLIT LOCK WASHER
24	12	45-1620	WASHER, SPLIT LOCK #10 MED.
25	4	48-0045	PIN, PULL 3/8 x 1 1/2"
26	1	50-9010	X-AXIS LINEAR GUIDE, VF-3
27	4	58-1550	1/8 NPT CONN. (BIJUR B3488)
28	1	58-2000	NYLON TUBING, 1/4" CL., 1.54FT
29	1	58-2010	NYLON TUBING, 5/32", 3.15FT
30	14	58-2100	SLEEVE, LUBE ASS'Y
31	11	58-2110	SLEEVE NUTS, LUBE ASS'Y
32	5	58-2111	COMPRESSION NUT B-1095
33	2	58-2130	SLEEVE, COMP. NYLON TUBING
34	1	58-2760	FITTING MANIFOLD, 2 WAY
35	2	58-3000	MANIFOLD, 4 WAY
36	1	58-3030	M6-1 TO 5/16-24 ELBOW
37	5	58-4000	FLOWMETER, FJB-000
38	1	58-9100	COPPER TUBING - XA, VF-3
39	1	58-9101	COPPER TUBING - XB, VF-3
40	2	58-9102	COPPER TUBING - XD, VF-3
41	1	58-9103	COPPER TUBING - XE, VF-3
42	1	58-9104	COPPER TUBING - XF, VF-3
43	1	59-6150	PLASTIC CARRIER 0130.06, 1.46FT
44	34	59-6650	PLUG, GUIDE RAIL, THK C-12
45	1	63-1031	CABLE CLAMP 1/4"
46	2	63-1032	CABLE CLAMP, KEYSTONE #8110





## VF-3 LEAD SCREW ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7009	BEARING HOUSING
2	1	20-7010	MOTOR MOUNTING
3	1	22-2629	KEY, 0.1875/0.1870 SQUARE
4	1	24-7478	BALL SCREW SPT. BRG. ASS'Y
5	1	24-9012	X-AXIS BALL SCREW, VF-3
6	1	30-1220	COUPLING ASSEMBLY, SERVO DRIVE
7	5	40-1610	SHCS, 1/4-20 x 1"
8	6	40-1697	SHCS, 1/4-20 x 3/4"
9	2	51-2012	BEARING LOCKNUT
10	1	51-2025	BEARING, FAFNIR RADIAL #304PP





## VF-3 SPINDLE SUB-ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7016A	SPINDLE HOUSING
2	1	20-7018K	SPINDLE SHAFT
3	1	20-7019	TOP SPACER RING, SPINDLE
4	1	20-7022	SPINDLE LOCK
5	1	20-7293	SPINDLE SLEEVE
6	6	40-16385	SHCS, 5/16-18 x 3/4"
7	1	44-1634	SSS, FULL DOG 10-32 x 3/8"
8	1	51-0021	BEARING, 6010
9	1	51-1005	BEARING, ANGULAR CONTACT (TRIPLEX)
10	1	51-1020	BEARING LOCK NUT #12
11	1	51-1030	BEARING LOCKNUT #10
12	1	55-0020	WAVE WASHER 3118
13	3	57-2984	"O" RING, BRAKE HUB 11 & 13"
14	1	57-2985	"O" RING (2-041)





## VF-3 GEAR BOX ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SHEET #
2	1	20-7062	BEARING FORK, GEAR CLUSTER	1
3	1	20-7064	SHAFT, GEAR CLUSTER	1
4	1	20-7065	TRANSFER GEAR CLUSTER	1
5	1	20-7170	DRIVE SHAFT, COMPLETE	1
6	1	20-7415	OVERFLOW DRAIN, DRY SUMP	1
7	1	20-7427	CLAMPING RING, SHOT PIN	1
8	1	20-7428	POSITIONING RING	1
9	1	20-7432	OIL SLINGER	1
11	1	20-9123	1 1/8" PULLEY MODIFICATION	1
12	1	20-9125	SPUR GEAR, MOTOR SHAFT	1
13	1	20-9126	TOP PLATE, GEAR BOX	1
14	2	22-7081	COUNTERWEIGHT, GEAR	1
18	1	22-9127	OIL SLINGER, VF-3	1
21	1	25-7434	SUMP TANK	1
24	1	30-3130B	PISTON ASS'Y, 7500 RPM	1
25	1	30-3140A	SHOT PIN ASS'Y	1
26	1	30-3150B	AIR MANIFOLD ASS'Y	1
28	2	32-2010	TELEMECHANIQUE 24" CABLE ASS'Y	1
30	2	40-1602	FHCS, 1/4-28 x 5/8"	1
31	3	40-1603	HHB, 1/2-13 x 1 1/2"	1
32	16	40-1632	SHCS, 1/4-20 x 1/2"	1
33	12	40-16385	SHCS, 5/16-18 x 3/4"	1
34	4	40-16413	MSHCS, M3 x 5	1
35	4	40-1669	BHCS, 8-32 x 3/8"	1
36	4	40-1697	SHCS, 1/4-20 x 3/4"	1
39	5	40-1850	SHCS, 10-32 x 3/8"	1
41	3	41-1500	PPHS, 8-32 x 3/8"	1
42	1	45-1682	WASHER, SPLIT LOCK 7/16 MED.	1
43	8	45-1700	WASHER, INTERNAL LOCK #8	1
44	3	45-1740	WASHER, BLACK HARD 1/2"	1
45	4	45-1800	WASHER, SPLIT LOCK 1/4" MED.	1
46	8	46-1617	NUT, HEX 8-32	1
47	1	46-1654	NUT, HEX 7/16-20	1
48	2	48-0020	PIN, DOWEL 1/4 x 1"	1
49	1	48-0050	PIN, DOWEL 1/8 x 7/16"	1
50	2	51-2020	RADIAL BEARING, #303PP	1
51	1	51-2022	RADIAL BEARING, #205PP	1
52	1	51-2030	RADIAL BEARING, #306PP	1
53	1	51-2040	RADIAL BEARING, #9105PP	1
54	1	51-2041	BRG. LOCK NUT, BH-05	1
56	2	55-0035	SPRING WASHER, #BS-204	1
57	2	55-0036	SPRING WASHER, #BS-205	1
59	3	56-0060	SNAP-RING, #5100-66	1
61	1	56-2087	SNAP RING, #5000-206	1
70	1	58-2745	OIL PLUG	1
85	1	58-9114	TRANS FILL TUBE, VF-3	1
88	1	59-7441	RETAINING RING, OIL SLINGER	1
90	1	62-2010	SPINDLE MOTOR, LINCOLN 7.5	1
91	1	63-1029	WIRE CLAMP, 3/8	1





## VF-3 GEAR BOX ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SHEET #
1	1	20-7011B	TRANSF. HOUSING, MACHINING (14-7011 CAST)	2
10	1	20-7487	OIL FILL CAP	2
15	1	22-7435	OILER PLATE	2
16	1	22-7445	DRAIN TUBE, DRY SUMP	2
17	1	22-7446	PICK UP TUBE, DRY SUMP	2
19	1	25-7264	SWITCH MOUNTING BRACKET	2
20	1	25-7433	SUMP BRACKET	2
22	1	25-9129	FAN BRACKET, DRY SUMP TRANSM.	2
23	1	25-9130	MOTOR SHROUD	2
27	1	32-1850A	GEAR PUMP MOTOR ASS'Y	2
29	1	36-3035	SPINDLE MOTOR FAN ASS'Y	2
37	4	40-1700	SHCS, 10-32 x 2"	2
38	4	40-1715	SHCS, 5/16-18 x 1 1/2"	2
40	5	40-2026	SHCS, 10-32 x 1"	2
55	1	53-3002	PRESSURE SWITCH PS-126	2
57	2	55-0036	SPRING WASHER, #BS-205	2
58	2	56-0055	SNAP-RING, #5100-212	2
60	1	56-0070	SNAP RING, #5000-187	2
62	2	57-0095	O-RING, 2-327	2
63	1	58-16700	STREET ELBOW, 1/8"	2
64	1	58-16732	1/8 x 1/8 MALE HEX JOINT	2
65	1	58-1674	ADAPTER MALE 1/4 NPT	2
66	3	58-2022	1/2 OD NATURAL TUBING	2
67	3	58-2065	COUPLING, 1/4 NPT	2
68	2	58-2070	1/4 NPT TO 3/8 COMPRESSION	2
69	1	58-2259	BARB. FIT. 1/4-18 NPT	2
71	1	58-2746	1/8 x 1/8 FEMALE COUPLER	2
72	1	58-3618	1/4 STREET ELBOW	2
73	1	58-3635	COUPLING, 1/8 MALE 3/8 C/F	2
74	1	58-3655	COUPLING, 1/8 TO 1/4 BRASS	2
75	1	58-3657	1/4 FEMALE 1/8 MALE ADPT.	2
76	2	58-3680	MALE 1/4 NPT - 3/8 TUBE	2
77	1	58-3695	1/4 NPT FEMALE 'T'	2
78	1	58-3735	1/8 NPT x 4" PIPE NIPPLE	2
79	1	58-7357	TOP PLATE TUBE - A	2
80	1	58-7358	TOP PLATE TUBE - B	2
81	1	58-7359	SHOT PIN TUBE - A	2
82	1	58-7360	SHOT PIN TUBE - B (SERVICE)	2
83	1	58-7361	HIGH GEAR TUBE	2
84	1	58-7362	LOW GEAR TUBE	2
86	1	59-2910	OIL COOLER	2
87	3	59-4005	CABLE CLAMP, 1/4 - 25/32	2
89	1	59-9135	SOUNDCOAT, MTR/GEAR SHROUD	2
92	3	76-2420	CRIMP RING, 12-10 STUD	2





## 16-POCKET TOOL CHANGER ASSEMBLY

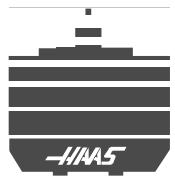
ITEM	QTY	DWG NUMBER	TITLE	SH #
3	1	20-7026	CAM, GENEVA DRIVER	1
9	1	20-7033	HOLDING PLATE, TOOL CHANGER	1
11	1	20-7035	VERTICAL AXLE	1
12	1	20-7036	CAP, TOOL CHANGER	1
13	1	20-7038	BEARING HOUSING, TOOL CHANGER	1
14	1	20-7039	GENEVA DRIVER	1
18	2	20-7106	VEE TRACK, TOOL CHANGER	1
20	1	20-7236	MOTOR MOUNTING PLATE	1
21	1	20-7255	TOOL #1 STANDOFF	1
24	1	25-7162	CONNECTOR BRACKET	1
26	1	25-7237	TOOL CHANGER COVER	1
27	1	25-7238	TRAP DOOR	1
28	2	26-7239	SPACER RING	1
32	6	40-1669	BHCS, 8-32 x 3/8"	1
33	2	40-1800	SHCS, 8-32 x 3/4"	1
34	4	40-1802	SHCS, 8-32 x 1 1/2"	1
35	32	40-16095	SHCS, 10-32 x 1/4"	1
36	12	40-1850	SHCS, 10-32 x 3/8"	1
37	32	40-1704	FHCS, 10-32 x 1/4"	1
38	6	40-1750	BHCS, 10-32 x 3/8"	1
39	1	40-16091	BHCS, 10-32 x 1"	1
40	4	40-16341	FHCS, 10-32 x 3/4"	1
42	4	40-2000	SHCS, 1/4-20 x 5/8"	1
43	42	40-1697	SHCS, 1/4-20 x 3/4"	1
45	4	40-16413	MSHCS, M3 x 5	1
46	6	40-16385	SHCS, 5/16-18 x 3/4"	1
47	6	40-1715	SHCS, 5/16-18 x 1 1/2"	1
48	5	43-7000	HEX HD BOLT, 5/16-18 x 1 3/4"	1
51	1	44-1710	CPSS, 1/4-20 x 3/8"	1
52	2	45-1603	#8 SPLIT LOCK WASHER	1
53	10	45-1800	1/4 SPLIT LOCK WASHER	1
55	1	45-1725	3/4 W FLAT WASHER	1
57	1	46-1705	3/4-10 ELASTIC LOCK NUT	1
58	2	48-0020	1/4 x 1" DOWEL PIN	1
59	1	48-1661	5/16 x 1 1/4" DOWEL PIN	1
60	2	48-1750	1/2 x 1 1/2 DOWEL PIN	1
61	2	51-0012	BEARING LOCK NUT, BH-06	1
62	2	51-0010	BEARING, DEEP GROOVE, #62	1
63	1	54-0010	CAM FOLLOWER, TOOL CHANGER	1
69	1	59-8000	NUMBER SET, 1-16	1
70	4	61-2110	TELEMECHANIQUE SWITCH	1
71	1	62-0020	GENEVA DRIVE MOTOR	1
105	2	32-2010	TELEMECHANIQUE 24" CABLE ASS'Y	1





## 16-POCKET TOOL CHANGER ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SH #
2	1	22-2065	LOCATING PIN, BODY	2
5	1	20-7029	TOOL HOLDING ARM, MACHINED	2
6	1	20-7030	TOOL CARRIAGE, MACHINED	2
7	1	20-7031	CARROUSEL, TOOL HOLDER	2
8	1	20-7032	GENEVA STAR SEGMENT	2
10	1	20-7034	SPACER, CAM FOLLOWER	2
15	1	30-7200A	ACTUATING ARM, ASS'Y, TC	2
16	16	20-7066	EXTRACTOR, CAT-40	2
17	16	20-7067	KEY, EXTRACTOR	2
19	3	22-7163	RIDER, TRAP DOOR	2
22	2	20-7263	SWITCH MOUNT BLOCK	2
23	16	25-7143	NUMBER BRACKET, TOOL POSITION	2
25	1	25-7168	DOOR OPENER BRACKET	2
29	16	25-7249	SLIDING PANEL	2
30	16	25-7250	COVER, SLIDING PANEL	2
31	1	25-7254	CONDUIT MOUNTING PLATE	2
41	3	40-1632	SHCS, 1/4-20 x 1/2"	2
44	4	40-1970	FHCS, 1/4-28 x 1"	2
49	4	43-1602	HEX HD BOLT, 1/2-13 x 3"	2
50	1	44-1622	SSS, K CUP PT 1/4-20 x 1/4"	2
54	17	45-1600	5/16 SPLIT LOCK WASHER	2
56	4	45-1740	1/2 BLK HARDENER WASHER	2
64	2	54-0020	BUSHING GUIDE WHEEL	2
65	4	54-0030	GUIDE WHEEL	2
66	2	54-0040	STANDARD BUSH, GUIDE WHEEL	2
68	16	24-2010	COMPRESSION SPRING	2
72	1	62-0030	SHUTTLE MOTOR	2
98	1	79-1000	WIRE CHANNEL, 1" x 2"	2
99	1	79-1001	COVER, 1" WIRE CHANNEL	2





## 16-POCKET TOOL CHANGER ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SH #
73	6	63-1031	CABLE CLAMP, 1/4" BLACK	3
74	1	70-1502	MTW WIRE, 14 GA GREEN, 13 FT	3
75	1	70-1904	WIRE, 18 GA GREEN, 2.666 FT.	3
76	1	71-1040	2 COND, 20 GA SHIELDED WIRE, 26.74 FT.	3
77	1	71-1050	7 COND, 24 GA SHIELDED WIRE, 13.91 FT.	3
78	1	71-1912	2 COND, 24 GA SHIELDED CABLE, 1.25 FT.	3
80	6	75-15041	LARGE MOLEX INSERT PIN - MALE	3
81	6	75-15042	LARGE MOLEX INSERT PIN - FEMALE	3
83	3	75-15044	LARGE MOLEX HOUSING 2-PIN FEMALE	3
84	4	75-15714	MOLEX HOUSING 4-PIN 0.100 FEMALE	3
85	22	75-15716	FEMALE INSERT (SRT PLUGS)	3
87	4	75-15718	4-PIN CONNECTOR (MALE)	3
88	14	75-15720	MALE INSERT (SRT PLUGS)	3
89	1	75-15721	LARGE MOLEX HOUSING 2-PIN MALE-PANEL MOUNT	3
92	7	76-2320	CRIMP CONNECTOR MEDIUM, BLUE RING	3
94	1	78-1950	HEATSHRINK TUBING, 1/8", 1.05 FT.	3
95	1	78-1952	HEATSHRINK TUBING, 1/4", 1.75 FT.	3
96	1	78-1953	HEATSHRINK TUBING, 1/2", 0.332 FT.	3
97	1	78-1995	CONDUIT, 1/2" EXTRA-FLEX, 10.16 FT.	3





## 16-POCKET TOOL CHANGER ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE	SH #
1	1	22-1098	STRAIN RELIEF, M.S.CONNECT	4
79	1	74-1572	90° 14-PIN MALE CONNECTOR	4
82	2	75-15043	LARGE MOLEX HOUSING 2-PIN MALE	4
86	1	75-15717	6-PIN CONNECTOR (MALE)	4
90	1	75-6000	SHELL, 6-PIN FEMALE CONNECTOR	4
91	2	76-2317	CRIMP CONN, SMALL SPADE	4
93	3	78-19505	HEATSHRINK TUBING, 1/16", 3" L	4
100	2	79-2000	1/2" 90° HUBBEL (NO STRAIN RELIEF)	4
101	1	79-2010	1/2" 0° HUBBEL (NO STRAIN RELIEF)	4
102	1	79-2025	1/2" GROUNDING FERRUL	4
103	1	79-2550	GLANDNUT 053-71814-2	4
104	1	79-2580	NYLON SEALING RING	4

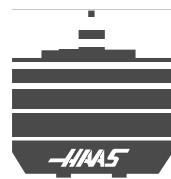




## 20-POCKET TOOL CHANGER ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7036	CAP, TOOL CHANGER
2	1	20-7038C	BEARING HOUSING, TOOL CHANGER
3	20	20-7067E	KEY, EXTRACTOR
4	1	20-7255A	TOOL #1 STAND OFF
5	1	20-7352	20-POCKET CAROUSEL
6	1	20-7353	20-POCKET GENEVA STAR
7	1	22-7035G	VERTICAL AXLE
8	20	22-7066B	CAT-40 TOOL CHANGER EXTRACTOR
9	20	24-2010	COMPRESSION SPRING
10	20	25-7143D	NUMBER BRACKET, TOOL POSITION
11	20	25-7249	SLIDING PANEL
12	20	25-7250B	SLIDING PANEL COVER
13	1	40-16091	BHCS, 10-32 x 1"
14	40	40-16095	SHCS, 10-32 x 1/4"
15	6	40-16385	SHCS, 5/16-18 x 3/4"
16	40	40-1697	SHCS, 1/4-20 x 3/4"
17	40	40-1704	FHCS, 10-32 x 1/4"
18	6	40-1715	SHCS, 5/16-18 x 1 1/2"
19	12	45-1600	WASHER, SPLIT LOCK 5/16 MED.
20	2	48-0020	PIN, DOWEL 1/4 x 1"
21	2	51-0010	BEARING, DEEP GROOVE, #62
22	1	51-0012	BEARING LOCK NUT, BH-6
23	1	59-8000	NUMBER SET, 1-20





## 20-POCKET TOOL CHANGER ASSEMBLY

ITEM	QTY	DWG NUMBER	TITLE
1	1	20-7029B	TOOL HOLDING ARM, MACHINED
2	1	20-7030E	TOOL CARRIAGE
3	1	20-7033F	HOLDING PLATE
4	2	20-7106	'V' TRACK, TOOL CHANGER
5	1	20-7236	MOTOR MOUNTING PLATE
6	2	20-7263	SWITCH MOUNTING BLOCK
7	1	22-2065	LOCATING PIN
8	1	22-7034	SPACER, CAM FOLLOWER
9	3	22-7163	RIDER - TRAP DOOR
10	1	25-7162	CONNECTOR BRACKET
11	1	25-7168	DOOR OPENER BRACKET
12	1	25-7237C	TOOL CHANGER COVER
13	1	25-7238C	TRAP DOOR, TOOL CHANGER
14	1	25-7254F	CONDUIT MOUNTING PLATE
15	2	26-7239	SPACER RING
16	1	30-7100B	20-POCKET CAROUSEL ASS'Y
17	1	30-7200A	ACTUATING ARM ASS'Y
18	1	30-7300A	GENEVA DRIVER ASS'Y
19	1	32-1800	SHUTTLE MOTOR ASS'Y
20	1	32-1900A	TURRET MOTOR ASS'Y
21	2	32-2000	TELEMECHANIQUE 8" CABLE ASS'Y
22	2	32-2010	TELEMECHANIQUE 24" CABLE ASS'Y
23	1	32-7010	TOOL CHANGER CONDUIT ASS'Y
24	1	32-7610A	CONDUIT ASS'Y, TOOL CARRIAGE
25	3	40-1632	SHCS, 1/4-20 x 1/2"
26	4	40-16413	MSHCS, M3 x 5
27	6	40-1669	BHCS, 8-32 x 3/8"
28	10	40-1697	SHCS, 1/4-20 x 3/4"
29	4	40-1702	FHCS, 10-32 x 5/8"
30	6	40-1750	BHCS, 10-32 x 3/8"
31	4	40-1803	SHCS, 8-32 x 1 1/4"
32	12	40-1850	SHCS, 10-32 x 3/8"
33	4	40-1970	FHCS, 1/4-28 x 1"
34	4	40-2000	SHCS, 1/4-20 x 5/8"
35	4	43-1602	HHB, 1/2-13 x 3"
36	5	43-7000	HHB, 5/16-18 x 1 3/4"
37	5	45-1600	WASHER, SPLIT LOCK 5/16 MED.
38	1	45-1725	WASHER, FLAT CUT 3/4"
39	4	45-1740	WASHER, BLACK HARD 1/2"
40	10	45-1800	WASHER, SPLIT LOCK 1/4" MED.
41	1	46-1705	LOCK NUT, ELASTIC, 3/4-10
42	2	48-1750	DOWEL PIN, 1/2 x 1 1/2"
43	1	54-0010	CAM FOLLOWER, TOOL CHANGER
44	2	54-0020	BUSHING, GUIDE WHEEL
45	4	54-0030	GUIDE WHEEL
46	2	54-0040	STANDARD BUSHING, GUIDE WHEEL
47	6	63-1031	CABLE CLAMP, 1/4"
48	1	70-0050	PLT4S-M CABLE TIES, BLACK
49	1	75-15721	LARGE MOLEX HOUSING MALE
50	1	78-1996	SPLIT FLEX TUBING 1/2" I.D.
51	1	79-1000	WIRE CHANNEL, 1" x 2", 1.75 FT.
52	1	79-1001	COVER, 1" WIRE CHANNEL, 1.75 FT.



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